HOUSEHOLDS RISK PREFERENCES AND PORTFOLIO ALLOCATION: A COLLECTIVE APPROACH*

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ABSTRACT

This work investigates the decision-making process of households' portfolio allocation using the English Longitudinal Study of Ageing data. I develop a collective portfolio choice model where households decide about stock market participation and then choose the optimal allocation. The model accounts for household risk tolerance, measured as a weighted sum of the households' members risk preferences. I study the determinants of household portfolio using the Heckman approach to control for selection into participation. The results show that household risk preferences affect portfolio allocation but not stock market participation. Last, comparing the collective and the standard unitary model, I show that the former approach fits significantly better the data.

Keywords household portfolio; collective model; risk aversion.

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1 Introduction

The workflow of the household decision-making process is of core interest in economics, and understanding its mechanisms might spread new light on consumers behaviours and choices. In this contest, household finances are of particular interest because of their potential impacts on households present and future economic status. For example, the responsibility of saving for retirement falls largely into individuals' hands, as well as the decision of pension schemes or the choice of credit cards and bank accounts. Household portfolio allocation is affected and affects large part of these financial choices and was broadly studied over past years. The standard models generally used to study portfolio choices predict that each household holds a fraction of its wealth in risky assets if the equity premium is positive (e.g.: Samuelson (1975) and Merton (1969)). These models rely on the so-called unitary approach, which considers the household as a unique decision unit that behaves as a single agent with well-defined preferences.

Chiappori (1988) shades new light on the household decision-making process, introducing the collective model. In this model, households behave as a multi-dimension system of several members, which may show different preferences. An intrahousehold bargaining process is assumed to take place and to drive the final choice among the household members, combining their preferences. The collective model is largely used in studies concerning household labour supply (e.g.: Chiappori (1988), Chiappori (1992)), consumption choices (e.g.: Cherchye et al. (2007), van Leeuwen et al. (2020)) and household production decisions (Apps and Rees (1997)), but to date only a few studies household portfolio allocation under this perspective, as Gomes et al. (2020) highlight. Among the few studies that adopt a collective approach to investigate household financial decisions, Addoum et al. (2016) study the connection between marital decisions, consumption, and household investments. They show that changes in marital status or spouses' relative income imply a significant reallocation of the household portfolio. Olafsson and Thornquist (2018) use the potential earnings of spouses, instead of actual earnings, as a proxy of the household decision-makers bargaining powers. In line with Addoum et al. (2016), they show that the higher is the weight of the wife, the lower is the household probability of holding equity. In other words, if the female partner has higher decision power, the household portfolio is less risky. Last, Gu et al. (2021) investigate the gender gap of bargaining power in the household portfolio decision making process. Their results show that the household portfolios reflect the preferences of the male partner 44% more than the female partner characteristics, with gender norms that play a relevant role in explaining this large difference.

This paper assumes that a bargaining process takes place between the two partners and drives the household portfolio choice. In this decision process, household members decide about stock market participation and optimal wealth allocation simultaneously. The bargaining process mainly concerns the household risk preferences, that play a crucial role in portfolio choices as largely documented in the literature (e.g.: Zhang (2017)). The relevance of risk aversion in this contest is a natural consequence of the uncertainty and the volatility that characterizes financial markets.
This paper investigates the household financial choices and their decision-making process, studying whether in married/co-living couples there is a partner that influences more the financial decision. Moreover, assuming that the household portfolio choice reflects partners' risk preferences, I study how these preferences combine and determine the portfolio allocation.

I derive a model of household portfolio allocation in which partners decide first about household risk preferences and then about stock market participation and optimal allocation of financial resources. Then, I study the effect of risk preferences on portfolio allocation using the English Longitudinal Study of Ageing (ELSA) panel dataset. Finally, I compare the standard unitary approach with the proposed collective approach. The results show that the collective model fits significantly better the data, and that a higher partners risk tolerance increases the share of wealth allocated in risky assets but does not affect household stock market participation.

First, this paper contributes to the household portfolio choice models with limited stock market participation (Gomes and Michaelides's (2005); Wachter and Yogo (2010)). Generally, researchers treated the household as a single decision-making unit and explain the large stock market non-participation rate with stock market participation costs. The literature refers to these models as unitary models and identifies the preferences of the decision-making unit with the male partner or the household head preferences. About costs, Vissing-Jorgensen (2002) introduces three types of participation costs: fixed or lump-sum entry costs, variable transaction costs and per period trading costs. My model departs from the standard unitary household assumption and follows the collective approach introduced by Chiappori (1988). The collective model was used to study households labour supply and consumption decisions, while portfolio allocation receives little attention, as Chiappori and Mazzocco (2017) and Gomes et al. (2020) describe.
I introduce a portfolio decision model that includes the household risk preferences measured as a weighted average of partners risk preferences. The weights can be interpreted as each agent bargaining power. Therefore, the partner who holds the "purse strings" (Bertocchi et al. (2014)) would have a higher decision power and influence in the determination of the household risk tolerance.
Second, I investigate the effect of group risk preferences in the household portfolio allocation process, that is a particular case of group decisions. Through the last decade, many studies investigate how risk preferences differ when agents act as groups and individually. De Palma et al. (2011) studies the aggregation of preferences of spouses concluding that their decision-making process is dynamic. At the beginning of the experiments, the male partners show more decision power, while this effect gradually decreases as time passes by among the game. Abdellaoui et al. (2013) use certainty equivalent methods to derive time and risk preferences of couples, assuming prospect theory. They study the decision-making process separately for individuals and couples, revealing that the probabilistic risk attitudes of single agents and couples showed similar judgmental biases. They also show that couples risk attitudes are a combination of spouses' preferences and that the correlations between risk attitudes of couple members are weak, but significant. Charness and Sutter (2012) show that groups (composed by stranger) are more rational than individuals, and their behaviours are in line with game-theoretic prediction. In other words, groups exhibit less behavioural biases than individuals. The studies mentioned so far highlight the characteristics of the group risk preferences, while this paper focuses on how those preferences combine and their role in the determination of the portfolio decision.

