ESSAYS ON AGING AND HUMAN CAPITAL

by

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To my parents,
who inspire me in countless ways

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CHAPTER I

Introduction

This dissertation comprises three distinct essays on aging and human capital. The first two essays examine how the prospect of widowhood and cognitive decline influence the division of labor of older couples, particularly with respect to financial knowledge and decision-making. The third essay discusses the selectivity of internet surveys for an older population. As a whole, this dissertation highlights the importance of cognition, one facet of ability that affects investments in and the productivity of human capital.

The first essay provides a new interpretation for an old pattern–that women tend to have lower levels of financial literacy than men. Women also tend to outlive their husbands, so they will eventually need to take over the management of family finances. Using a new survey of older couples, I find that women acquire additional financial literacy as they approach widowhood. These results are consistent with a model in which the household division of labor breaks down when a spouse dies. The model shows that women have incentives both to delay acquiring financial knowledge and also to begin learning before widowhood. This essay is the first empirical examination of the financial literacy of both members of couples and provides a life-cycle interpretation of the gender gap in financial literacy.

The second essay, written with Robert Willis, complements the first by investigating a different source of uncertainty affecting the division of labor and the management of household finances. Alzheimer's disease and other dementias cause progressive declines in cognition that lead to a complete loss of functional capacities. These declines pose enormous financial risk to the household due to the high costs of care and the potential for financial mismanagement by an impaired decision-maker. Therefore, the early detection of Alzheimer's, in spite of the incurability of the disease, can potentially yield large benefits if it enables preparation prior to the loss of mental faculties. In this essay we analyze the impact of information about cognitive decline on the choice of financial respondent in a large-scale survey of older Americans. We find that couples with investments that are individually controlled are much more responsive to a diagnosis of a memory-related disease than couples who passively receive their retirement income. This finding is consistent with a model of the value of information: households with the most to gain financially from preparation are most responsive to information about cognitive decline.

The final essay, written with Gwenith Fisher and Robert Willis, addresses a challenge in the use of new technologies in survey research. Fielding surveys over the internet provides many benefits over traditional survey modes like mail questionnaires and telephone interviews, including lower cost, greater speed, and ease of customization. This essay discusses the implications of surveying older populations using the internet, focusing on selectivity problems. Using a survey in which some variables are collected in a single mode to web users and non-users alike, we find that for an older population, an internet sample selects on age and education, as one might expect, but also on cognition. An internet-only sample would miss an increasing number of persons, particularly those with lower fluid and crystallized in-

telligence, at older ages. Because of selection, an internet-only sample would lead to an overestimate of level of intelligence and an underestimate of the rate of cognitive decline with aging.

CHAPTER II

Aging and Strategic Learning: The Impact of Spousal Incentives on Financial Literacy

2.1 Introduction

Empirical studies have found that women tend to have, on average, lower levels of financial literacy than men (Fonseca et al., 2010; Lusardi and Mitchell, 2008; Kotlikoff and Bernheim, 2001). This gap may reflect a division of labor within the household such that men are responsible for financial matters. However, women also tend to outlive their husbands, so they will eventually need to take over this task. Women therefore have an incentive both to delay acquiring financial knowledge and also to begin learning prior to widowhood. Financial literacy is a critical form of financial knowledge that is linked to important economic outcomes. Economists view investment in human capital as a purposive process, and in this chapter, I show that the acquisition of financial literacy is no different.

This chapter presents a model of the human capital investment process of longer-lived spouses over the life cycle and tests the model's predictions using innovative new data on financial literacy and financial decision-making. The management of household finances is likely to both be subject to a division of labor and to be taken care of by men, who will most likely be survived by their wives. I show that the prospect of widowhood provides an incentive for women to accumulate financial

literacy. In particular, the model generates three results. First, if the household finances are managed by their husbands, women may rationally delay learning about finances. Secondly, investments in financial knowledge should increase as widowhood becomes more imminent; lastly, longer durations of widowhood provide additional incentives for accumulating more human capital.

While I analyze the model specifically for women and financial literacy, the model is generalizable to any task specialized in by the shorter living spouse. Using a cross-sectional sample that links husbands and wives, I use variation in the husbands' life expectancies to analyze how women accumulate human capital relative to their husbands (who do not have this incentive to increase learning in old age) as women approach widowhood. I find that women increase their financial literacy as they approach widowhood. At an estimated increase of 0.04 standard deviations per year approaching widowhood, 80 percent of women in my sample would catch up with their husbands prior to the expected onset of widowhood.

Financial knowledge is critical due to its relationship to economic outcomes and its policy implications. Financial literacy is linked to financial decision-making and outcomes, including more effective wealth management (Hilgert et al., 2003), better management of credit and debt (Hilgert et al., 2003; Lusardi and Tufano, 2009), retirement planning (Lusardi and Mitchell, 2007, 2009), increased saving (Kotlikoff and Bernheim, 2001; Carlin and Robinson, 2010), and higher stock market participation (Delavande et al., 2008; van Rooij et al., 2007). Given these links, having sufficient financial literacy is becoming even more important since the responsibility for retirement planning has shifted to individuals. Wealth management has become increasingly complex as predictable streams of retirement income from defined benefit pensions have been replaced by defined contribution plans that need to be managed

both before and after retirement (Mitchell and Schieber, 1998). In addition, financial literacy has become a prominent policy issue. While the government identified increasing financial literacy as a policy goal in 2003 (Fair and Accurate Transaction Act), this goal has become an even higher priority in the wake of the 2008 economic crisis. The large numbers of foreclosures, defaults, and debt problems that arose during the housing and financial crisis highlight the costs of financial illiteracy for individuals with low and high levels of wealth. Furthermore, policy proposals to privatize Social Security would introduce further individual responsibility for retirement planning and require even more knowledge.

This chapter makes a number of contributions. This is, to my knowledge, the first study to analyze investments in financial knowledge in a life-cycle framework. While a number of studies have shown that women have lower levels of financial literacy than men, I show that women accumulate knowledge as they approach widowhood, suggesting that a gender gap in financial literacy may reflect strategic responses of women to incentives over the life cycle.

Second, this chapter is the first to link the financial knowledge of the two members of a couple. By using the *spousal* gap in financial literacy rather than differences between women and men in different households, I can investigate how financial knowledge relates to the division of labor over the life cycle. I also use a detailed set of cognitive measures to show that the narrowing of the wife-husband gap in financial knowledge reflects advances on the part of women and is not merely an artifact of men's cognitive decline.

This chapter combines ideas about the household division of labor with human capital theory. Section 2.2 provides additional background on financial knowledge as human capital in the context of the household division of labor and widowhood.

Section 2.3 presents a theoretical model of the timing of a woman's investment in financial human capital over her lifetime. Section 2.4 describes the data used, and Section 2.5 presents evidence that older women acquire financial knowledge as widowhood approaches. These effects remain even when controlling for the cognitive decline of the husband. Section 2.6 concludes.

2.2 Financial literacy, human capital, and specialization

The management of household finances is an important type of non-market production that requires its own form of human capital. One major component of this human capital is financial literacy. There is increasing public and scholarly interest in financial literacy and informed financial decision-making, in part because of the poor financial outcomes that are associated with low levels of financial literacy: problems with debt (Lusardi and Tufano, 2009) and lack of retirement planning (Lusardi and Mitchell, 2007, 2009), among others. At the same time, studies have found that Americans tend to display low levels of financial literacy (Bernheim, 1998; Hilgert et al., 2003; Lusardi and Tufano, 2009). In particular, Lusardi and Mitchell (2006) find that financial illiteracy is widespread among older Americans. Recent government policies, including the establishment of the Consumer Financial Protection Bureau, aim to increase financial literacy among the public.

Studies have shown that women tend to have lower levels of financial literacy than men (Fonseca et al., 2010; Lusardi and Mitchell, 2008; Kotlikoff and Bernheim, 2001). This is true even for younger women (Lusardi et al., 2009a; Chen and Volpe, 2002), in spite of the gains in educational attainment younger women have made relative to men. Low levels of financial literacy may not be problematic if one's partner has higher literacy and specializes in managing household finances. As Becker (1985)

shows, under a number of assumptions, it is efficient for members of a household to specialize in particular tasks. However, such reliance on a partner can have serious consequences when one is unable to divide tasks among household members either before the formation of a household or during widowhood.

In American households, men are usually primarily responsible for household finances.[1] In the Cognitive Economics Study used in this chapter, only 16 percent of couples report that the woman is the most financially knowledgeable person in the household. A person may become the financial specialist in a couple for a number of reasons. First, the person with a greater stock of financial knowledge when entering the marriage might be more likely to specialize; this could favor the older member of the couple, typically the man. This advantage may arise from past experience with money and finances, possibly through one's occupation. Educational sorting may play a role, if college-educated women were more likely to major in non-quantitative fields. Second, in addition to the initial stock of knowledge however acquired, another factor may simply be interest or enthusiasm on the part of the specialist, or fear or avoidance on the part of the non-specialist. Third, the division of labor may also be a product of intra-household bargaining. Whatever the root causes, women tend to be less financially literate than men. Since women are likely to outlive men, this leads again to the question of what happens when this division of labor is no longer sustainable.

Indeed, some economists have shown that the expected duration of a household affects how labor is divided. Johnson and Skinner (1986) find that greater divorce risk increases the labor supply of women, and Stratton (2005) shows that cohabi-

[1] Another form of non-market production is the management of health and medical matters. In the United States, women tend to specialize in these matters. Studies show between 60 to 80 percent of women are primary decision makers about health care (including selecting doctors and health insurance) for their families, with an additional 18 to 22 percent reporting making joint decisions with partners or spouses (Salganicoff et al., 2002, 2005). Critically, however, men are much less likely to outlive a spouse and be tasked with replicating this knowledge.

tating couples, whose relationships are typically shorter in duration than those of married couples, have less intra-household specialization in housework than married couples. While widowhood is a completely different form of relationship termination, it operates similarly by ending a person's ability to reap the benefits of specialization. This suggests that the nature of the division of labor within a household changes over time and therefore calls for continued investment.

Widowhood is a very likely outcome for most married women, who not only face longer life expectancies than men but are also typically younger than their husbands. According to 1995 marital status life tables, 75 percent of marriages not ending in divorce end in widowhood (Schoen and Standish, 2001). Furthermore, the mean duration of widowhood in the Health and Retirement Study is about nine years (author's own calculations). Although the gender disparity in life expectancies has changed over time, widowed women still outnumbered widowed men four to one in 2003 (U.S. Census Bureau, 2004). The prospect of many years without the couple's financial specialist creates incentives for women to prepare by acquiring financial knowledge.[2]

The notion that financial knowledge is a form of human capital was introduced in Delavande et al. (2008), which related the production of human capital to portfolio choice. Human capital accumulation is purposive based on its costs and benefits, and likewise, financial illiteracy or lack of financial knowledge can be costly for widows for a number of reasons. Even a widow who plans to delegate the management of her finances to a professional or a relative needs enough knowledge to choose someone

[2]This chapter focuses on the incentives created by the prospect of widowhood faced by women. Incentives may arise from other aspects of gender differences in aging and mortality. For example, a woman may plan on being responsible for finances when her husband becomes cognitively or physically impaired due to aging, if she believes these her husband's decline will occur before her own. Chapter III examines the role of cognitive decline and Alzheimer's disease on financial decision-making using a longitudinal dataset. Because the empirical analysis in this chapter employs a single cross-section, I cannot identify declines of husbands relative to declines of wives.

trustworthy and to recognize if she is being bilked. If she manages her own finances, she needs to be knowledgeable enough to distinguish fraudulent offers from legitimate ones. On the other hand, a widow who recognizes her lack of knowledge but does not trust any individuals or financial institutions may lose potential gains by keeping all of her money in cash. Lack of financial knowledge can also lead to anxiety about money. A woman with insufficient financial knowledge may find herself in widowhood without a firm understanding of how much she can afford to spend, what her holdings are, or how quickly to decumulate during widowhood.

Since investment decisions and payoffs are realized over the life cycle, an important aspect of human capital accumulation is the timing of such investments. Mincer and Polachek (1974) argue that the human capital investments and time allocation of individuals will be influenced by expectations of future family and market activities. In most applications such as formal education and on the job training (Ben-Porath, 1967), it is advantageous to invest early to capture the longest stream of benefits. On the other hand, some investments (such as religious devotion as investment in the afterlife, studied by Azzi and Ehrenberg (1975)) do not usually yield benefits until much later in life, so that the payoffs to such investments should increase with age. Similarly, household specialization creates delays in the returns to investing in knowledge related to the spouse's tasks. The time horizon for the payoffs also affects the benefits to human capital investments; Jayachandran and Lleras-Muney (2009) investigate the effect of a sudden drop in maternal mortality in Sri Lanka and find that this increase in women's life expectancy increases human capital investments in girls.

In this chapter, I develop a model to help explain the timing of human capital investments in the spouse's tasks and the effects of differing time horizons arising

from gender differences in life expectancies. Using an innovative new dataset, I study the financial knowledge of husbands and wives, and in doing so I am able to learn more about an aspect of household production that is not well understood. One theme underpinning the human capital literature is that investments are purposive, and I show that the timing of investments in financial human capital is purposive as well.

2.3 Theoretical framework

This section presents a simple model, assuming no uncertainty, to build intuition for the effects at play. To model the woman's decision to accumulate human capital related to something in which she does not specialize, consider a time span that begins with marriage ($t = 0$) and lasts until the end of the wife's life in period T. The woman will outlive her husband, who passes away at time $t = D$ (see Figure 2.1). Therefore, widowhood spans from time D to T. Assume the husband specializes in household finances from the beginning of the marriage. The marital match is taken as exogenous.

Assume further that non-wage financial resources can only be used if at least one person in the household has financial knowledge. A new widow with no financial knowledge will not be able to access any non-wage financial resources until she acquires some financial knowledge.[3] In this case, smoothing of consumption (or earnings) implies that a widow will want at least some financial knowledge at the time of widowhood. This is most realistic in a situation in which the husband was wholly responsible for all household financial matters.

A woman only begins to use this financial knowledge after her husband dies, after

[3]Or, one could hire a professional to manage finances, which incurs a monetary rather than time cost. Doing so also requires enough knowledge to evaluate the abilities or trustworthiness of potential advisors and to monitor their activities.

which the returns to her stock of financial human capital K are $v(K)$ annually until her death. The present discounted value (after depreciation) of a marginal unit of financial human capital over the course of her life is then:

$$P_t = \begin{cases} [\beta(1-\delta)]^{D-t} \sum_{j=0}^{T-D} \beta^j v'(K_t) & \text{if } t < D \\ \sum_{j=0}^{T-t} \beta^j v'(K_t) & \text{if } t \geq D \end{cases}$$

where β is the subjective discount factor and δ is the depreciation rate of human capital. Prior to widowhood, the value of a marginal increase in financial human capital is the present value of the stream of annual benefits realized during widowhood for a total of $T - D$ years, discounted by the number of years a woman must wait until the stream begins ($D - t$ years). At time zero, the present value of the benefits are low due to the D-year delay until widowhood. The value increases as a woman approaches widowhood, at which point it declines because of the decreasing number of years the knowledge can be used.

Assuming that units of human capital have a constant marginal product of one, and that it is independent of the number of units newly acquired or of the current stock of knowledge, the time path of P_t follows Figure 2.2. P_t can therefore be interpreted as the demand for financial human capital at time t.

This demand is time variant, so a marginal cost curve is required to pin down the time-path of human capital investments. Time allocated to acquiring financial knowledge will be at the expense of other activities. In its simplest form, assume that this marginal cost curve is upward sloping and fixed over time, with its position determined by underlying ability. In this case, as P_t shifts upward, a woman will acquire more human capital until widowhood (with the rate of accumulation increas-

ing with age), after which point she will no longer acquire more units, as the costs exceed the benefits. She will therefore use whatever human capital she acquired by time D for the duration of widowhood.

The derivative of P_t with respect to the time to widowhood D is

$$\frac{dP_t}{dD} = [\beta(1-\delta)]^{D-t}\frac{1}{1-\beta}\left(\beta^T ln\beta + (\beta - \beta^{T+1-D})ln[\beta(1-\delta)]\right) < 0. \tag{2.1}$$

The negative sign of this derivative confirms the intuition that one approaches widowhood, the marginal benefit increases.

The derivative with respect to the length of widowhood (holding D constant):

$$\frac{dP_t}{d(T-D)} = -[\beta(1-\delta)]^{D-t}\frac{1}{1-\beta}\beta^{T+1-D}ln\beta > 0. \tag{2.2}$$

Therefore, the shorter the time to widowhood, the greater the demand for financial human capital. The longer the duration of widowhood, the greater the demand for financial knowledge.

The ratio of the magnitude of the two derivatives is

$$\frac{-\frac{dP_t}{dD}}{\frac{dP_t}{d(T-D)}} = \frac{\beta^T ln\beta + (\beta - \beta^{T+1-D})ln[\beta(1-\delta)]}{\beta^{T+1-D}ln\beta}. \tag{2.3}$$

Assuming $\beta = 0.97$ [4] and $\delta = 0.03$, with $T - D$ the length of widowhood and D the time to widowhood, the mean ratio in my sample ranges from 1.53 to 3.28 (see Table 2.1). The ratio is larger the more imminent widowhood is and the longer the duration of widowhood. The ratio is also larger the greater the depreciation rate of human capital and the lower the discount factor β. Therefore, the effect of the time to widowhood on the acquisition of financial literacy should be greater in magnitude than the effect of the duration of widowhood.

[4] Gourinchas and Parker (2002) estimate a structural model using U.S. CEX data and find that high school graduates have a discount factor of 0.96 and college graduates have a discount factor of 0.97.

Lastly, a large depreciation rate δ of human capital also increases the incentive to delay the investment. In the context of financial knowledge, depreciation may take the form of specific knowledge becoming obsolete as financial institutions and rules change.

In sum, the model predicts that a woman will acquire financial knowledge very slowly at the beginning of the marriage and delay larger investments in human capital. The rate of investing will increase as the expected time of widowhood approaches. After her husband dies, she takes charge of the finances and accrues payoffs to her financial knowledge.

This framework is described in terms of financially specializing husbands and their wives, but it can easily apply to any couple in which one person outlives the other and the shorter living spouse specializes in at least one task. The fact that women have longer life expectancies than men and are typically younger than their husbands makes it easier to test the implications of such a model. Had the longer-living spouse specialized in household finances from the beginning of the match, the time-path of human capital investments related to finances would more closely follow the Ben-Porath prediction[5] — front-loaded investments that decline over time.

2.4 Data

The data for the empirical analysis come from the Cognitive Economics Survey (CogEcon),[6] which is an innovative new survey of a national sample of persons 51 and older and their spouses regardless of age. The first wave, administered in the

[5]The Ben-Porath model includes a key feature that I have dropped for simplicity: the ability of the current capital stock to increase the productivity of subsequent investments. This feature allows his model to generate a time path that begins with full time learning and drops sharply, in contrast to the smooth concave function generated by mine.

[6]The Cognitive Economics Survey is supported by NIA program project P01 AG026571, "Behavior on Surveys and in the Economy Using HRS," Robert J. Willis, PI. In addition to Willis, University of Michigan faculty Gwen Fisher, Miles Kimball, Matthew Shapiro, and Tyler Shumway and graduate students Brooke Helppie and Joanne Hsu had roles in designing and fielding the CogEcon study.

spring and summer of 2008, includes a twenty-five question battery on financial literacy, detailed measures of income, wealth and portfolio allocation plus measures of risk tolerance, self-assessed financial knowledge, use of records and other sources of information and several questions on decision-making. An additional survey was administered to these respondents in 2009 to follow up after the onset of the economic downturn beginning in the fall of 2008.

These respondents also participated in the Cognition and Aging in the USA study (CogUSA),[7] which includes an extremely detailed cognitive assessment. In addition, respondents were asked questions about their subjective expectations, including their subjective survival probabilities. The combined survey allows for the linking of cognitive and economic measures. Furthermore, unlike many other studies that designate one financial respondent in a household, this study collects measures of financial decision-making and financial knowledge from both husbands and wives.

Because the model predicts that women will increase their financial knowledge acquisition prior to the death of their spouses, the empirical analysis requires measures of the expected time of widowhood. Life expectancies and survival probabilities for CogEcon respondents are drawn from 2004 period life tables published by the National Center for Health Statistics at the U.S. Department of Health and Human Services and the National Vital Statistics System at the Centers for Disease Control and Prevention.[8] Alternative survival measures employ subjective survival questions as well as objective survival probabilities predicted using the Health and Retirement Study, a much larger scale longitudinal survey of similarly-aged individuals.[9] These

[7]The CogUSA Study is sponsored by the National Institute of Aging, grant number R37 AG007137, "Assessing and Improving Cognitive Measurements in the HRS," John J. McArdle, PI.

[8]The life tables by age and sex used in my analysis are found in Tables 2 and 3 from Arias (2007). These 2004 life tables were the most up-to-date versions published by the National Center for Health Statistics at the time the CogEcon Survey was fielded.

[9]The HRS (Health and Retirement Study) is sponsored by the National Institute of Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan. Some variables were provided by the RAND HRS Data file (RAND HRS Data, 2010). See http://hrsonline.isr.umich.edu for more information.

measures are described in more detail in Section 2.5.4.

2.4.1 Sample and demographics

CogEcon collects information from 748 unique households[10], defined as couples or individuals without partners. The analysis sample includes 233 couples in which both members have participated in the survey (466 respondents). 286 unmarried respondents also participated in the survey. An additional 229 respondents have partners about whom we have partial or no information due to complete or partial non-response. Further information about response rates and the derivation of the analysis sample can be found in Appendix 2.7.

Table 2.2 reports the demographic characteristics of all respondents with spouses in the sample. The average age of women is 60.5 years, with men about 2.5 years older. According to life tables, these women face a life expectancy of 24 years, while their husbands have a mean life expectancy of about 19 years. Men have slightly more years of education than their wives in this sample. Only 16 percent of wives report being most knowledgeable about finances.

2.4.2 Outcomes of interest: financial knowledge

General financial literacy

The survey includes a financial literacy battery of 25 questions. Each of these questions is a statement, and the respondent is asked whether s/he thinks the statement is true or false, and how sure s/he is of that that response on a twelve-point scale based on her/his degree of certainty (see Figure 2.3). Whether a respondent sees the true or false version of a question is randomized. Questions are converted to the true version so that the scale can be interpreted as "0% surely (correct answer)"

[10]Three same-sex households are excluded as there are no established patterns that indicate that the shorter-living member is more likely to be the financial specialist in such couples.

to "100% surely (correct answer)." The responses are re-scaled to a zero-one scale.[11] An individual's financial sophistication score is calculated by taking each respondent's mean score across questions in the battery and normalizing across all survey respondents. A within-couple relative score is computed using the wife-husband difference in normalized mean scores.

Topics covered include interest compounding, diversification and risk, financial terms, stock market concepts, taxation, and inflation. For the full text of each question, see Appendix 2.7.3. To account for the fact that not all respondents may participate in the stock market, some analyses will employ a financial literacy score that excludes the fifteen stock related questions. As can be seen in the summary statistics in Table 2.3, men have, on average, higher levels of financial literacy than women whether or not stock questions are included.

Additional outcomes

While financial literacy is the central measure of financial knowledge in this chapter, I also replicate the analysis with several other measures to see if similar patterns hold with respect to the imminence and expected duration of widowhood. The 2008 survey asks each respondent to rate on a six point scale his ability to deal with day-to-day financial matters as well as his understanding of the stock market. In 2009, respondents were asked how often they follow the stock market, as well as whether they think stock returns have exceeded bond returns over the last 100 years. Respondents' beliefs about stock market returns, as well as the extent to which they follow the market, complement financial literacy as measures of general knowledge

[11] The re-scaling is based on the assumption that respondents have in mind a probability that the statement in the question is true, and they select their answer choice by rounding off their probability to the nearest choice on our 12-point scale. We can then construct intervals within which a respondent would round to each answer choice, and the point-value we assign is the midpoint of this interval. For instance, those who believe a statement is true with certainties between 95 percent and 100 percent would round up to 100 percent surely true, so that choice is assigned the value 0.975.

because they have direct bearing on financial planning, stock market participation, and investment behavior. Correct beliefs about stock market returns may also reflect greater involvement in household investments. The full text of these questions are provided in Appendix 2.7.

2.4.3 Cognitive ability, health, and risk tolerance measures

While the model emphasizes the effect of a spouse's mortality on the division of labor, a spouse's declining cognition or health status are other factors that would similarly necessitate learning about his tasks. Summary statistics for these factors are reported in Table 2.3.

One of the most widely accepted theories of cognitive abilities is the *Gf-Gc* theory (Cattell, 1941; Horn, 1965; Horn and Cattell, 1966, 1967). Primary abilities are divided into two broad dimensions: fluid intelligence (Gf) and crystallized intelligence (Gc). Fluid intelligence represents reasoning abilities that result from biological influences on intellectual development, such as heredity or injuries to the nervous system. Crystallized intelligence refers to the use of accumulated knowledge and skill and represents the results of educational investments and experience rather than underlying ability. The distinction between fluid and crystallized intelligence is similar to the notion of ability versus human capital in labor economics. Other cognitive abilities include episodic memory and processing speed.

Financial literacy can be interpreted both as a form of human capital as well as a form of crystallized intelligence. While crystallized intelligence tends to increase through the accumulation of knowledge, fluid intelligence peaks early in life and declines over the remaining life cycle. Psychologists have verified that both fluid intelligence and the episodic memory decline with age (McArdle et al., 2007; Verhaeghen and Salthouse, 1997; McArdle et al., 2002). Furthermore, episodic memory

is typically among the first cognitive functions to deteriorate during aging (Backman et al., 2001). Measures of fluid intelligence and episodic memory can thus be used to control for the cognitive decline of respondents and to conduct robustness checks on my results.

Fluid intelligence is measured using a normalized W-score of the Woodcock-Johnson III Number Series test. Respondents are given a sequence of numbers with a missing number, and they are asked the value of the missing number. The W-scores used by psychologists are scaled using a large external norming sample, but here I normalize the scores among all CogUSA respondents for easier interpretation. Episodic memory (conceptualized as a form of fluid intelligence) is measured using a Total Recall score, which is derived by testing both immediate and delayed recall of a list of ten words. Again, I use scores that are normalized using all CogUSA respondents. As can be seen in Table 2.3, in the CogEcon sample, men tend to have higher Number Series scores, but lower Total Recall scores, than women.

Additional cognition measures can be used in place of financial knowledge as falsification tests. I will use a variety of cognitive measures: working memory, processing speed, verbal reasoning, and numeracy/mathematical skill. The Mental Status battery includes the Serial 7s test, which is a measure of working memory, or the ability to actively store and manipulate information in order to conduct complex cognitive tasks, including learning or reasoning. The Mental Status score also uses tests of backwards counting, date naming, object naming, and President/Vice President naming. The Woodcock-Johnson III Visual Matching test measures processing speed, and studies show that "measures of speed tend to share about 75% of the age-related variance with various cognitive measures" (Salthouse, 2000). The Woodcock-Johnson III Verbal Analogies test measures the respondent's ability to

reason using lexical knowledge; it is a verbal measure of fluid intelligence. Lastly, numeracy or mathematical skill is measured with the Woodcock-Johnson III Calculation test. The Number Series and Calculation tests are the two scores that are most highly correlated with financial literacy.

In addition to his cognitive decline, a husband's poor physical health may also contribute to a woman taking over his tasks. One overall measure of health is the question, "Would you say your health is excellent, very good, good, fair, or poor?" This self-rated health measure is coded from 1 (for poor) and 5 (for excellent). Women rate their health slightly higher than men (See Table 2.3), though this difference is not statistically significant.

Lastly, a risk tolerant woman may be more willing to delay investments in her husband's tasks than a risk averse woman. The Cognitive Economics survey asks questions about hypothetical gambles similar to those asked in the Health and Retirement Study to measure risk tolerance (Barsky et al., 1997). Respondents are assigned one of six ordinal categories of risk tolerance based on which of the hypothetical gambles are accepted or rejected.

2.5 Empirical results and discussion

2.5.1 The CFO and the household division of labor

The most direct question related to household division of labor asks "Which member of the immediate family is most knowledgeable about your family's assets, debts, and retirement planning?" Respondents may specify "me," "my spouse/partner," "both me and my spouse/partner," or "someone else in the family" as the household's "Chief Financial Officer." About 16 percent of women in couples report being most knowledgeable, and less than half report being at least equally knowledgeable (see Table 2.2).

A unique advantage of the CogEcon study is that it poses the same questions to both members of a couple whenever possible. Table 2.4 cross-tabulates the two members' responses to the question about who is most financially knowledgeable within the household. 152 couples, comprising 65 percent of these married couples, gave strongly consistent answers. This includes couples for which both specify "both of us", or one member specifies "me" and the partner/spouse specifies "my spouse/partner." Weakly consistent answers are answers that are not the same but are non-contradictory. These include cases in which one member specifies "both of us," whereas the spouse/partner chooses either "me" or "my spouse/partner," or if one member of a couple skips the question. 71 couples, or 30 percent of married couples, gave weakly consistent answers. Other combinations are contradictory and are considered inconsistent; ten couples, or four percent of married couples, fall in this category. Because of the small number of couples with inconsistent answers, the analysis will ignore these discrepancies and will generally consider the woman's response as representative of the couple.

To verify that the question on financial knowledge provides information about the division of labor, I investigate how financial knowledge relates to financial decision-making using the question "Who (among members of your immediate family) makes the decisions about how to save for retirement and other large expenses?" Responses to the two questions are highly correlated. Among those in couples, over 60 percent of respondents name the same person (or persons, in the case of the "both" answer choice) as the most knowledgeable as well as the decision-maker. Over one third of respondents state that both members of the couple make decisions while only one is most knowledgeable, a small number state the reverse, and for 2 percent of couples both are most knowledgeable but one makes the decisions. Only about 2 percent

of respondents give inconsistent answers to the two questions — for instance, the partner is most knowledgeable, but the respondent himself makes the major decisions. Since these inconsistent responses are so few in number and because a majority of respondents state that decisions are made by both members of the couple, the most knowledgeable person is a meaningful measure without incorporating additional data about who makes the major decisions.

Table 2.5 reports the characteristics of households with a female, male, or joint CFO. Only 16 percent of couples have female CFOs. The CFO tends to be more educated, have more financial literacy, and have more fluid intelligence (as measured by the Number Series score) than his or her spouse; this is true for couples with male CFOs as well as those with female CFOs. These patterns are consistent with the idea that where one spouse has a comparative advantage with respect to fluid intelligence or education, s/he becomes the CFO. In addition, the intra-couple age gap is smaller in couples with female CFOs than those with male CFOs. Also, small differences in the Number Series score become amplified in the differences in financial literacy, which may be a product of specialization.

Similar patterns can be seen in Table 2.6, which reports the proportion of couples for which the woman has higher levels of the characteristic than her husband. These proportions are higher when women are CFOs; lower when men are CFOs; and in between when both are jointly CFOs. The results verify that the patterns in Table 2.5 are not driven by a few outliers.

2.5.2 Descriptive non-parametric analysis: Financial literacy by age

The cross-section can be used as a synthetic cohort to see if patterns of financial knowledge within couples change with age. My model predicts that women should increase their financial knowledge as they approach widowhood. Furthermore, if

their husbands' cognition and/or health deteriorates earlier than their own, women will have greater incentive to acquire more knowledge relative to their husbands. Because the survey is not currently longitudinal, there are no measurements of baseline knowledge for women. To measure changes in financial knowledge in the synthetic cohort, I instead use the husbands' knowledge as a baseline.

Figure 2.4 shows the age profile of the financial sophistication score based on the husband's age. The age profile is estimated using a lowess plot (locally weighted scatterplot smoothing), which non-parametrically estimates:

$$wife's\ financial\ literacy - husband's\ financial\ literacy = f(husband's\ age). \tag{2.4}$$

Men's financial sophistication follows a flat or upside-down U-shape, whereas women's financial sophistication score is upward sloping with respect to their husband's age, which can be seen in the graph on the left. A similar pattern emerges when stock questions are excluded, as seen in Figure 2.5.

To see if this pattern holds when women are matched to their husbands, I plot the wife-husband difference in financial sophistication on the right side graph of Figure 2.4. Within couples, the wife's score rises relative to her husband's score as he ages and his life expectancy shortens; this is true also when excluding stock questions in Figure 2.5. These patterns are not sensitive to bandwidth choice. Univariate regressions of the wife-husband difference in financial scores on the husband's life expectancy show the same negative relationship. The slopes for the full financial score estimate and the non-stock financial score estimate are statistically significant at the ten percent and five percent level, respectively (see Table 2.7). This is consistent with the notion that women invest in their human capital as their husbands age.

Possible confounders

Is this active learning on the part of the women, in anticipation of their husbands' decline in health and cognition? The age profiles in financial knowledge detailed above are also consistent with two different explanations unrelated to my theoretical model. First, the gains in women's knowledge relative to men may not actually reflect any actual gains; women's knowledge may remain constant while their husbands' cognition declines. Secondly, older women may have been in charge of finances throughout their marriages, thereby violating the assumptions of the synthetic cohort analysis employed here, and the results may merely reflect cohort effects.

Cognitive decline of husbands One might be concerned that these age profiles are generated by older men paired with younger women, such that an increase in the wife-husband financial knowledge gap is driven solely by a decline in the husband's ability, rather than a true increase in the woman's ability. Figure 2.6 shows age profiles of various other cognitive scores, plotted against the husband's age (comparable to the upper left panel of Figure 2.4). These graphs are generated by locally weighted scatterplot (lowess) smoothing. Aside from the Total Recall score, none of the other cognitive measures have a wife-husband gap that increases with the husband's age. The scores for husbands and wives track each other remarkably closely by the husband's age; if anything, for Verbal Analogies (a measure of reasoning using lexical knowledge) and Visual Matching (a measure of processing speed), men seem to gain on women at the oldest ages. Furthermore, the Number Series scores, which have been shown to be strong predictors of financial literacy and wealth (McArdle et al., 2009), have parallel profiles for both men and women when plotted against the husband's age. These patterns suggest that the age profile of financial literacy

scores does not merely track underlying patterns of cognitive decline of husbands and wives. Because the Total Recall score is the exception, all regression analyses will include controls for the husbands' and wives' Recall Score.

