Online Appendixes

"Aging and Strategic Learning: The Impact of Spousal Incentives on Financial Literacy" by Joanne W. Hsu

1 Data appendix

1.1 Response rates

1,222 participants who completed the CogUSA study[1][2] were invited to complete the CogEcon study.[3] 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: $187/243 = 76.95\%$.

[1]The Cognition and Aging in the USA Study (2011) is part of the Unified Studies of Cognition (CogUSC) led by cognitive psychologist Jack McArdle at the University of Southern California. More information about CogUSA is available at cogusc.usc.edu.

[2]The first wave of CogUSA 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, .36 more years of education ($p < 0.2$).

[3]The Cognition Economics Study (2012) is supported by National Institute on Aging program project P01-AG026571, "Behavior on Surveys and in the Economy Using HRS," Robert J. Willis, PI. More information about CogEcon is available online at http://ebp-projects.isr.umich.edu/CogEcon/surveys.html.

These response rates yielded the following CogEcon respondents:

- 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.

1.2 Derivation of the analysis sample

The Cognitive Economics Study 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 both 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.

1.3 Financial knowledge survey questions used in the analysis

The full text of all questions is available in the documentation section of the CogEcon website (http://ebp-projects.isr.umich.edu/CogEcon/surveys.html). The financial literacy battery includes questions 17 through 41. Questions 18, 19, 22, 24, 25, 28, 31, 33, 34, 35, 36, 39, 40, and 41 are considered stock questions, while questions 17, 20, 21, 23, 26, 27, 29, 30, 32, and 38 are categorized as unrelated to stocks. Whether a respondent sees the true or false version of a question is randomized. The respondent is asked whether s/he thinks the statement is true or false, and how sure s/he is of that response on a 12-point scale based

on her/his degree of certainty (see Figure A1). 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.

All of these questions have been fielded on the RAND American Life Panel (Delavande et al., 2008); 16 of these questions were also fielded on the 2008 wave of the Health and Retirement Study (Lusardi et al., 2009), and twelve were fielded on the Wisconsin Longitudinal Study.

Regressions in Section V.D.2 use proxies for financial knowledge from the Health and Retirement Study 2002-2010 waves[4]: questions P097 (following the stock market) and P047 (subjective expectations of stock market having positive returns in one year).

Additional analyses in Section 3.2 of this online appendix use two other measures of financial knowledge from the Cognitive Economics 2008 Survey: questions 12 (self-rated financial knowledge) and 10 (self-rated stock knowledge). Additional outcomes are drawn from the Cognitive Economics 2009 survey: questions 89 (historical knowledge) and 82 (following the stock market).

1.4 Designating a CFO for wealth measurement

Households in the analysis sample have two reports for wealth questions, one from each spouse. I select a spouse's responses for the net worth calculation based on the following algorithm using responses to the question, "Which member of the immediate family is most knowledgeable about your family's assets, debts, and retirement planning?":

1. If the husband says "me," select the husband
2. If the wife says "me," select the wife (replacing the existing assignment)
3. If CFO is unassigned and the husband says "my spouse/partner," select the wife
4. If CFO is unassigned and the wife says "my spouse/partner," select the husband
5. If CFO is unassigned and either spouse says "both me and my spouse/partner," select the husband
6. If CFO is unassigned and either spouse says "someone else in the family," select the husband.

[4]The Health and Retirement Study (2014) is sponsored by the National Institute on Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan.

2 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 at 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:

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

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:

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

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

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

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

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

3 Additional robustness checks

3.1 Alternative widowhood measures

The model presented suggests that the returns to financial knowledge depend on the entire survival function of both husbands and wives and are therefore not linear in age. Given the non-monotonic relationship between age and survival probabilities, the returns should

still be positively associated with the husband's age and negatively associated with the wife-husband age gap. Column (1) of Table A3 reports estimates of Equation (5) replacing the time to widowhood and duration of widowhood with husband's age and the wife-husband age gap, and the results, while imprecisely estimated, are consistent with the main results.

As a further robustness check, I use alternative widowhood measures constructed using a few special features of the CogEcon data. While life table measures mask much of the variation in actual survival expectations, I use 10-year subjective survival expectations and objective survival probabilities predicted using each person's observable characteristics. Converting single-point probabilistic measures to measures in time units as implied by the model and 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.

These survival probabilities can be used to compute a probability of widowhood in ten years, that is, the joint probability of the wife's survival and husband's mortality.[5] Therefore, Equation (5) is re-estimated replacing the time to widowhood and duration of widowhood with the probability that a woman becomes a widow in ten years. These results generally confirm that the higher the probability of widowhood, the greater the wife's level of financial knowledge.