The rest of the paper is organized as follow: Section 2 introduces the collective household model for household's portfolio allocation. Section 3 describes the ELSA dataset, Section 4 presents the empirical analysis and Section 5 concludes.

2 Theoretical model

This section introduces the theoretical model that studies the heterogeneity of household portfolio choice considering the risk preferences of both household decision-makers. The model assumes that the household members decide first about the household risk preferences, and then about the optimal portfolio allocation. I use a mean-variance utility function[3] where the household risk tolerance is measured as a weighted average of partners risk preferences.

2.1 Collective model: household utility and weighted risk aversion

Assume that the economy has only two assets: a risk-free asset (representative of the treasury bill market) and a risky asset (representative of the stock market). The two assets have different expected returns: the risk-free asset has certain returns r while the risky asset has returns $\tilde{r} = r + \tilde{s}$, where $\tilde{s} \sim N(\mu_s, \sigma_s^2)$. Each household *h* has two decision makers (partners), agents *a* and *b*, and holds the initial wealth w_h. The household wants to maximize its utility $u(W_h)$, where W_h represents the expected household wealth after assets returns. The crucial decision is about α, that identifies the proportion of wealth w_h allocated in risky assets.

The household wealth W_h is:

$$W_h = w_h[(1-\alpha)(1+r) + \alpha(1+\tilde{r})] = w_h[(1+r) + \alpha\tilde{s}] \tag{1}$$

Thus, the household utility maximization program can be written in terms of the value function V_h as a function of α:

$$\max_{\alpha} V_h(\alpha) = \max_{\alpha}\ u(W_h) \ = \ \max_{\alpha}\ \ u(w_h[(1+r) + \alpha\tilde{s}]) \tag{2}$$

Assuming CARA (exponential) utility function of the form $u(z) = -e^{-\rho z}$, where ρ is the absolute risk aversion coefficient, household utility becomes:

$$u(W_h) = -e^{-\rho_h W_h} \tag{3}$$

where ρ_h identifies the household risk preference. ρ_h is a weighted sum of the partners risk preferences, where the weights represents the bargaining power of each partner in the decision making process. Therefore, household risk aversion is:

$$\rho_h = \mu_a\rho_a + \mu_b\rho_b \tag{4}$$

where $\rho_{a,b}$ are the risk preferences of the household decision makers, and $\mu_{a,b}$ are the bargaining powers. I normalize the weights as follow:

$$\gamma = \frac{\mu_a}{\mu_a + \mu_b} \qquad (1-\gamma) = \frac{\mu_b}{\mu_a + \mu_b} \tag{5}$$

such that $\gamma \in [0, 1]$ and ρ_h becomes:

$$\rho_h = \gamma\rho_a + (1-\gamma)\rho_b \tag{6}$$

[3]Mean-variance utility is equivalent to CARA utility, as I show in Section A.1. Section A.2 of the Appendix provides a second version of the model where household utility is a weighted sum of partners utility .

Thus, $V_h(\alpha)$ in Equation 2 becomes:

$$\begin{aligned}\max_{\alpha} V_h(\alpha) &= \max_{\alpha} E[u(W_h)] = \max_{\alpha} E[-e^{-\rho_h W_h}] \\ &= \max_{\alpha}\ \rho_h w_h[(1+r) + \alpha\mu_s - \frac{1}{2}\alpha^2\sigma_s^2\rho_h w_h]\end{aligned} \tag{7}$$

Solving the first order condition for α, the optimal share of wealth allocated in risky assets is:

$$\alpha = \frac{\mu_s}{\sigma_s^2 w_h \rho_h} \tag{8}$$

The optimal α is proportional to the risk premium μ_s and decreasing in the variance (risk) of returns and in household risk aversion.
Under the condition of Equation 8 and with the strong assumption that all households have the same information about stock market returns, the heterogeneity in households' portfolio depends on wealth and risk preferences[4].