Cohort effects Using the cross-section as a synthetic cohort assumes that the experiences of individuals over the age distribution of the cross-section reflect the experiences of individuals as they age through each successive cohort, as if I had observed a single cohort longitudinally.[12] An alternative hypothesis consistent with my results is that older women have been household CFOs throughout the marriage, while younger women are less likely to do so. This would cause the synthetic cohort to produce spurious support for the model's predictions.

However, social changes across cohorts suggest otherwise; historical marriage and divorce patterns are likely to bias the data *against* my model's predictions. Women in younger cohorts are likely to have married at an older age, as seen in the CPS and Census data in Figure 2.7.[13] Although the median age of women married before 1949 (the 5th percentile in my data of the year of first marriage, marked on the figure with a vertical line) was slightly higher, there was subsequently an upward trend over time. Therefore, the younger women in my sample have had greater incentive to gain financial knowledge prior to marriage. In addition, if the dispersion of power within a couple is greater when the spousal age gap is larger, we may not expect the younger spouses of the older men to have as much control over finances. Younger couples are likely to be more "egalitarian" than older couples, and therefore older women might be less likely (and older men more likely) to be household CFO.

[12] One common use of the synthetic cohort is the computation of life table life expectancies, which are expected to be downward biased because younger cohorts will have the benefit of medical advances not available to those who are already elderly.

[13] This figure was constructed using Table MS-2 posted online by the U.S. Census Bureau at http://www.census.gov/population/www/socdemo/hh-fam.html.

The prospect of divorce, which has changed considerably over time, may also lead women to learn about finances earlier in life. Historical divorce rates in the United States are shown in Figure 2.8.[14] Although the rates were slightly higher in the mid 1940s than than in the 1950s, divorce rates climbed rapidly through the 1960s and 70s. Divorce rates remained high through the 80s and declined only more recently. The sharp increase in divorce rates would create incentives for the younger women in my sample to insure themselves by acquiring more knowledge earlier in adulthood. Figure 2.9 confirms a similar pattern in my sample; the women who are married to the oldest men are less likely to have ever been divorced.

These patterns, in addition to changing norms due to the rise of feminism, would create greater incentives for younger women (relative to older women) to learn early and/or become CFOs in the household. All of these cohort effects should produce downward bias on any estimates of the effects of life expectancy on financial knowledge.

2.5.3 Regression analysis using life table widowhood measures

Because CogEcon surveys both the husband and the wife in a couple whenever possible, I can link members of a couple for analysis. I estimate the effect of expected time to widowhood and expected length of widowhood (derivations in Appendix 2.8) on women's financial knowledge. Table 2.3 reports summary statistics of the financial knowledge variables and measures of husband's life expectancy and widowhood used in the analysis. Women have on average -0.37 standard deviations less financial literacy than their husbands, though this gap narrows to -0.31 when stock-related questions are excluded. Women are most knowledgeable about finances in only 16

[14] Statistics prior to 1950 are drawn from U.S. Bureau of the Census (1954) and are based on population figures including the armed forces overseas. Numbers from 1950 onward are from U.S. Census Bureau (2004); divorce rates for 1998-2002 exclude California, Colorado, Indiana, and Louisiana from both the numerator as well as the population denominator.

percent of couples, but they are equally knowledgeable in 33 percent of couples. In this sample, life tables indicate an expected time to widowhood (conditional on the woman outliving the man) of about 14 years, with an expected duration of widowhood (also conditional on the woman outliving the man) of 12.9 years.[15]

Table 2.8 uses the couple-level data to analyze the the difference between a woman and her husband's financial sophistication mean score and presents results for the following equation:

$$d(financial\ sophistication) = \gamma_1(expected\ time\ to\ widowhood) + \gamma_2(expected\ duration\ of\ widowhood) + X\beta + \epsilon \quad (2.5)$$

where $d(x)$ designates the wife-husband difference in x.

The first column of Table 2.8 estimates the equation with no covariates, while the second column includes the usual education and health controls. Column (3) adds the memory and fluid intelligence (Number Series) of both husband and wife, and the woman's risk tolerance. Including these cognition variables increases the magnitude and precision of the estimated coefficient on the time to widowhood. A one-year reduction in the expected time to widowhood is associated with a statistically significant 0.04 standard deviation increase in the wife-husband difference in normalized financial sophistication, which is about 11 percent of the mean difference. This result arises even when controlling for the Recall score, a cognitive measure that declines markedly with age.

Several of the questions in the financial sophistication battery are related to the stock market, and these concepts may not be relevant to members of households who

[15]These figures use life table aggregate statistics from individuals of all marital statuses, so it assumes that the mortality of husbands and wives are uncorrelated, and that if there is a marriage treatment effect on life expectancy, its magnitude does not differ between husbands and wives. If one does not condition on the woman outliving the husband, life tables also indicate an average life expectancy of almost 20 years for the husbands, with wife-husband difference in life expectancies of over four years. All analysis using these unconditional measures yield similar results.

do not participate in the stock market. I construct a second financial literacy score from the ten questions that are unrelated to the stock market and normalize them over all respondents. Table 2.9 repeats the financial sophistication analysis with this smaller set of non-stock related financial literacy questions. The coefficient on the husband's life expectancy increases substantially in magnitude; in the specification with full controls in the third column, this coefficient increases 15 percent to -0.048 from -0.041 in Table 2.8. The coefficient on the expected length of widowhood is unchanged and is still statistically insignificant.

The Number Series score is a strong predictor of financial knowledge, and since this is a measure of fluid intelligence, having a higher Number Series score can be interpreted as lowering the woman's marginal cost of acquiring knowledge. A one standard deviation increase in the wife's Number Series score is associated with a 0.32 standard deviation increase in her financial literacy, relative to her husband. Coefficients on the control variables are generally as expected: lower risk tolerance for women is associated with more financial knowledge, and the lower the education and health levels of the husbands, the greater the woman's financial knowledge. Likewise, the greater are a woman's levels of health or education, the greater her financial knowledge, and these effects are smaller in magnitude than those of her husband's levels.

Even after including for the Total Recall score, which declines strongly with age and therefore helps control for the husband's cognitive decline, I still find a statistically significant effect of time to widowhood on financial literacy. The magnitude of the effect is large; if all women acquired financial literacy at the estimated 0.04 standard deviation per year, almost 80 percent of women in the sample would fully catch up with their husband's current level of financial literacy before the expected onset

of widowhood. The coefficients on the expected duration of widowhood are positive — the longer the length of widowhood, the more financial literacy the woman has relative to her husband — but are not statistically significant. This is consistent with the fact that the model predicts the effect of the marginal year closer widowhood should be much larger than the marginal year during widowhood.

As a robustness check, I run false regressions of equation (2.5) by replacing the difference in financial sophistication scores on the left hand side with differences in cognition scores. Table 2.10 reports the results for the six cognition scores detailed in Section 2.4.3. Because the left hand side variables are all wife-husband differences in normalized scores, the coefficients are directly comparable to each other. The columns are in order from most highly correlated to least correlated to financial literacy. All but one of the falsification regressions have coefficients on the time to widowhood that are smaller in magnitude than the same coefficient in the financial literacy regression; two of them have positive estimated coefficients. The one measure with a similar coefficient on time to widowhood, Total Recall, has a low correlation with financial literacy; furthermore, the main regressions in Tables 2.8 and 2.9 control for the recall score. This demonstrates that the estimated effect of time to widowhood on financial literacy is not a spurious relationship solely attributable to the cognitive decline of men.

2.5.4 Robustness: regression analysis using alternative probabilistic survival measures

The ideal explanatory variables would be the woman's subjective expectation of her husband's life expectancy as well as her subjective expected length of widowhood. Life table life expectancies by age and sex mask much of the variation in actual survival expectations across individuals. In the absence of questions elicit-

ing expectations of the timing of one's partner's mortality, I will need to impose various assumptions in order to derive a proxy for these expectations. In this section, I construct objective and subjective probabilistic measures of the imminence and duration of widowhood, and then I present the results using each of these measures. Converting probabilistic measures to measures in time units as used in the main analysis would require strong assumptions about the shape of each individual's entire survival function, so I leave these survival measures in their probabilistic form.

The equations I estimate with these alternate survival measures are identical to Equations 2.5 but replace the expected length of widowhood with the husband's probability of surviving at least another ten years, and the expected length of widowhood by the wife-husband difference in their respective ten-year survival probabilities. These results generally confirm that the lower the husband's survival probability (and therefore the more imminent widowhood is), the greater the wife's level of financial knowledge.

Life table survival probabilities

The most straight-forward approach would be to assume that individuals have expectations in accordance with published life tables as shown in Table 2.8. In the previous analysis, I have used the expected time to widowhood and the expected years of widowhood calculated from 2004 period life tables, by age and sex. An alternative measure from the life table is the ten-year-ahead survival probability, which is defined as $\prod_{x=age}^{10}(1 - q(x))$, where $q(x)$ is the life table hazard of dying between age x and $x + 1$.

Using life tables requires the assumption that a woman's expectation of the timing and length of widowhood are, in expectation, the same as those in these life tables. One problem is that life tables are constructed as population-level averages, and par-

ticular individuals' life expectancies and mortality probabilities will diverge (either positively or negatively) from the life tables as a result of individual characteristics such as health status. Women will have some information, some observed in the survey and some not, that may make their expectations deviate from life tables. In addition, life table statistics are biased due to their use of synthetic cohorts.

Subjective survival probabilities

While life tables reflect the experience of entire populations, individual expectations are likely to deviate heterogeneously from these population measures. I use subjective survival probability questions that are asked of each CogEcon respondent in the second wave of CogUSA. These questions ask "What is the percent chance that you will live to be X or more?" where X is an age that is between 11 and 15 years in the future (or more, in the case of spouses who are younger than 50). Therefore, these responses represent the subjective $Pr(alive\ at\ age\ X|current\ age)$. Appendix 2.7.4 describes these questions in more detail.

A number of studies have analyzed the relationship between actual mortality and the subjective survival probabilities elicited in surveys. Subjective survival probabilities have been shown, on average, to be close to those in life tables, and they covary with variables like health conditions, smoking behavior and socio-economic status in the same way as actual mortality outcomes do (Hurd and McGarry, 1995). The probabilities are consistent with individuals' observed mortality patterns (Elder, 2010; Smith et al., 2001) and are updated by individuals in response to new information, such as the onset of health conditions (Hurd and McGarry, 2002; Smith et al., 2001). Perozek (2008) uses responses to survival expectations questions to construct subjective life tables which are shown to predict the unusual direction of revisions to subsequent Social Security Actuary life expectancies.

Whether or not these responses predict mortality, one can argue that individual life-cycle behavior reflects subjective beliefs rather than actuarial probabilities. Therefore, subjective probabilities can be used in my analysis, with additional assumptions required to account for the different target ages faced by respondents. This strategy assumes that a woman's beliefs about her husband's mortality are identical to her husband's own beliefs about his own mortality.[16]

Because the time horizon of the subjective survival questions varies between 11 and 15 years ahead, responses for different time horizons are not comparable at face value. I interpolate a ten-year-ahead survival probability by assuming assuming that one-year hazard rates are constant over the 11-15 year horizons of the subjective survival questions. Constant hazards implies that $Pr(alive\ in\ 10\ years|age) = (1-q(age))^{10}$ and $Pr(alive\ at\ age\ X|age) = (1-q(age))^{X}$, where $q(.)$ is the annual mortality hazard and X the target age posed in the subjective survival questions. Solving both equations for $q(.)$, setting them equal to each other and rearranging yields:

$$Pr(alive\ in\ 10\ years|age) = Pr_{subj}(alive\ at\ age\ X|age)^{\frac{10}{X-age}} \tag{2.6}$$

I calculate this ten-year-ahead survival probability from the age 75 question for those under 65, since the constant hazard assumption is more realistic for shorter time horizons. I retain the original values of those who report 0 and 100 percent probabilities. These probabilities have a 0.56 correlation with life table probabilities, with a wife-husband difference that is smaller than the life tables (see Tables 2.11 and 2.12).

[16]Unfortunately for my analysis, to my knowledge no surveys that field these subjective survival expectations questions query both members of a couple about their spouse's survival prospects.

Rounding and survey noise Here, I take the responses to the subjective survival probability questions at face value. However, respondents may round their responses; Manski and Molinari (2010) analyze expectations questions in the HRS and find that respondents round to varying degrees. CogEcon asks a number of follow-up questions in the expectations module that shed some light on the extent of rounding.

Those under 65 who report a survival probability to 75 that is a multiple of 10 or 25 (but not 50) are asked a followup: "When you said X percent just now, did you mean this as an exact number or were you rounding or approximating?" Those who reported they approximated were then asked, "What range of numbers did you have in mind when you said 50 percent?" Of the 322 who reported a multiple of 10 or 25 (but not 50), 205 stated they had approximated. To better understand the direction of rounding, one can compare the reported probability to the midpoint of the range later reported. For 40.0 percent of those 322, the reported survival probability and the midpoint of the range are the same; 29.3 percent report a probability that is less than the midpoint, and the remaining 30.7 percent report a probability exceeding the midpoint. The mean difference is 1.46 percentage points. This suggests symmetric rounding. If noise is introduced through rounding or through general survey noise like classical measurement error, these measures will produce attenuation bias in my estimates.

Objective predicted survival probabilities (HRS)

Because CogEcon and the Health and Retirement Study share many socio-demographic, cognitive and physical health measures, one can use the effect of these variables on observed mortality in HRS to predict mortality for CogEcon respondents.

I estimate a probit model of survival using respondents of the 1998 wave of the HRS and their survival outcomes using the 2008 Tracker File. The covariates in-

clude gender, race, years of education, couple status, birth year, episodic memory, mental status, depressive symptoms, an index of health measures, self-rated health, smoking status, and alcohol consumption, all measured in 1998. I use the estimated parameters to predict ten-year survival for CogEcon respondents. As can be seen in Tables 2.11 and 2.12, these predicted survival probabilities are highly correlated with life table probabilities, and have less variance and are of higher levels than the subjective probabilities.

Standard error adjustment for two-step estimation Estimation with predicted survival probabilities uses a two-stage procedure in which mortalities are predicted in the first stage using HRS data, and the main equation of interest is estimated in the second stage. Since the husband's predicted survival and the difference between the wives' and their husbands' survival probabilities are predicted with error, the variance-covariance matrix of the main estimating equation will require an adjustment for the generated regressors. The adjustments made here are suggested by Murphy and Topel (1985), and details about the adjustments can be found in Appendix 2.9. Due to the large sample size of the first-stage HRS estimates, the correct standard errors are only slightly larger than the uncorrected ones.

Results with alternate probabilistic life measures

This section presents regression results using the alternate measures of survival. Summary statistics for these probabilistic measures are reported in Tables 2.11 and 2.12. Figure 2.10 displays scatterplots of the survival probabilities generated using each of the methods for CogEcon respondents in couples whose partners are also in the survey.

In order to maintain comparability of units across the measures, I have chosen to

use ten-year survival probabilities instead of life expectancies. Using ten-year probabilities involves weaker assumptions (as outlined above) than life expectancies, which require assumptions about the entire hazard function from the individual's current age onward. In both tables, the first column presents results using the ten-year probabilities from U.S. life table; the second from subjective survival probabilities, and the third from objective predicted probabilities from HRS probit estimation. Since all of these measures are ten-year survival probabilities, the coefficients on the husband's survival probabilities are comparable across specifications, as are the coefficients on the difference between a woman's and her husband's survival probabilities. However, since the first and last columns are based on averages (by age and sex for life tables, and for various personal characteristics in the case of the HRS estimates), I expect these coefficients to be estimated with less precision. On the other hand, the subjective survival measures are subject to survey noise, which should lead to attenuation bias.

All of the regressions reported in Table 2.13 show that the effect of husbands' survival probabilities on financial sophistication is negative, as predicted by the model, though the estimates are not statistically significant. With subjective probabilities, a ten percent decrease in husband's survival probability is associated with an increase in the woman's financial sophistication score of 0.06 standard deviations over her husband's score. While the signs of the effect of husband's survival probabilities are consistent with the model's predictions for both types of financial knowledge, the estimated magnitudes appear to be small.

Regressions with non-stock financial literacy as the dependent variable are reported in Table 2.14. Like the main results with expected time to widowhood, the magnitude of the effects of the husband's survival probabilities are much larger for

non-stock financial literacy than general financial sophistication; for the HRS predicted probabilities, the effect is doubled. This suggests that increases in financial knowledge with the risk of widowhood are being made both in the realm of stocks and even more so in more basic topics.

In all sets of regressions, the effect of the expected duration of widowhood (as measured as the difference in the survival probabilities of husbands and wives) is sensitive to the method used for deriving those probabilities. Given that the length of widowhood is a secondary effect, is is not surprising that the effect of widowhood is weaker than the effect of the timing of the onset of widowhood.

2.5.5 Regression analysis using other outcomes

I now turn to additional measures of financial knowledge: women's self-rated financial knowledge, historical knowledge of the stock market, and closely following the stock market. Because these measures are absolute levels rather than relative to their husbands, the use of the synthetic cohort for these outcomes is less compelling. Nevertheless, results from analysis using each of these measures instead of financial literacy provide additional supporting evidence that women increase knowledge as their husband's life expectancies decrease.

Self-rated knowledge The CogEcon survey includes two self-rated measures of financial knowledge. Respondents are asked the degree to which they agree with the following statements: "I am good at dealing with day-to-day financial matters, such as checking accounts, credit cards, mortgages, installment payments, and budgeting," and "I understand the stock market reasonably well." Respondents select from a six-point Likert scale: strongly agree (six points), agree, slightly agree, slightly disagree, disagree, and disagree strongly (one point). Summary statistics for this and subse-

quent financial knowledge measures are reported in Table 2.15. On average, women report much higher levels of financial skills than stock skills (5.0 versus 2.9). The first two columns of Table 2.16 show ordered probit regressions of women's self-rated measures on their husband's life expectancy, their expected length of widowhood, and other control variables. Like the analysis of financial literacy, these regressions show that reductions in the time to widowhood are associated with increases in self-rated stock market knowledge and self-rated financial skills. The coefficients on husband's life expectancy are statistically significant in both regressions.

While the first two columns of Table 2.16 only use the wife's self-report, columns (3) and (4) use the wife-husband difference used in the financial battery analysis. The main outcome used in this chapter, the wife-husband difference in financial sophistication scores, is a relative measure of the woman in relation to her husband. While the financial sophistication battery allows for an objective ratio, the husbands and wives may have different cut-points on the latent variable underlying each self-reported outcome. Therefore, the self-reports may not be appropriate for use as a wife-husband relative measure. That said, these regressions still yield the expected result of negative coefficients on time to widowhood.

Historical knowledge and following the stock market Another outcome measure is knowledge about the historical returns of stocks relative to bonds. The following question was posed in the post-crash (2009) wave of the CogEcon survey: "On average *over the last 100 years*, how do you think the *annual rate of return on stocks* has compared to *the annual rate of return on bonds*?" Respondents may indicate whether stock returns have been higher than bond returns, bond returns have been higher than stock returns, and both returns were the same. In the period between

1908 and 2006, the arithmetic average of annual total real stock market returns was 8.5 percent, while the arithmetic average of annual long-term government bond returns was 5.5 percent (Siegel, 2007). Answering this question correctly not only is evidence of greater financial knowledge, but also has implications for stock market participation, retirement planning, and other financial matters. About 57 percent of women gave correct answers (see Table 2.15). Average marginal effects from a probit estimation with an outcome of one if respondents report that stock returns have been higher than bond returns are reported in the fifth column Table 2.16. As predicted by my model, women with less time to widowhood are more likely to answer correctly, and the average marginal effect is statistically significant at the five percent level.

The CogEcon post-crash survey also asks respondents "How closely do you follow the stock market?" with the answer choices "very closely," "somewhat," and "not at all." Following the stock market more closely may be a sign of greater involvement in handling finances or increased learning about the economic and financial environment. An ordered probit of this question is reported in the sixth column of Table 2.16. As the time to widowhood shortens, women are more likely to follow the stock market more closely (statistically significant at the one percent level). This effect is consistent with women learning more about finances as they approach widowhood.

2.6 Conclusion

Empirical studies on financial literacy have generally shown that women have less financial knowledge than men (Fonseca et al., 2010; Lusardi and Mitchell, 2008; Kotlikoff and Bernheim, 2001). One possible explanation for this gender gap is that it reflects the household division of labor. Unequal life expectancies of household

members imply that a division of labor that emerges when the couple forms will eventually change when the longer-living spouse takes over the responsibilities held by the shorter-living spouse. Household financial management is a task that is frequently the responsibility of the husband, who generally has a shorter life expectancy than the wife. Because the benefits of financial knowledge for women are not realized until she is a widow, the theoretical model predicts that a woman has an incentive to delay the acquisition of financial knowledge until later in life. Conversely, because knowledge cannot be acquired instantaneously, she also has an incentive to begin her acquisition of financial knowledge well before widowhood so that she will be equipped with the knowledge needed to manage her wealth when her husband dies.

Using matched data on wives and husbands, I show that women do indeed increase their financial knowledge on a number of dimensions as their husbands age. Women acquire financial literacy at a rate of 0.04 standard deviations per year; at this rate, about 80 percent of the women in the sample would catch up with their husbands in financial literacy before the expected onset of widowhood. In addition, women have increased self-rated financial skills and follow the stock market more closely as widowhood becomes more imminent. Because cohort effects related to age at first marriage and divorce probabilities work against my finding a result, my estimates are underestimates of the actual effects. Furthermore, I find statistically significant effects of the time to widowhood in spite of the measurement error associated with using population-average life table calculations.

However, I do not find a statistically significant effect of the expected length of widowhood on women's financial knowledge. This may not be surprising given that the model predicts a much larger effect of time to widowhood than the length of widowhood. Assuming a discount factor of 0.97 and no depreciation, the effect of

time to widowhood is predicted to be on average 50 percent larger than the duration's effect, with the gap widening if human capital is assumed to depreciate. Furthermore, while the model does not specify the functional form of the returns to financial knowledge, the financial decisions faced by widows may be less complex than the planning decisions made earlier in the life cycle. If this is the case, then the marginal returns to financial knowledge may decline sharply after a certain threshold. Women may aim to reach a level of financial knowledge at widowhood sufficient to manage their decumulation, but not necessarily so much as to make complex investment decisions.

The financial literacy outcome uses the husband's literacy as a baseline in order to identify effects from a synthetic cohort formed by a cross-section. My results show that older women do indeed plan strategically for the future by investing in financial knowledge as widowhood becomes more imminent. This supports the idea that the poor economic outcomes associated with widowhood may reflect insufficient preparation due to an unexpectedly early onset of widowhood. In addition, poor outcomes may also reflect low levels of husband's financial knowledge; in this case, merely catching up with their husbands (as most women would if they continue to acquire knowledge at the rates I have estimated) may not equip women with the tools needed to manage their finances alone.

The model can be applied not only to financial literacy but also to any other task specialized in by a spouse. In addition, the model can also be generalized to other questions related to the length of time a person can depend on a spouse to continue specializing. Korniotis and Kumar (2011) find that older investors exhibit greater investment knowledge, but that these effects are offset by the adverse effects of cognitive aging which further incentivizes early planning for women who may

want to prepare not only for widowhood but also for the cognitive decline of their husbands. Future work will specifically consider the effects of cognitive decline. Since the model shows declining incentives to invest after widowhood, it sheds some light on the stylized fact that widows have very low levels of financial knowledge. The model can also be applied more generally to the expected duration of the union rather than the expected timing of widowhood, so the same implications can be drawn for women facing varying probabilities of divorce.

One extension not yet considered is the availability of an outside option for dealing with the shorter-living spouse's tasks. Instead of learning to manage her own wealth, she can have a third person, whether an adult child or a financial planner, manage her finances on her behalf. Indeed, the third-person option may be one reason why women do not appear to react to a longer expected duration of widowhood.

2.7 Appendix A: Data appendix

2.7.1 Response rates

1,222 participants who completed the CogUSA study[17] were invited to complete the Cognitive Economics Survey. The invitees included 371 uncoupled individuals, 304 couples in which both members were invited (608 individuals) and 243 couples in which only one member was invited.

The reasons for which these 243 partners were not invited:

- 48 only partially completed the CogUSA study
- 138 refused to participate in the CogUSA study
- 24 did not provide an interview for CogUSA for unspecified reasons
- 4 were removed from the CogUSA sample for unknown reasons
- 4 were not interviewed by CogUSA due to language problems
- 25 were physically or mentally unable to conduct the CogUSA telephone interview.

CogEcon had an overall response rate of 80.61 percent, yielding a sample size of 985 respondents. Response rates of mutually exhaustive sub groups:

- uncoupled individuals: $286/371 = 77.09\%$
- members of couples in which both members were invited: $512/608 = 84.21\%$
- individuals whose partners were not invited: $187/243 = 76.95\%$.

These response rates yielded the following CogEcon respondents:

[17]The 2008 wave of the CogUSA study was conducted in two stages, a telephone interview, then a face-to-face interview. Of the 3224 contacted for the telephone interview, 1514 completed this interview, for a response rate of 47 percent that was on target for a Random Digit Dialing sample methodology. 1230 (81 percent) of telephone respondents completed a face-to-face interview. Respondents and non-respondents to the face-to-face interview were not statistically significantly different at the 5 percent level in terms of cognition (Serial 7s and Mental Status), age, sex, race, couple status, and self-rated health status. Respondents had, on average, 0.36 more years of education ($p < 0.2$).

- 286 uncoupled individuals
- 468 coupled individuals whose partners also completed CogEcon
- 44 coupled individuals who completed CogEcon but whose partners completed CogUSA only
- 187 coupled individuals who completed CogEcon but whose partners did not complete CogUSA.

Among the 304 couples with both members invited to CogEcon, there were 26 couples with no respondents, and 42 couples with one respondent (half of whom were male, half were female). The remaining couples provided one complete survey for each individual.

Among the 851 invitees in couples, men responded at a rate that was about 2 percentage points higher than women, though the difference is not statistically significant.

All of the empirical results reported in this paper are estimated using unweighted data, as couple-level weights have not been developed for this survey.

2.7.2 Derivation of the analysis sample

The Cognitive Economics survey is composed of 985 individuals in 751 households (including 286 singletons). To construct my sample, I drop the 286 singletons as well as those in same sex couples (3 couples in total). Doing so leaves 462 households, which are composed of

- 233 couples about which we have full information (cognition data from CogUSA and financial knowledge data from CogEcon),
- 21 couples for which we have full information about the wife and cognition data only about the husband,

- 21 couples for which we have full information about the husband and cognition data about the wife, and
- 187 couples with only one respondent with no information about the partner.

When the wife-husband difference in financial sophistication is used as the dependent variable, the maximum sample possible is the 224 couples from which both members completed at least part of the financial literacy battery in CogEcon in addition to CogUSA. The dependent variable here is constructed using CogEcon responses from both members of the couple. Due to item non-response for some variables, actual sample sizes will vary according to the specification used.

2.7.3 Survey questions used in the analysis

Financial literacy questions in CogEcon

The following tables list the question number and the text of both true and false versions of each financial literacy question on the Cognitive Economics survey, with the mean score on each question for women and men in the 224 couples in the sample. All of these questions have been fielded on the RAND American Life Panel (Delavande et al., 2008); sixteen of these questions were also fielded on the 2008 wave of the Health and Retirement Study (Lusardi et al., 2009b), and twelve are currently being fielded on the Wisconsin Longitudinal Study.

Questions related to stock

	Question text		Mean score	
	True Version	**False Version**	Women	Men
18	Financially, investing in the stock market is better than buying lottery tickets.	Financially, investing in the stock market is no better than buying lottery tickets.	0.82	0.90

19	When an investor spreads money between 20 stocks, rather than 2, the risk of losing a lot of money decreases.	When an investor spreads money between 20 stocks, rather than 2, the risk of losing a lot of money increases.	0.74	0.79
22	Mutual funds do not pay a guaranteed rate of return.	Mutual funds pay a guaranteed rate of return.	0.65	0.76
24	It is easy to find mutual funds that have annual fees of less than one percent of assets.	It is hard to find mutual funds that have annual fees of less than one percent of assets.	0.54	0.58
25	Even if you are smart, it is hard to pick individual company stocks that will have better than average returns.	If you are smart, it is easy to pick individual company stocks that will have better than average returns.	0.59	0.61
28	It is possible to invest in the stock market in a way that makes it hard for people to take unfair advantage of you.	There is no way to avoid people taking advantage of you if you try to invest in the stock market.	0.69	0.71
31	An employee of a company with publicly traded stock should have little or none of his or her retirement savings in the company's stock.	An employee of a company with publicly traded stock should have a lot of his or her retirement savings in the company's stock.	0.55	0.53

33	It is a good idea to own stocks of foreign companies.	It is best to avoid owning stocks of foreign companies.	0.61	0.68
34	Even older retired people should hold some stocks.	Older retired people should not hold any stocks.	0.76	0.80
35	You should invest in either mutual funds or a large number of different stocks instead of just a few stocks.	You should invest most of your money in a few good stocks that you select rather than in lots of stocks or in mutual funds.	0.69	0.72
36	To make money in the stock market, you should not buy and sell stocks too often.	To make money in the stock market, you have to buy and sell stocks often.	0.68	0.68
39	It is better for young people saving for retirement to combine stocks with long-term (inflation protected) bonds than with short-term (inflation protected) bonds.	It is better for young people saving for retirement to combine stocks with short-term (inflation protected) bonds than with long-term (inflation protected) bonds.	0.59	0.58
40	If you invest for the long run, the annual fees of mutual funds are important.	If you invest for the long run, the annual fees of mutual funds are unimportant.	0.68	0.73

41	Buying a stock mutual fund usually provides a safer return than a single company stock.	Buying a single company stock usually provides a safer return than a stock mutual fund.	0.74	0.77

Questions not related to stock

	Question text		Mean score	
	True Version	**False Version**	Women	Men
17	An investment advisor tells a 30-year-old couple that $1,000 in an investment that pays a certain, constant interest rate would double in value to $2,000 after 20 years (by the time they are 50). If so, that investment would be worth $4,000 after 40 years (by the time they are 70).	An investment advisor tells a 30-year-old couple that $1,000 in an investment that pays a certain, constant interest rate would double in value to $2,000 after 20 years (by the time they are 50). If so, that investment would not be worth $4,000 for at least 45 years (until they are at least 75).	0.71	0.80

20	If you start out with $1,000 and earn an average return of 10% per year for 30 years, after compounding, the initial $1,000 will have grown to more than $6,000.	If you start out with $1,000 and earn an average return of 10% per year for 30 years, even after compounding, the initial $1,000 will have grown to less than $6,000.	0.58	0.71
21	The more you diversify among stocks, the more of your money you can invest in stocks.	The more you diversify among stocks, the less of your money you should invest in stocks.	0.59	0.61
23	Young people should hold somewhat riskier financial investments than older people.	Older people should hold somewhat riskier financial investments than young people.	0.78	0.80
26	Using money in a bank savings account to pay off credit card debt is usually a good idea.	Using money in a bank savings account to pay off credit card debt is usually a bad idea.	0.65	0.74
27	You could save money in interest costs by choosing a 15-year rather than a 30-year mortgage.	You could save money in interest costs by choosing a 30-year rather than a 15-year mortgage.	0.84	0.88

29	If the interest rate falls, bond prices will rise.	If the interest rate falls, bond prices will fall.	0.55	0.60
30	Taxes affect how you should invest your money.	Taxes do not affect how you should invest your money.	0.68	0.75
32	For a family with a working husband and a wife staying home to take care of their young children, life insurance that will replace three years of income is not enough life insurance.	For a family with a working husband and a wife staying home to take care of their young children, life insurance that will replace three years of income is more than enough.	0.78	0.74
38	It is important to take a look at your investments periodically to see if you need to make changes.	Once you have made an initial decision about the investment mix for your portfolio, you should avoid making changes to your portfolio until you are close to retirement.	0.85	0.84

Other measures of financial knowledge in CogEcon

Questions asked on the Cognitive Economics 2008 Survey (answer choices in parentheses):

Self-rated financial knowledge Question 12: I am good at dealing with day-to-day financial matters, such as checking accounts, credit cards, mortgages, installment payments, and budgeting. (Strongly agree, agree, slightly agree, slightly disagree, disagree, strongly disagree).

Self-rated stock knowledge Question 10: I understand the stock market reasonably well. (Strongly agree, agree, slightly agree, slightly disagree, disagree, strongly disagree).

Questions asked on the Cognitive Economics 2009 Survey (answer choices in parentheses):

Historical knowledge Question 89: On average *over the last 100 years*, how do you think the *annual rate of return on stocks* has compared to *the annual rate of return on bonds*? (Stock returns have been higher than bond returns, bond returns have been higher than stock returns, both returns were the same).

Following the stock market Question 82: How closely do you follow the stock market? (Very closely, somewhat, not at all).

2.7.4 Subjective survival probability in CogEcon

These survival questions were asked as part of the Cognitive Economics / CogUSA survey section on expectations. The questions are designed to elicit a respondent's belief about the likelihood that a future event will be realized.

At the beginning of this section, respondents are read the following:

> 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 that you think there is absolutely

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

For example, no one can ever be sure about tomorrow's weather, but if you think that rain is very unlikely tomorrow, you might say that there is a 10 percent chance of rain. If you think there is a very good chance that it will rain tomorrow, you might say that there is an 80 percent chance of rain.

The survey proceeds with questions eliciting the respondent's probabilistic expectations of future events. One set of questions asks about the respondent's survival probabilities. Respondents are asked "What is the percent chance that you will live to be X or more?" where X is the target age, determined according to the following table.

Age of respondent	Target age	Years to target age
<65	75 and 85	>10 and >20
65-69	80	11-15
70-74	85	11-15
75-79	90	11-15
80-84	95	11-15
85-89	100	11-15
≥90	none	n/a

These questions elicit the following: Pr(alive at least 10-15 years from now | alive today).

The survival probability measure in the model is the sequence of g_{t+1} over the maximum length of life, where

g_{t+1} = Pr(husband dies right before $t+1$) = Pr(husband lives exactly until t).

This measure can be transformed as follows:

S_t = pr(husband is alive during time t) = $\sum_{t}^{\infty} g_{j+1}$. This is the "survivor function," or the probability that the duration equals or exceeds t

$h_{t+1} = \frac{S_t - S_{t+1}}{S_t} = \frac{g_{t+1}}{S_t}$. This is the hazard function, or the probability of dying during $t+1$ conditional on being alive during t

$d_{t+1} = 1 - h_{t+1} = \frac{S_{t+1}}{S_t}$. This is the probability of surviving at least to $t+1$ conditional on surviving to t.