3.1.1 Life table probabilities

As a baseline, I construct 10-year widowhood probabilities using 10-year-ahead survival probabilities for both the husband and the wife from the 2004 period life tables. These are defined as $\prod_{x=age}^{10}(1-q(x))$, where $q(x)$ is the life table hazard of dying between age x and $x+1$. As in the main analysis, using life tables requires the assumption that a woman's expectation of widowhood are, in expectation, the same as those in these life tables.

3.1.2 Subjective survival probabilities

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 for spouses who are younger than 50).

Because the time horizon of the subjective survival questions varies, responses for different time horizons are not comparable at face value. I interpolate a 10-year-ahead survival probability by assuming that one-year hazard rates are constant over the 11-15 year horizons.[6] The implied widowhood probabilities have a 0.31 correlation with those derived from life tables, though their means are very similar (see Table A2). A number of studies have analyzed the relationship between subjective survival probabilities and actual mortality. Subjective probabilities have been shown, on average, to be close to those in life tables, and they covary

[5]Note that there are three alternatives to becoming a widow in ten years: both spouses remain alive, both spouses have passed away, and the wife has passed away while the husband survives. In all three of these situations, the woman would not need additional financial knowledge.

[6]I retain the original values of those who report 0 and 100 percent probabilities.

with health conditions, smoking and socio-economic status in the same way as actual mortality outcomes (Hurd and McGarry, 1995). On average, the probabilities are consistent with individuals' observed mortality patterns (Elder, 2013; Smith et al., 2001) and are updated by individuals in response to new information like the onset of health conditions (Hurd and McGarry, 2002; Smith et al., 2001).

Since one can argue that individual life-cycle behavior reflects subjective beliefs rather than actuarial probabilities, subjective probabilities are suited for use in robustness checks. 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, and that both interpret the 0-100 scale identically.[7]

3.1.3 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 as of 2008. The covariates include 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. These predicted probabilities have a 0.76 correlation with life table probabilities, and have less variance and are of lower levels than the subjective probabilities (see Table A2).

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 objective survival probabilities are predicted with error, the variance-covariance matrix of the main estimating equation will require an adjustment for the generated regressors. I use the two-step maximum likelihood estimation described in Murphy and Topel (1985). Due to the large sample size of the first-stage HRS estimates, the correct standard errors are only slightly larger than the uncorrected ones.

3.1.4 Results with alternate probabilistic widowhood measures

Regression results are reported in columns (2) through (4) of Table A3. Column (2) presents results using the ten-year widowhood probabilities from U.S. life tables; column (3) from subjective survival probabilities, and column (4) from objective predicted probabilities. Since all of these measures are ten-year widowhood probabilities, the coefficients are comparable across specifications. 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, albeit more so for life tables than the predicted probabilities. On the other hand, the subjective survival

[7] 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.

measures are subject to survey noise and rounding,[8] which should lead to attenuation bias.

All of the regressions reported in Table A3 show that the effect of widowhood probabilities on financial literacy is positive, as predicted by the model. The effect of objective predicted probabilities is precisely measured at the 5 percent level; a 10 percentage point increase in the probability of widowhood is associated with an increase in the woman's financial literacy of 0.19 standard deviations relative to her husband's score.

3.2 Other financial knowledge outcomes

The survey also includes other measures of financial knowledge, which I analyze separately. The 2008 survey asks each respondent to rate his own ability to deal with day-to-day financial matters and his understanding of the stock market. In 2009, respondents were asked in a follow-up survey how often they follow the stock market, as well as whether they think stock returns have exceeded bond returns over the last 100 years.[9] 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 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. Because most these measures are absolute levels rather than relative to their husbands, and those that can be differenced (self-rated skills) are not only ordinal but are unlikely to be answered on the same latent scale by husbands and wives, 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 they approach widowhood.

3.2.1 Self-rated knowledge

Respondents are asked the extent 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, from strongly agree (six points) to strongly disagree (one point). Summary statistics for these and subsequent financial knowledge measures are reported in the first row of Table A4. On average, women report much higher levels of financial skills than stock skills. The first two columns of Table A4 show ordered probit regressions of women's self-rated measures on the expected time to widowhood, 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, though the effects are not precisely measured.

[8] Manski and Molinari (2010) find evidence of rounding in expectations questions on the HRS. CogEcon asks a number of follow-up questions in the expectations module that suggest the rounding that occurs is symmetric. If noise is introduced through rounding or through general survey noise like classical measurement error, these measures will produce attenuation bias in my estimates.