2.2 Preference shifter

The solution proposed in Equation 8 implies that the heterogeneity in α depends entirely on risk preferences and household wealth, assuming that individuals have common priors (i.e., they all experience the same stock expected returns and return variance). However, it is unlikely that household demographics such as education, income or age do not affect household portfolio decision.
In what follows, I allow household characteristics to affect the household portfolio choice process through risk preferences. Risk preferences now are a function of household and partners characteristics, $\rho_h = \rho_h(z)$, where $z = \beta x + \epsilon$. x is a vector of household demographics (e.g.: ages, education, income), β is a parameter matrix and ϵ is the i.i.d. error term that represents the unobserved variation in taste shifts across households. Therefore, the maximization problem in Equation 7 becomes:

$$\max_{\alpha} V_h(\alpha) = \max_{\alpha}\ [\rho_h(z)]w_h[(1+r) + \alpha\mu_s - (\frac{1}{2}\alpha^2\sigma_s^2 w_h[\rho_h(z)])] \tag{9}$$

and the optimal α is:

$$\alpha = \frac{\mu_s}{\sigma_s^2 w_h[\rho_h(z)]} \tag{10}$$

Equation 8 and Equation 10 show that the optimal proportion of wealth allocated in risky assets depends on risk preference, stock market returns and wealth itself. However, the former implies that household or individual demographics do not affect portfolio choices, while a large amount of literature shows that they influence household finances. Education (Cooper and Zhu (2016), Poterba et al. (2013)), health (Poterba et al. (2013)), age (Ameriks and Zeldes (2004), Bertocchi et al. (2014)), wealth (Wachter and Yogo (2010)) and financial literacy (Jappelli and Padula (2015), Lusardi (2008)) are only some of the determinants of household portfolio decision. Thus, non including them in the model may produce severe bias in the estimation.

[4]The assumption about homogeneous expectation allows to infer the implied degree of absolute risk aversion of the stockholders, i.e. only for those households whose share of wealth allocated in risky assets is observed.

The solution proposed in Equation 10 shows that the optimal share of wealth allocated in risky assets is positive for each household. In other words, if the risk premium μ_s is positive, every households invests a fraction of its financial wealth in the risky asset, as in Samuelson (1975) and Merton (1969). However, a large fraction of households does not hold stocks: this is the so-called stock holding puzzle (e.g.: Guiso et al. (2003) describe and discuss this issue across European countries).

2.3 Introducing stock market participation costs

One of the possible explanations of the stock holding puzzle are stock market participation costs. They reduce risky assets' expected returns and increase the probability of losses. Therefore, depending on the amount that they have to pay, the households may decide to not participate. Vissing-Jorgensen (2002) identifies three main types of costs that affect the stock market participation choice: fixed entry costs (learning about financial markets), variable transaction costs (trading fees or bid-ask spread) and per period trading costs (broker subscription or bank fees). Working with US data, Vissing-Jorgensen (2002) estimates that a relatively low per period cost (50$ per month) explains the non participation of half of non-stockholders.

Including costs in the portfolio choice process means that the household utility maximization problem has now two steps: the first concerns the stock market participation decision (i.e.: $\alpha > 0$ or $\alpha = 0$) and the second solves the utility maximization problem, following Equation 10. In case of costs, the expected household wealth after assets returns W_h is described by the following framework:

$$\begin{aligned} &\alpha = 0 \rightarrow W_h = W_{hs} = w_h[(1+r)] \\ &\alpha > 0 \rightarrow W_h = W_{hr} = w_h[(1-\alpha)(1+r) + \alpha(1+r+\tilde{s})] - C \end{aligned} \tag{11}$$

where C are the stock market fixed entry costs payed at the end of the period. The household evaluates whether holding risky assets is convenient or not, considering that in case of stock market participation it has to pay the lump sum cost C. W_{hs} and W_{hr} represent the expected household wealth at the end of the period in the two cases, non- and stock-holding, respectively. Then, the optimal amount allocated in risky assets α solves:

$$E[u'(w_h((1+r) + \alpha\tilde{s}) - C) \cdot w_h(\tilde{s})] = 0 \tag{12}$$

and $\alpha = 0$ is a solution of the maximization problem if and only if the equity premium is 0.
I define the certainty equivalent of the risk premium $\tilde{s}$ as follow:

$$E[u(w_h((1+r) + \alpha\tilde{s}) - C)] = u[w_h((1+r) + \alpha\hat{s}) - C] \tag{13}$$

where $\hat{s}$ represents the risk adjusted equity premium. Therefore, the household evaluates:

$$\begin{aligned} &\mathbf{E}[u(W_{hr})] > u(W_{hs}) \rightarrow \mathbf{E}[u(w_h((1+r) + \alpha\tilde{s}) - C)] > u(w_h(1+r)) \\ &\rightarrow w_h(1+r) + w_h\alpha\hat{s} - C > w_h(1+r) \\ &\rightarrow w_h > \frac{C}{\alpha\hat{s}} \end{aligned} \tag{14}$$

The condition derived in Equation 14 defines a threshold of minimum wealth for potential investors that is proportional to fixed costs *C*, optimal share of wealth allocated in risky assets, α, and the risk adjusted equity premium $\hat{s}$:

$$\bar{w} = \frac{C}{\alpha\hat{s}} \tag{15}$$

Then, when the household initial endowment of wealth is lower than $\bar{w}$, non-participation is the optimal choice, otherwise the household invests α share of its financial wealth in risky asset and pays *C* at the end of the period.

3 ELSA data

ELSA[5] is a longitudinal survey that collects data from a representative sample of English people aged 50+. It is a biennial survey (first wave in 2002) that aims to gather data to study all the problems and aspects of ageing, like social care, retirement, pension policies and social participation. The original sample of ELSA (first wave) was selected from the Health Survey for England (HSE[6]) respondents in the period 1998-2001. After the first survey in 2002, younger age groups are refreshed to balance the panel over time.