Subjective survival questions in the survey speak to d_{t+1}. Those who are younger than 65 years are asked, "What is the percent chance that you will live to be 75 or more?" (P028), in which case t is defined as the current age and $t+1$ is defined as age 75.

2.8 Appendix B: Equations for life table widowhood measures

Suppose that the current age of the wife is x and the age of the husband's age is y during the time of the survey.

Let l_d^f be the woman's life table probability of surviving from birth to age d and l_d^m the husband's life table probability of surviving from birth to age d. Let q_d^m be the life table probability that the husband dies at age d (this is the life table one-year mortality rate at age d).

The probability that the woman becomes a widow t years from the survey is the joint probability that woman is alive in t years, the man is alive in t years, and that the man dies at age $(y+t)$, conditional on the woman and her husband both being alive at ages x and y, respectively. This probability can be expressed as:

$$f(x, y, t) = \frac{l_{x+t}^f}{l_x^f} \frac{l_{y+t}^m}{l_y^m} q_{y+t}^m. \tag{2.7}$$

The probability that a woman will outlive her husband is therefore the sum of $f(x, y, t)$ over all possible years of the onset of widowhood:

$$Pr(\text{woman outlives her husband}) = \sum_{t=0}^{\infty} f(x, y, t). \tag{2.8}$$

The expected time to widowhood and the expected duration of widowhood, conditional on a woman outliving her husband, are:

$$E[\text{Time to widowhood}|\text{woman outlives husband}] = \frac{\sum_{t=0}^{\infty}(t)f(x, y, t)}{\sum_{t=0}^{\infty} f(x, y, t)} \tag{2.9}$$

$$E[\text{Length of widowhood}|\text{woman outlives husband}] = \frac{\sum_{t=0}^{\infty}(e^{f}_{x+t})f(x, y, t)}{\sum_{t=0}^{\infty} f(x, y, t)} \tag{2.10}$$

where e^{f}_{x+t} is the woman's remaining life expectancy at age $x + t$.

2.9 Appendix C: Standard error adjustment for two-stage analysis

Because the regressions using the HRS predicted ten-year survival probabilities employ two-step estimation, the covariance matrix of the second step equation must be corrected. I use the two-step maximum likelihood estimation described in Murphy and Topel (1985).

This section employs the Greene's notation (Greene, 2002, p.510):

> Theorem 17.8: Asymptotic Distribution of the Two-Step MLE [Murphy and Topel (1985)]. If the standard regularity conditions are met for both log-likelihood functions, then the second-step maximum likelihood estimator of θ_2 is consistent and asymptotically normally distributed with asymptotic covariance matrix

$$V_2^* = \frac{1}{n}(V_2 + V_2[CV_1C' - RV_1C' - CV_1R']V_2)$$

where

$$V_1 = Asy.Var[\sqrt{n}(\hat{\theta}_1 - \theta_1)] \text{ based on } lnL_1$$

$$V_2 = Asy.Var[\sqrt{n}(\hat{\theta}_2 - \theta_2)]; \text{ based on } lnL_2$$

$$C = E\left[\frac{1}{n}\frac{\partial lnL_2}{\partial \hat{\theta}_2} \cdot \frac{\partial lnL_2}{\partial \hat{\theta}_1^T}\right]$$

$$R = E\left[\frac{1}{n}\frac{\partial lnL_2}{\partial \theta_2} \cdot \frac{\partial lnL_1}{\partial \theta_1^T}\right].$$

$\hat{V}_1$ and $\hat{V}_2$ are the uncorrected first and second stage variance matrices. The matrices required for correction are estimated as:

$$\hat{C} = \frac{1}{n}\sum_{i=1}^{n} \frac{\partial lnf_{i2}}{\partial \hat{\theta}_2} \cdot \frac{\partial lnf_{i2}}{\partial \hat{\theta}_1^T} \quad \text{and} \quad \hat{R} = \frac{1}{n}\sum_{i=1}^{n} \frac{\partial lnf_{i2}}{\partial \hat{\theta}_2} \cdot \frac{\partial lnf_{i1}}{\partial \hat{\theta}_1^T}. \tag{2.11}$$

As usual, n is the number of observations. The total number of second stage regressors is $m + k$ where k is the number of non-predicted second-step regressors, and m is the number of regressors generated by the first step. There are T first-stage regressors.

Since the parameters estimated in the two steps are based on different samples (HRS in the first step and CogEcon in the second), $\hat{R}$ is exactly zero (Murphy and Topel, 1985, p.377).

Now, consider each derivative in the two matrices. In the first-step probit log likelihood contribution of each person:

$$lnf_{i1} = F(\theta_1, x_{1i}) = y_i ln\Phi(x_i^T\theta_1) + (1 - y_i)ln(1 - ln\Phi(x_i^T\theta_1)) \tag{2.12}$$

$$\frac{\partial lnf_{i1}}{\partial \hat{\theta}_1} = \frac{\partial lnf_{i1}}{\partial x_i\hat{\theta}} \cdot \frac{\partial x_i\hat{\theta}}{\partial \hat{\theta}_1} = statascore * x_i. \tag{2.13}$$

Note that the score reported by STATA is the first derivative of the log likelihood for the probit with respect to $x\beta$. The other derivatives are different for the linear regression second step and probit second step.

Linear regression second stage For analysis of general financial knowledge within the household, I regress wife-husband difference in financial sophistication on husband's predicted survival, the wife-husband difference in predicted survival, and control variables. Therefore, the estimating equation is:

$$Difference\ in\ finsoph = x_2\theta_2 + \gamma_1\Phi(x_{1husband}\theta_1) + \gamma_2(\Phi(x_{1self}\theta_1) - \Phi(x_{1husb}\theta_1))$$

where

$\frac{\partial lnf_{i2}}{\partial \hat{\theta}_2}$: $N \times (m+k)$ vector (one column for each 2nd stage regressor)

$$\begin{aligned} lnf_{i2} &= ln1 - ln(\sqrt{2\pi\sigma^2}) - \frac{1}{2}\cdot\left(\frac{y - X^T\theta_2}{\sigma}\right)^2 \\ \frac{\partial lnf_{i2}}{\partial \hat{\theta}_2} &= \frac{(y_i - x_i^T\theta_2)}{\sigma^2}\cdot x_i^T \end{aligned} \tag{2.14}$$

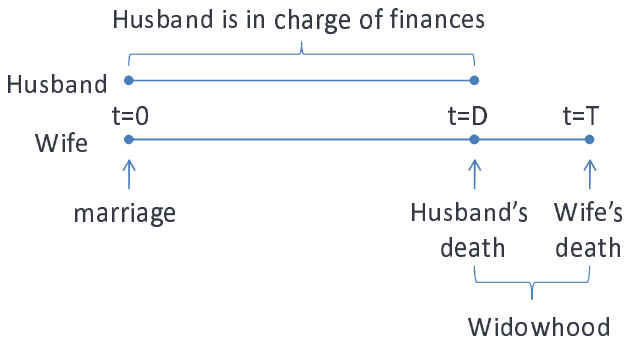
$\frac{\partial lnf_{i2}}{\partial \hat{\theta}_1^T}$: $N \times T$ vector (one column for each parameter predicting generated regressor). Let θ_2 related to generated regressors be $[\gamma_1, \gamma_2]$, where γ_1 denotes the husband's survival and γ_2 denotes the difference in own and husband's survival.

$$\begin{aligned} lnf_{i2} &= ln1 - ln(\sqrt{2\pi\sigma^2}) - \frac{\left\{y_i - x_i^T\theta_2 - (\gamma_1 - \gamma_2)\Phi(x_{1husb}\theta) - \gamma_2\Phi(x_{1self}\theta)\right\}^2}{2\sigma^2} \\ \frac{\partial lnf_{i2}}{\partial \hat{\theta}_1} &= -2\frac{residual}{2\sigma^2}\cdot[-(\gamma_1 - \gamma_2)\phi(x1_{husb}\theta)x1_{husb} - \gamma_2\phi(x_{1self}\theta)x_{1self}] \end{aligned} \tag{2.15}$$

Lastly, I use STATA's degree of freedom adjusted variance matrix for the second step $\hat{V}_2$.

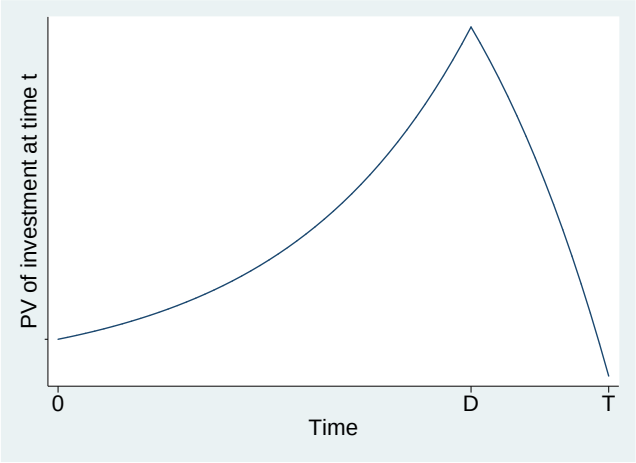
2.10 Figures and Tables

Figure 2.1: Timeline of analysis



The initial division of labor breaks down at time D.

Figure 2.2: Present value of an additional unit of human capital at time t



The payoffs to financial human capital are realized for the woman when she is a widow, for $T - D$ years. While her husband is still alive, the value of a marginal increase in financial human capital is discounted by the number of years a woman must wait until the stream begins ($D - t$ years). At time zero, the present value of the benefits are low due to the D-year delay until widowhood. The value increases as a woman approaches widowhood, at which point it declines because of the decreasing number of years the knowledge can be used.

Figure 2.3: A financial literacy question on CogEcon

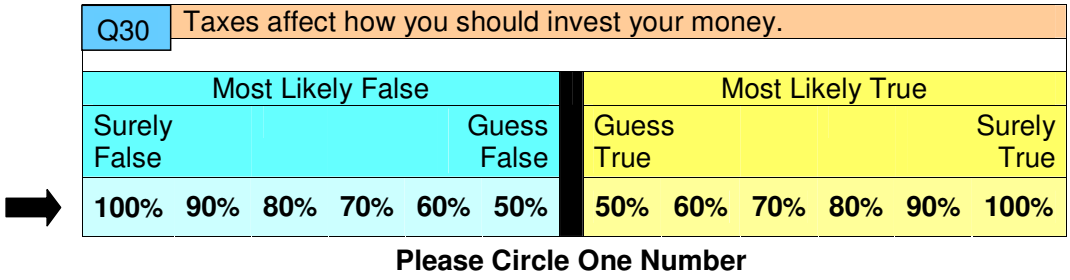
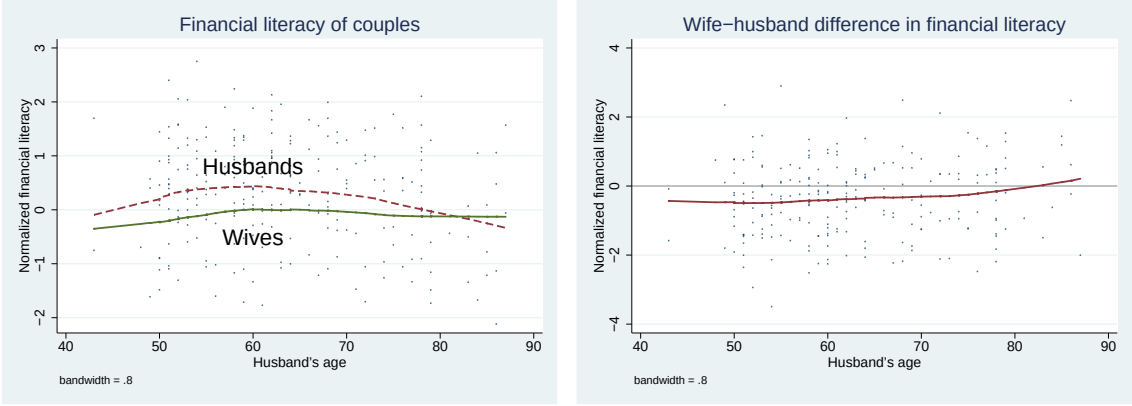
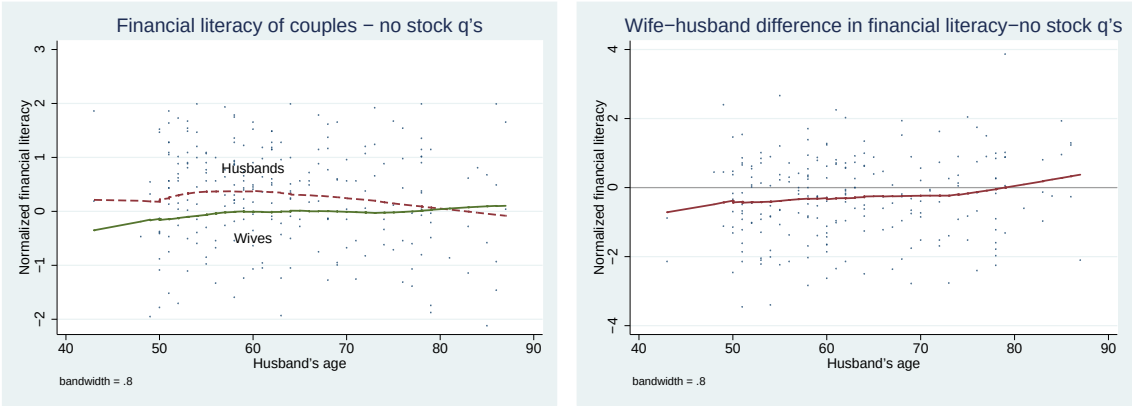


Figure 2.4: Financial literacy and husband's age



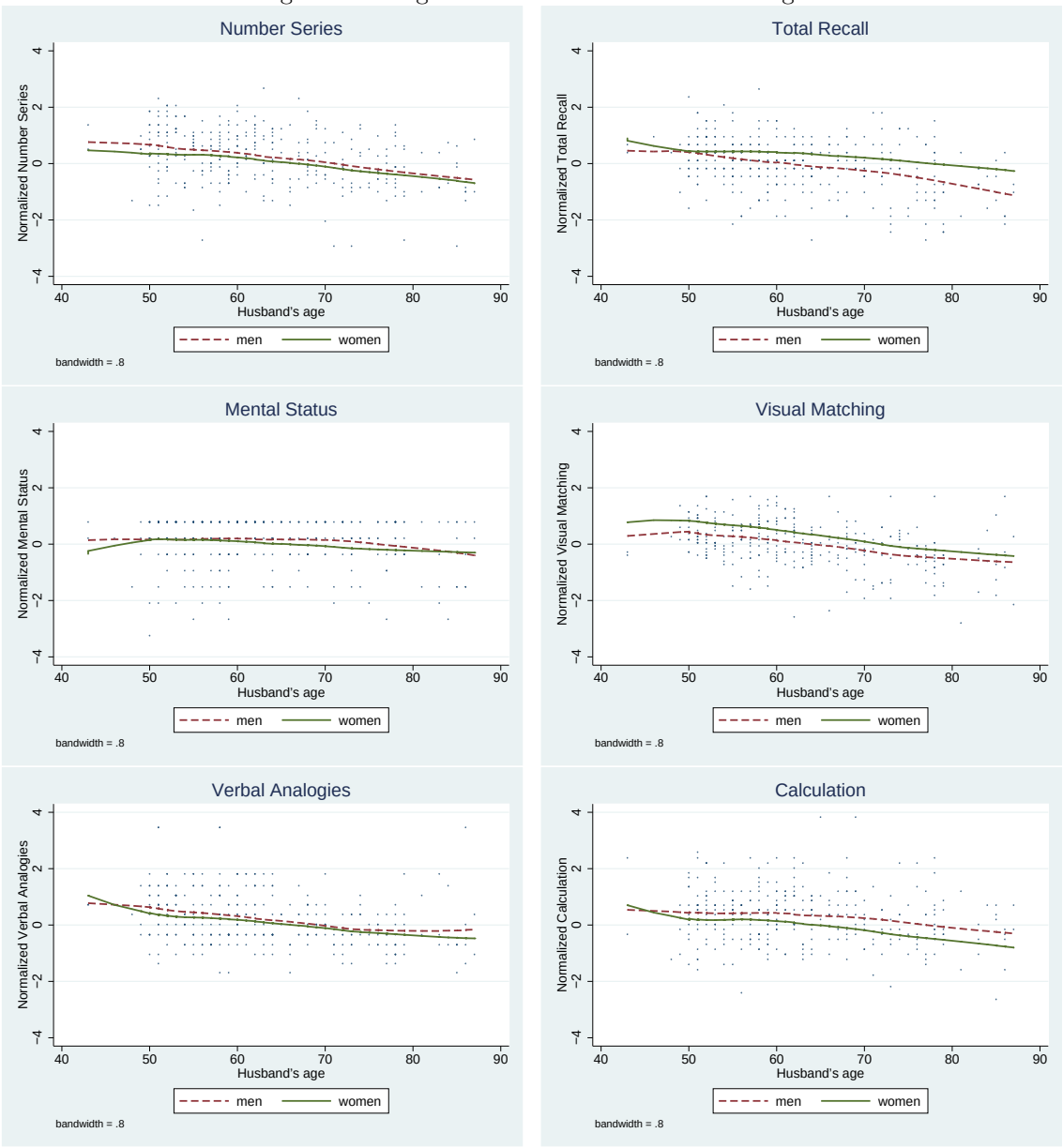
OLS regression of the right panel is reported in Table 2.7.

Figure 2.5: Financial literacy (no stock questions) and husband's age



OLS regression of the right panel is reported in Table 2.7.

Figure 2.6: Cognitive measures and husband's age



All scores are standardized. Unlike financial literacy, women's cognition scores do not systematically gain on their husband's scores. The cognition variables are detailed in Section 2.4.3.

Figure 2.7: U.S. historical age at first marriage

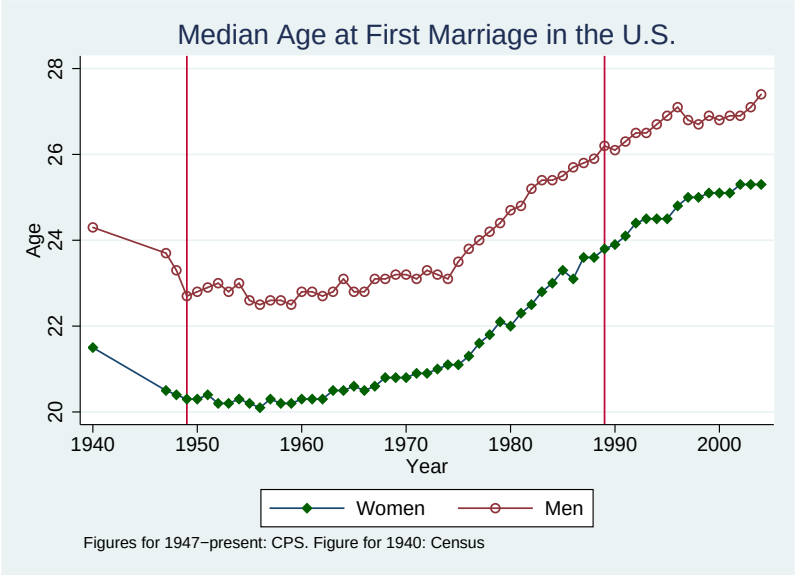
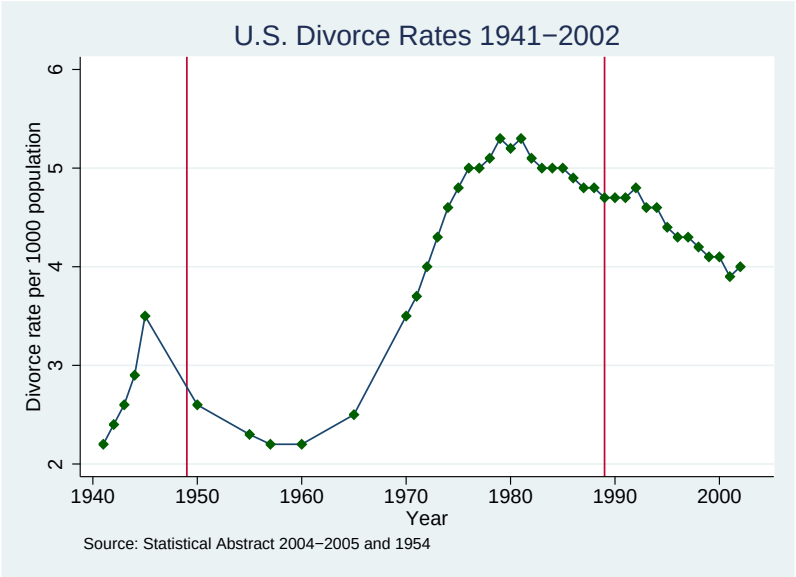
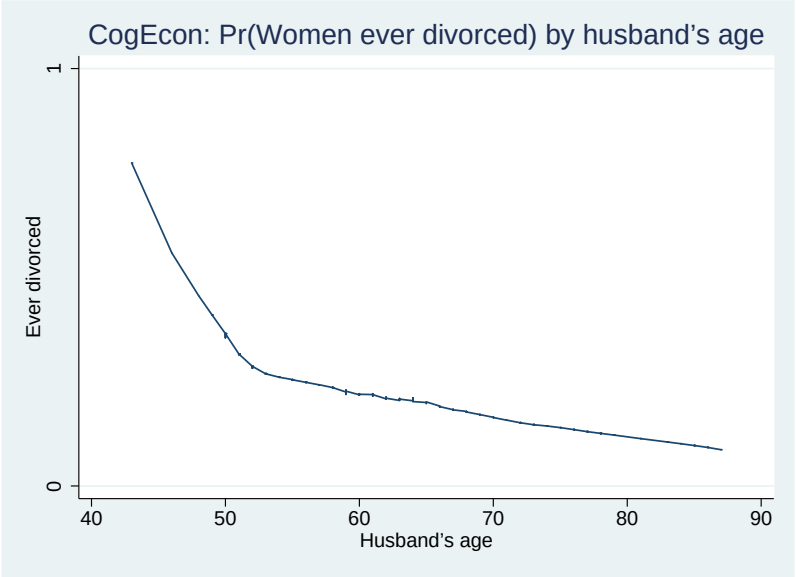


Figure 2.8: U.S. historical divorce rates



Vertical lines indicate the 5th and 95th percentile of year of first marriage among partnered respondents in the CogEcon sample. Younger women face greater incentives than older women to acquire financial literacy early in life.

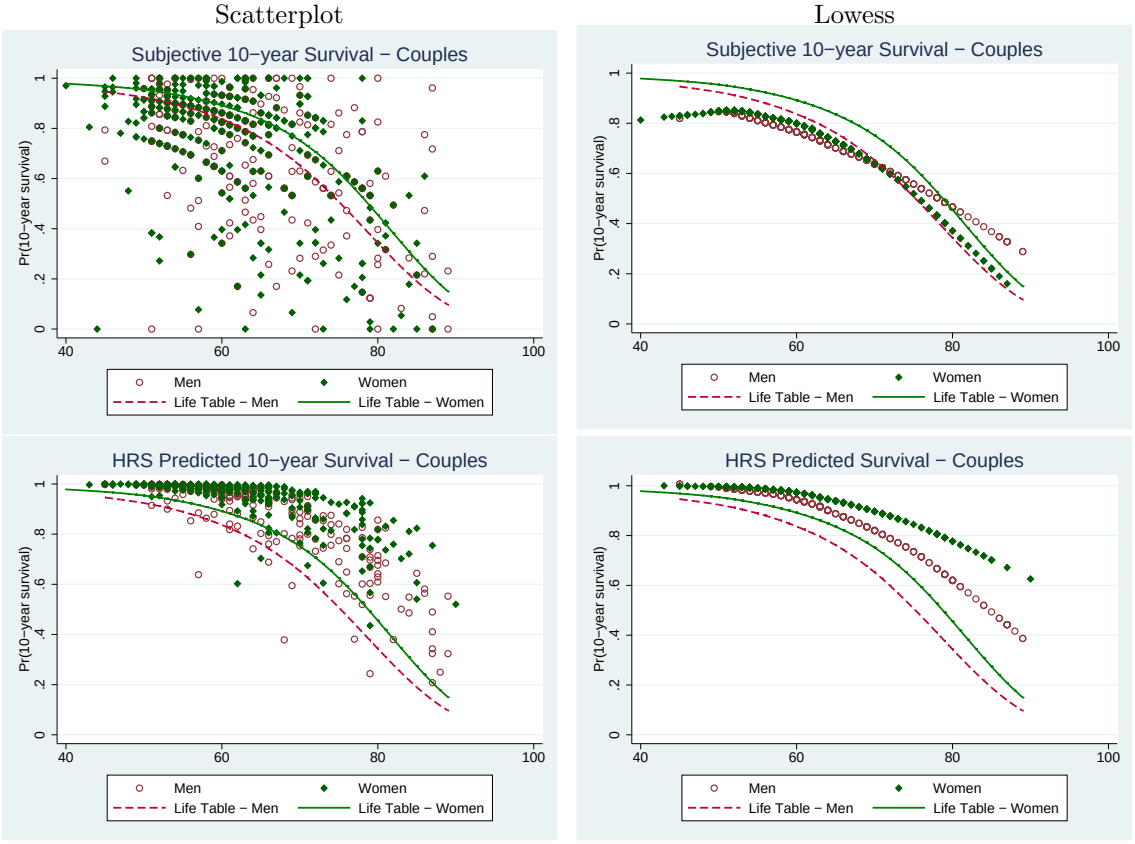
Figure 2.9: Probabilities of ever being divorced for women in the CogEcon sample, by husband's age



Older women in the sample are less likely than younger women to have ever been divorced.

Figure 2.10: Individual and life table 10-year survival probabilities

Scatterplot | Lowess



Solid and dashed plots represent life table survival probabilities. Scatterplots are generated using CogEcon respondents with partners.

Table 2.1: Ratio of the marginal effect of time to widowhood and length of widowhood on the value of human capital

Variable	Mean	SD	Min	Max
ratio with $\delta = 0.00$	1.52	0.15	1.21	2.23
ratio with $\delta = 0.03$	2.03	0.25	1.53	3.28
ratio with $\delta = 0.05$	2.38	0.33	1.663	4.00

If the depreciation of financial literacy is zero, the magnitude of the effect of time to widowhood on would be on average 1.52 times the magnitude of the effect of the duration. If human capital depreciates, the effect of time to widowhood is even greater relative to the effect of the duration.

Table 2.2: Demographic characteristics of the analysis sample

	Women		Men		
Variable	**Mean**	**N**	**Mean**	**N**	**Diff.**
Age	60.53	224	62.86	224	-2.326 ***
	(9.44)		(10.04)		
Life expectancy (years)	24.00	224	19.25	224	4.758 ***
	(7.47)		(6.91)		
Years of education	14.42	224	14.65	224	-0.228 *
	(1.99)		(2.16)		
Who is most knowledgeable about finances?					
Me	0.161	223	0.491	216	-0.321 ***
	(0.367)		(0.501)		
Me OR Both of us	0.489	223	0.866	216	-0.372 ***
	(0.501)		(0.342)		

Standard deviations in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 2.3: Summary of regression variables

Variable	Mean	SD	N
Outcomes			
Wife-husband diff. in normalized financial literacy	-0.37	1.10	224
Wife-husband diff. in fin. literacy (no stock questions)	-0.31	1.25	224
Key explanatory variables			
Expected time to widowhood (years)	14.39	5.74	224
Expected length of widowhood (years)	12.92	2.87	224
Other regressors			
Woman's risk tolerance (6 point scale)	2.36	1.39	214
Husband's self-rated health (5 point scale)	3.63	1.00	224
Woman's self-rated health (5 point scale)	3.73	0.96	224
Husband's years of education	14.65	2.16	224
Woman's years of education	14.42	1.99	224
Woman's Recall score (normalized)	0.40	0.85	224
Husband's Recall score (normalized)	-0.06	0.94	223
Woman's Number Series score (normalized)	0.17	0.84	224
Husband's Number Series score (normalized)	0.34	0.88	224

Table 2.4: Consistency of responses to "Who is most financially knowledgeable" within couples

	Wife's response					
Husband's response	Me	Partner	Both	Someone else	No Response	Total
Me	4	84	19	0	3	110
Partner	20	4	6	0	0	30
Both	15	20	47	1	0	83
Someone else	0	1	0	1	0	2
No response	0	5	3	0	0	8
Total	39	114	75	2	3	233

Only 10 couples (4%) report inconsistent answers about who is the household CFO, defined as the person who is most financially knowledgeable within the household.

Table 2.5: Comparative advantage and the division of labor: characteristics of couples by gender of CFOs

	Wife-husband Differences in				
CFO	Age	Educ.	Normalized Number Series	Normalized Financial Literacy	N
Wife	-1.33	0.69	0.13	0.30	36
Husband	-2.60	-.62	-0.44	-0.71	112
Both	-2.40	-.12	0.05	-0.16	73
Someone else	-4	2.5	0.91	0 .21	2
No Response	1	-3	0.65	-2.10	1
Total	-2.33	-0.23	-0.17	-0.37	224

The Household CFO is defined as the person who is most financially knowledgeable within the household. The CFO tends to be more educated, have more financial literacy, and have more fluid intelligence (as measured by the Number Series score) than his or her spouse; this is true for couples with male CFOs as well as those with female CFOs.

Table 2.6: Comparative advantage and the division of labor: proportion of couples in which the woman has higher levels of characteristics than her husband, by gender of CFOs

CFO	Age	Education	Number Series	Financial Literacy	N
Wife	0.250	0.417	0.472	0.583	36
Husband	0.134	0.214	0.304	0.259	112
Both	0.192	0.274	0.452	0.521	73
Someone Else	0.000	0.500	1.000	0.500	2
No Response	1.000	0.000	1.000	0.000	1
Total	0.174	0.268	0.388	0.397	224

Table 2.7: Wife-husband difference in financial literacy and husband's age

	All questions	No stock questions
Husband's age	0.013	0.017
	(0.007)*	(0.008)**
Const.	-1.212	-1.379
	(0.466)***	(0.526)***
N	224	224
R^2	.015	.019
F	3.37	4.237

* significant at 10%; ** significant at 5%; *** significant at 1%

These regressions are OLS versions of the graphs on the right panels of 2.4 and 2.5. As the husband ages, the woman gains financial literacy relative to her husband.

Table 2.8: Financial literacy regressions (all questions)

	(1)	(2)	(3)
Expected time to widowhood	-0.035	-0.037	-0.041
	(0.02)*	(0.02)*	(0.02)**
Expected duration of widowhood	0.037	0.042	0.043
	(0.04)	(0.04)	(0.04)
Woman's health		0.047	0.063
		(0.078)	(0.078)
Husband's health		-0.082	-0.092
		(0.075)	(0.076)
Woman's education		0.056	0.035
		(0.041)	(0.045)
Husband's education		-0.11	-0.105
		(0.038)***	(0.043)**
Woman's risk tolerance			0.0008
			(0.054)
Woman's Recall			-0.028
			(0.091)
Husband's Recall			-0.042
			(0.09)
Woman's Number Series			0.321
			(0.109)***
Husband's Number Series			-0.197
			(0.099)**
Const.	-0.349	0.533	0.754
	(0.377)	(0.739)	(0.894)
N	224	224	213
R^2	0.016	0.061	0.13
F	1.844	2.338	2.729

* significant at 10%; ** significant at 5%; *** significant at 1%

OLS regression with dependent variable: wife-husband difference in normalized financial sophistication score

Table 2.9: Financial literacy regressions (no stock questions)

	(1)	(2)	(3)
Expected time to widowhood	-0.042	-0.044	-0.048
	(0.022)*	(0.022)**	(0.023)**
Expected duration of widowhood	0.04	0.043	0.041
	(0.045)	(0.045)	(0.045)
Woman's health		0.032	0.044
		(0.088)	(0.088)
Husband's health		-0.018	-0.037
		(0.084)	(0.086)
Woman's education		0.08	0.039
		(0.046)*	(0.051)
Husband's education		-0.143	-0.124
		(0.043)***	(0.048)**
Woman's risk tolerance			-0.041
			(0.062)
Woman's Recall			0.034
			(0.104)
Husband's Recall			-0.061
			(0.102)
Woman's Number Series			0.387
			(0.124)***
Husband's Number Series			-0.248
			(0.112)**
Const.	-0.231	0.643	1.134
	(0.426)	(0.832)	(1.018)
N	224	224	213
R^2	0.019	0.069	0.144
F	2.161	2.668	3.065

* significant at 10%; ** significant at 5%; *** significant at 1%

OLS regression with dependent variable: wife-husband difference in normalized non-stock financial literacy score This table reproduces the regressions in Table 2.8, replacing the dependent variable with a financial literacy score that excludes all stock questions. The coefficients are qualitatively the same, but the effect of the time to widowhood is larger in magnitude here.

Table 2.10: Falsification tests: regressions using cognition outcomes

	Fin Soph	Number Series	Calcu-lations	Verbal Analogies	Mental Status	Total Recall	Visual Matching
Time to widowhood	-0.038 (0.02)*	0.001 (0.018)	0.014 (0.02)	-0.016 (0.018)	-0.002 (0.019)	-0.038 (0.021)*	-0.009 (0.02)
Duration of widowhood	0.038 (0.04)	-0.012 (0.036)	0.016 (0.039)	0.014 (0.037)	0.044 (0.038)	0.003 (0.042)	0.05 (0.04)
Woman's risk tolerance	0.019 (0.054)	0.055 (0.048)	0.013 (0.053)	-0.041 (0.05)	0.094 (0.052)*	0.069 (0.057)	0.026 (0.054)
Woman's health	.051 (0.078)	0.039 (0.069)	0.189 (0.077)**	-0.032 (0.072)	0.118 (0.074)	0.097 (0.082)	0.101 (0.077)
Husband's health	-0.07 (0.077)	0.06 (0.068)	-0.035 (0.076)	0.063 (0.071)	-0.038 (0.073)	0.027 (0.08)	-0.006 (0.076)
Woman's education	0.08 (0.042)*	0.169 (0.037)***	0.13 (0.041)***	0.145 (0.039)***	0.069 (0.04)*	0.06 (0.044)	0.002 (0.041)
Husband's education	-0.128 (0.039)***	-0.137 (0.035)***	-0.155 (0.038)***	-0.071 (0.036)**	-0.022 (0.037)	-0.124 (0.041)***	-0.058 (0.038)
Const.	0.387 (0.757)	-0.957 (0.672)	-0.926 (0.733)	-1.208 (0.696)*	-1.858 (0.717)***	1.307 (0.788)*	0.303 (0.745)
N	214	214	213	214	213	213	214
R^2	0.075	0.121	0.121	0.069	0.063	0.08	0.031
F	2.384	4.042	4.024	2.196	1.968	2.534	0.929

* significant at 10%; ** significant at 5%; *** significant at 1%

OLS regression with dependent variables: wife - husband difference in normalized cognition. These falsification tests reproduce the regression in column (1) of Table 2.8, replacing the dependent variable with the wife-husband difference in cognition scores and omitting the cognition scores (Number Series and Recall) on the right hand side. The cognition variables are detailed in Section 2.4.3. Because the cognition scores are normalized, the coefficients are directly comparable with those estimated using the wife-husband difference in financial literacy in column (1).