[9] The follow-up was designed to capture changes in respondents' financial situations in the wake of the economic crisis. The full financial literacy battery was not re-administered in the follow-up, so the two waves cannot be used for longitudinal analysis of the main financial literacy outcomes used here.

3.2.2 Historical knowledge and following the stock market

Another outcome measure is knowledge about the historical equity premium. The CogEcon survey asked in a followup in 2009: "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, or both returns were the same. Between 1908 and 2006, the arithmetic average of annual total real stock market returns was 8.5 percent, while that of 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. 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 column (5) of Table A4. As predicted by my model, women with less time to widowhood are more likely to answer correctly.

The CogEcon post-crash followup also asks respondents "How closely do you follow the stock market?" with the answer choices "very closely" and "somewhat" coded as one, and "not at all" or non-response coded as zero. 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. Average marginal effects of a probit of this variable is reported in column (6) of Table A4. As the time to widowhood shortens, women are more likely to follow the stock market more closely. This is consistent with women learning more about finances as they approach widowhood.

References

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Cognition Economics Study. 2012. CogEcon Public Core Release (Version 1.0) public use dataset. Produced and distributed by the University of Michigan with funding from the National Institute on Aging (grant number NIA P01 AG026571), Ann Arbor, MI.

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Appendix figures and tables

Figure A1: A financial literacy question on CogEcon

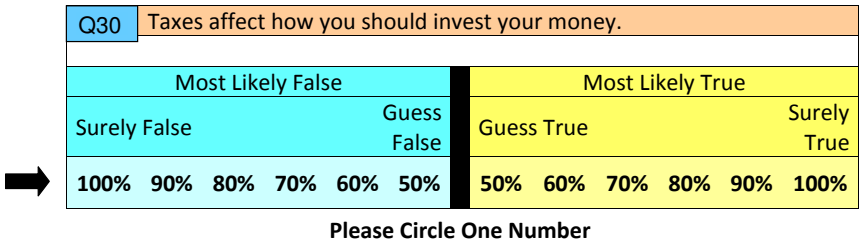
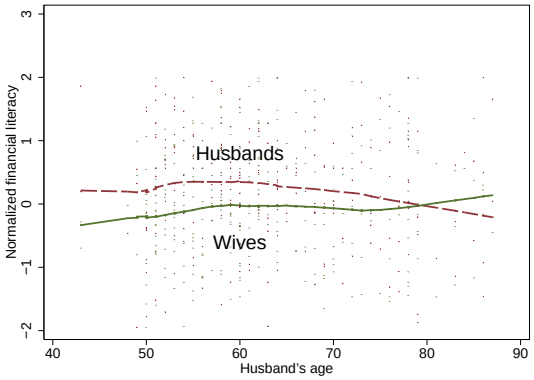
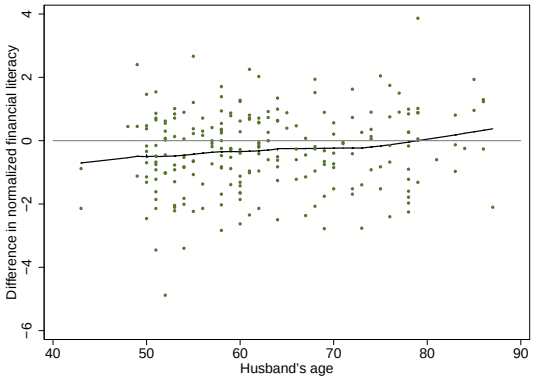


Figure A2: Financial literacy (no stock questions) and husband's age

(a) Financial literacy of couples



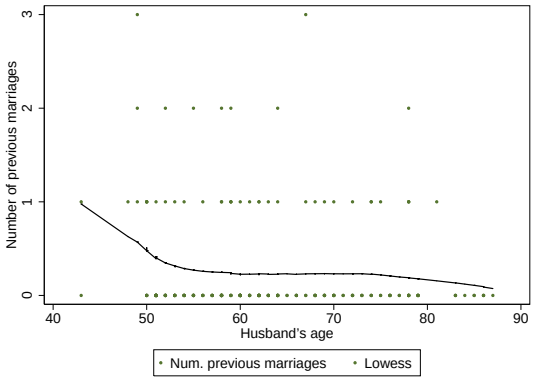
(b) Wife-husband difference in financial literacy