This paper works with Wave 8 of ELSA, which collects data about 8445 individuals, interviewed between May 2016 and June 2017. Researchers introduced a series of new and innovative measures that have broadened the scope of the study. Among the new questions, Wave 8 includes three self-assessed measures of risk preferences: one related to the general propensity to take risks, one to financial risk taking and one to the health domain. The purpose of this paper is to study the household portfolio decision process and these questions are of particular interest because of the crucial role of risk tolerance in financial choices. Several papers point out that these qualitative questions predict behaviour across various domains (Caliendo et al. (2009), Fouarge et al. (2014)), including risk preferences, when experimental data (like lottery choices) are not available.

In ELSA, the participants answer to the following general risk tolerance question:
Are you generally a person who is fully prepared to take risk, or do you try to avoid taking risks?
The respondent chooses an integer between 0 (Avoid taking risks) and 10 (Fully prepared to take risks)[7]. The predefined structure of the answers implies that they return a self-assessed measure of risk tolerance, rather than risk aversion. Then, these measures should be positively correlated with α according to Equation 10, where the risk measure, ρ_h, represents relative risk aversion.

The survey provides a second question, related to respondents patience:
Are you generally an impatient person, or someone who always shows great patience?
The respondent chooses an integer between 0 (Very impatient) and 10 (Very patient)[8].

The correlation between partners' risk preferences (both general and financial) is always positive and significant, but relatively weak (coefficient vary between 7.7% and 17.7%, depending on the

[5] Banks et al. (2021).The English Longitudinal Study of Ageing was developed by a team of researchers based at University College London, NatCen Social Research, the Institute for Fiscal Studies, the University of Manchester and the University of East Anglia. The data were collected by NatCen Social Research. The funding is currently provided by the National Institute on Aging in the US, and a consortium of UK government departments coordinated by the National Institute for Health Research. Funding has also been received by the Economic and Social Research Council.

[6] More information about HSE at `http://healthsurvey.hscic.gov.uk`.

[7] Financial risk tolerance question is: *Thinking specifically about your finances, spending and savings, are you a person who is fully prepared to take risk, or do you try to avoid taking risks?*

[8] Financial patience question is: *Thinking specifically about your finances, spending and savings, are you generally an impatient person, or someone who always shows great patience?*

specific item considered). The highest correlation is the one between the financial risk tolerance of husband and wife, that may be a signal of assortative matching of partners.

3.1 Sample selection and description

The survey distinguishes between three financial unit categories: singles, couples with separate finances and couples with joint finances. I use the data about individuals who are in a *couple with joint finances* aged less than 90 years. I select the male-female couples that have positive income (labour and pension income, including state benefit transfers), non-negative net financial wealth (the sum of savings and investments, subtracting financial debts from credit cards, overdrafts and other private debts but not mortgages) and share of net financial wealth allocated in risky assets between 0 and 1 (computed as the ratio between the amount of risky assets and the household net financial wealth). The final sample is composed of 1442 male-female couples, i.e. 2884 individuals[9].

Table 1 presents the households' basic demographics, while Tables 2 and 3 show the sample statistics of partners. Table 2 distinguishes partners by gender, while Table 3 distinguishes partners by financial respondent (and non-financial respondent). The financial respondent is the partner that answers to the Income & Asset section of the ELSA survey. Note that the selected households have *joint finances*: in these cases, the ELSA interviewer asks financial information only to one of the two spouses (financial respondent) and her/his answers are copied in the survey of the partner (non-financial respondent).

Table 1: ELSA Wave 8 summary statistics: *couples with joint finances*.

	All	Non-stockholders	Stockholders
hh obs	1442	371	1071
financial respondent: male	60.8%	54.9%	62.8%
hh income: mean (weekly £)	649.5	533.3	689.7
hh income: median (weekly £)	572.9	459.8	615.5
hh income: std (weekly £)	408.5	328.4	425.5
net financial wealth: mean (thousand £)	152.8	44.6	190.2
net financial wealth: median (thousand £)	66.9	13.0	101.0
net financial wealth: std (thousand £)	267.5	179.8	282.4
gross financial wealth: mean (thousand £)	153.7	45.3	191.1
gross financial wealth: median (thousand £)	67.1	15.0	103.0
gross financial wealth: std (thousand £)	267.4	179.8	282.2
stock share of financial wealth	32.6%	-	43.9%
share of hh income : male (γ)	66.6%	66.2%	66.7%
share of hh income : respondent (γ)	56.3%	54.9%	56.8%

Table 1 shows that around 75% of the households hold risky assets, where risky assets are defined as shares, bonds, stocks and shares ISAs or life insurance ISAs[10]. The share of stockholders is relatively high; however, ISAs products are widely spread among the English population and, included in the definition of *risky assets*, consistently increase the participation rate of households. Labour and pension income are higher among stockholders, as well as net and gross household financial wealth. This is in line with the fixed entry costs assumption of Section 2.3: a higher household wealth corresponds to a lower impact of fixed entry costs on the portfolio returns, increasing the

[9]Table 1 in the Appendix shows the sample selection procedure and the correspondent number of observations.