Table 2.11: Summary of 10-year survival probabilities

Measure	**Variable**	**Mean**	**SD**	**Min**	**Max**	**N**
Life table	Husband	0.72	0.21	0.10	0.95	238
	Wife - husband	0.11	0.10	-0.07	0.65	238
Subjective -	Husband	0.71	0.24	0	1	224
constant hazard	Wife - husband	0.05	0.27	-0.83	0.77	214
HRS predicted	Husband	0.87	0.16	0.21	0.99	216
probabilities	Wife - husband	0.08	0.13	-0.20	0.62	215

Table 2.12: Cross-correlation table of alternate 10-year survival measures

Variables	Life Table	Subjective survival	HRS predicted
Life table	1.000		
Subjective survival	0.562	1.000	
HRS predicted	0.827	0.573	1.000

Table 2.13: Robustness check: Financial literacy regressions using 10-year survival measures

	Life table 10-year survival	Constant hazard life table	HRS predicted (adjusted se)
Husband's Pr(surv)	-0.664	-0.634	-0.328
	(0.594)	(0.454)	(1.017)
Diff Pr(surv)	0.332	-0.38	2.005
	(1.151)	(0.382)	(1.187)*
Woman's health	-0.063	-0.075	-0.015
	(0.078)	(0.084)	(0.081)
Husband's health	0.089	0.094	-0.031
	(0.076)	(0.085)	(0.083)
Woman's education	0.037	0.036	0.052
	(0.045)	(0.046)	(0.045)
Husband's education	-0.106	-0.107	-0.114
	(0.042)**	(0.044)**	(0.042)***
Woman's risk tolerance	-0.005	-0.012	-0.015
	(0.054)	(0.058)	(0.053)
Woman's Recall	-0.022	-0.016	-0.05
	(0.091)	(0.097)	(0.091)
Husband's Recall	-0.032	-0.062	0.007
	(0.09)	(0.093)	(0.092)
Woman's Number Series	0.33	0.34	0.329
	(0.11)***	(0.114)***	(0.109)***
Husband's Number Series	-0.192	-0.186	-0.152
	(0.099)*	(0.105)*	(0.097)
Const.	1.011	1.07	0.805
	(0.994)	(0.893)	(1.332)
N	213	196	211
R^2	0.13	0.136	0.166
F	2.733	2.64	3.607

* significant at 10%; ** significant at 5%; *** significant at 1%

Dependent variable: wife-husband difference in normalized financial literacy scores, all questions.

Table 2.14: Robustness check: Financial literacy regressions (no stock questions) using 10-year survival measures

	Life table 10 year survival	Constant hazard Life table	HRS predicted
Husband's Pr(surv)	-1.083	-0.767	-1.012
	(0.678)	(0.521)	(1.176)
Diff Pr(surv)	-.385	-.522	1.208
	(1.313)	(0.439)	(1.371)
Woman's health	.041	.054	.015
	(0.089)	(0.097)	(0.094)
Husband's health	-.036	-.023	.073
	(0.086)	(0.098)	(0.096)
Woman's education	.041	.039	.054
	(0.051)	(0.053)	(0.052)
Husband's education	-.125	-.12	-.13
	$(0.048)^{***}$	$(0.051)^{**}$	$(0.048)^{***}$
Woman's risk tolerance	-.048	-.062	-.056
	(0.061)	(0.066)	(0.061)
Woman's Recall	.042	.036	.022
	(0.104)	(0.112)	(0.105)
Husband's Recall	-.052	-.116	-.011
	(0.103)	(0.107)	(0.106)
Woman's Number Series	.397	.409	.394
	$(0.125)^{***}$	$(0.131)^{***}$	$(0.126)^{***}$
Husband's Number Series	-.24	-.252	-.21
	$(0.113)^{**}$	$(0.121)^{**}$	$(0.112)^{*}$
Const.	1.809	1.433	1.387
	(1.116)	(0.944)	(1.392)
N	213	196	211
R^2	.142	0.152	.16
F	3.019	2.997	3.458

* significant at 10%; ** significant at 5%; *** significant at 1%

Dependent variable: wife-husband difference in normalized financial literacy scores, excluding stock questions.

Table 2.15: Summary of other financial knowledge outcomes

Variable	Mean	Std. Dev.	Min.	Max.	N
Woman's self-rated financial skills	5.03	0.99	1	6	238
Woman's self-rated stock market understanding	2.95	1.36	1	6	232
Wife-husband difference in self-rated financial skills	0.01	1.48	-4	5	217
Wife-husband difference in self-rated stock market understanding	-0.77	1.63	-5	5	210
Woman's correct response to "Stocks historically outperform bonds?"	0.57	0.50	0	1	187
Woman's "How closely do you follow the stock market?"	0.66	0.63	0	2	212

Full text of these questions are found in Appendix 2.7.3. Self-rated financial skills and stock market understanding: coded as 6 for "strongly agree" and 1 for "strongly disagree." Historical stock/bond returns: coded as 1 if respondents correctly reported that stock returns have exceeded bond returns. Follow the stock market: coded as 2 for "very closely," 1 for "somewhat" and 0 for "not at all."

Table 2.16: Regressions of other financial knowledge outcomes

	(1) Woman's Financial skills	(2) Woman's Stock market	(3) Difference Financial skills	(4) Difference Stock market	(5) Stocks returns (AME)	(6) Follow stock market
Expected time to widowhood	-0.021 (0.012)*	-0.021 (0.012)*	-0.028 (0.012)**	-0.009 (0.012)	-0.012 (0.005)**	-0.041 (0.014)***
Expected length of widowhood	-0.043 (0.022)**	0.028 (0.021)	-0.031 (0.021)	0.03 (0.022)	-0.004 (0.011)	-0.028 (0.025)
Woman's health	0.142 (0.077)*	0.172 (0.075)**	0.019 (0.076)	0.113 (0.076)	0.026 (0.037)	0.161 (0.091)*
Husband's health	-0.13 (0.077)*	-0.052 (0.073)	-0.129 (0.075)*	-0.052 (0.074)	-0.035 (0.035)	-0.062 (0.087)
Woman's education	-0.066 (0.043)	0.023 (0.041)	-0.024 (0.044)	0.024 (0.045)	-0.032 (0.021)	0.016 (0.047)
Husband's education	0.018 (0.042)	-0.02 (0.04)	-0.051 (0.042)	-0.093 (0.042)**	0.055 (0.02)***	-0.101 (0.049)**
Woman's risk tolerance	0.069 (0.053)	0.009 (0.051)	0.011 (0.053)	-0.031 (0.054)	0.007 (0.025)	0.019 (0.062)
Woman's Recall	0.177 (0.092)*	-0.039 (0.089)	0.0002 (0.09)	0.118 (0.091)	0.063 (0.045)	0.036 (0.106)
Husband's Recall	-0.061 (0.09)	0.013 (0.088)	-0.098 (0.089)	-0.161 (0.091)*	0.069 (0.044)	0.343 (0.108)***
Woman's Number Series	0.186 (0.11)*	0.087 (0.106)	0.455 (0.11)***	0.217 (0.108)**	0.123 (0.053)**	0.171 (0.13)
Husband's Number Series	0.029 (0.094)	0.097 (0.091)	-0.124 (0.096)	-0.072 (0.096)	-0.05 (0.044)	0.235 (0.109)**
N	238	232	217	210	187	212

* significant at 10%; ** significant at 5%; *** significant at 1%

Dependent variables: woman's self-rated financial skills and stock market skills; wife-husband differences in self-ratings, woman's knowledge that stocks have historically outperformed bonds, woman's closely following the stock market.

CHAPTER III

The Implications of Alzheimer's Disease Risk for Household Financial Decision-Making

3.1 Introduction

Alzheimer's disease and other dementias cause progressive declines in cognition that lead to a complete loss of functional capacities. This may pose enormous financial risk to all members of a household. First, Alzheimer's is associated with high costs of care, including the costs of identifying and paying for nursing home services and home care; second, cognitive impairment of a financial decision-maker can lead to financial mismanagement. The financial risks highlight the potential benefits of preparing for the loss of functional capacities and raise the question: how do households respond to early signs of cognitive impairment and official diagnoses of Alzheimer's or dementia? In this chapter we focus on the impacts of self-reported difficulties with money and memory disease diagnoses on the household division of labor for financial decision-making tasks.

A series of articles about Alzheimer's disease in the *New York Times* describe the difficulties some older individuals have handling money, for example, forgetting to pay bills, participating in fraudulent schemes, and signing contracts they don't understand. These difficulties often later give way to a diagnosis of Alzheimer's, as well as serious financial problems. Indeed, medical research has shown that such

problems are an early sign of dementias like Alzheimer's.

The emergence of difficulties handling money can be extremely problematic if one does not have assistance with this task. Married individuals could potentially rely on their cognitively intact spouses to assume responsibility of finances. Using the Health and Retirement Study (HRS), a longitudinal, nationally representative study of older Americans, we employ survival analysis and other regression methods to examine if and when financial responsibility is transferred from one spouse to another as a result of cognitive decline. We find that as the cognition of the primary financial decision-maker declines, the management of finances is eventually turned over to the unimpaired spouse. However, the switch often does not occur until well after the impaired spouse reports difficulties handling money. This suggests that a cognitively impaired individual often continues to make financial decisions even after he is aware of his difficulties handling money.

To understand the variation in the timing of this switch, we analyze an economic model of the value of information about future cognitive impairment. There is surprisingly little consensus among medical professionals—let alone patients and loved ones—about the value of early detection of Alzheimer's. On one hand, given the irreversibility of Alzheimer's, a diagnosis may introduce unnecessary emotional trauma. On the other hand, a diagnosis allows couples to alter their plans and prepare for the future, which can be financially beneficial. Our model highlights both the emotional cost of new information and the financial benefits of using that information to re-optimize for the future. Based on the model, we hypothesize that, holding emotional costs constant, one source of variation in the net benefit from re-optimization is the level of individual oversight needed to manage a household's existing financial assets.

In their model about forms of human capital that are useful for the management

of wealth, Delavande et al. (2008) show that the benefits of financial competence are proportional to the amount of wealth one manages. Households who rely on fixed income sources, such as pensions and Social Security, need only a modest amount of day-to-day oversight of finances relative to those who actively manage wealth, such as savings in 401(k) accounts. Protecting household finances against mismanagement by a cognitively impaired husband may involve establishing trusts, assigning power-of-attorney, or otherwise transferring financial responsibility to the wife.

In fact, couples who actively manage their retirement accounts transfer responsibility more quickly after the emergence of money difficulties and at higher levels of cognition. A diagnosis increases the hazard of switching the financial respondent by a factor of 2.2 for couples who control their retirement accounts relative to those who passively receive retirement income. These results hold even after controlling for wife's cognition, education, wealth, and stock ownership. This is consistent with an economic model of the value of information: households with the most to gain financially from preparation are most responsive to information about cognitive decline.

3.2 Background

In this section, we will provide some background on the issues at hand. We will begin with a description of Alzheimer's disease and its impact on the division of labor. In particular, we focus on the management of finances and the financial vulnerability of older persons. Lastly, we discuss the value of a diagnosis of Alzheimer's, a form of information about cognitive decline.

3.2.1 Aging, dementia, and Alzheimer's Disease

Dementia is defined as the loss of cognitive and mental functions severe enough to impair a person's daily functioning. These losses reflect declines from a previous baseline, and they must include the impairment of memory and at least one other cognitive function.[1] One of the earliest signs of dementia is forgetfulness, which is often accompanied by functional difficulties in areas like language, social skills and reasoning skills. Estimates show that nearly 15 percent of Americans over the age of 70, or 3.4 million individuals, suffer from some form of dementia (Plassman et al., 2007).

Dementing disorders are distinct from normal aging in that dementia is characterized by diminished functional capacity. A person experiencing typical aging will be largely independent in his daily activities, in spite of possible complaints about memory loss. A person aging with dementia becomes dependent on others for activities necessary for daily living and will begin behaving in socially inappropriate ways. Under typical aging, a person may complain about memory loss but can generally recount in detail these bouts forgetfulness, whereas a demented person would generally be unable to recall these incidents (American Medical Association, n.d.).

Dementia represents a set of symptoms, characterized by reduced functional capacity, that can be caused by a number of diseases or conditions. Alzheimer's disease is the most common form of dementia and accounts for an estimated 60 to 90 percent of all dementia cases (Brookmeyer et al., 2011; Alzheimer's Association, 2011). The prevalence of Alzheimer's has been estimated at 13 percent of those over 65 and 43

[1] These functions are, as defined by the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition,* cited in Holsinger et al. (2007): agnosia, failure to recognize or identify objects despite intact sensory function; aphasia, deterioration of language function (impairment); apraxia, impaired ability to execute motor activities despite intact motor abilities, sensory function, and comprehension of the required task; delirium, a disturbance of consciousness that is accompanied by a change in cognition that cannot be better accounted for by a preexisting or evolving dementia; executive functioning, the ability to think abstractly and to plan, initiate, sequence, monitor, and stop complex behavior.

percent of those over 85 (Alzheimer's Association, 2011). The defining abnormalities of Alzheimer's disease are amyloid plaques and neurofibrillary tangles in the brain, though these features cannot be definitively identified until the brain is examined in an autopsy.

Individuals with dementias like Alzheimer's suffer progressive declines in cognition that worsen continuously over a period of years. Other common forms of progressive dementia include include vascular dementia, dementia with Lewey bodies, Parkinson's disease, or some combination thereof. Some dementias are brought about by a single event, such as cardiac arrest or brain injury; these dementias are static but are also generally irreversible.

For all causes of dementia, doctors assess a patient's cognition using neuropsychological tests, including tests for memory, problem-solving skills, and thinking and reasoning skills. One of the more widely used (and commonly studied) tests for screening and assessing the severity of dementia is the Mini-Mental State Examination (MMSE), which covers a number of cognitive functions in about ten minutes (Holsinger et al., 2007).

While all forms of dementia are associated with memory impairment, the defining feature is the loss of functional capacity (Marson, 2001). Health professionals rely on a standardized list of activities, known as the Activities of Daily Living (ADLs), to determine the functional status of patients. Basic ADLs include walking, bathing, toileting and other requirements of personal care and hygiene. Instrumental ADLs (IADLs) refer to more complicated tasks, like those involved in managing a household and its finances. Pérès et al. (2008) find that individuals who are eventually diagnosed with dementia perform more poorly on IADLs than those who do not develop dementia.

At this time, Alzheimer's and most other forms of dementia have no cure.[2] Current treatments include drugs that can help manage the cognitive symptoms of Alzheimer's for a limited period of time.[3] While research on the prevention, treatment, and early detection of Alzheimer's is underway, reactions to the value of early detection are quite varied.

3.2.2 Human capital and cognitive decline: the case of financial management

Many couples have a division of labor that results in each member specializing in particular tasks. For instance, one member (often the wife) may be primarily responsible for health care for the family, while the other (frequently the husband) may be the household "Chief Financial Officer" (CFO) responsible for household finances. Individuals will typically invest in the human capital relevant to their specialty early on in order to reap the benefits of their knowledge over the course of their adult lives.

A division of labor may be efficient, but only if the union is intact and if both members continue to hold the mental and physical abilities required by their responsibilities. Chapter II discussed the role of widowhood in the division of labor, but what happens if one member of the couple begins to lose skills due to a dementing disease such as Alzheimer's? The death of a spouse necessarily disrupts the division of labor, but cognitive decline can have consequences that are even more severe.[4] Wise financial management and decision-making become even more important given the high costs of care associated with Alzheimer's, including the complexity of iden-

[2] Dementias with certain causes, like infection, nutritional deficiencies, or drug interactions, may be reversible. A meta-analysis of dementia studies showed that less than ten percent of cases were potentially reversible; in articles that provided follow-up information, only 0.6 percent of cases reversed at least partially (Clarfield, 2003).

[3] http://www.alz.org/alzheimers_disease_standard_prescriptions.asp

[4] The analysis of Chapter II focused on women, who tend not to be CFOs but are more likely than men to become widows. While more women than men have dementia (Alzheimer's Association, 2011), this gap is attributable to gender differentials in mortality. Indeed, mild cognitive impairment (MCI) is more prevalent among men than women (Petersen et al., 2010). The same issues regarding dementia and financial decision-making arise regardless of the gender of the financial CFO.

tifying and paying for nursing home services and home care.

Furthermore, while the onset of widowhood is instantaneous and impossible to ignore, the cognitive decline associated with dementias like Alzheimer's occurs progressively and disrupts division of labor in a more subtle way. Individuals might be physically able to continue the division of labor, but cognitive impairment makes it harder to do certain tasks well, especially if the tasks require thinking and reasoning. Declines in ability lead to declines in productivity of human capital and consequently the loss of comparative advantage in tasks that require high cognitive function. Therefore, one way to mitigate the impact of Alzheimer's on a patient's family is to restructure the division of labor such that a person who is cognitively intact is responsible for cognition-intensive tasks.

Financial management is one such task that can be very complex and requires high cognitive function. As discussed in Chapter II, this task has become more complicated as regular streams of retirement income from defined benefit pensions have been replaced by retirement plans that need to be actively managed both before and after retirement. Korniotis and Kumar (2011) find evidence that older investors "exhibit worse stock selection ability and poor diversification skill," which the authors attribute to aging-related cognitive declines. Reduced cognitive function predicts both low asset accumulation as well as less participation in the financial markets (Benjamin et al., 2006). Other studies have found similar patterns with respect to numeracy and the accumulation of wealth (Banks and Oldfield, 2007; Banks et al., 2010; Smith et al., 2010).

Declines in financial capacity, the productivity of financial human capital, have been detected in Alzheimer's patients. Studies have shown that those with mild cases of Alzheimer's have significantly impaired financial abilities, particularly with respect

to complex tasks (Marson et al., 2000), even though their basic calculation skills may still be intact (Martin et al., 2003). The impairment in financial abilities is even more severe among those with moderate Alzheimer's (Marson et al., 2000). Studies have also found particularly rapid declines in financial skills among Alzheimer's subjects, particularly in their susceptibility to simple fraud (Martin et al., 2008).

While it may be unsurprising that researchers have identified reduced financial abilities among individuals who already have Alzheimer's, the worsening of financial abilities can be found prior to the onset of dementia and Alzheimer's. Triebel et al. (2009) detect declining financial skills in patients with mild cognitive impairment (MCI) in the year before developing Alzheimer's. While not all individuals with mild cognitive impairment convert to Alzheimer's, cross-sectional studies have shown that individuals with MCI also have impaired financial abilities (Griffith et al., 2003; Okonkwo et al., 2008).

Ideally, individuals would be aware of their own declining cognitive capacity early in the process and change their own behavior accordingly in order to mitigate the effects of such declines on their households. Alarmingly, however, individuals with mild cognitive impairment (Okonkwo et al., 2008) and dementia (Van Wielingen et al., 2004) are not fully aware of their deteriorating financial skills. This suggests that self-reported measures of cognitive functioning may actually overestimate the financial skills of the cognitively impaired. Furthermore, their proxy informants or caregivers also systematically misjudge the financial abilities of patients (Okonkwo et al., 2008), as well as their general cognitive and other functional abilities (Loewenstein et al., 2001). This lack of awareness on the parts of both the impaired and their caregivers will lead to increased financial vulnerability if the impaired individual continues to make financial decisions.

3.2.3 The financial vulnerability of older Americans

Regardless of cognitive status, older Americans are more financially vulnerable than the general population. Not only have most of the elderly left the labor market, but they face greater medical costs in their declining health, and they are frequently targets of financial abuse and exploitation. At the same time, the financial tasks facing the elderly can be quite complex. These tasks include budgeting and decumulation, leaving enough money for essentials, managing credit and debt, dealing with bills (including medical bills), managing retirement wealth, planning for medical or nursing home care, bequests, and so on. Even seemingly minor oversights can lead to large problems: the *New York Times* describes a former lawyer who forgot to pay his bills, and then later stopped paying creditors altogether. By the time his wife noticed something was wrong, most of their money had vanished (Kolata, 2010b).

Financial abuse and exploitation is endemic among older Americans. Financial exploitation is defined as the "unjust, improper, and/or illegal use of [an older person's] resources, property, and/or assets" (National Research Council et al., 2003). Examples of financial abuse include cashing an older person's checks without permission; forging an older person's signature or coercing him into signing a contract, will or other document; stealing or misusing an older person's financial resources; and so forth (Teaster et al., 2006, p. 9).

In 2004, financial exploitation was one of the most common forms of elder abuse investigated and substantiated by Adult Protective Services (Teaster et al., 2006). Financial exploitation cases outnumbered cases of physical abuse as well as emotional and psychological abuse. A survey of older Americans and their adult children found that half of the older respondents exhibited at least one of the "warning signs of current financial victimization." These warning signs include being asked for money,

to play lotteries, or participate in other schemes; not feeling comfortable making major financial decisions alone; or not understanding financial decisions being made on their behalf (Infogroup/ORC, 2010, p. 38).[5]

However, the consequences of incompetent financial decision-making or financial abuse will vary across households. The extent of a household's vulnerability to either risk depends on the volatility and exposure of their assets and any future potential income. If a household's retirement income comes primarily from wealth that is individually managed, then the household will be exposed to the risk of poor investment decisions. In such a case, it would be possible to quickly and easily squander wealth that was meant to last months or even years. For example, an older doctor somehow became the director of several clinics; one used his name to engage in fraudulent billing, and another took out mortgages without his knowledge. By the time his son noticed, the doctor's savings had been completely emptied out by a scammer, and all that was left was his Social Security income (Kolata, 2010b).

Others may have fewer assets under their direct control. Those who depend primarily on regular streams of income that are not actively managed may be less likely to incur severe losses as a result of incompetent decision-making. Active decisions are generally not required to receive monthly streams of income like defined benefit pensions or Social Security income. Furthermore, individuals whose income is limited to such streams do not have direct access to future income that could be spent unwisely or exploited in scams. The problems these individuals face are likely to be limited to cash flow issues—leaving enough money each month for necessities, refraining from buying items they would not otherwise buy if they were cognitively intact, knowing how to access the money, or remembering to pay the bills.

[5]This survey also found that 40 percent of adults with parents over 65 are worried that their parents "will become less able to handle personal finances over time"; 36 percent of the parents over 65 have the same worry about themselves (Infogroup/ORC, 2010, p. 23)

3.2.4 The value of information: costs and benefits

In an article about advances in the early diagnosis of Alzheimer's, the author asks: "Does it help to know you are likely to get a disease if there is nothing you can do?" (Kolata, 2010a)

Readers who thought that early detection held little value emphasized the idea that there is nothing one can do with such information.[6] Early detection is seen as merely delivering "devastating knowledge" (Winer, 2010), given the inevitability of decline with Alzheimer's. The question above hinges on the idea that one may not be able do anything with this information—with no cure, a diagnosis provides only emotional costs and no benefits. The role of psychological costs, including anxiety and fear, have been emphasized in research about HIV testing (see Thornton, 2008) and behavioral research on decision-making, including health decisions (for example Caplin and Leahy, 2001; Koszegi, 2003; Frank, 2004), both of which have parallels to the case of Alzheimer's diagnoses.

Others, in spite of the incurability and irreversability of Alzheimer's, see value in this information, precisely because they would take action as a result of early detection. One reader states: "I most definitely do want to know if [Alzheimer's] is in store for me so that I can begin to plan the rest of my life while I am still 'in charge.' Most important, I would invest my savings in a supportive, long-term living arrangement, one that I would choose, on my own terms. And I would decide myself what to do with all my 'stuff' - my books, collections, clothing and furniture." (Bloom, 2010)[7]

[6] Some examples: "Even assuming that the new diagnostic test for Alzheimer's is 100 percent accurate, what good does that knowledge do? There is no drug that cures the disease, only ones that mitigate the symptoms at an early stage. My wife died four years ago from Alzheimer's at age 69. She and her family suffered with the disease for seven years after the initial diagnosis. Had we known earlier, everyone would have suffered even longer." (Eisen, 2010) A doctor's perspective, in an Op-Ed: "The doctor's most basic tenet is that of primum non nocere—first, do no harm. Until we have a more definite idea about what causes Alzheimer's, early-detection tests may do patients more harm than good." (Pimplikar, 2010)

[7] A geriatric psychiatrist agrees: "Scientists' understanding of Alzheimer's disease may not be clear enough to

A positive diagnosis would allow an individual who knows that s/he will suffer cognitive decline to prepare for that impairment. In this respect, preparation is as much about protecting the rest of their household from the externalities of future poor decision-making as it is about preparing themselves individually for such impairment. This reflects the logic of the two-selves model (Thaler and Shefrin, 1981). In this model, a single agent is represented as two players: a "planner," whose utility is derived as the present value of future gains, and a "doer," who receives the utility from prior planning in a present period. In the context of dementia, preparation is needed to protect the planning-self—who will no longer exist after dementia exacts a sufficient toll—from a future "doer" who has no ability to plan or to act altruistically toward other members of the household. For instance, a cognitively intact person may believe that if he developed Alzheimer's he would not have the awareness to derive utility from high-quality nursing care. In spite of this, he may still want to plan for such nursing care in order to increase the utility of his spouse or loved ones, who may suffer disutility if he suffered bedsores due to insufficient care, for example.

Armed with foreknowledge about one's cognitive decline, the "planner" can begin preparation for a state of cognitive impairment. One retirement planning magazine suggests gathering a group of experts: a financial advisor to plan for incapacity and paying for costs of care, an attorney to establish trusts and use other legal vehicles to protect financial assets and medical planning, and a geriatric-care manager to help with finding caregivers (Garland, 2010). While the suggestion may not be feasible for all households dealing with dementia, it highlights that one can take actions in a

develop tools for diagnosis and treatment. But Sanjay W. Pimplikar falls into the trap into which many of us physicians find ourselves: thinking that without a medical treatment, 'many individuals would simply prefer to be spared the emotional trauma of a diagnosis.' This runs contrary to the spoken wishes of many people with memory loss. They are grateful to hear that their disorienting and frightening experiences have a name. And if the Alzheimer's disease is diagnosed early (providers can do this today with a skillful history and clinical exam), they can actively plan for their future. The real emotional trauma comes when patients and families are confronted with incomprehensible personality changes, memory lapses and difficulty functioning that are unrecognized by their medical providers."(Czapiewski, 2010)

number of areas: financial, legal, and medical or day-to-day care, among others. In this chapter, we will focus on the first of these areas.

Households may want to alter their financial plans well before cognition and functional capacities are lost. Expenditures on goods and leisure activities might be re-allocated to earlier ages when a person still has normal cognition and functioning. Alternatively, such expenditures may be delayed or cancelled outright in favor of saving for expensive care in old age. Dementias like Alzheimer's are progressive and expensive to manage, so the most direct financial implication of foreknowledge is to ensure access to care. Additionally, if a spouse is present, one may want to ensure that the spouse's financial needs are taken care of during the period of cognitive impairment. Furthermore, a spouse is also commonly the caretaker of a dementia patient, so this spouse may be in a position to monitor behavior and actions, such as how the patient handles money, as cognition declines. A financially competent, or involved, spouse may notice the danger signs and know when it is optimal to assume responsibility of finances.

Sharing financial responsibilities with a cognitively intact spouse or loved one (and eventually delegating responsibilities completely to that person) can be a key form of preparation. Problems understanding or remembering to pay bills are frequently cited in anecdotal accounts and academic studies of dementia and Alzheimer's (Kolata, 2010b; Loewenstein et al., 2001; Okonkwo et al., 2006; Martin et al., 2008; Okonkwo et al., 2008; Griffith et al., 2003), so for some, altering financial planning may also be as basic as ensuring that bills are paid correctly and on time.

Households who manage their own investments tend to have more assets to protect, which makes turning over financial responsibilities even more important. One *New York Times* reader comments: "By the time [my father's] dementia became

manifest, I was forced to learn the entire universe of money-management without benefit of his experience and expertise ... Please, if you have assets to protect, make sure your family understands the details before it's too late."[8] These households will also be more vulnerable to financial abuse, since they have assets that can be exploited.

Knowing preparation is necessary requires some awareness of one's current or future cognitive status. Because of the gradual nature of cognitive decline, mild impairment may not be easily detected. While cognitive impairment is more easily concealed than physical impairment, loved ones, particularly spouses or children, are likely to notice and can persuade an individual to see a doctor. Financial advisors, lawyers, doctors, and others who work with the elderly may also be in a position to notice cognitive decline. However, due to privacy obligations, lawyers and doctors may not inform family members or loved ones. Even those without privacy obligations will not find it easy to deal with these situations. Recent articles in the *Journal of the American Medical Association* aim to help clarify the role of physicians who might be in a position to notice financial decision-making problems in their patients (Sabatino, 2011; Widera et al., 2011).

In summary, the value of information—in this case information with a large negative emotional cost—is determined largely by what individuals can do with such information. There is no cure that can be applied after this information is revealed, so the utility value of information is derived from changes in one's own behavior and planning. In this chapter, we focus on adjustments to financial decision-making that might reduce the financial costs of Alzheimer's.

[8]Susan, Chester County PA, October 31st, 2010, 10:24 am, Comments to Kolata (2010b)

3.3 Theoretical framework

Early detection of Alzheimer's, before the onset of symptoms, is a source of information about the trajectory of one's cognition and functional capacity. To formalize the variation in beliefs about the value of this information, consider a model first proposed by Boozer and Philipson (2000) to analyze the demand for HIV tests. An individual is one of two types, each with its own utility function. In our context, one type undergoes normal aging (U^N); the other type develops Alzheimer's disease (U^A). Let y be a vector of behaviors over time that is a function of p, the subjective belief of one's own probability of developing Alzheimer's.

Therefore, the expected utility gained from a particular type of behavior is

$$V(y,p) = pU^A(y) + (1-p)U^N(y) + \mathbb{I}(pE_A + (1-p)E_N) \tag{3.1}$$

where $\mathbb{I}$ is one if the individual takes a medical test that reveals his type.

The prior belief is denoted by p_0. If an individual is tested for Alzheimer's, p_A is the posterior belief after a positive test, and p_N is the posterior belief after a negative test. If the test perfectly predicts whether or not one will eventually develop Alzheimer's, p_A equals one and p_N equals zero. Otherwise, p_A and p_N reflect updated beliefs based on new information from the doctor. For simplicity, we assume that the test is administered while a person still has normal cognition.

The emotional impact of receiving a diagnosis (positive or negative) is E, with the emotional impact of remaining in ignorance normalized to zero. The "emotional trauma of a diagnosis" (Pimplikar, 2010) of Alzheimer's is $E_A < 0$. The benefit of knowing you will retain your cognition is denoted by $E_N > 0$.

Behavior y is chosen optimally given a person's underlying beliefs. If one tests positive for Alzheimer's, a person re-optimizes his behavior based on his posterior

beliefs, formed with the new information about his type, y_A. If a person learns he will not develop diagnosis and will undergo normal aging, his new optimal behavior bundle is y_N. A person who does not take the test will act in accordance with his prior subjective beliefs and continues his behavior y_0.

Utility is then

$$V(y,p) = \begin{cases} V(y_A, p_A) = U^A(y_A) + E_A & \text{if one receives a positive test} \\ V(y_N, p_N) = U^N(y_N) + E_N & \text{if one tests normal} \\ V(y_0, p_0) = p_0 U^A(y_0) + (1-p_0)U^N(y_0) & \text{if one does not take the test.} \end{cases}$$

The value of information is "equal to the expected utility with the information (under the assumption of optimal reaction) minus the expected utility without" (Birchler and Bütler, 2007). If c denotes the pecuniary cost in units of utility of acquiring a diagnosis, the value of information is positive if

$$p_0 V(y_A, p_A) + (1-p_0)V(y_N, p_N) - c > V(y_0, p_0) \tag{3.2}$$

where the left-hand side is the net utility gained from the information, and the right-hand side is the utility gained if a person behaved in accordance with his prior.

Plugging in for V and rearranging shows that one would take the test if:

$$p_0 \overbrace{\left[U^A(y_A) - U^A(y_0)\right]}^{\text{Benefit from preparation}} + (1-p_0) \overbrace{\left[U^N(y_N) - U^N(y_0)\right]}^{\text{Benefit of freedom from fear}} > \overbrace{-\left[p_0 E_A + (1-p_0)E_N\right] + c.}^{\text{Emotional and pecuniary cost of test}} \tag{3.3}$$

The two expressions on the left hand side represent the increased utility derived from behavior that is changed with new information, or behavior that is *information elastic* (Boozer and Philipson, 2000). If re-optimization after a new Alzheimer's diagnosis does not generate changes in behavior (and therefore utility), then information about Alzheimer's has little value. More specifically, information is only valuable if

the utility gain from the information exceeds the emotional (and pecuniary) cost of the information.

We can think of y as a stream of behaviors from now until death. In our context, behaviors might include the intertemporal allocation of consumption, saving, portfolio allocation and the management of finances, and leisure activities. Other behaviors may involve other preparation for old age by turning over the management of finances to a loved one, designating a power of attorney, writing medical directives, undertaking estate planning, and so forth. There is currently little conclusive evidence about behavior that specifically lowers the risk of Alzheimer's disease, so we assume that the objective probability of developing Alzheimer's is exogenous.