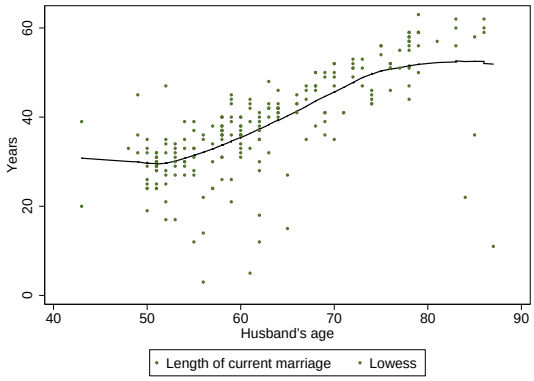
Data sources: CogEcon and CogUSA

Figure A3: Demographic and wealth patterns in CogEcon, by husband's age

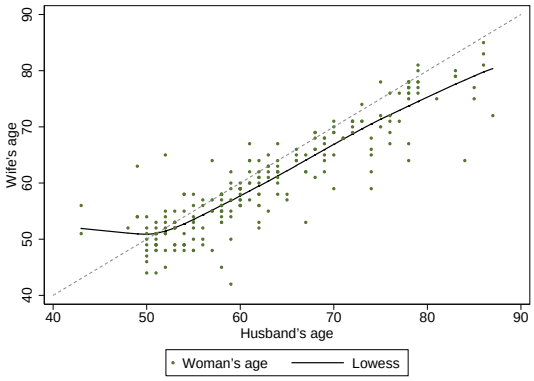
(a) Number of previous marriages for women



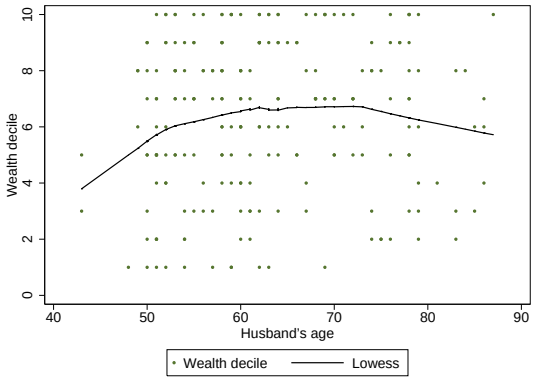
(b) Length of current marriage



(c) Ages of husbands and wives



(d) Wealth deciles



Data sources: CogEcon and CogUSA.

Table A1: Within-couple consistency of responses to "Who is most financially knowledgeable"

	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 percent) report inconsistent answers about who is the household CFO. Data source: CogEcon.

Table A2: Robustness check: Summary of 10-year widowhood probabilities

Measure	**Mean**	**SD**	**Min**	**Max**	**N**
Life table	0.184	0.115	0.037	0.656	224
Subjective	0.202	0.162	0.000	0.768	204
HRS predicted	0.101	0.129	0.001	0.622	214

Data sources: CogEcon and Health and Retirement Study.

Table A3: Robustness check: Financial literacy regressions using age and alternative widowhood measures

	(1)	(2)	(3)	(4)
	Age	10-year Widowhood Probabilities		
		Life table	Subjective survival	HRS predicted
Husband's age	0.012			
	(0.008)			
Wife-husband age difference	-0.011			
	(0.018)			
Pr(Widow)		1.204	0.245	1.934**
		(0.780)	(0.533)	(0.812)
R^2	0.017	0.130	0.143	0.148
F	1.868	2.085	2.112	2.330
N	224	211	192	203

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

Dependent variable: wife-husband difference in normalized financial literacy scores. Control variables: wealth decile, and wives' and husbands' health, education, Number Series, Visual Matching, Working Memory, and Matrix Reasoning. Data sources: CogEcon and Health and Retirement Study.

Table A4: Regressions of other financial knowledge outcomes: Cognitive Economics Study

	(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 (AME)
Mean dependent variable	*5.03*	*2.99*	*0.005*	*-0.697*	*0.577*	*0.513*
Expected time to widowhood	-0.018	-0.020	-0.025	-0.016	-0.014	-0.004
	(0.021)	(0.020)	(0.020)	(0.020)	(0.009)	(0.009)
Expected duration of widowhood	-0.063	0.029	-0.039	0.032	0.019	-0.021
	(0.041)	(0.040)	(0.040)	(0.041)	(0.021)	(0.018)
N	236	230	215	208	182	238

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

Ordered probit regressions in columns (1) through (4), and probit regressions in columns (5) and (6), with dependent variables specified in the column headers. Coefficients reported in all columns, except columns (5) and (6) which report average marginal effects. Control variables: wealth decile, and wives' and husbands' health, education, Number Series, Visual Matching, Working Memory, and Matrix Reasoning. A description of these questions are found in Section 1.3 of this online appendix. Data sources: CogEcon and CogUSA.