[10]ISA (Individual Saving Account) is a class of retail investment arrangement available to residents of the United Kingdom, with favorable tax condition. They offer four types of account: cash ISA, stocks & shares ISA, innovative finance ISA (IFISA) and lifetime ISA.

probability of participation[11]. The last two rows of Table 1 show the share of household labour and pension income of the financial respondent and male partner. On average, males contribute more to household income, with no difference between stockholders and non-stockholders. The financial respondent also generally holds a larger share of the household income, but the difference between the two partners is now ten percentage points lower. This is not a surprise, indeed around 40% of the financial respondent are females, which generally earn lower salary/pension.

Table 2 shows partner characteristics by gender. Comparing participants and non-participants households, a relevant difference concerns the education of partners: highly educated partners (college or higher education completed) are almost one-third among stockholders, while only one over ten non-stockholders complete college/university. With respect to risk preferences, males have higher risk tolerance than females. Wives show lower risk tolerance (general and financial) both when comparing stockholders and non-stockholders partners, in line with the literature. Moreover, the stockholders show a higher risk tolerance than non-stockholders, especially for financial risk preferences. Table 3 shows partner characteristics by financial and non-financial respondent. First, female financial-respondent are more among the non-stockholders, while the differences in age are negligible and the proportion of highly educated and low educated individuals is in line with Table 2. Concerning risk preferences, the differences between financial and non-financial respondents are tight: As mentioned above, this attenuation derives from the fact that 40% of the financial respondents are females, which shows a lower risk tolerance.

Table 2: ELSA Wave 8 summary statistics - male and female partners.

	All	Non-stockholders	Stockholders
age: male	68.5	68.4	68.6
age: female	66.2	66.3	66.1
low edu: male	32.5%	50.7%	26.2%
mid edu: male	41.9%	37.7%	43.3%
high edu: male	25.6%	11.6%	30.4%
low edu: female	29.9%	43.9%	25.0%
mid edu: female	48.5%	46.4%	49.2%
high edu: female	21.6%	9.7%	25.8%
general risk: male	5.0	4.8	5.1
general risk: female	4.2	4.1	4.3
financial risk: male	3.6	3.2	3.8
financial risk: female	2.9	2.8	2.9

Table 4 gives an overview of the households wealth (and portfolio) allocation. Total household wealth is increasing in household income and is higher among stockholders. Comparing the first three quartiles of the income distribution, the wealth of stockholders is almost twice the wealth of non-stockholders. Last, the households with higher income are generally younger. On average, housing accounts for more than 70% and less than 65% of total wealth for non- and stockholders, respectively, with at least five percentage points of difference between the two categories. Risky assets account for 10-15% of the household wealth, and their share is independent of income and rather stable among stockholders portfolio. This pattern is in line with the entry costs hypothesis presented in Section 2.3: comparing two households with the same optimal α and different financial wealth, the household with lower financial wealth invests a lower amount of money in risky assets,

[11] Assume that there are two households with the same risk preferences and demographics, but different financial wealth. In other words, the households have the same optimal α, but the total amount of money allocated in risky assets differ. The household with a higher financial wealth invests a higher amount in risky assets and obtains higher returns (in absolute terms), with a lower impact of fixed costs on its finances.

Table 3: ELSA Wave 8 summary statistics - financial respondent and non-respondent partners.

	All	Non-stockholders	Stockholders
financial respondent: female	39.2%	45.0%	37.2%
age: respondent	67.5	67.7	67.4
age: non respondent	67.2	67.0	67.2
low edu: respondent	29.2%	47.2%	23.0%
mid edu: respondent	45.1%	41.0%	46.6%
high edu: respondent	25.6%	11.9%	30.4%
low edu: non respondent	33.2%	47.4%	28.3%
mid edu: non respondent	45.2%	43.1%	46.0%
high edu: non respondent	21.6%	9.4%	25.8%
general risk: respondent	4.8	4.7	4.8
general risk: non respondent	4.5	4.3	4.6
financial risk: respondent	3.3	3.0	3.5
financial risk: non respondent	3.1	3.0	3.1

therefore the potential financial returns may not cover the fixed entry costs and the decison-makers decide to not hold risky assets.

These statistics are in line with the findings of Banks and Smith's (2000). They study the evolution of English households portfolio composition between 1980 and 2000, working with the Family Expenditure Survey (FES) and the Financial Research Survey (FRS) data. They show that housing and pensions funds account for the largest share of the household portfolio, with a progressive shift from housing towards financial assets over time. This shift was the consequence of tax-favoured products (TESSAs, replaced by ISAs in 1999) created by the government to try to encourage pension savings during the 90s.

Table 4: Composition of total gross household wealth by stock market participation and household labour and pension income quartile[a].

					in wealth %					
stock market participation	income quartile	obs	age male	wealth (thousands £)	housing	safe assets	risky assets	physical wealth	debt (£)	mortgage (thousands £)
No	1^{st}	145	71	246	68,7	27,6	0,0	4,5	446	1.8
	2^{nd}	110	69	220	70,7	32,1	0,0	2,5	615	5.0
	3^{rd}	66	66	327	75,9	21,5	0,0	3,3	1.017	8.8
	4^{th}	50	64	680	73,8	17,1	0,0	9,5	1.196	45.4
Yes	1^{st}	216	70	514	63,4	15,1	13,3	8,4	487	6.4
	2^{nd}	254	69	461	66,6	15,8	11,7	6,1	493	4.0
	3^{rd}	290	69	608	65,3	14,8	14,2	6,1	1.097	4.1
	4^{th}	311	67	905	60,2	14,1	15,6	10,5	1.454	17.5

[a] *wealth* is net total household wealth, *housing* is gross housing wealth (the value of owner occupied primary housing before mortgage debt is subtracted), *safe assets* are money invested in "safe" assets such as bank accounts, savings accounts and cash ISAs, *risky assets* are money invested in "risky" assets such as shares, bonds, stocks and shares ISAs or life insurance ISAs, *physical wealth* represents alternative investments (second homes, farm or business property, works of art etc), *debt* is credit cards, overdrafts, other private debt but not mortgages.