An individual may choose to preemptively prepare for the prospect of Alzheimer's even without a definitive diagnosis. If a person has a very high prior belief about getting Alzheimer's (p_0 close to one), he may have mechanisms in place for someone else to take over finances, choose to invest in safer assets, or save sufficiently for long-term nursing care. In this case, a positive diagnosis does not effect substantial changes in behavior, and therefore behavior is information *inelastic*; y_0 is already quite close to y_A. Indeed, Boozer and Philipson (2000) show that the greatest gains from test results are reaped by those who would be surprised by those results. Figure 3.1 plots the costs and benefits of information by p. If emotional costs of a positive diagnosis are low, then most individuals would derive benefit from a diagnosis. Only those with p_0 very close to 0 or 1 would not expect to gain utility from a diagnosis. This is because their behavior y_0 is already very close to y_N or y_A, respectively, and therefore the benefits of preparation or freedom from fear are very low. If emotional (or pecuniary) costs are high, very few individuals would find it worthwhile to have information; only those with values of p_0 close to 0.5 would seek a diagnosis.

If we interpret p as the probability of developing Alzheimer's within a specific time horizon, say five years, the model also generates predictions of how the value of information depends on the timing in which it is revealed. Consider, for example, beliefs p that represent the probability of developing Alzheimer's within five years. A person at age 20 has a close to zero probability of developing Alzheimer's in such a short time frame; furthermore, the potential benefits of changing behavior, such as turning over finances to a loved one, will not be reaped until old age. Therefore, such information holds little value for such a young person who is far, in terms of age and cognition, from developing Alzheimer's.

As a person progresses into old age, the risk of Alzheimer's increases dramatically. Researchers have found that starting at age 65, the probability of developing Alzheimer's doubles every five years (Khachaturian, 2000), and almost 50 percent of those 85 and older have Alzheimer's. One's p increases accordingly as one ages, and as can be seen in Figure 3.1, the value of information also increases to a point. When one is very old and Alzheimer's is very likely, information no longer carries much value because the posterior p generally will not be much different than the prior belief at such an advanced age or low cognition. Consequently, information like a diagnosis generates few changes in behavior if it is revealed when a person is very young and has a very low p, or when a person is very old and has suffered much cognitive decline already, and has a very high p.

We have implicitly assumed so far that the subjective prior is formed rationally and is at least partially based on current medical knowledge. In reality, one may have a poor understanding of the risk factors of Alzheimer's and may have irrationally low or high prior beliefs, when the objective probability of developing Alzheimer's may be very different. Medical professionals therefore are in a position to update the

beliefs of patients, perhaps by through an educational role that increases a patient's awareness of actual risk factors. These patients with unrealistically high or low priors would gain greatly from such information, even if the information is not in the form of an accurate test.

Re-optimizing and choosing a new y bundle after a positive diagnosis of Alzheimer's yields *benefits from preparation*, formalized in the first term of Equation (3.3). Given a person is the type who will eventually develop Alzheimer's, this term describes the utility that would be gained if a person changed his behavior from y_0, based on his prior subjective belief, to y_A, the optimal bundle chosen under the new information from a diagnosis. The greater the differences between y_A and y_0, and therefore the utility derived from each bundle, the greater the value of information.

One key dimension of re-optimization and changing y is through financial preparation. Individuals can become especially financially vulnerable in old age, and the potential losses of wealth are even more severe if one is trying to make financial decisions under cognitive impairment. Therefore, those who would retain control of their finances under y_0 would be subject to a substantial reduction in their budget when they suffer cognitive decline. These individuals will necessarily see a reduction in their subsequent consumption and lower levels of utility $U^A(y_0)$. If such a person were to instead learn that he would eventually develop Alzheimer's, his behavior would change—for him, y_A chosen after a diagnosis is very different than y_0 chosen optimally in the absence of a diagnosis. The more his behavior changes, the greater the benefits from preparation.

Behavior may be more information elastic if a person's finances are particularly vulnerable to losses due to poor decision-making. This theoretical framework therefore predicts that households with more to lose—for example, those with investments

that must be individually managed—will respond more actively to signs of cognitive decline and memory disease diagnoses than those with less to lose under cognitively impaired decision-making. These individuals would choose y_A that is very different than their default y_0, particularly if their prior belief on p_0 was very low.

Conceptually U^A and U^N are the same with respect to consumption and other behaviors engaged during periods of normal cognition. However, the utility gained from behavior changes after the onset of Alzheimer's, perhaps by the separation of the "doer" from the "planner." While preferences under normal cognition are assumed to be well-behaved, a person with such severe Alzheimer's that he has no awareness of his surroundings may have little to no marginal utility of consumption. A forward-looking person may therefore re-allocate his consumption earlier to periods of low cognition and place less emphasis on high-quality nursing care.

Even if a person's own marginal utility of consumption is low under Alzheimer's, though, a spouse or loved one may derive great disutility from seeing him experience poor nursing care. If a person cares about the spouse's utility, he may want to reduce current consumption and increase precautionary saving in order to afford more expensive nursing home care. In this case, his forward-looking altruistic marginal utility of consumption would drive re-allocating consumption later in the life-cycle. We can think of the utility function here as representative of however couples make decisions and abstract away from any cooperative or non-cooperative decision-making processes. Consequently, individuals with and without spouses may have different preferences before and after the onset of Alzheimer's, with differing optimal paths of consumption.

Re-optimizing with a new behavior path after a test reveals a person to be of normal type yields *benefits of freedom from fear*, the second term of Equation (3.3).

Certainty that a person will not develop Alzheimer's may enable a person to reduce precautionary savings intended to pay for long term nursing care, and he would no longer need contingency plans based on cognitive decline. He might re-allocate consumption with the knowledge he will retain his ability to think and reason.

The right hand side of Equation (3.3) represents the utility cost of paying for the test, and the expected emotional impact of the diagnosis. This emotional impact may be the emotional relief associated with a normal diagnosis, or the trauma from a diagnosis of dementia. In sum, individual variation in the value of an Alzheimer's diagnosis can be traced to the degree to which behavior is information elastic, differences in prior beliefs, and the expected emotional cost of the test.

3.4 Empirical approach and data

In this chapter, we focus on the decision to change the household's financial decision-maker within the household and therefore restrict our analysis to couples. As discussed in Section 3.3, the value of information and its associated changes in behavior depends in part on its timing. Behavior changed too early—when a person is young, has normal cognition, and has low subjective and objective prior probabilities of developing Alzheimer's—is of little value. Likewise, attempts to change behavior at a very advanced age or when cognition is already impaired may be too late to result in any increases in utility relative to the counterfactual. We analyze the impact of new information—a diagnosis of a memory-related disease—on the timing of this change. Because our empirical analysis focuses on older Americans, the possibility of learning or changing behavior too early has probably passed, but we can observe how behavior changes at various points of aging or cognitive decline.

We begin with descriptive analysis of two-way relationships between the choice

of financial decision-maker, cognition, functional capacity, and memory disease diagnoses. We then proceed with regression models—probit and survival models—to analyze how the choice of financial respondent relates to cognitive decline over time, the emergence of problems handling money, and most importantly the diagnosis of a memory-related disease. Because these are analyses of couples, we consider characteristics of both members of each couple. The theoretical model predicts that the financial respondent switch should occur more quickly for households whose wealth is individually managed. Because the speed of cognitive decline varies across individuals, we also use cognition as analysis time in survival analysis to examine how low cognition falls before a failure occurrence.

The empirical analysis uses several waves of the Health and Retirement Study (HRS),[9] a nationally representative longitudinal survey of Americans over the age of 50 and their spouses. Since its first wave in 1992, follow-up surveys have been conducted approximately every two years. New cohorts are added every six years to maintain the steady state design. The survey content includes individual- and household-level information about family demographics, health status, cognition, functional limitations, assets, debts, and others. In the 2008 wave, the HRS interviewed over 18,000 individuals.

The HRS is supplemented by the Aging, Demographics, and Memory Study (ADAMS), a national population-based study of dementia (Langa et al., 2005). A sample of 856 HRS respondents over the age of 70 participated in an extensive in-home cognitive assessment and received a diagnosis of normal, 'cognitive impairment, not demented' (CIND), or dementia. Follow-up assessments were conducted for those diagnosed with CIND, or whose diagnoses were unclear at baseline. Each ADAMS

[9]The HRS (Health and Retirement Study) is sponsored by the National Institute of Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan. Some variables were provided by the RAND HRS Data file (RAND HRS Data, 2010). See http://hrsonline.isr.umich.edu for more information.

respondent also participated in the HRS, so the diagnoses can be linked to HRS cognition data to verify the validity of HRS measures.

3.4.1 Measures used in the empirical analysis

Cognitive decline A 27-point cognitive scale is administered to self-respondents who are 51 and older. The scale includes a ten-word immediate and delayed recall test (0-20 points) that measures episodic memory, a serial 7s test that measures working memory (0-5 points), and a backwards counting test that measures mental processing speed (0-2 points). These tasks were derived from the Mini-Mental State Examination commonly used by physicians and other well-validated scales, and they display "satisfactory psychometric properties" (Herzog and Wallace, 1997; Herzog and Rodgers, 1999).

Scores from waves from 2006 and earlier include imputations for missing data (Fisher et al., 2009), while those from 2008 are raw scores and do not include imputations. Crimmins et al. (2011) determined cut points of the 27-point cognitive scale that would generate the same population prevalence of dementia and 'cognitive impairment, not demented' (CIND) among the HRS sample as that found in the Aging, Demographics, and Memory Study (ADAMS). Scores between 12 and 27 points are considered normal, 7-11 points CIND, and 0-6 points correspond to dementia. Those who have proxy respondents are coded with scores of zero,in the dementia range. Proxy interviews are generally triggered by low scores on a more basic cognition test.

Information: memory disease diagnoses Beginning in 1998, the HRS has asked each respondent, "Has a doctor ever told you that you have a memory-related disease?" This question is re-asked at each interview and is our primary variable of information

about cognitive decline.

Awareness of financial capacity: Money IADL The HRS asks respondents about their ability to perform both ADLs and Instrumental Activities of Daily Living (IADLs). One such IADL question asks the respondent, "Because of a health or memory problem, do you have any difficulty with managing your money—such as paying your bills and keeping track of expenses?" If a respondent answers "yes," "don't do," or "can't do," he is coded as having difficulties handling money. This money IADL variable can thus be used as an indicator for having problems handling money. This variable can be used both as an intermediate outcome—financial capacity—as well as an indicator of self-awareness, or a source of information.

Financial respondents A measure of financial responsibility in the household in the HRS is the "financial respondent," who answers all survey questions related to household finances and wealth. This person is selected when the couple enters the study, in accordance with the question about the person most knowledgeable about household finances. The wording of the question varies slightly across waves:

- Which of you is most knowledgeable about your family's assets, debts and retirement planning? (husband, wife, or partner) (1992)
- I will be asking some questions about your financial situation and health care costs. Which of you would know more about this, you or your (husband/wife/partner)? (1993)
- I would like to interview both you and your [husband/wife/partner]. I will be asking some questions about family assets, debts and retirement planning. Which of you is the most knowledgeable about this, you or your [husband/wife/partner]?

(1998)

During the introductory section of each wave's interview, the interviewer determines whether or not the financial respondent assignment needs to be changed. A new financial respondent can be seen as a strong signal that the previous financial respondent is no longer the most knowledgeable about household finances. While this measure was designed for survey management purposes, rather than as a direct measure of financial decision-making, the financial respondent measure is the best measure available in the data. As seen in Chapter II, the financial respondent in a couple tends to have higher financial literacy than the spouse, and in most cases is the husband. The financial respondent also tends to either singly or jointly make the major financial decisions for the household.

The choice of financial respondent is our measure of behavior y; in our empirical analysis, we look for changes in the financial respondent within couples in response to cognitive decline.

Household wealth We use two variables related to household wealth. First, we use the natural log of total wealth (net value of total wealth, not including secondary home), with households with negative wealth coded as zero. Second, we use the tercile of share of wealth held in stock; those who do not own any stocks are coded as zero. Both of these variables are based on wealth calculations drawn from RAND HRS Data (2010). We also construct an indicator for owning retirement accounts with investments that are personally managed.

Variation in the benefits of preparation: individually managed wealth Impaired financial decision-making exposes households to more severe consequences if they hold wealth that requires personal management. The HRS asks of those who report

participating in defined contribution pension or retirement plans: "Are you able to choose how the money in your account is invested?" We create an indicator that takes the value of one for the first wave at which the couple reports holding at least one account that allows the holder to choose how the money is invested, and each wave thereafter. In doing so, our measure is not contaminated by moving assets out of individually controlled accounts as a form of preparation.

3.4.2 Descriptive statistics

All analysis in this chapter is conducted at the household level from the perspective of the member who was the financial respondent when the couple entered the HRS. The analysis sample is restricted to waves in which the cognition score was collected, waves 1998 through 2008. Table 3.1 reports summary statistics from the first year a couple appears in the analysis sample. Most financial respondents at baseline are male. Likewise, they are older than their spouses and are more educated than their spouses. Approximately 1/3 of couples have retirement accounts for which they can choose their investments. About 63 percent of households do not hold any wealth in stock.

The bottom of Table 3.1 summarizes the cognition of baseline financial respondents and their spouses, measured during the first year the couple appears in the analysis sample. Most respondents have cognition scores in the normal range. About 11 percent of initial financial respondents and 13 percent of spouses have scores in the CIND range, and 4 percent and 8 percent in the dementia range, respectively. In about 90 percent of couples, the baseline financial respondent has a cognition score in the same or better range than his spouse (see Table 3.2). Few respondents (less than 2 percent) report having been diagnosed with a memory disease. About 5 percent of initial financial respondents and 10 percent of spouses report having

problems handling money.

It should be noted that our sample is subject to left censoring. Due to the design of the HRS, members of different cohorts entered the study at different ages. Therefore, some couples are young during the first wave of analysis, while others are older. If some couples switched financial decision-makers prior to the onset of the survey, or if they passed on responsibility to an adult child, our analysis will not capture these events.

3.5 Descriptive analysis

3.5.1 Validation of cognition measures

27-point cognition scores and actual diagnoses of dementia or CIND

The use of the 27-point cognition scores and the cutoffs for CIND and dementia can be validated using the ADAMS. ADAMS respondents were administered the same cognitive tests as all other HRS respondents in addition to additional assessments, resulting in a determination of whether the respondent is normal, CIND, or demented. Figure 3.2 displays a box plot of cognition scores for ADAMS respondents who were found to be normal, CIND, or demented as of the most recent wave available of the ADAMS. The scores reported were the most recent scores from the core HRS interview available at the time of the ADAMS diagnosis. Therefore, the scores may be slightly higher than what the respondents would have achieved if measurement of the 27-point tests occurred at the same time as the ADAMS assessment, given that cognition tends to decline with age. As seen in Figure 3.2, over 80 percent of ADAMS respondents with a normal outcome have cognition scores in the normal range (greater than 12, or above the topmost red horizontal line). The interquartile range of CIND respondents is mostly in the CIND cognition score range, though the median is at 11 points, the upper cutoff of the range. Those with a dementia

diagnosis have scores that span both the CIND and the dementia score ranges, and again the median at the dementia/CIND threshold. The cognition scores and the cutoffs proposed by Crimmins et al. (2011) are largely consistent with the diagnostic conclusions from ADAMS, which validates the use of these 27-point scores alone for all respondents.

Comparison of objective and subjective (self-reported) measures

During each interview, All respondents underwent a cognitive assessment using the objective 27-point scale, and were also asked whether they have received a memory disease diagnosis. In Figure 3.3, we pool all respondents (regardless of coupleness status) and all waves to compare the objective cognition measure and the self-reported memory disease diagnosis. The incidence of self-reported memory disease diagnoses increases as the cognition score declines. However, only 15 percent of respondents with dementia-range cognition scores report a memory disease diagnosis (see Table 3.3). One possible explanation is that some of the remaining 85 percent do indeed have such a disease, but never received a diagnosis from a doctor. Alternatively, these may be false negatives in the sense that the respondents were once diagnosed but either are unaware of the diagnosis or have forgotten. To our knowledge, no studies have examined the reasons for the low rates of self-reported memory disease diagnoses, but studies about rates of undiagnosed dementia find results ranging between 35 percent and more than 90 percent (Olafsdottir et al., 2000).

3.5.2 Cognition and financial skills / responsibility

Cognition and financial capacity: problems handling money

Financial capacity can be ascertained from an IADL question asked by the HRS: “Because of a health or memory problem, do you have any difficulty with managing

your money—such as paying your bills and keeping track of expenses?" Figure 3.4 graphs the proportions of all respondents that answer yes, don't do, can't do, and no, split by the cognition score. As the cognition score declines, the proportion reporting "no difficulty" declines as well. While very few of those with cognition scores in the normal range report having difficulties handling money, more than one third of those in the dementia range report difficulties (see Figure 3.5).

Cognition and financial responsibility: the financial respondent

Figure 3.6 displays a bar graph of the proportion of respondents who are the financial respondent in their households, by their cognition score. Because all uncoupled individuals are necessarily financial respondents, the analysis only includes those in couples. All waves are included. The lower the cognition score, the less likely an individual is to be a financial respondent, but 37 percent of coupled respondents serve as financial respondents. Figure 3.7 groups the cognition scores into the normal, CIND, and dementia ranges; the pairwise differences in proportions of respondents who are financial respondents are statistically significant across the three groups.

Changes in wealth and changes in cognition

Do declines in cognition generate reductions in wealth? In Figure 3.8, we present a lowess curve of wave to wave changes in total wealth (in thousands of dollars) plotted against changes in cognition on the 27-point scale. Large declines in cognition are associated with large declines wealth, which is consistent with anecdotal evidence presented above. This graph should only be taken as suggestive evidence, however, for a number of reasons. First, declines in wealth may reflect transfers to children in order to qualify for Medicaid and avoid private financing of nursing home care. Secondly, large swings in cognition can only occur for those who started with

relatively high cognition. For example, a person who is borderline CIND-normal can decline by a maximum of 11 points on the scale, which according to this graph is associated with zero change in wealth. Lastly, if wealth is calculated using responses from a cognitively impaired financial respondent, those values may not reliably reflect wave-to-wave changes. Indeed, Venti (2010) finds that longitudinal estimates of IRA values in the HRS are made difficult by inaccuracies in respondent reports.

3.5.3 Lowess estimates over the 27-point cognition score

Financial capacity and financial responsibility

Do baseline financial respondents turn over responsibility for finances at the same level of cognition that they report having difficulties managing money? Figure 3.9 displays two graphs; both include a lowess curve of being the financial respondent as well as a lowess of the absence of money difficulties plotted on the 27-point cognition scale. Both of these graphs only include individuals in couples who were the financial respondent at the baseline. The first graph includes those who do not have retirement investments that are individually chosen, while the second graph includes respondents who do. In both cases, although the proportion of respondents without money problems begins to decline at the lower end of the normal cognition range and drops sharply in the CIND and dementia ranges, the proportion of individuals who are financial respondents remains quite stable until the CIND-dementia threshold. For those in the dementia range a larger proportion of individuals are financial respondents than report no difficulties handling money. This suggests that some of these financial respondents may make financial decisions in spite of reporting difficulties handling money. However, the gap between the two lines is much narrower for those who can choose how their retirement wealth is invested, so fewer households are exposed to the risk of bad financial decisions. This also provides some suggestive

evidence that the decision to switch the financial respondent is different for the two groups.

These graphs imply that for many individuals, reporting difficulties managing money precedes switching the financial respondent. Table 3.4 cross-tabulates couple-wave observations and shows that for 87 percent of observations in which initial financial respondents report having trouble handling money, they are still the financial respondent. Table 3.5 tabulates the order of the two events: reporting problems handling money on the part of the initial financial respondent, and switching the financial respondent. Note that one or more of these events occur for 1575 couples; neither event occurs for the remaining couples. Among the couples that have experienced at least one event, nearly three quarters of them reported difficulties handling money first. For most of these, the financial respondent switch has not yet occurred. An additional 5 percent had both events occurring in the same wave. About 20 percent switched the financial respondent before the baseline financial respondent reported difficulties managing money.

A possible reason for this discrepancy—that a person remains the financial respondent in spite of having problems handling money—is that the spouse may be even worse off. In this case, the baseline financial respondent may retain his comparative advantage even in light of his difficulties handling money. The regression analysis will address this issue.

Memory disease diagnoses and financial responsibility

Receiving a diagnosis of a memory-related disease is a strong indication from a medical professional that one's cognition is declining. Being able to recall and report this diagnosis to an interviewer demonstrates self-awareness of cognitive decline. How do rates of being financial respondents and of memory disease diagnoses change

as cognition declines? We know that memory disease diagnoses rise and financial respondents fall in the dementia range of cognition scores, but do these changes track each other?

Figure 3.10 displays lowess estimates of being the financial respondent and not having a memory disease diagnosis, plotted against the cognition score. The upper graph includes respondents who have retirement accounts that are individually managed, and the lower graph includes those who do not have such accounts. In both cases, when respondents are in the normal cognition range, the two lines are parallel. Regardless of the nature of retirement accounts, some individuals with a memory disease diagnosis serve as financial respondents, and this proportion is fairly constant throughout the range.

The pictures diverge for those in the dementia range. Among those without individually managed retirement accounts, the proportion of individuals who are financial respondents is much higher than the proportion of respondents without a memory disease diagnosis, and the gap increases the lower the cognition score. However, the opposite is the case for respondents with retirement investments that are individually chosen. Among those in the dementia range, a much smaller proportion of individuals are financial respondents than have not had memory disease diagnoses. This provides suggestive evidence that how the financial respondent decision relates to a memory disease diagnosis depends on the nature of financial decisions being made—namely, whether or not retirement wealth needs to be individually managed.

Kaplan-Meier estimation Kaplan-Meier survival estimates (Figure 3.11) show that those with accounts that are individually managed have a greater hazard of switching the financial respondent than those who do not; a log-rank test rejects the null that

these hazard functions are equal (log rank test: $\chi^2(1) = 26.83$; $Pr > \chi^2 = 0.0000$). However, having individually managed retirement accounts does not increase the hazard of reporting problems handling money (log rank test: $\chi^2(1) = 1.57$; $Pr > \chi^2 = 0.2109$). Individuals tend to report difficulties with money at the same levels of cognition, regardless of the nature of their retirement wealth.

In summary, cognition scores negatively correlate with having a memory-related disease diagnosis and having problems handling money in the expected manner. In particular, the lower the cognition score, the higher the likelihood of reporting a diagnosis and problems handling money. The emergence of financial incapacity with low cognition is consistent with medical research on Alzheimer's. Couples do switch financial respondents when the original respondent's cognition declines, but many log-cognition respondents remain the financial respondent for their households. In general, among those with cognition in the CIND or dementia range, the proportion who are financial respondents exceeds the proportion who retain their financial capacity. Therefore, some low-cognition individuals are financial respondents even while they report having problems handling money. However, the gap between rates of problems handling money and being the financial respondent is much smaller for those who have individually controlled retirement accounts. At dementia ranges of cognition, rates of being the financial respondent exceed of having no memory disease diagnosis if retirement wealth is *not* individually controlled. This implies that some demented individuals are serving as the financial respondent in spite of suffering from a memory-related disease. The reverse is true for couples who do have individually controlled investments. The next section uses regression techniques to further understand these patterns.

3.6 Regression analysis

Here, we analyze how the financial outcomes, financial capacity (measured by respondent self-reports of difficulties handling money) and financial responsibility (measured by identifying the financial respondent in the couple) are affected by cognition and memory disease diagnosis. As before, the unit of analysis is a couple, and each observation will contain attributes of both the first financial respondent and his or her spouse. The reference point of the observation is the person who was designated the most financially knowledgeable when the couple first entered the survey. Where we refer to "own education" or "own cognition," we mean the characteristics of the financial respondent at baseline; we refer to the other member of the couple as "the spouse." Because there can only be one financial respondent in the couple, each couple only has one observation per wave.

Couples exit the sample when one spouse dies, or the couple otherwise dissolves—this is a source of censoring, which can be addressed using survival analysis. Another source of right-censoring comes from couples who are still intact, with no reports of money difficulties or switching of the financial respondent, during the most recent 2008 wave of the HRS.

The regression analysis employs the following variables (see Section 3.4.1 for more details):

- Individual-level demographic characteristics of both members of the couple: gender, age, and education,
- Individual-level cognition: indicators for having a cognition score in the CIND or dementia range, self-reported diagnoses of memory-related diseases, and self-reported difficulties handling money of both members of the couple, and

- Household financial characteristics: tercile of household assets held in stock (zero if the household owns no stock), natural log of total wealth.

3.6.1 Bivariate probit regression

The fact that the two financial responsibility outcomes—difficulties handling money, and no longer being the financial respondent—should be correlated suggests the use of bivariate probit analysis. The descriptive analysis above shows that people develop difficulties handling money before they turn over being the financial respondent to the spouse. If the financial respondent switch occurs at the same time as the original respondent reports difficulty handling money, then the coefficients should be the same for both equations. If a particular coefficient is larger in the equation estimating difficulties handling money, then the decision to switch financial respondents is less responsive.

Table 3.6 presents results of a bivariate probit regression of two financial outcomes: difficulties handling money for the initial financial respondent in column (1), and switching the financial respondent in column (2). The reference point is the member of the couple who was the financial respondent at baseline. Having a memory disease diagnosis is strongly associated with difficulties with money, but the effect of a diagnosis on switching the financial respondent much smaller in magnitude and not statistically distinguishable from zero. However, the interaction effect of the memory disease diagnosis and an indicator of retirement wealth that can be individually managed is positive and statistically significant for the financial respondent switch. This interaction effect has a negative, statistically insignificant effect on the probability of having problems managing money.

This means that while a memory disease diagnosis is associated with switching the financial respondent (though the coefficient is indistinguishable from zero), the

effect is even larger for households in which investments in retirement wealth can be individually controlled. It is precisely those couples that are more potentially more exposed to poor financial decisions that are more responsive to memory disease diagnoses in terms of switching the financial respondent.

The probability of switching the financial respondent is less responsive to the respondent being CIND than is the probability of reporting having problems handling money. Column (3) reports χ^2 tests for the difference in each coefficient across the two equations. For both the CIND and dementia indicators, the coefficients for the money problem outcome are larger in magnitude than those of the switching financial respondent outcome, and for CIND the difference is statistically significant. This provides additional evidence that some individuals who have difficulties handling money have not yet been replaced as the financial decision-maker.

3.6.2 Survival analysis

Survival analysis using age as analysis time

While a bivariate probit model explicitly assumes the two financial outcomes are correlated, the model does not address right censoring caused by the dissolution of couples due to divorce or widowhood. Furthermore, couples who have not switched their financial respondents may still do so in the future, creating another source of right censoring. Survival models treating the two outcomes as "failures" account for such censoring and explicitly model durations so we can compare how time to reporting problems handling money relates to the time to changing financial respondents. Although the bivariate probit model shows that the two equations are correlated, standard survival models assume the two are independent. Here, durations are measured in calendar time, using the baseline financial respondent's age at each wave of observation.

Table 3.7 reports results from Cox proportional hazards models; column (1) treats reporting difficulties handling money as the failure, and column (2) treats switching the financial respondent as the failure. The main effect of a memory disease diagnosis is much larger for reporting difficulties managing money than for the financial respondent switch, increasing the hazard by a factor of 3.3 and 1.5, respectively. However, the interaction of a memory disease diagnosis with choosing one's own retirement investments has a large, statistically significant positive impact on switching, doubling the hazard, and virtually no impact on having problems managing money. This is consistent with the idea that those with more to lose—those with individually managed retirement accounts—do indeed respond to a memory disease diagnosis above and beyond those who do not choose their own investments.

Having a cognition score in the CIND range more than doubles the hazard of problems handling money relative to being in the normal cognition range. However, a CIND score only increases the hazard of switching the financial respondent by less than a factor of 1.5. This suggests that the hazard of switching of the financial respondent is less responsive to declines in cognition to CIND than the hazard of difficulties handling money, as shown in the descriptive analysis. Given that the evidence in medical research shows that financial capabilities suffer when cognitive declines are still mild, the lack of responsiveness to being in the CIND range can pose problems to the household. That said, dementia increases the hazard of difficulties handling money to 435 percent, and the hazard of switching the financial respondent responds similarly (483 percent), so when declines are severe, families do adjust accordingly.

Having a spouse in the CIND or dementia range reduces the hazard function of money difficulties, to 72 percent and 77 percent of the hazard associated with having

normal cognition spouse. Again, the switching of financial respondents is much more responsive to being in the spouse being in the dementia range than in CIND. If the baseline financial respondent is female, the hazard of having problems handling money only increases by a factor of 1.2, while the hazard of switching the financial respondent to the spouse triples. Therefore, the characteristics of both members of the couple are important.

Unlike the bivariate probit regression, this analysis assumes the two "failures"—money difficulties and the financial respondent switch—are independent. Column (3) of Table 3.7 reports the results of a Cox proportional hazards model that restricts the analysis to those who have reported difficulties handling money, and treats the financial respondent switch as the failure. Note that this sample size is quite small (1739 couple-wave observations) so estimates are not precise, but qualitatively the results are the same: the interaction of choosing investments and memory disease diagnosis has a large positive effect on the hazard of switching the financial respondent.

Survival analysis using cognition scores as analysis time

While the previous analysis measures durations in terms of calendar time, we can also treat the 27-point cognition score itself as the "time scale." This would allow us to how much cognition deteriorates before the occurrence of the two failures-developing problems handling money, and switching the financial respondent. Using cognition scores as analysis time in a survival framework is a transformation similar to operational time (Lee and Whitmore, 2006).

To use these scores as analysis "time," cognition scores should decline monotonically with age. Table 3.8 tabulates the wave-to-wave changes in cognitive status among HRS respondents. About 83 percent of wave-to-wave changes in cognition remain within the same cognitive status: for example back-to-back scores in the

normal range. Most of these within-status changes are small, and on average they are declines in scores. Approximately 10 percent are transitions into worse cognitive states, from normal to CIND or dementia, and CIND to dementia. These changes have an average of a 6.5 point decline the cognition scores. Only 6 percent of wave-to-wave changes are improvements from one cognition category to another. Of these, the vast majority are CIND to normal transitions.

Cognition scores are negatively monotonic for the most part (particularly after a respondent has moved out of the normal range), so they can be treated as analysis time. Some individuals receive the same cognition score in multiple waves; we can either drop the duplicate waves or perturb scores in order to deal with the fact that survival analysis cannot deal with multiple observations at the same point in "time." If an individual receives the same cognition score in two waves, we subtract 0.01 from the more recent score. If an individual receives the same cognition score in three waves, we add 0.01 to the first measurement and subtract 0.01 from the most recent measurement. The two methods have similar results, so we report the analysis using the full sample with perturbed scores.

Table 3.9 reports the results of the estimation of Cox proportional hazards models, one for each failure—problems managing money, and the financial respondent switch. While the main effect of a memory disease diagnosis increases the hazard of having problems managing money by a precisely-measured factor of 1.87, it does not increase the hazard of switching the financial respondent. However, the interaction of a diagnosis and controlling investments has no effect on the hazard of difficulties handling money but increases the hazard of switching the financial respondent to 157 percent of the baseline hazard, with a p-value of 0.09.

Competing risks and Cox proportional hazards models In using cognition scores as analysis time, there is another source of censoring (in addition to the lack of failure during the most recent measurement): reaching the lowest cognition score. Cognition scores are on a 27-point scale and cannot take values outside this range, so in this framework when a person has reached a score of zero, or has been replaced with a proxy respondent in the survey, cognition scores are then censored. Therefore a more appropriate model would be a competing risks survival model. Here, we report the results of a competing risks regression where the failure object of interest is the switching of financial respondents within a couple or the emergence of problems handling money, and the competing risk is the attainment of the lowest cognition score.

While the estimates in Table 3.9 does not account for the competing risk of reaching a zero cognition score, Table 3.10 reports results from the analogous competing risks models. The results of the Cox proportional hazards model and the competing risks model are quite similar, but accounting for the competing risk strengthens the estimates of the effects of a memory disease diagnosis and its interaction with controlling investments. Surprisingly, the main effect of having a memory disease diagnosis, while doubling the hazard of difficulties handling money, decreases the hazard of switching the financial respondent, though it is not statistically significant. However, its interaction effect with controlling one's investments is large and statistically significant; if one has accounts that are individually invested, being diagnosed with a memory disease more than doubles the hazard of switching the financial respondent (hazard ratio of 2.1), even though this interaction term has no effect on problems handling money. This result is consistent with the idea that those with much to gain from preparing for cognitive decline—those with assets that are at risk of being

mismanaged by the original financial respondent—prepare by switching the financial respondent more quickly.

Given that problems handling money tend to precede the financial respondent switch, we also estimate models of this switch with problems handling money as an explanatory variable. Results from the estimation of a Cox proportional hazards model and a competing risks model are reported in Table 3.11. Even controlling for these problems managing money, the two models again confirm the large, significant effect of a memory disease diagnosis on switching the financial respondent *for those who control investments in their retirement accounts*. In fact, for the competing risks regression in column (2), the hazard ratio of the interaction effect is a statistically significant 2.2.

Reporting having trouble handling money has a strong (and statistically significant, for the Cox model) effect on the hazard. If the initial financial respondent reports no problems, the hazard is reduced; if the spouse reports no problem, the hazard is increased. In all specifications, other spousal characteristics also matter in the expected way; in some cases they matter more than the initial financial respondent's characteristics. The older, more educated, and more cognitively intact a spouse is, the greater the hazard of switching financial respondents. The effect of the spouse's age is not statistically significant in the competing risk regression, which is not surprising given that the regression already controls for spouse's cognition. Own age and education do not have a statistically significant effect on the hazard.

Holding a greater share of wealth in stock and log wealth have very little effect on the hazard of switching the financial respondent. While this is inconsistent with the intuition of the theoretical model that wealthier individuals have more to lose from poor financial decision-making, it confirms the most important factor is whether or

not assets are individually controlled. Therefore, the indicator for holding retirement wealth that is individually controlled is not merely a proxy for portfolio allocation or wealth.

3.7 Conclusion

How one prepares for cognitive decline depends on how much one has to lose by failing to prepare. For example, poor financial decisions may have a smaller impact for someone who is living on predictable streams of income than for those with retirement wealth that needs to be individually managed. Therefore, we expect variation in responses to diagnoses of memory-related diseases like Alzheimer's disease. In this chapter, we analyze how the person in the couple serving as the financial respondent changes as cognition declines to impaired and demented levels.

We find that households tend to wait until cognition has fallen quite low to make the switch. In particular, this switch often occurs well after the original financial respondent has reported having difficulties handling money.

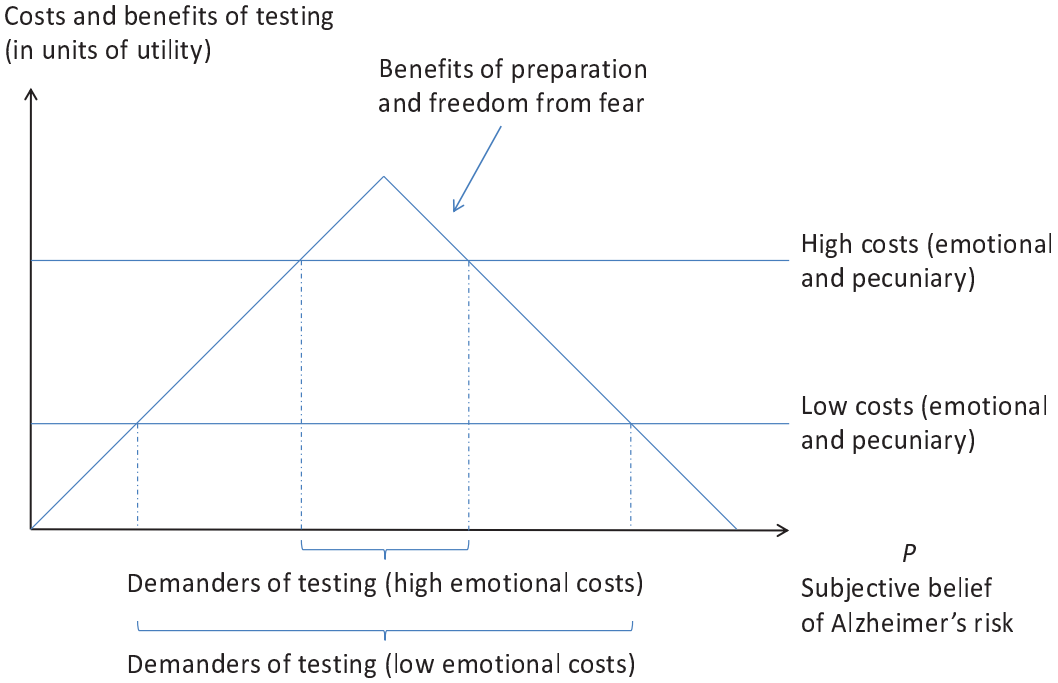
To analyze how this financial respondent switching behavior varies according to the nature of their retirement wealth, we use a number of econometric methods. The same story arises in all of the regression analyses—bivariate probit models, survival analysis using calendar age, and survival analysis using cognition as analysis time. There is variation in how quickly financial respondents switch in response to cognitive decline, memory disease diagnoses, and even the emergence of problems handling money. After controlling for wealth, those with individually managed retirement accounts switch financial respondents more responsively to memory disease diagnoses. They also switch at higher levels of cognition—in other words, before suffering too much decline—and sooner after reporting problems handling money.

This is consistent with an economic model of the value of information about future states. If information about future cognition enables re-optimization and preparation by have someone else manage retirement wealth, then the information is useful. If one does not have the ability to prepare, for instance, if one holds no individually managed retirement wealth that can be handed over to a spouse, then the information is not helpful. This is not just an effect of higher wealth, which has a small, positive but imprecisely estimated effect on the financial respondent switch in all specifications. Spousal characteristics are also important and influence the decision to switch financial respondents in the expected direction. The decision depends not only on how poor one's cognition is, but how poor is the cognition of the spouse to whom one might potentially turning over the finances. This provides evidence that the most important factor is one of comparative advantage relative to one's spouse.

Another option we cannot observe in our data is passing on responsibility of finances to an adult child. Having adult children nearby may enhance monitoring; these children may more easily notice poor decision-making. On the other hand, frequent contact with children may make it more difficult to notice changes in cognition in the parent. If children only see their parents during major holidays, the time distance between visits makes cognitive decline more noticeable. Indeed, including child proximity measures in the regressions does not influence the effect explanatory variables of interest, cognition and memory disease diagnoses; furthermore, the sign of their coefficients is extremely sensitive to the specification and is never statistically significant, and there were dropped from our analysis. Future research will enable us to examine in greater detail the nature of the division of labor within older couples as well as the role of their adult children.

3.8 Figures and Tables

Figure 3.1: Value of information as a function of subjective risk of Alzheimer's



Graph adapted from Figure 1 of Boozer and Philipson (2000).

Figure 3.2: Cognition score of ADAMS respondents, by eventual outcome

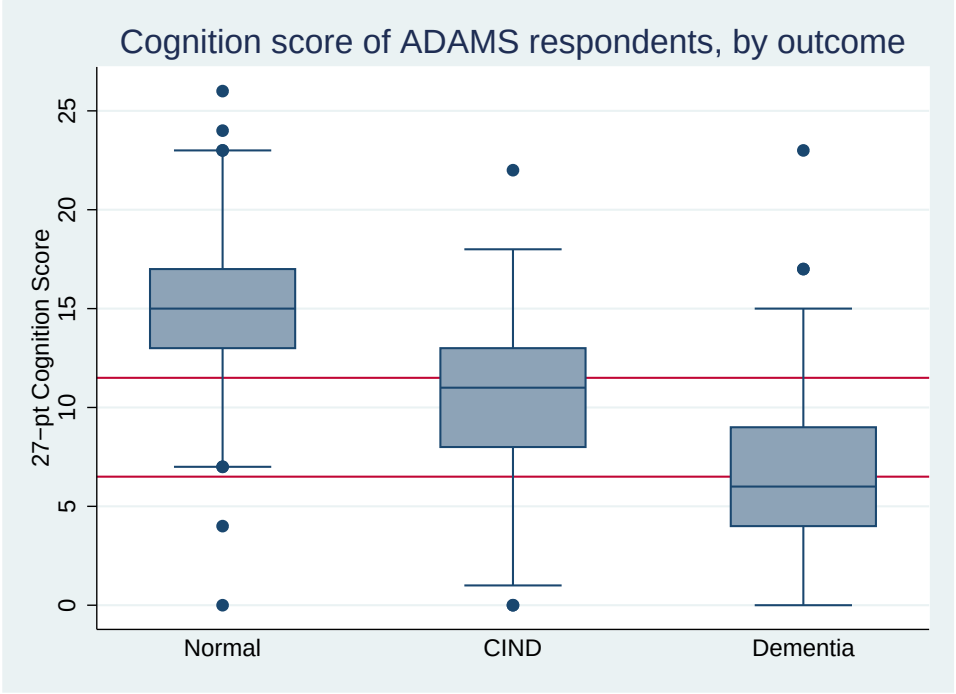


Figure 3.3: Self reported memory disease diagnoses, by cognition score

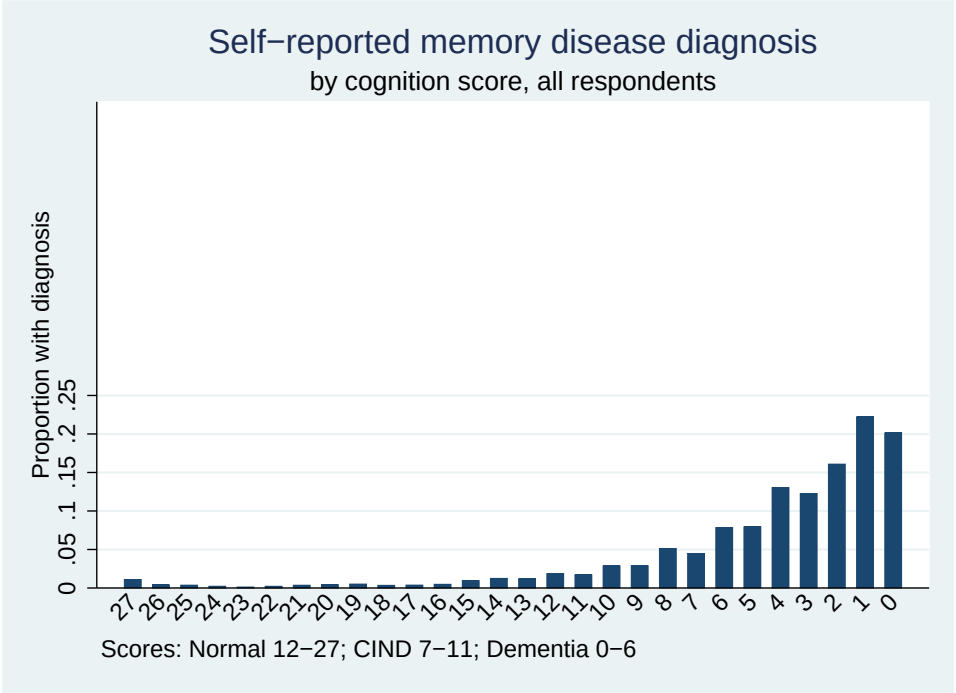


Figure includes all respondents.

Figure 3.4: Self-reported difficulties handling money, by cognition score

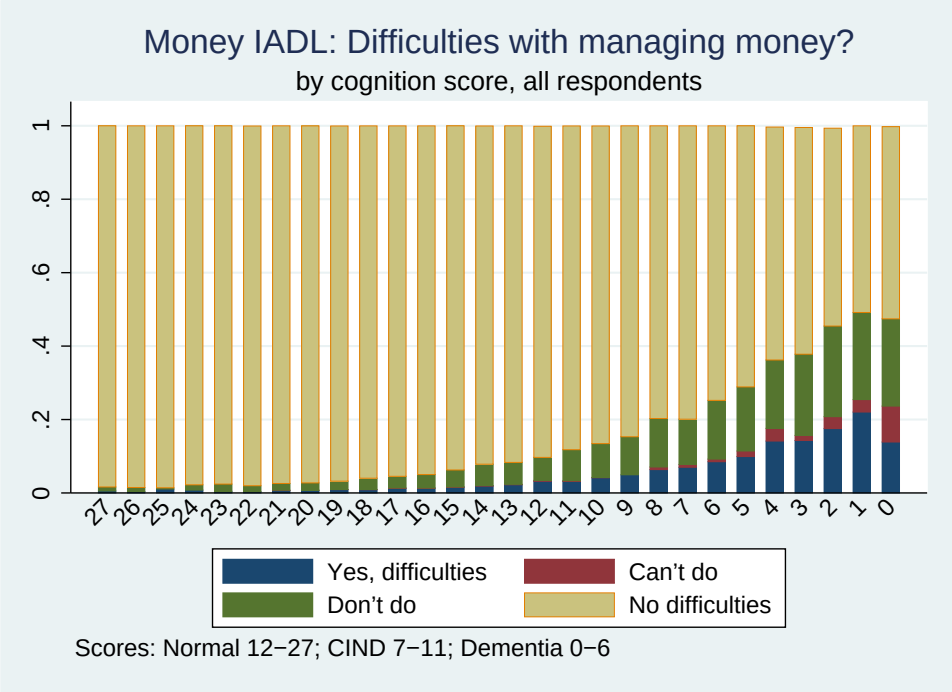


Figure includes all respondents.

Figure 3.5: Self-reported difficulties handling money, by cognition score range

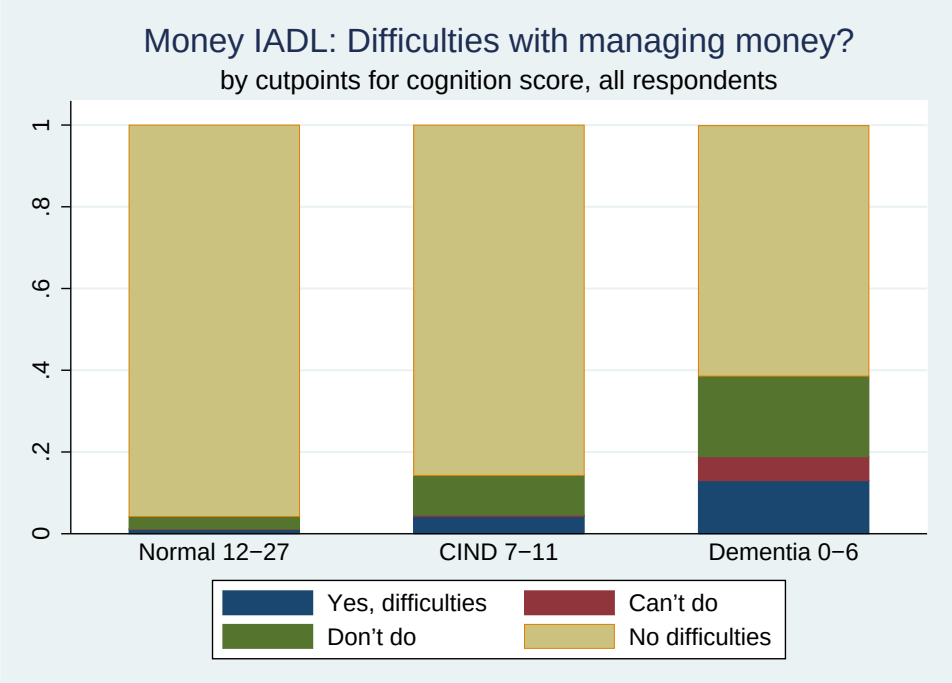


Figure includes all respondents.

Figure 3.6: Proportion of individuals who are financial respondents, by cognition score

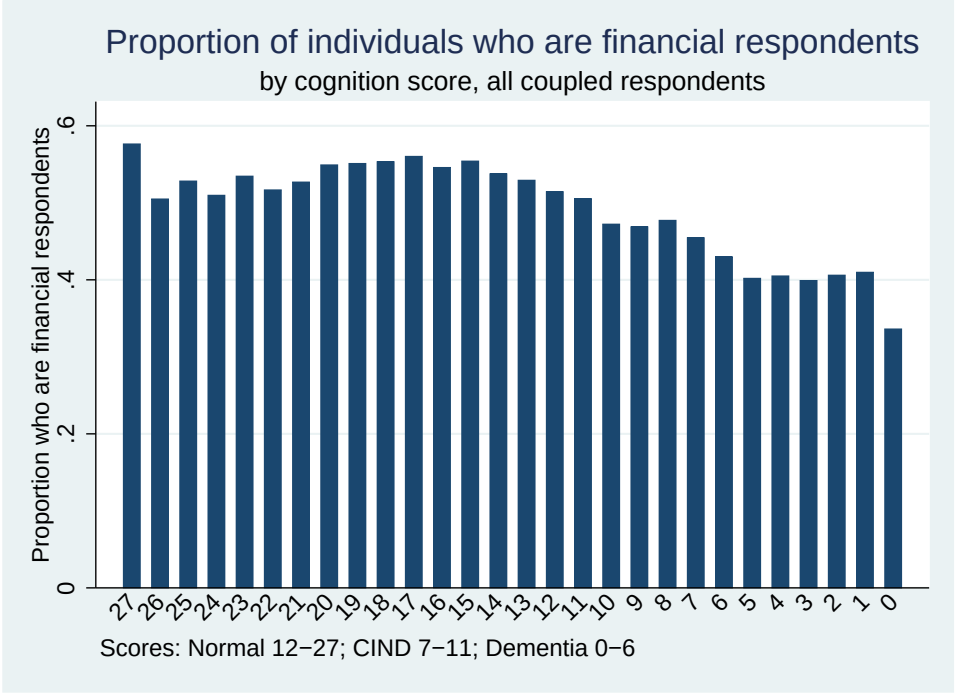


Figure includes all respondents in couples.

Figure 3.7: Proportion of individuals who are financial respondents, by cognition score range

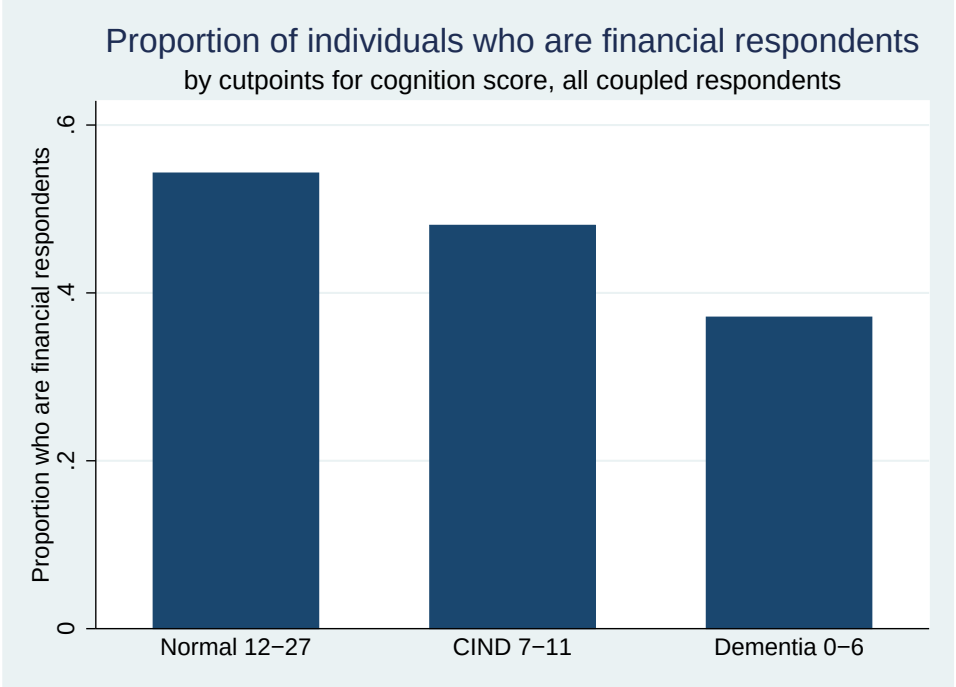


Figure includes all respondents in couples.

Figure 3.8: Lowess estimates of change in wealth (in thousands of dollars) and change in cognition

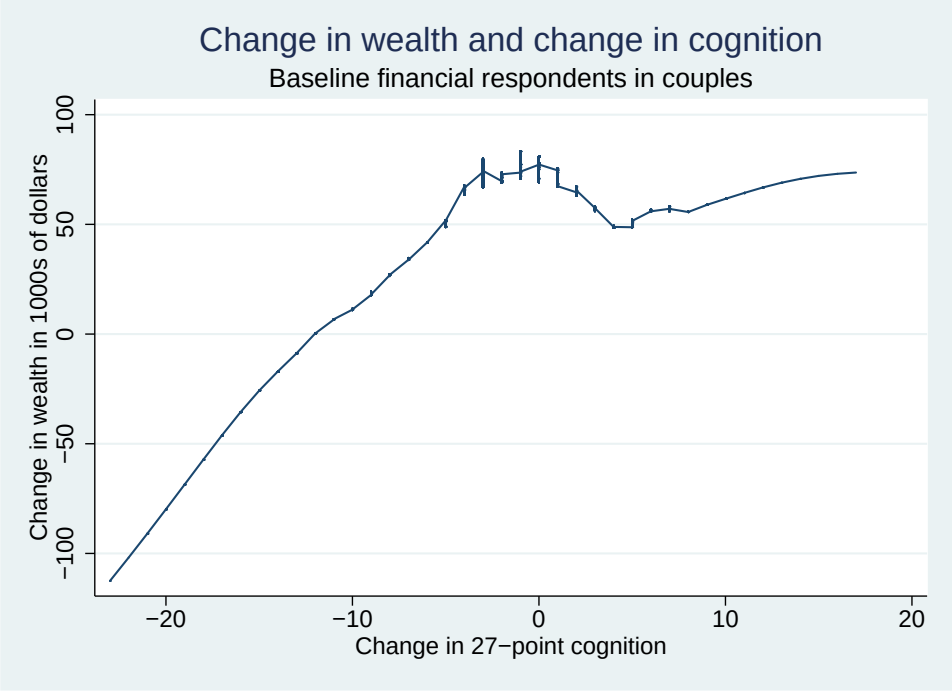


Figure 3.9: Financial respondents and the absence of difficulties handling money by cognition score, separated by nature of retirement wealth

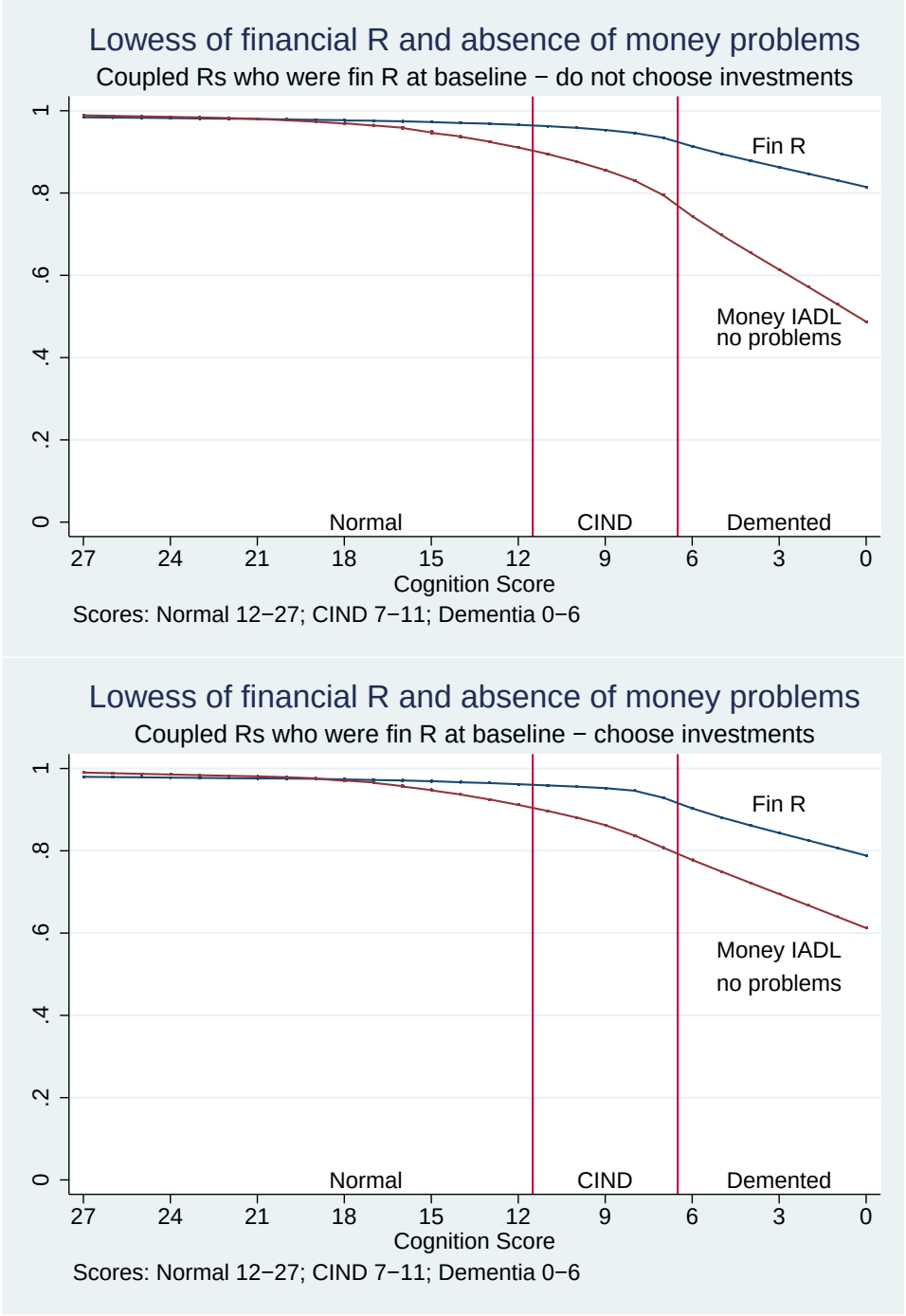


Figure includes all respondents in couples who were financial respondents during the baseline wave.

Figure 3.10: Financial respondents and memory diagnoses over cognition scores, separated by nature of retirement wealth

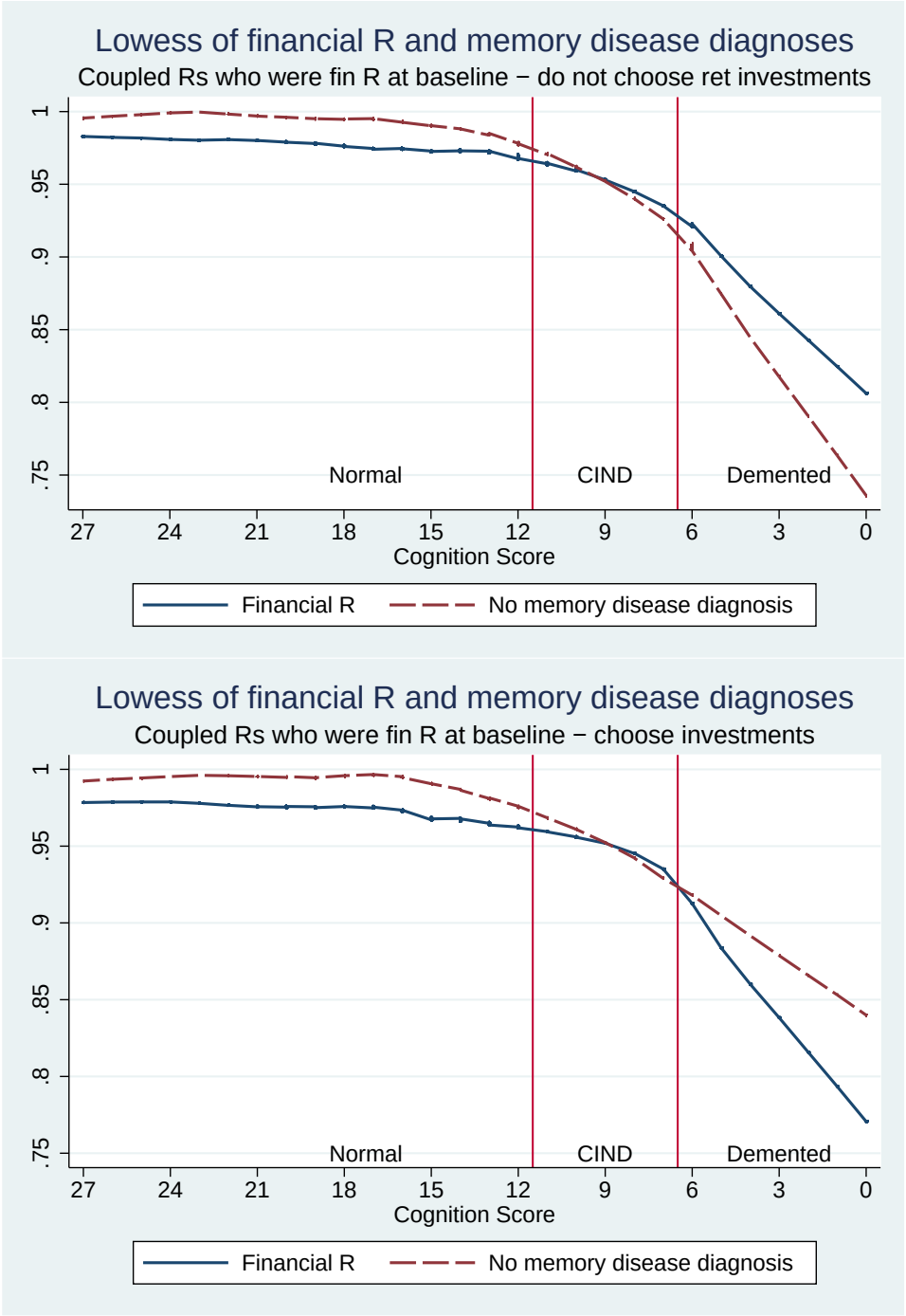


Figure includes all respondents in couples who were financial respondents during the baseline wave.

Figure 3.11: Kaplan-Meier survival estimates of problems handling money and being the financial respondent, separated by nature of retirement wealth

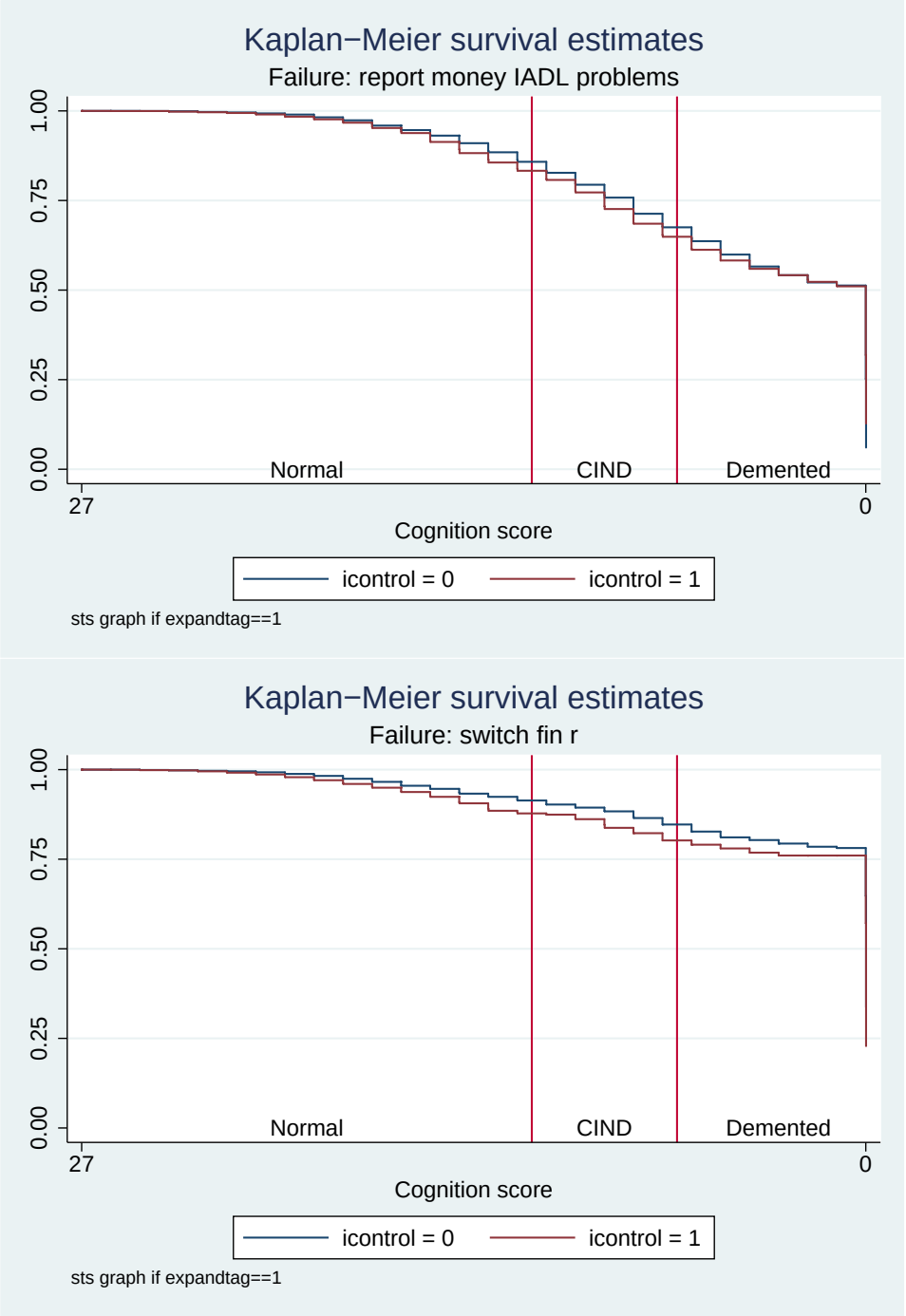


Figure includes all respondents in couples who were financial respondents during the baseline wave.

Table 3.1: Summary statistics of financial respondents during the first wave analysis

Variable	**Mean**	**Std. Dev.**	**N**
Female	0.362	0.481	7103
Own age	63.817	9.6	7103
Spouse's age	63.18	10.201	7103
Years of school	12.793	3.146	7103
Spouse's years of school	12.245	3.133	7103
Tercile of stock share if stock> 0, otherwise 0	0.744	1.084	7103
Log total household assets	11.999	1.594	7103
Choose investments for retirement accounts	0.318	0.466	7103
Own cognition in normal range	0.845	0.362	7103
Own cognition in CIND range	0.108	0.31	7103
Own cognition in Dementia range	0.048	0.213	7103
Own problems handling money	0.045	0.207	7103
Own memory disease diagnosis	0.015	0.12	7103
Spouse's cognition in normal range	0.791	0.406	7103
Spouse's cognition in CIND range	0.131	0.337	7103
Spouse's cognition in Dementia range	0.078	0.268	7103
Spouse's problems handling money	0.092	0.289	7103
Spouse's memory disease diagnosis	0.018	0.135	7103

Table 3.2: Cognition of baseline financial respondent and spouse

	Own cognition			
Spouse's cognition	Normal	CIND	Dementia	Total
Normal	4,941	666	392	5,999
CIND	466	188	112	766
Dementia	215	75	48	338
Total	5,622	929	552	7,103

Table 3.3: Proportion of respondents with memory disease diagnoses, by cognition score range

Cognition score	Proportion with Memory disease diagnosis	Std. Dev.	Freq.
Normal	.007	.082	57332
CIND	.0301	.171	8856
Dementia	.156	.363	4029
Total	.018	.134	70217

Table reports results for all respondents, person-wave observations.

Table 3.4: Financial respondents and difficulties handling money

Problems Handling money	1 if financial respondent Mean	Std. Dev.	Freq.
No	.968	.176	23701
Yes	.864	.343	1371
Total	.962	.190	25072

Table reports results for observations in the analysis sample only; person-wave observations.