3.2 Weights

The model in Section 2 defines ρ_h as a weighted household risk tolerance, where weights are the normalized bargaining powers of partners, γ and $(1-\gamma)$ respectively. Measuring the bargaining powers of household members is one of the main issues of collective models. These powers may change relative to the kind of decision that the household is taking (e.g., the decision-making

processes of financial choices may differ from other consumption choices like employment or childcare).
The first study that investigates the within household allocation sharing rule and its determinants is Browning et al. (1994). They show that the allocation of resources is proportional to the relative share of household income of partners. In other words, the income pooling hypothesis, i.e. that it is the household total income that matter for the decision outcomes, is not consistent with the data. Their conclusion shows that it is the share of household income of each partner that affects the intrahousehold allocation of resources. Recently, Attanasio and Lechene (2014) study the within-household shift in bargaining power using data about the cash transfer program *Progresa* in rural Mexico. This state program generates a large variation in the wife's relative household income (about 20% of household total expenditures), explicitly changing the control of resources within the treated households. They show that this shift changes the balance of power within the couple, concluding that one of the determinants of the within-household bargaining power is the share of the current income of each partner.

I follow these results to construct a measure of partners bargaining powers. The couples of the sample manage their finances jointly and have a unique, shared household wealth. Within the household, it is likely that one partner earns more than the other. Therefore, the income insurance that the high-income partner receives is lower than the one that he/she provides. To compensate this risk gap, the high-income partner has a higher control over household finances. Then, he/she can adjust the household risk, and consequently the household portfolio, to cover the partial income insurance that the partner can not provide. Concluding, I assume that the bargaining power of each partner is proportional to their own share of household income, using the partners share of household income (labour, pension and state benefit income) as a proxy of the bargaining powers. The idea is that the higher is the wife/husband share of income, the higher is her/his control on the portfolio allocation decision.

Table 5 shows the income percentiles of ELSA partners by financial respondent and by gender[12]. Male and financial respondent partners earn more. However, males median income is twice the median income of females, while this difference reduces among financial and non-financial respondents, even if it remains large and significant (the gap is about 35% of non-respondent median income).
Figures 3.1, 3.2 and 3.3 compare the box plots, the histograms and the kernel densities of wives and husbands weekly income distributions, measured in pounds. Both distributions are clearly non-normal and show positive skewness, with long right tails, and a concentration of the mass of the distribution on the left. Males income is higher (the husbands median income is two times the wives median income) and has a higher variability (sd_m = 341.4 £ against sd_f = 202.4 £ of wives) and longer right tails. Wage differences may depend on individual circumstances (e.g.: number of dependent children, company size and type of occupation) and reduce since the introduction of the Equal Pay Act in 1975 in the UK, but still affect the English society.

Table 6 shows the percentile of share of household income (γ) of financial respondent and males partners. On average, the male partner earns the 66.5% (sd: 19.9%) of household labour and pension income, while the financial responding partner share is 56.3% (sd: 25.2%). The fact that the financial respondent has 10% less power depends mainly on the share of females financial

[12] Note that there is one household where the female reports negative earnings: in this case, I consider the male partner as the only income supplier with a share of household income equal to 1. Therefore, there are 74 one-income couples where males are the only income source, while only 73 females with no income.

Table 5: Partners weekly income percentiles. Income is the sum of employment and self-employment income, private and state pension income, and state benefit transfers.

	individual income = 0	Income percentiles 10%	25%	50%	75%	90%
male	15	177 £	257 £	366 £	541 £	726 £
female	73	51 £	96 £	172 £	277 £	406 £
financial respondent	28	91 £	178 £	309 £	488 £	690 £
financial non-respondent	60	69 £	130 £	230 £	351 £	531 £

Table 6: Partners share of household income - percentiles. Income is the sum of employment and self-employment income, private and state pension income, and state benefit transfers.

	share of hh income = 0	Share of hh income percentiles 10%	25%	50%	75%	90%	share of hh income = 1
male	15	41.8%	55.4%	68.2%	80.3%	90.1%	74
financial respondent	28	20.9%	38.2%	58.4%	75.7%	87.8%	61

Figure 3.1: Female and Male income - boxplot.