Table 3.5: Onset of money problems and switching the financial respondent

Events				Years between events	
Problems handling money	Switch financial respondent	Freq	%	Mean	SD
1st event	n/a	1089	0.69	3.21	3.56
1st event	2nd event	76	0.05	4.72	3.17
Events happened same wave		73	0.05	0.00	0.00
2nd event	1st event	48	0.03	-4.44	2.62
n/a	1st event	289	0.18	3.12	3.55
TOTAL		1575	100.00	2.89	3.74

Table 3.6: Bivariate probit regressions with outcomes "Difficulties handling money" and "no longer financial respondent"

	(1) Difficulties Handling money	(2) Not Financial Respondent	(3) χ^2 test (P-value)
Female	-0.02	0.43***	27.8
	(0.05)	(0.07)	(0.00)
Age	0.02***	0.00	5.10
	(0.01)	(0.01)	(0.02)
Spouse's Age	-0.01	0.02***	13.53
	(0.00)	(0.01)	(0.00)
Own education	-0.01	-0.01	0.20
	(0.01)	(0.01)	(0.66)
Spouse's education	-0.02*	0.03	7.48
	(0.01)	(0.01)	(0.01)
Own cognition: CIND	0.49***	0.23***	11.1
	(0.05)	(0.07)	(0.00)
Own cognition: dementia	1.00***	0.99***	0.02
	(0.07)	(0.09)	(0.90)
Spouse's cognition: CIND	-0.24***	-0.28***	0.35
	(0.06)	(0.07)	(0.55)
Spouse's cognition: dementia	-0.18*	-0.65***	14.7
	(0.09)	(0.10)	(0.00)
Control investments	0.01	0.09	1.01
	(0.05)	(0.06)	(0.31)
Memory disease diagnosis	1.22***	0.13	54.8
	(0.09)	(0.13)	(0.00)
Control X Diagnosis	-0.01	0.49*	3.87
	(0.19)	(0.22)	(0.05)
Spouse diagnosis	0.04	-0.13	0.99
	(0.12)	(0.14)	(0.32)
Spouse's problems handling money	-0.12	-0.26***	2.02
	(0.07)	(0.08)	(0.16)
Stock share tercile	0.00	-0.03	1.54
	(0.02)	(0.02)	(0.21)
Log total assets	-0.09***	-0.00	10.46
	(0.02)	(0.02)	(0.00)
Const.	-1.39***	-4.01***	36.98
	(0.28)	(0.34)	(0.00)
ρ	0.27***		
	(0.04)		
N	25072		

* significant at 5%; ** significant at 1%; *** significant at 0.1%

Coefficients reported. Estimation uses HRS household level weights (unweighted results are very similar). For regression results, robust standard errors in parentheses (couple-level clusters). For χ^2 tests, p-values in parentheses.

Table 3.7: Cox proportional hazards models with age as analysis time

	(1)	(2)	(3)
Regression type	Cox PH	Cox PH	Cox PH
Analysis time	Age	Age	Age
Failure	Money IADL	Not fin R	Not fin R conditional on money IADL
	b/se	b/se	b/se
Female	1.014	2.748***	2.065***
	(0.07)	(0.21)	(0.38)
Spouse's Age	0.981***	1.011	0.991
	(0.00)	(0.01)	(0.01)
Own education	0.975*	0.991	0.987
	(0.01)	(0.01)	(0.03)
Spouse's education	0.983	1.074***	1.055
	(0.01)	(0.02)	(0.03)
Own cognition: CIND	2.306***	1.429***	1.071
	(0.17)	(0.15)	(0.23)
Own cognition: dementia	4.352***	4.832***	2.654***
	(0.35)	(0.47)	(0.52)
Spouse's cognition: CIND	0.692***	0.577***	0.684
	(0.06)	(0.06)	(0.15)
Spouse's cognition: dementia	0.750**	0.342***	0.321**
	(0.08)	(0.06)	(0.12)
Control investments	1.190**	1.163*	0.960
	(0.08)	(0.09)	(0.17)
Memory disease diagnosis	3.294***	1.469*	1.211
	(0.32)	(0.24)	(0.32)
Control X Diagnosis	1.160	1.950**	2.001
	(0.20)	(0.50)	(0.78)
Spouse diagnosis	1.062	0.866	0.818
	(0.19)	(0.25)	(0.46)
Spouse's problems handling money	0.852	0.619***	0.936
	(0.08)	(0.08)	(0.28)
Stock share tercile	1.002	0.932*	0.820*
	(0.03)	(0.03)	(0.07)
Log total assets	0.886***	0.993	1.139*
	(0.02)	(0.03)	(0.06)
N	25072	25072	1739

* significant at 5%; ** significant at 1%; *** significant at 0.1%

Hazard ratios reported.

Table 3.8: Changes in cognition scores over time

Change in cognitive status	Change in cognition score		Freq.	Percent
	Mean	SD		
Normal to Normal	-0.22	3.20	45,738	76.4
Normal to CIND	-5.09	2.77	4,111	6.87
Normal to Dementia	-13.52	4.58	925	1.55
CIND to Normal	4.71	2.64	3,032	5.06
CIND to CIND	-0.13	1.78	2,836	4.74
CIND to Dementia	-5.78	2.91	1,029	1.72
Dementia to Normal	8.90	2.77	142	0.24
Dementia to CIND	3.69	1.82	474	0.79
Dementia to Dementia	-0.65	1.86	1,580	2.64
Total	-0.56	3.97	59,867	100.00

All respondents included.

Table 3.9: Cox proportional hazards models using cognition as analysis time, two failures estimated separately

	(1)	(2)
Regression type	Cox PH	Cox PH
Analysis time	Cognition score	Cognition score
Failure	Money IADL	Not fin R
Female	0.982	2.668***
	(0.07)	(0.21)
Age	1.013*	0.991
	(0.01)	(0.01)
Spouse's Age	1.003	1.032***
	(0.01)	(0.01)
Own education	0.991	1.000
	(0.01)	(0.01)
Spouse's education	0.971**	1.075***
	(0.01)	(0.02)
Spouse's cognition: CIND	0.735***	0.550***
	(0.06)	(0.06)
Spouse's cognition: dementia	0.698**	0.343***
	(0.08)	(0.06)
Control investments	1.256***	1.292***
	(0.08)	(0.10)
Memory disease diagnosis	1.870***	0.928
	(0.17)	(0.15)
Control X Diagnosis	0.976	1.568
	(0.17)	(0.41)
Spouse diagnosis	1.000	0.808
	(0.18)	(0.24)
Spouse's problems handling money	0.937	0.678**
	(0.09)	(0.10)
Stock share tercile	1.066*	0.984
	(0.03)	(0.03)
Log total assets	0.922***	1.051
	(0.02)	(0.03)
N	24334	24334

* significant at 5%; ** significant at 1%; *** significant at 0.1%

Hazard ratios reported.

Table 3.10: Competing risks regressions using cognition as analysis time, two failures estimated separately

	(1)	(2)
Regression type	Competing risks	Competing risks
Analysis time	Cognition score	Cognition score
Failure	Money IADL	Not fin R
Female	0.842*	2.206***
	(0.07)	(0.28)
Age	1.006	1.004
	(0.01)	(0.01)
Spouse's Age	1.011	1.010
	(0.01)	(0.01)
Own education	1.015	1.014
	(0.01)	(0.02)
Spouse's education	0.951***	1.053*
	(0.01)	(0.03)
Spouse's cognition: CIND	0.722***	0.566**
	(0.07)	(0.10)
Spouse's cognition: dementia	0.593***	0.347***
	(0.08)	(0.11)
Control investments	1.104	1.042
	(0.10)	(0.14)
Memory disease diagnosis	1.837***	0.932
	(0.19)	(0.20)
Control X Diagnosis	0.960	2.121*
	(0.19)	(0.72)
Spouse diagnosis	0.971	0.590
	(0.22)	(0.37)
Spouse's problems handling money	0.964	0.525*
	(0.12)	(0.14)
Stock share tercile	1.082*	1.002
	(0.04)	(0.06)
Log total assets	0.912***	1.003
	(0.02)	(0.05)
N	23037	23783

* significant at 5%; ** significant at 1%; *** significant at 0.1%

Hazard ratios reported.

Table 3.11: Survival analysis using cognition as analysis time: problems managing money as an explanatory variable

	(1)	(2)
Regression type	Cox PH	Competing risks
Analysis time	Cognition score	Cognition score
Failure	Not fin R	Not fin R
Female	2.660***	2.202***
	(0.21)	(0.28)
Age	0.988	1.002
	(0.01)	(0.01)
Spouse's Age	1.032***	1.010
	(0.01)	(0.01)
Own education	1.000	1.014
	(0.01)	(0.02)
Spouse's education	1.078***	1.054*
	(0.02)	(0.03)
Spouse's cognition: CIND	0.554***	0.566**
	(0.06)	(0.10)
Spouse's cognition: dementia	0.349***	0.352***
	(0.07)	(0.11)
Control investments	1.275**	1.031
	(0.10)	(0.14)
Memory disease diagnosis	0.745	0.814
	(0.12)	(0.20)
Control X Diagnosis	1.658	2.205*
	(0.44)	(0.76)
Spouse diagnosis	0.794	0.587
	(0.24)	(0.37)
Own problems handling money	1.503***	1.276
	(0.15)	(0.22)
Spouse's problems handling money	0.688**	0.528*
	(0.10)	(0.14)
Stock share tercile	0.980	0.999
	(0.03)	(0.06)
Log total assets	1.059*	1.008
	(0.03)	(0.05)
N	24334	23783

* significant at 5%; ** significant at 1%; *** significant at 0.1%

Hazard ratios reported.

CHAPTER IV

Internet Access and Cognitive Ability: An Analysis of the Selectivity of Internet Interviews in the Cognitive Economics Survey

4.1 Introduction

Differences in findings drawn from data collected by internet and mail surveys represent a mixture of mode effects generated by different responses to the same question in the two modes and selective differences in coverage of the population that respond to the two modes. In this chapter, we use detailed information on the cognitive abilities of respondents in the Cognitive Economics Survey (CogEcon) to study the implications of selection on cognitive ability for studies of an older population who participates in internet surveys. From earlier studies of internet interviewing of the Health and Retirement Survey (HRS) sample, we know that internet access is strongly related to age and education in the older population (Couper et al., 2007). If valid inferences about population characteristics and behavior are to be drawn from web surveys, it is important to understand this selectivity, make appropriate statistical adjustments or, if that is not feasible, consider supplemental data collection to overcome selectivity biases associated with internet interviewing.[1] These issues are of particular importance for studying economic decision-making by

[1] See Schonlau et al. (2009), for a discussion of these issues in the context of HRS.

older populations because decisions made by older people about finances, retirement and health are significantly influenced by their cognitive abilities which, in turn, are correlated with age and education.

The Cognitive Economics Survey (CogEcon) is an innovative new survey administered by mail and internet to a national sample of 1222 persons, age 51 and older and their spouses regardless of age, who are participants in the Cognition and Aging in the USA study (CogUSA)[2]. A major goal of the CogUSA study is to provide scientific guidance to the HRS in order to improve its measures of higher order cognitive abilities which are theorized to play an important role in determining the quality of economic and health decisions by older Americans. As discussed in Chapter II, one of the most widely accepted theories of cognitive abilities is the *Gf-Gc* theory (Cattell, 1941; Horn, 1965; Horn and Cattell, 1966, 1967). Primary abilities are divided into two broad dimensions: fluid intelligence (Gf), broadly defined to include reasoning abilities, and crystallized intelligence (Gc), accumulated knowledge and skill. The distinction between fluid and crystallized intelligence is similar to the notion of ability versus human capital in labor economics. CogUSA measures many components of fluid and crystallized intelligence during an extremely detailed, three-hour cognitive assessment of sample members.

The CogEcon survey, supported by a separate NIA program project led by Robert Willis, was designed by a team of economists to help understand the cognitive bases of economic decision-making.[3] The CogEcon questionnaire, which has a median length of 53 minutes on the internet version, includes a battery of twenty-five questions on

[2]The CogUSA Study is sponsored by the National Institute of Aging, grant number R37 AG007137, "Assessing and Improving Cognitive Measurements in the HRS," led by John J. McArdle, PI, a quantitative psychologist at the University of Southern California, who is a co-investigator in the Health and Retirement Study.

[3]The Cognitive Economics Survey is supported by NIA program project P01 AG026571, "Behavior on Surveys and in the Economy Using HRS," Robert J. Willis, PI. In addition to Willis, the design team includes Daniel Benjamin, Miles Kimball, Claudia Sahm, Matthew Shapiro, and Tyler Shumway. Gwen Fisher, Brooke Helppie McFall, and Joanne W. Hsu oversaw the internet and mail data collection and also provided valuable help on the survey design.

financial sophistication, detailed measures of income, wealth and portfolio allocation plus measures of risk tolerance, self-assessed financial knowledge, use of records and other sources of information and several questions on decision-making. By linking psychological and economic measures, the combined survey provides crucial evidence about which of the new cognitive measures in CogUSA would be most productive to add to the HRS.

4.2 Survey design

4.2.1 The CogUSA Study

The CogUSA Study consists of three survey components, as depicted in Figure 4.1. The study begins with a 40 minute telephone interview that replicates the sections of the HRS[4] questionnaire on demography, health and cognition. These wave 1 interviews were conducted between June and December 2007. For each respondent this telephone survey was followed as quickly as possible—ideally, within a week—by wave 2, a three hour face-to-face assessment of the cognitive abilities of respondents on a large number of different tasks measuring components of fluid and crystallized intelligence. Finally, the wave 3 telephone interview wave took place at a randomized interval of one to twenty-four months following the personal interview. In addition to re-testing several components of ability using a telephone administration, this second telephone interview administered the same subjective probability questions fielded by HRS during its 2008 wave.

One of the goals of the CogUSA is to develop efficient methods of assessing well-recognized components of intelligence and personality that can be administered by surveys using either face-to-face or telephone administration.[5] For example, McArdle, Rodgers, Fisher, Horn, and Woodcock developed an adaptive Number Series

[4] See Section 3.4 for more details about the HRS.
[5] See Section 4.6 for a full description of these measures.

test that was piloted in HRS experimental modules in 2004 and 2006.[6] The adaptive Number Series test covers the same range of ability covered by 47 items in the standard Woodcock-Johnson (WJ-III) test in about four minutes and no more than six questions. This adaptive test is repeated in the CogUSA telephone interview, while the full WJ-III number series test is conducted in the in-person wave.[7]

Among the many cognition measures in our survey, we focus our attention to standardized scores of three tests: Number Series, Retrieval Fluency and Vocabulary, all drawn from the in-person interview (wave 2). In preliminary research with the CogEcon data, the Number Series test, which is a measure of quantitative reasoning, has been shown to be more significantly related to measures of economic knowledge and economic status than other cognitive measures. Vocabulary, a test from the Wechsler Adult Intelligence Scale (WAIS), measures a form of crystallized intelligence that includes expressive vocabulary, verbal knowledge, and fund of information. Lastly, Retrieval Fluency is a measure of long-term retrieval from stored knowledge, also from the WJ-III. In this test, respondents are asked to name as many items as possible in a specific category during a short period of time. These three were chosen to cover disparate forms of cognition.

4.2.2 The Cognitive Economics Survey

Members of the CogUSA sample whose cognitive ability was assessed in wave 2 face-to-face interviews were invited to participate in the CogEcon mail/internet survey in 2008. In addition, CogEcon fielded a 2009 Post-Crash survey to follow up with respondents after the economic crisis, and plans are underway for new waves

[6] The number series test asks a person to fill in the missing number in a sequence. An easy example is 1, 2, 3, _ ; a little harder one is 2, 4, _ , 256. (Note that the actual items are copyrighted and cannot be reproduced). An adaptive test can dramatically reduce the number of items needed to assess a person's ability by asking questions that are of most relevance to a person's ability.

[7] The 47-item test is "somewhat adaptive," so that few respondents answer all 47 items.

of data to be collected in the fall of 2011 and in 2013. The CogEcon Study content includes many aspects of economic decision-making, including income, assets, and another form of crystallized intelligence, financial sophistication/literacy (see Section 2.4.2 for more details).

The CogEcon sample frame consists of the 1222 individuals, including age-ineligible spouses, who completed the first two waves of CogUSA. The invitees range in age from 38 to 96 years, with a mean age of 64.0 years. Of the invitees, 816—just over two-thirds of respondents[8]—reported using the internet regularly.

To avoid conflict with wave 2 of the CogUSA survey, the CogEcon survey was divided into two releases; 921 were assigned to the first release (fielded in February and March of 2008), and 301 were assigned to the second (fielded in July 2008; see Figures 4.1 and 4.2). All individuals in the first release who indicated that they had used the internet "regularly"[9] during the baseline wave 1 telephone interview of the CogUSA were sent a letter inviting them to participate in an internet interview; those without access were sent a letter with a mail version of the survey enclosed.

In the first CogEcon sample release, 624 respondents were invited to completed the internet version of the survey and 297 to complete the mail version. In the second sample release, we invited all 301 persons to complete a mail survey regardless of internet access—no internet survey was administered in this second release. Of these, 189 had reported at baseline that they used the internet regularly. Since individuals were randomly assigned to sample releases, assigning these individuals to a mail survey forms the basis for a randomized mode experiment, analyzed in detail in Hsu

[8]This is substantially higher than the internet usage rate found in the HRS. This is possibly due to the sampling frame used for the CogUSA, based on random-digit dialing. Furthermore, since CogUSA was described as a study on cognition and aging in the recruitment letter from the Survey Research Center, those with lower cognition may have declined to participate in higher numbers than those in the HRS sample. Since internet access is related to ability, such an effect would lead to fewer respondents without internet access in the CogUSA sample.

[9]Question number W303 from HRS was used. It reads: "Do you regularly use the World Wide Web, or the Internet, for sending and receiving e-mail or for any other purpose, such as making purchases, searching for information, or making travel reservations?"

and McFall (2011).

Our analysis in this chapter takes two primary forms, shown in Figure 4.3. First, we characterize differences, if any, between those reporting internet access and those without access on the basis of attributes measured in CogUSA. This is represented as the dotted rectangle in the first row of the figure (maximum sample size: 1222). Because CogUSA was implemented in the same mode at each wave for all respondents—telephone for wave 1 and in-person for wave 2—this analysis will not be subject to mode effects. Second, we restrict the analysis to the CogEcon sub-sample. Since Release 1 of CogEcon was mixed-mode, some differences may be due to mode effects rather than selectivity. Comparing internet users and non-users in the mail-only Release 2 provides an opportunity to isolate selection issues. This comparison is shown in the second row of Figure 4.3.

4.3 Results

4.3.1 Internet Coverage and Determinants of Access

While respondents with internet access outnumber those without at a rate of nearly two to one, the probability of internet access differs dramatically by the age and education of CogUSA respondents. This can be seen in the probit regression results in the first column of Table 4.1 and is very similar to the pattern of internet access seen in HRS data. The second column adds the respondent's standardized Number Series score (a measure of fluid intelligence), Vocabulary score (a measure of crystallized intelligence), and Retrieval Fluency (a measure of long-term retrieval), all obtained in the CogUSA in-person survey. Both Number Series and Vocabulary have a strong positive relationship to internet access. A one standard deviation increase in the Number Series score is associated with an 8 percentage point increase in the probability of internet access. Likewise, a one standard deviation increase in

Vocabulary increases internet access by 0.06. This implies that respondents with internet access tend to be of considerably higher ability than those without, even after controlling for age and education. Retrieval Fluency is also positively related to internet access, but the coefficient is not precisely estimated. The third column adds coupleness status, coded as one if the respondent is married or partnered and zero otherwise. The slight increase in the likelihood for internet access for those in couples is unsurprising given economies of scale and the ease of sharing computers and internet access within a household.

A scatter plot of predicted probabilities from the regression in column (2) is presented in Figure 4.4 along with non-parametric lowess estimates of the unconditional probability of access by age. The lowess plot shows that on average, 60-year-old respondents in CogUSA have an 80% predicted probability of internet access, while for the oldest members this probability is 20% or below. The scatter of points around the lowess plot indicates considerable variation in the probability of being in the internet sample that is associated with differences in education and cognition.

Ability differentials between the internet and mail eligible samples are shown more directly in Figure 4.5, which presents kernel density estimates of the distribution of the standardized cognition scores in the two samples. The mean Number Series scores in the internet and mail samples are, respectively, 0.29 and -0.60, with standard deviations of 0.85 and 1.003. Thus, overall there is about a 0.89 difference in means (nearly one standard deviation) in the Number Series scores between the two subsamples. Internet users have Vocabulary scores that exceed those of non-users by 0.76 on average, and their distributions are particularly different from each other. Internet users also have higher Retrieval Fluency scores, though the dispersion of Retrieval Fluency is much smaller than Number Series and Vocabulary.

We can also consider variables from the CogEcon study; doing so, however, restricts the sample to at most 985 observations. Furthermore, these variables may be subject to mode effects. Running the three specifications in Table 4.1 on the smaller CogEcon sample yields point estimates that are very similar to those found in the CogUSA sample (CogEcon results reported in Table 4.2), so we can be confident that the CogEcon sample is representative of the larger CogUSA sample.

In Table 4.3, we consider economic determinants of internet access, and therefore restrict the analyses to those who completed the CogEcon study. Column (1) reports results with only demographic explanatory variables. Column (2) also includes the three cognition scores as well as the standardized financial sophistication score, a measure of crystallized intelligence obtained in the CogEcon study. Including financial sophistication somewhat weakens the effect of the Number Series score relative to column (2) in Table 4.2. The positive and statistically significant effects of Number Series, Retreival Fluency, and financial sophistication score all remain. This provides additional evidence that those who participate in the internet sample are of higher ability than their counterparts in the mail sample.

Lastly, we investigate the relationship of internet access to income and wealth. We use the natural log of earnings (with those not working coded as zero) and the natural log of total wealth (with negative and zero values of wealth coded as zero). Column (3) of Table 4.3 reports regressions including demographics, log income, and log wealth, excluding cognition, while the last column includes all covariates.

Greater earnings and wealth both increase the probability of having internet access. The effect of earnings suggests that occupational exposure to computing technology may have a role in internet access for older Americans. This may also reflect some of the effects of being retired and having less of a need for computers or internet

access for work.[10]

However, including cognition and financial literacy weakens the effects of earnings and wealth. Comparing columns (3) and (4) of Table 4.3, the marginal effect of log wealth is reduced by about 40 percent, from 0.013 to 0.008, with the inclusion of the two scores. Furthermore, the inclusion of cognition and financial sophistication reduces the effect of education from 0.038 to 0.012, or almost 70 percent.

The effect of cognition is not quite as sensitive to the inclusion of economic variables (see columns (2) and (4)). This suggests that even after controlling for standard demographic and economic variables, there is still selection into internet access on the basis of cognitive ability. A one-standard deviation increase in the Number Series score increases the probability of internet access by 0.05, and the same increase in Vocabulary is associated with a 0.08 increase in internet access. In the full specification in the last column, demographic and cognition (Number Series and Vocabulary) variables are statistically significantly related to internet access; economic variables are positive but not statistically significant here.

These results used pooled data from respondents without internet access, who necessarily responded by mail, and those with internet access, who were randomly invited to respond by mail or internet. Of the variables in Table 4.3, earnings, wealth and financial literacy were collected in CogEcon using the two modes; the demographic variables were collected in CogUSA using the same mode for all respondents. To verify that our results are not driven by mode effects, we repeat the analysis of Table 4.3 using only CogEcon Release 2: 146 with internet access, and 83 without. All of these individuals completed mail surveys, so group differences are not due to mode. The results of these regressions, reported in Table 4.4, are largely con-

[10]We unfortunately do not have information on whether respondents access the internet from home, work, or elsewhere.

sistent with the results from the complete sample. The main exception is that in the full sample, the effect of log wealth exceeded that of log earnings, and the opposite is true here in the mail-only Release 2 subsample. Because in both specifications the marginal effect of earnings is not statistically different from that of wealth (p-values of 0.6130 and 0.4719 in the full sample and the Release 2 subsample, respectively), this discrepancy is not problematic.

4.3.2 Response rates in CogEcon

Response rates to the CogEcon survey differed quite dramatically by mode. CogEcon achieved an overall response rate of 86.72% for internet invitees and 71.62% for mail invitees in Release 1.[11] Of those who were initially assigned to the internet mode, 83.4 percent submitted a completed questionnaire either by internet or mail while 74.7 percent of those initially assigned to the mail mode returned a questionnaire. A probit model of response rates to Release 1 shows that being an internet user who was invited to take the internet survey is associated with a 0.12 increase in the probability of response (the first column of Table 4.5).[12] We also see that the Number Series score also has a positive, statistically significant impact on the probability of response.

To see if this difference is more a function of unmeasured ability or personality differences between mail and internet invitees than a true mode effect, we analyze Release 2 data, in which respondents with and without internet access were all invited to complete a mail survey. As can be seen in the second column of Table 4.5, having

[11] Of the 624 who were invited to do the internet survey in CogEcon Release 1, 492 (79.2 percent) submitted complete interviews. There were also 25 "partial" interviews by people who failed to hit the "submit" button at the end of the interview; some of these are largely complete, while others have very few questions answered. In addition, 251 mail interviews were submitted, including 30 respondents with internet access who eventually requested paper questionnaires. In sum, 921 CogUSA respondents were invited to participate in Release 1 of the CogEcon Survey and 743, or 80.6 percent, returned completed questionnaires.

[12] These probit regressions exclude 30 internet invitees who eventually responded using a mail questionnaire included in a reminder letter.

internet access is *not* associated with increased likelihood of response. Likewise, we no longer see an impact of Number Series on response.[13] Therefore, the results of the Release 1 response rate analysis are likely due to mode effects (see Hsu and McFall, 2011).

Personality We also investigated difference in personality by internet access. The Big Five personality traits—extroversion, agreeableness, conscientiousness, neuroticism, and openness—do not vary systematically between web users and non-users (see Section 4.6 for more details on personality traits). Likewise, Need for Cognition also does not vary. None of these personality traits are statistically significant in univariate regressions of internet access, nor are they significant when added to the full specifications of determinants of access with demographics, cognition, and wealth. In addition, the Big Five traits and Need for Cognition also do not predict response to the 2008 CogEcon study. These results are not reported here for brevity.

4.4 Discussion

4.4.1 How does selectivity of the internet sample affect inferences from data?

One of the major goals of the CogEcon/CogUSA collaboration is to provide evidence on the relationship between cognitive ability and economic decision-making. The cognitive measures obtained in CogUSA may be interpreted within the theory of "fluid and crystallized intelligence" (Cattell, 1941, 1987). Crystallized knowledge (Gc) is thought to represent acculturated knowledge, and fluid reasoning (Gf) is thought to represent reasoning and thinking in novel situations.[14] Connections between *Gf/Gc* theory and human capital theory have been developed by Willis and

[13] Similar results hold when analyzing all mail surveys in both releases.

[14] The current form of $GfGc$ theory (Horn, 1988, Horn, 2003) contains 8 broad cognitive functions: 1. Fluid Reasoning (Gf). 2. Acculturation Knowledge (Gc). 3. Short-term memory (Gsm) 4. Processing Speed (Gs) 5. Long-term Retrieval (Glr), 6. Visual Processing (Gv), 7. Auditory Processing (Ga). 8. Quantitative Knowledge (Gq). For purposes of our model, we consider only the first two functions.

McArdle (n.d., forthcoming) and have been used to study the accumulation of financial knowledge and financial decision-making by Delavande et al. (2008).

In this section, we examine the age trajectories of the Number Series score, a well-established component of fluid intelligence collected in the CogUSA, and two measures of different types of crystallized intelligence: Vocabulary, a well-established measure from CogUSA, and a newly developed measure of financial sophistication from the CogEcon survey. From an economic point of view, the financial sophistication score measures a form of human capital which, from a psychological point of view, is largely a component of crystallized intelligence.[15] Our interest in this chapter is simply to illustrate the degree to which the selectivity of an internet sample might produce misleading inferences utilizing data from the full CogUSA sample and both the internet and mail components of the CogEcon survey.

Over the lifespan, fluid reasoning ability increases rapidly during childhood and adolescence, reaching a peak between ages 15-20, and then begins a linear decline that continues among cognitively normal adults without dementia until death. In contrast, crystallized abilities tend to continue increasing at least through middle age and then remain relatively unchanged through the rest of life. In other words, patterns of age-related decline are evident for fluid intelligence, but not crystallized intelligence. These theoretically predicted patterns are illustrated in Figure 4.6. Using the full CogUSA sample, non-parametric lowess estimates of the age trajectories of the Number Series, Vocabulary, and financial sophistication scores are presented in Figure 4.7.

As predicted by *Gc/Gf* theory, the Number Series score decreases linearly throughout the 50+ age range of the sample while the financial sophistication measure only

[15] Psychometric analysis of the financial sophistication measures is currently underway by several researchers in the Willis P01 project (NIA program project P01 AG026571).

begins declining at late ages. From a substantive point of view, it is important to note that these cross-sectional age trajectories represent an unknown mix of age and cohort effects.[16] Given the methodological focus of this chapter on selectivity issues, this distinction is not critical. For our purposes, the key message of Figure 4.7 is that the trajectories we see in the full sample are broadly consistent with theoretical expectations.

The fact that internet access is strongly correlated with age, education, Number Series score, and Vocabulary score implies that participation in an internet survey will be selective on fluid and crystallized intelligence, and both quantitative and verbal skills. The pattern of selection by age is illustrated in the first panel of Figure 4.8, in which non-parametric lowess curves of the standardized Number Series score versus age are plotted separately for respondents with internet access, respondents without internet access, and the full sample; the second and third panels display the same for Vocabulary and financial sophistication scores. While the rate of decline is similar for mail and internet eligible respondents, the slope of the full sample age profile is much steeper, reflecting differential selection at older ages. Since the full sample age profile is a weighted average of the age profiles for the mail eligible group and the internet eligible group, these slopes are consistent with the declining predicted probability of having internet access with age as shown in Figure 4.4.

At younger ages, the full sample is dominated by internet eligible respondents; those who are mail eligible are of lowest ability. Likewise, at older ages, our full sample is composed primarily of mail respondents, and those captured in the internet

[16]There is good reason to think that cohort effects are important for these measures. The "Flynn Effect" refers to a well-documented increase across cohorts of scores on tests of fluid intelligence. (See Flynn (2007) and Schaie (2005) for an extensive discussion of these findings.) Examination of gender differences in the financial literacy scores shows a decline in scores for females at older ages which is almost surely a cohort effect reflecting a traditional household division of labor. Chapter II addresses possible cohort effects by looking at intra-couple differences in financial sophistication.

eligible are of very high ability. Therefore, not only does the internet eligible sample select on the basis of age, it also selects on the basis of ability at both ends of the age distribution. An internet-only sample would miss an increasing number of persons, particularly those with lower ability, at older ages. Because of selection, it is clear that an internet-only sample would lead to an overestimate of level of intelligence and an underestimate of the rate of cognitive decline with aging.

Analysis of survey data must take selectivity into account. In the case of the CogEcon survey, we recognized that selection would be an issue when we began thinking of administering an internet survey and, therefore, decided to supplement it with a mail survey in order to cover the entire CogUSA sample. However, this is not an option with many internet surveys.

4.4.2 Propensity score weighting

In the above analysis, we have established that internet users differ fundamentally from internet non-users, and that a internet-only sample would be subject to selection on cognition in addition to standard demographic variables. Propensity score weighting is one method of correcting for the selection bias arising from variation in internet access. In this section, we create weights based on our probit regressions of internet access and compare weighted means from a internet-only subsample to means from the a full sample of internet users and non-users. For simplicity, we treat the full CogUSA sample as representative random sample of the population of interest in order to abstract away from non-response issues within the CogUSA study and attempt to weight the internet sub-sample to resemble the full sample.

Rosenbaum and Rubin (1983) developed the use of propensity scores to adjust for non-random assignment of treatments in observational studies (see also Little and Rubin, 2002). The valid use of propensity scores requires *strong ignorability*.

Following the notation in Schonlau et al. (2009), strong ignorability requires that for an outcome of interest Y, and X covariates used to estimate the propensity for internet access I,

$$P(I = 1|X, Y) = P(I = 1|X) \text{ for almost all X and Y.} \tag{4.1}$$

In our context, this requires that the outcome of interest Y and internet use I are independent, conditional on a set of covariates X.

If the strong ignorability condition is met, inverse probability weights can be used to construct consistent estimates of parameters of the distribution of Y (Schonlau et al., 2009). We use predicted probabilities estimated from the two probit regressions from Table 4.1; the weights are the inverse of these predicted probabilities, normalized so the weights have a mean of one. We construct one set of weights using only standard demographic information as explanatory variables: age, sex, education, and coupleness status. The second set of weights also includes cognition variables, which unlike the demographic variables are not standard data collected by surveys. Figure 4.4 displays a scatterplot of these propensity scores.

This comparison of the two sets of weights is similar to work on whether attitudinal or lifestyle questions are useful additions to propensity score estimates for weighting data. Harris Interactive, a company that specializes in web surveys, uses a set of attitudinal variables called "webographic" variables. Schonlau et al. (2004) find that propensity scores using "webographic" variables improve some of the bias that emerges from a web-only sample. Indeed, weighting using propensity scores from demographic variables alone produce large discrepancies in "webographic" measures for web-using and non-using samples (Schonlau et al., 2007). Here, we continue our focus on the role of cognition.

To analyze the weighted and unweighted descriptive statistics of web-users and the

full sample, we consider the prevalence of 14 health conditions: diabetes, high blood pressure, cancer, lung disease, heart conditions, stroke, arthritis, past and present smoking status, and others. Each variable is coded as one if the respondent reported the condition, and zero otherwise; these were asked on CogUSA and therefore are not subject to mode effects. We also considered a number economic variables: currently working for pay (collected by telephone for all respondents in the third wave of CogUSA), an indicator for owning one's own home, and values of retirement wealth and total wealth. Internet users and internet non-users have statistically significant differences in means for 11 of the 14 health conditions and all of the economic variables. The two groups do not have statistically significant differences in means for having fallen in the last two years, ever smoked, psychological or emotional problems, and incontinence.

Table 4.6 reports means of each variable, with the the mean of the CogUSA "population" in column (1) and means from the internet-using subsample with and without weights in columns (2) through (4). For nearly all outcomes with statistically significant differences between internet users and non-users, applying weights (whether the weights in column (3) or column (4)) reduces the difference means of the internet sample with the full sample. The only exception is lung disease: the weights without cognition increase the difference, but the weights with cognition do bring the weighted internet-only mean closer to the full sample mean.

For 11 of the 14 health variables, using weights computed with cognition scores reduced the gap between internet-only and full sample means more than weights computed using only demographic characteristics. In particular, weights without cognition exacerbated differences in means for three of the four outcomes for which web-only means were similar to the full sample mean (fallen in the last two years, ever

smoked, and incontinence), while weights with cognition preserved the similarities between web users and the full sample. However, for three of the four economic variables, the weights without cognition closed the gap more than the weights with cognition. In our case, it appears that propensity score weights based on our analysis do help correct for selectivity in some, but not all, outcomes.

4.5 Conclusion

In general, data collected through internet and mail surveys can yield differences in data that are a combination of differential responses to the same question in the two formats and selection effects due to differing coverage of the population responding to each mode. By using data obtained in the face-to-face interview of CogUSA in conjunction with data from the mixed-mode CogEcon survey, we have been able to analyze the selectivity of internet interviews without being subject to mode effects.

After controlling for age, sex, and education, we find that the Number Series and Vocabulary scores have a strong positive relationship to internet access. The effect of the Number Series score is only reduced with the inclusion of the financial sophistication score, a measure of crystallized intelligence.

Our results suggest that those with internet access will tend to be of higher ability, both in terms of fluid and crystallized intelligence, than those without internet access. In addition, the degree of selectivity increases as respondents' ages increase. First, the older the person, the less the likely he or she is to be included in our internet sample. Since fluid intelligence declines with age, that means an internet sample loses more and more people—particularly those with low fluid intelligence and those who have acquired little financial knowledge—as the age of respondents increases. Consequently, not only would an internet-only sample overestimate the abilities and

knowledge of participants, it would underestimate the rates of decline with age in fluid and crystallized intelligence relative to data with full population coverage.

4.6 Appendix: Summary of WJ-III Number Series and personality measures

CogUSA Data Collection in General Respondents completed a 35-40 minute telephone interview, followed by a three-hour face-to interview scheduled within 1-14 days after the initial telephone interview. The telephone interview comprised a series of questions to gather demographic characteristics, internet use, health status, and basic cognitive measures. The face-to-face interview was a much more in-depth assessment of cognitive functioning, as well as personality and a few other measures. The cross-battery set of cognitive measures included a series of tests from the Woodcock-Johnson III (WJ-III) tests of cognitive abilities and achievement.

Number Series The Number Series test in the WJ-III battery is a measure of fluid intelligence that measures quantitative reasoning (Woodcock and Mather, 2001). This ability involves reasoning with concepts that depend upon mathematical relationships. The task required the respondent to look at a series of numbers with a number missing from the series. The respondent needed to determine the numerical pattern, and then provide the missing number in the series. Answers were scored correct or incorrect for each item, and a standardized score (called a W-score) was computed based on WJ-III standard scoring (Woodcock and Mather, 2001).

Retrieval Fluency The Retrieval Fluency test in the WJ-III battery measures an aspect of long-term retrieval, specifically retrieval from stored knowledge. The Respondent is asked to name as many examples as possible from a particular category within a fixed period of time.

Vocabulary The Vocabulary test from the Wechsler Adult Intelligence Scale (WAIS) is a measure of crystallized intelligence that measures expressive vocabulary, verbal knowledge, and fund of information. The test also addresses other cognitive abilities, including learning ability, and concept and language development.

Big Five Personality Inventory Personality refers to relatively stable characteristics of thought, affect, and behavior. In this study, we conceptualized personality in terms of the Big Five model of personality, which describes five broad personal traits: conscientiousness (being goal-directed, organized, and detail-oriented), agreeableness (having a tendency to get along easily with others), extroversion (enjoys social engagement and interacting with others), openness to experience (willing to try new things), and neuroticism (having a tendency to worry a lot). These five characteristics were measured via self report with the 44-item Big Five Inventory (BFI; John et al. (2008)). Participants indicated the extent to which he/she agreed with a series of statements that describe him/herself using a 5-point Likert-type response scale ranging from Strongly Disagree to Strongly Agree.

Need for Cognition Need for cognition is an individual difference variable defined by (Cacioppo and Petty, 1982, p. 116) as "the tendency for an individual to engage in and enjoy thinking." Studies by Cacioppo and colleagues (e.g., Cacioppo and Petty (1982); Cacioppo et al. (1996)) have posited that individuals high or low in need for cognition make sense of their world and approach problem solving differently. For example, individuals high in need for cognition think about things, seek, acquire, and reflect on information, whereas those low in need for cognition prefer to obtain information from other sources, including other people, by making social comparisons, or using cognitive heuristics, rather than figuring things out for themselves.

We measured need for cognition in this study using the 18-item short form measure validated by Cacioppo et al. (1984). Participants responded to each item using a 5-point Likert-type response scale ranging from Strongly Disagree to Strongly Agree. Variables for analysis were constructed in two ways. First, we constructed a single, composite summary measure of all 18 items. Secondly, we constructed three separate dimensions of the need for cognition scale based on Tanaka et al. (1988). The three dimensions were (1) cognitive confidence (the extent to which one is confident about engaging in cognitive activities), (2) cognitive persistence (the extent to which one enjoys engaging in cognitive tasks), and (3) cognitive complexity (a tendency to prefer complex problems more than simple ones).

4.7 Figures and Tables

Figure 4.1: Timing of the Cognitive Economics Study

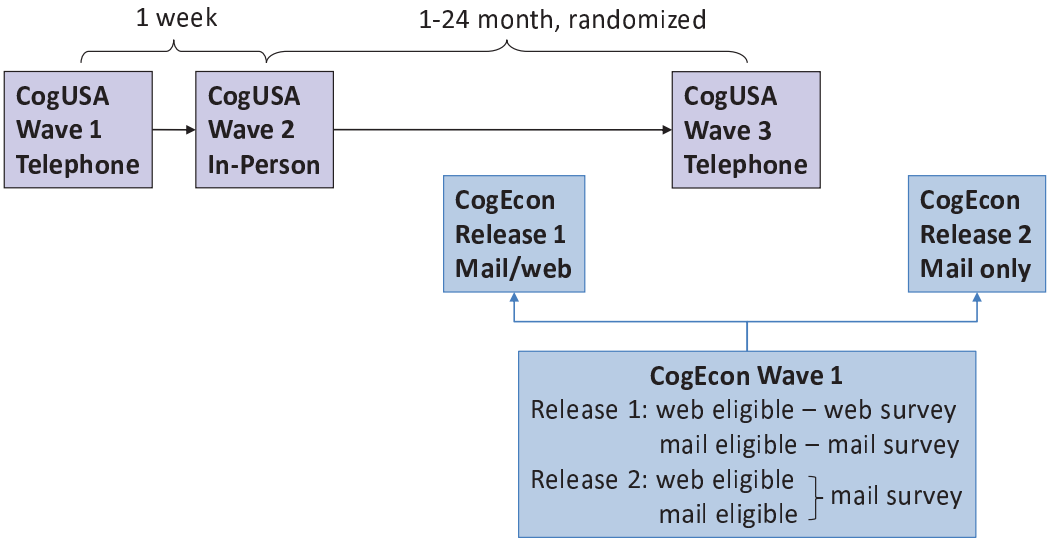


Figure 4.2: CogUSA and CogEcon flow chart

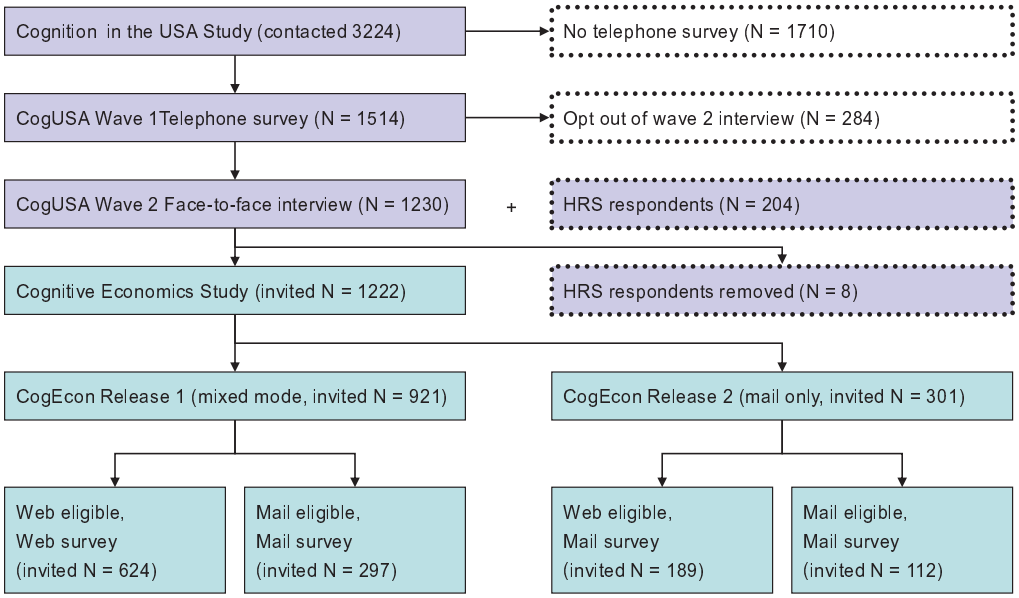
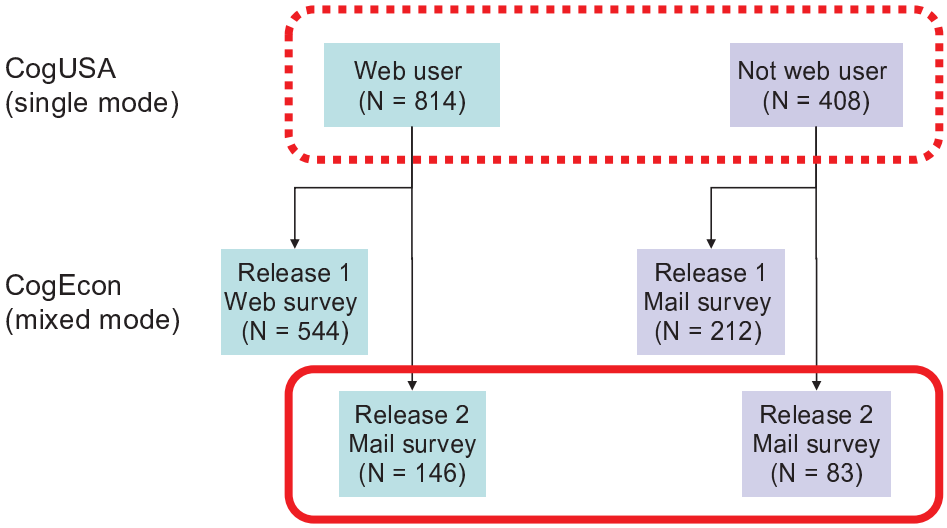


Figure 4.3: Web users and non-users on CogUSA and CogEcon



Each wave of CogUSA was implemented in the same mode for all respondents (waves 1 and 3 over the telephone; wave 2 in person). CogEcon fielded its 2008 survey by mail to some respondents and web for other users. Note that the 544 web users in release 1 include 30 respondents who submitted a mail questionnaire. These 30 either requested a mode switch or did not respond until we sent a final reminder with a paper survey.

Figure 4.4: Predicted probabilities of internet access

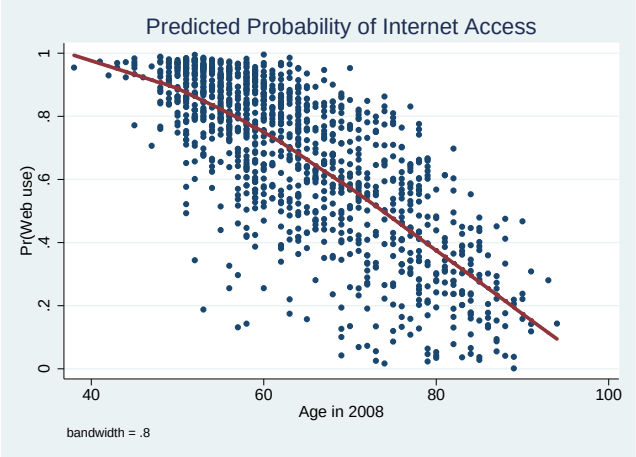


Figure 4.5: Densities of cognition scores, by internet access

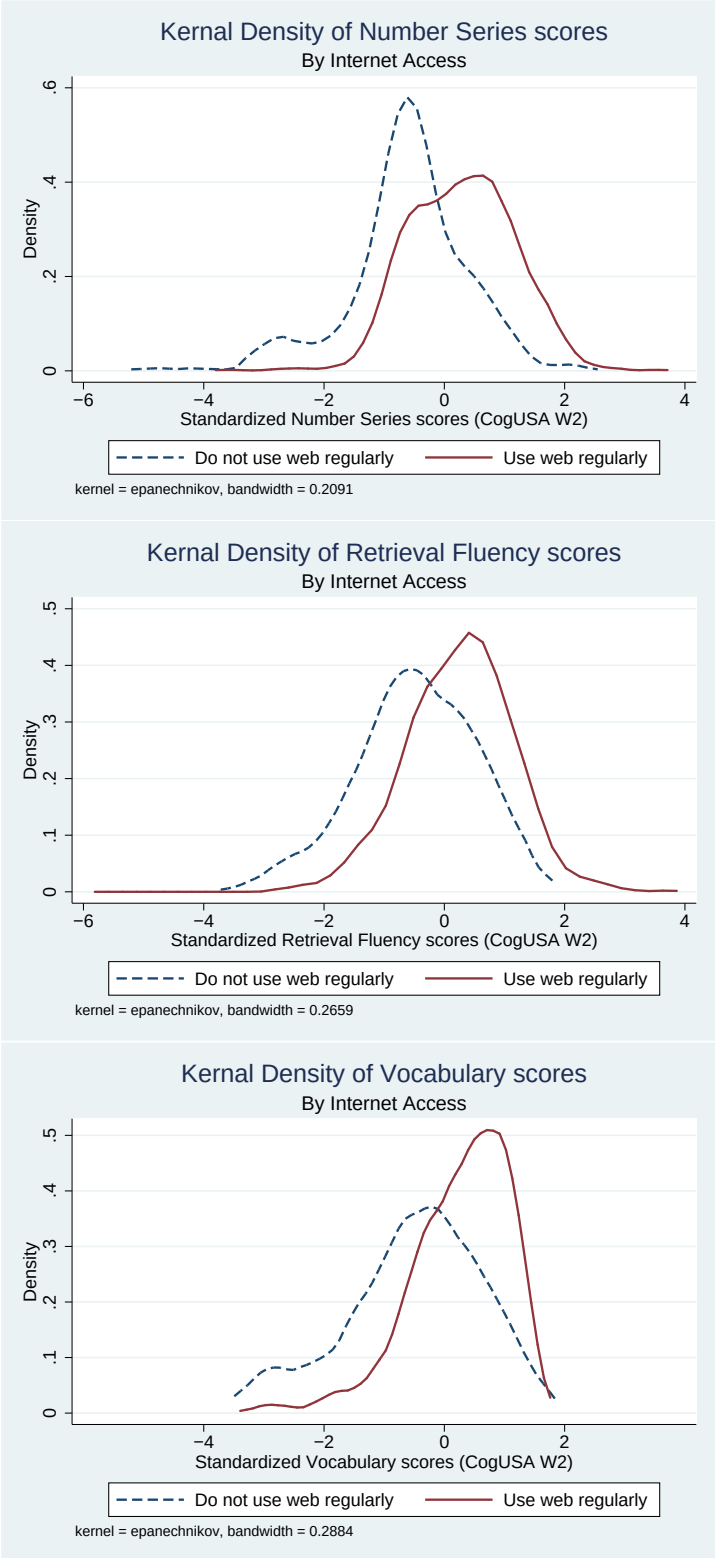


Figure 4.6: Life cycle pattern of fluid and crystallized intelligence

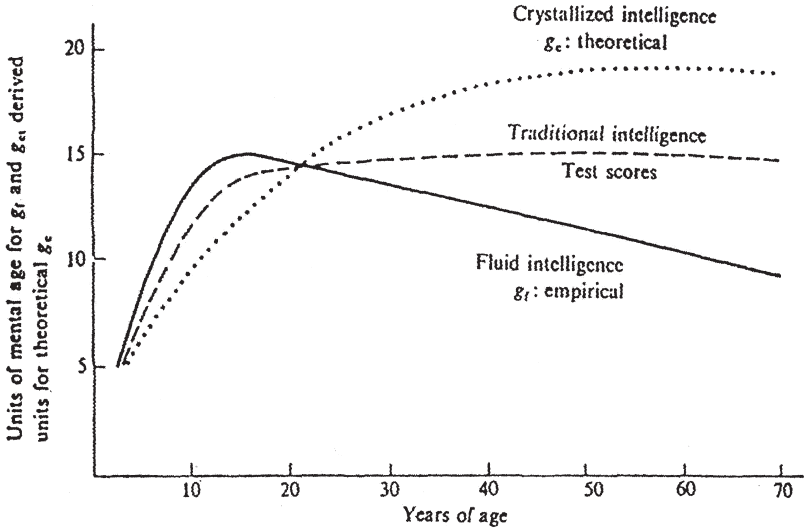


Figure 1. A theoretical description of life span curves of intellectual abilities. From *Intelligence: Its structure, growth and action* (p. 206) by R. B. Cattell, 1987, Amsterdam: North-Holland. Copyright 1987 by Elsevier Science Publishers. Reprinted with permission.

Figure from McArdle et al. (2002).

Figure 4.7: Age profile of standardized scores

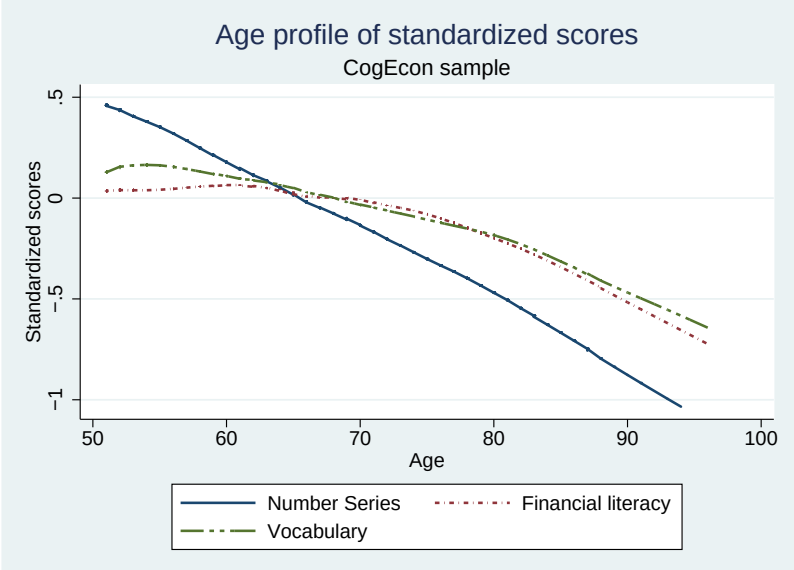


Figure 4.8: Age profiles of standardized scores, by internet access

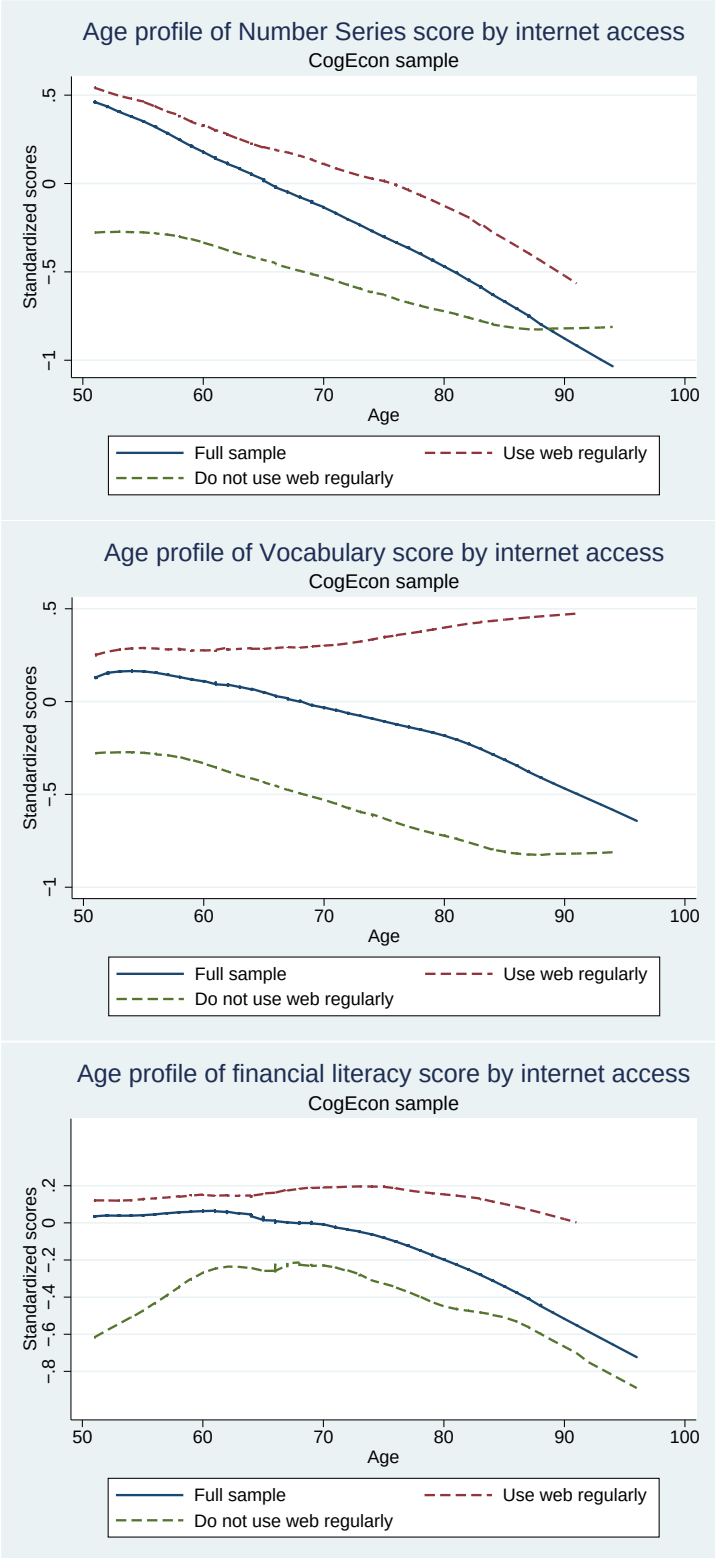


Figure 4.9: Age profiles of standardized scores, by education

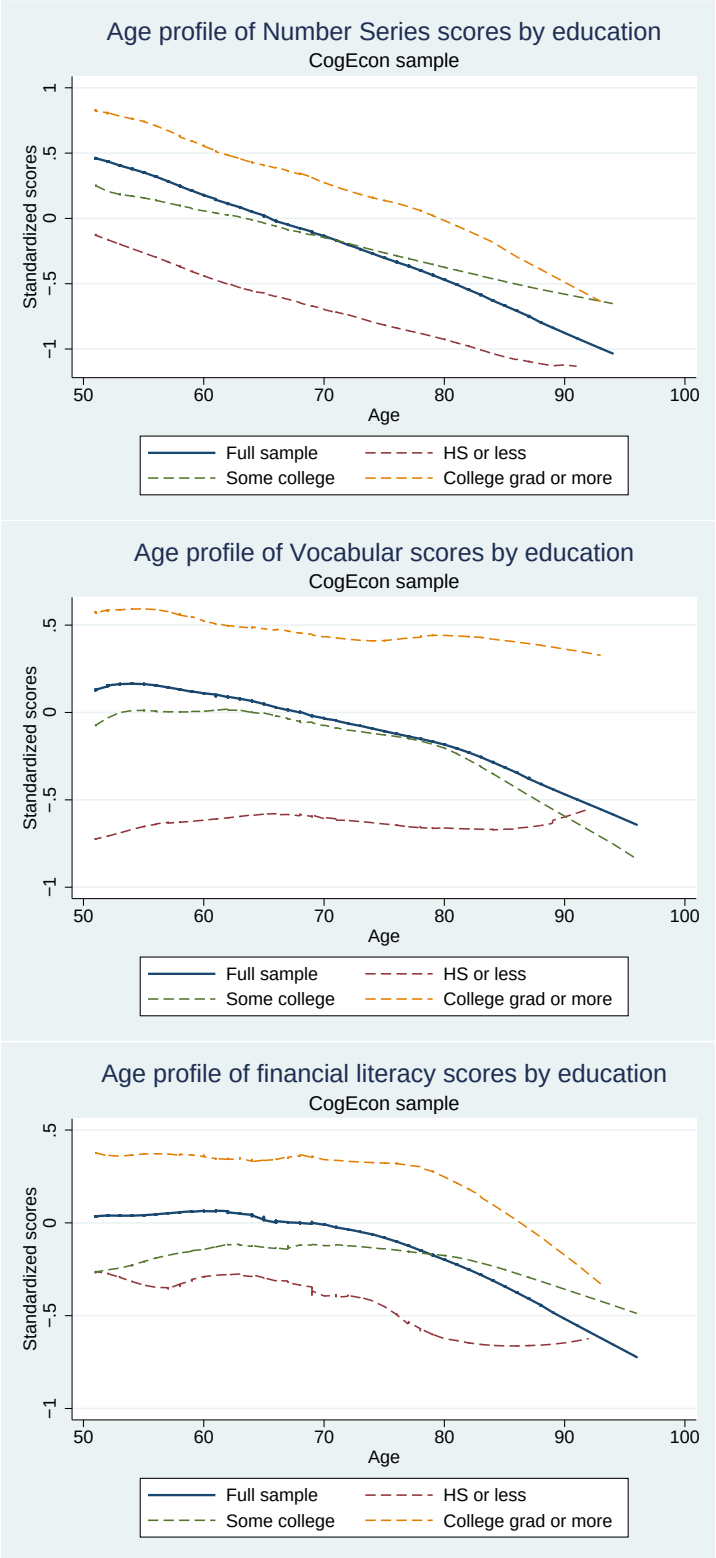


Table 4.1: Probit model of determinants of internet access - CogUSA and CogEcon

	(1)	(2)
Age	-0.01***	-0.01***
	(0.00)	(0.00)
Female	0.06*	0.06*
	(0.02)	(0.02)
Education	0.05***	0.02**
	(0.01)	(0.01)
Coupled	0.08**	0.05
	(0.03)	(0.03)
Number Series (standardized)		0.08***
		(0.02)
Retrieval Fluency (standardized)		0.02
		(0.01)
Vocabulary (standardized)		0.06***
		(0.01)
N	1207.00	1207.00

* significant at 5%; ** significant at 1%; *** significant at 0.1%

Dependent variable is 1 if the respondent uses the internet regularly, 0 otherwise. Average marginal effects reported. Robust standard errors in parentheses (couple-level clusters).

Table 4.2: Probit model of determinants of internet access - CogEcon only (full sample)

	(1)	(2)
Age	-0.01***	-0.01***
	(0.00)	(0.00)
Female	0.05	0.05*
	(0.03)	(0.02)
Education	0.05***	0.02**
	(0.01)	(0.01)
Coupled	0.08**	0.06*
	(0.03)	(0.03)
Number Series (standardized)		0.07***
		(0.02)
Retrieval Fluency (standardized)		0.01
		(0.01)
Vocabulary (standardized)		0.08***
		(0.01)
N	969.00	969.00

* significant at 5%; ** significant at 1%; *** significant at 0.1%

Dependent variable is 1 if the respondent uses the internet regularly, 0 otherwise. Average marginal effects reported. Robust standard errors in parentheses (couple-level clusters).

Table 4.3: Probit model of determinants of internet access, with income and wealth - CogEcon full sample

	(1)	(2)	(3)	(4)
Age	-0.012***	-0.009***	-0.010***	-0.009***
	(0.001)	(0.001)	(0.001)	(0.001)
Female	0.048	0.058*	0.059*	0.063*
	(0.025)	(0.025)	(0.025)	(0.025)
Education	0.046***	0.014*	0.038***	0.012
	(0.006)	(0.006)	(0.006)	(0.006)
Coupled	0.089**	0.063*	0.070*	0.055
	(0.030)	(0.029)	(0.031)	(0.030)
Number Series (standardized)		0.058**		0.050**
		(0.019)		(0.019)
Retrieval Fluency (standardized)		0.017		0.015
		(0.014)		(0.014)
Vocabulary (standardized)		0.081***		0.079***
		(0.015)		(0.015)
Financial literacy (standardized)		0.023		0.017
		(0.014)		(0.014)
Log(Earnings)			0.009**	0.005
			(0.003)	(0.003)
Log(Net wealth)			0.013**	0.008
			(0.004)	(0.004)
N	943.000	943.000	943.000	943.000

* significant at 5%; ** significant at 1%; *** significant at 0.1%

Dependent variable is 1 if the respondent uses the internet regularly, 0 otherwise. Average marginal effects reported. Robust standard errors in parenthesis (couple-level clusters).

Table 4.4: Probit model of determinants of internet access, with income and wealth - CogEcon Release 2 only

	(1)	(2)	(3)	(4)
Age	-0.014***	-0.010***	-0.010**	-0.008*
	(0.003)	(0.003)	(0.003)	(0.003)
Female	0.043	0.041	0.050	0.042
	(0.058)	(0.054)	(0.057)	(0.053)
Education	0.053***	0.014	0.043**	0.011
	(0.013)	(0.016)	(0.014)	(0.016)
Coupled	0.115	0.083	0.115	0.090
	(0.066)	(0.062)	(0.068)	(0.064)
Number Series (standardized)		0.116**		0.107**
		(0.037)		(0.038)
Retrieval Fluency (standardized)		0.019		0.023
		(0.033)		(0.033)
Vocabulary (standardized)		0.071*		0.068*
		(0.030)		(0.030)
Financial literacy (standardized)		0.010		0.012
		(0.032)		(0.031)
Log(Earnings)			0.014*	0.009
			(0.006)	(0.006)
Log(Net wealth)			0.006	0.000
			(0.010)	(0.010)
N	217.000	217.000	217.000	217.000

* significant at 5%; ** significant at 1%; *** significant at 0.1%

Dependent variable is 1 if the respondent uses the internet regularly, 0 otherwise. Average marginal effects reported. Robust standard errors in parentheses (couple-level clusters).

Table 4.5: Probit model of determinants of survey response

	(1)	(2)
	Release 1	Release 2
Internet access	0.122***	0.047
	(0.032)	(0.060)
Age	0.003*	0.004
	(0.001)	(0.003)
Female	-0.015	0.006
	(0.026)	(0.047)
Education	0.002	0.010
	(0.007)	(0.013)
Number Series (standardized)	0.035*	0.020
	(0.018)	(0.033)
Retrieval Fluency (standardized)	0.015	0.028
	(0.015)	(0.033)
Vocabulary (standardized)	-0.013	-0.053
	(0.016)	(0.032)
Coupled	0.046	-0.033
	(0.029)	(0.061)
N	874.000	295.000

* significant at 5%; ** significant at 1%; *** significant at 0.1%

Average marginal effects reported. 30 web-eligible respondents from Release 1 who did not respond until a final reminder with an attached paper questionnaire are excluded. Robust standard errors in parentheses (couple-level clusters).

Table 4.6: Means of selected outcomes, with and without propensity score weights

	(1)		(2)		(3)		(4)	
	Full Sample	Web-mail	Web unadjusted		Web-adjusted (No cognition)		Web-adjusted	
	Mean	Diff.	Mean	Diff.	Mean	Diff.	Mean	Diff.
Diabetes	0.155	***	0.135	-0.020	0.156	0.002	0.148	-0.006
High blood pressure	0.484	***	0.428	-0.056	0.488	0.004	0.480	-0.003
Cancer	0.130	***	0.107	-0.023	0.140	0.010	0.126	-0.004
Lung disease	0.057	**	0.045	-0.012	0.075	0.018	0.062	0.005
Heart condition	0.187	***	0.143	-0.044	0.188	0.001	0.168	-0.018
Stroke	0.050	***	0.034	-0.016	0.057	0.007	0.048	-0.001
Arthritis	0.450	***	0.416	-0.034	0.475	0.025	0.457	0.007
Fallen last 2 years	0.299		0.273	-0.026	0.269	-0.030	0.290	-0.009
Ever smoked	0.523		0.521	-0.002	0.562	0.039	0.536	0.013
Currently smoke	0.200	**	0.170	-0.031	0.151	-0.049	0.156	-0.044
Memory disease	0.019	*	0.012	-0.007	0.011	-0.008	0.013	-0.006
Psychological problem	0.133		0.144	0.011	0.133	0.000	0.145	0.012
Trouble sleeping	2.495	*	2.520	0.025	2.513	0.018	2.506	0.011
Incontinence	0.211		0.200	-0.011	0.233	0.022	0.220	0.009
Work for pay	0.505	***	0.615	0.110	0.497	-0.008	0.530	0.025
Own home	0.895	***	0.916	0.021	0.896	0.001	0.893	-0.002
Retirement wealth	184	***	225	23%	189	3%	192	5%
Total wealth	909	**	1118	23%	996	-11%	1013	2%

Each cell is a separate estimates of the mean of the variable specified in the row. Columns specify what sample is used and what weights are used. For web-mail differences in column (1), * significant at 5%; ** significant at 1%; *** significant at 0.1%. Retirement wealth and total wealth are reported in thousands of dollars, and their respective full sample / web sample differences are reported as percents. Own home, retirement wealth (thousands of dollars), and total wealth (thousands of dollars) means were calculated using only the CogEcon sample. All others were calculated using the CogUSA sample with the sample sizes specified in the table.

CHAPTER V

Conclusion

This dissertation is an empirical examination of human capital and aging. While the three essays are separate and distinct, in all three I consider the role of cognition, which can be interpreted as the ability parameter of a human capital accumulation equation. In the first two essays, I focus on human capital investments related to the household division of labor–specifically for the task of managing family finances. I find empirical patterns that initially appear to reflect sub-optimal human capital decisions, but I show how these patterns actually reflect rational responses to incentives. First, I provide a life-cycle interpretation of the gender gap in financial literacy and show that women do indeed respond to the risk of widowhood by acquiring financial human capital. Second, we find that households often do not switch their financial respondent even after s/he has become demented. However, households with personally invested retirement wealth are much more responsive to a diagnosis of a memory-related disease like Alzheimer's disease relative to those without such wealth holdings. In the third essay, we find that an internet-only survey of older Americans will select highly on both quantitative and verbal forms cognition, even after controlling for age and education. Together, these three essays shed light on aspects of the accumulation and deterioration of human capital as individuals age.

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