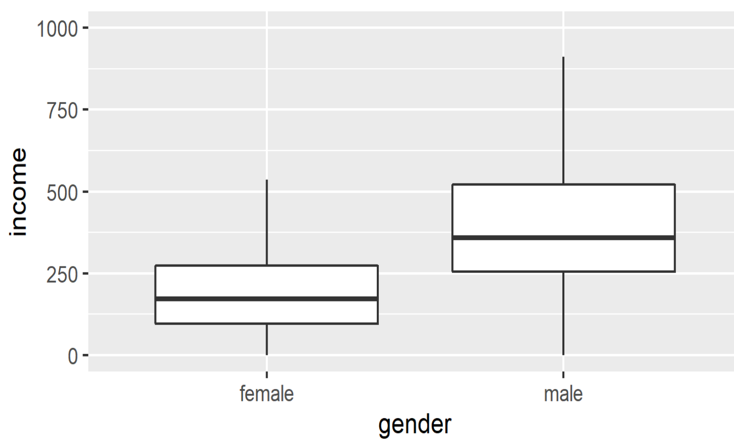

Figure 3.2: Female and Male income - histogram.

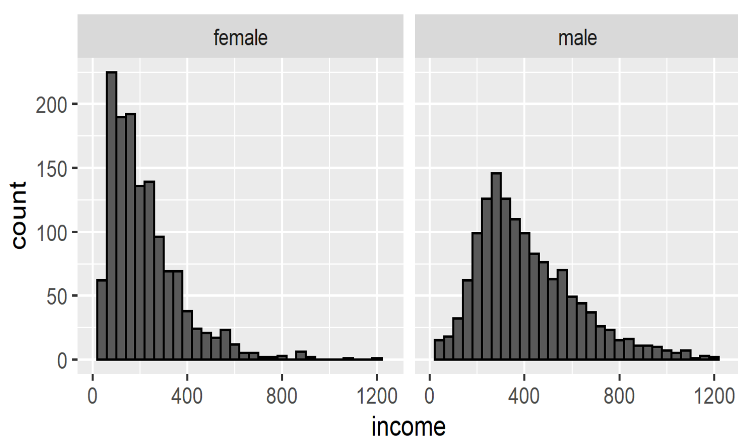

Figure 3.3: Female and Male partners income - kernel densities.

respondents (40% circa), which earn a lower income than their partners, as Figure 3.1, 3.2 and 3.3 and Table 5 show.

4 Results

This Section analyses empirically the implication of the theoretical model described in Section 2. First, I compare two econometric models that estimate household portfolio allocation using the general and the financial risk tolerance, respectively. This first step drives the choice of the baseline model, which uses the financial measure. Then, I discuss the results of the estimates, focusing on the determinants of household stock market participation and household share of wealth allocated in risky assets. Finally, I provide evidence that the collective model fits significantly better the data compared to the standard unitary model generally used in the literature.
I present a reduce form analysis, that studies the effect of the collective risk tolerance on household portfolio allocation conditioning on a set of household demographics. The estimation of a structural model would allow studying how the demographics determine the household risk preferences and the role of the unobserved heterogeneity component of risk tolerance (see Section 2.2), however, this goes beyond the scope of this paper and is left for future work.
The empirical analysis does not consider distribution factors that are relevant elements of the collective models. Distribution factors are defined as exogenous conditions that may affect the bargaining power of the spouses without altering their preferences. Some examples are divorce law or other policies that explicitly change the distribution of resources within the household (e.g., see Attanasio and Lechene (2014)). Due to data limitations, it is not possible to identify proper distribution factors and study their effects in this analysis.

4.1 Heckman correction method

The estimates of the household optimal portfolio allocation present a problem of incidental truncation: the explanatory variables are always observed, while the dependent variable (the share of household wealth invested in risky assets, α) is available only for a subset of the population. In other words, I observe α only for those households that decide to invest in risky assets. Therefore, the rule determining whether α is observed or not does not depend directly on the outcome of α

itself. Concluding, the truncation of the dependent variable is incidental because it depends on household decision to participate in the stock market.

I use the approach proposed by Heckman (1979) to estimate the effects of risk preferences on household portfolio allocation. This method allows the correction of bias from non-randomly selected samples or incidentally truncated dependent variables. First, it estimates the probability of observing the dependent variable using a probit model (selection equation) and then includes these results in the linear OLS estimation of the dependent variable (outcome equation). In other words, the second stage corrects for non-random selection by incorporating a transformation of the predicted probabilities of observing the dependent variable as an additional explanatory variable. This is the so-called Heckman two-step procedure.

In this analysis, the two dependent variables of the Heckman procedure are household stock market participation (selection equation) and the share of wealth invested in risky assets (outcome equation). In other words, the first stage estimates the probability $P(\alpha > 0)$, while the second stage estimates α.

4.2 Exclusion restriction

An exclusion restriction is required for non-parametric identification. There must be at least one variable that appears with a non-zero coefficient in the selection equation but does not appear in the outcome equation: this variable is essentially an instrument.

In this case, the selection equation includes age and age squared of the male partner, a dummy for large age difference in the couple (more than 10 years), household income and net total wealth quartiles, job market participation, a sickness index[13], education, risk tolerance, patience scores and numeracy score of both partners. The outcome equation does not include partners' numeracy scores, which serves as exclusion restriction.
Numeracy approximates the individual cognitive skills. I assume that agents with low numeracy need more time to improve their financial knowledge, increasing the stock market fixed entry costs. These higher costs decrease the potential returns of their investments. Then, those households with low numeracy may decide to not hold stocks. This assumption implies that all the households below a minimum threshold of numeracy do not participate in the stock market, while all the stockholders are above that threshold. Thus, numeracy affects household stock market participation, but the heterogeneity in α of those who participate does not depend on cognitive skills. Numeracy is based on a set of questions about simple math exercises, like computing percentages, fractions, additions and subtractions. I use the 5 questions that ask to compute a sequence of subtractions: respondents have to subtract 7 from 100, and then 7 from the previous result and so on, five times. I compute individual numeracy score as the sum of correct answers of the respondent. I aggregate the scores from 2 to 4, obtaining a total of 4 possible categories for each partner: no numeracy skills (0 correct answers), low numeracy (1 correct answer), medium numeracy (2 to 4 correct answers) and high numeracy (5 correct answers) Tables 9, 10, 7 and 8 show the construction and the distribution of numeracy and numeracy categories. On average, the numeracy score is higher among stockholders and males and financial respondents, i.e., those with higher bargaining power, show higher numeracy skills than females and non-financial respondents, respectively.

[13]It is constructed with principal component, using the numerous questions of ELSA related to participants health conditions. For more information see Dal Bianco (2020).

Table 7: Numeracy: partners by gender

Male numeracy

numeracy	classification	Freq.	Percent	Cum.
0	0	45	3.1	3.1
1	low	220	15.3	18.4
2	mid	84	5.8	24.2
3	mid	33	2.3	26.5
4	mid	54	3.7	30.3
5	high	1,005	69.7	100.00
Total		1,442	100.00	-

Female numeracy

numeracy	classification	Freq.	Percent	Cum.
0	0	76	5.3	5.3
1	low	331	23.0	28.3
2	mid	90	6.2	34.5
3	mid	45	3.1	37.6
4	mid	61	4.2	41.8
5	high	838	58.1	100.00
Total		1,442	100.00	-

Table 8: Numeracy and stock market participation: partners by gender

Male numeracy

numeracy	non-stockholders		stockholders	
category	obs	%	obs	%
0	26	7,0%	19	1,8%
low	79	21,3%	141	13,2%
mid	44	11,9%	127	11,9%
high	222	59,8%	783	73,2%

Female numeracy

numeracy	non-stockholders		stockholders	
category	obs	%	obs	%
0	38	10,2%	38	3,6%
low	91	24,5%	240	22,4%
mid	53	14,3%	143	13,4%
high	189	50,9%	649	60,7%

Table 9: Numeracy: partners by financial respondent

Respondent numeracy

numeracy	classification	Freq.	Percent	Cum.
0	0	35	2.4	2.4
1	low	254	17.6	20.0
2	mid	72	5.0	25.0
3	mid	31	2.2	27.2
4	mid	66	4.6	31.8
5	high	983	68.2	100.00
Total		1,442	100.00	-

Non-respondent numeracy

numeracy	classification	Freq.	Percent	Cum.
0	0	86	6.0	6.0
1	low	297	20.6	26.6
2	mid	102	7.1	33.7
3	mid	47	3.3	37.0
4	mid	49	3.4	40.4
5	high	860	59.6	100.00
Total		1,442	100.00	-

Table 10: Numeracy and stock market participation: partners by financial respondent

Respondent numeracy

numeracy	non-stockholders		stockholders	
category	obs	%	obs	%
0	21	5,7%	14	1,3%
low	79	21,3%	175	16,4%
mid	45	12,1%	124	11,6%
high	226	60,9%	757	70,7%

Non-respondent numeracy

numeracy	non-stockholders		stockholders	
category	obs	%	obs	%
0	43	11,6%	43	4,0%
low	91	24,5%	206	19,3%
mid	52	14,0%	146	13,6%
high	185	49,9%	675	63,1%

4.3 Empirical estimates

This Section presents the empirical results of the paper. First, I focus on the selection of the collective model that serves as a benchmark through the analysis, then, I study the determinants of the household portfolio allocation and, last, I compare the collective and the unitary approach.
The main results presented in this paper distinguish partner characteristics (demographics and risk) by gender. In Appendix Section C I will provide additional robustness checks using financial respondent and non-respondent partner demographics.

4.3.1 Baseline model selection

The ELSA survey provides two self-assessed measures of individual risk preferences. The former asks about risk preferences in general, while the latter asks about risk preferences in financial

contexts (spending, savings).
Table 11 compares the outcome equation of the Heckman estimates of two specification that differ because of the type of risk tolerance used: Column (1) uses the financial risk tolerance, and Column (2) uses the general risk tolerance. Note that both risk measures are at the household level. Then, they are the weighted sum of partners risk preferences, where the weights are the share of household income of each spouse.
I use maximum likelihood estimation, which provides two evaluation metrics of the goodness of fit of the models, the information criteria Akaike (AIC) and Schwarz (BIC). Results are qualitatively the same and, based on AIC and BIC of Table 11, Column (1), i.e. the model that uses financial risk preferences, has to be preferred. Therefore, in what follows I focus on financial risk preferences and use Column (1) Table 11 as the baseline model.

Table 11: Heckman outcome equation: household share of net financial wealth allocated in risky assets. General vs financial risk tolerance measure. Partners characteristics by gender.

share of risky assets	Financial risk measure (1)	General risk measure (2)
demographics[a]	*	*
financial risk: hh	0.0312***	
	(0.0053)	
general risk: hh		0.0107**
		(0.0052)
Constant	0.1944	0.3804
	(0.6672)	(0.6740)
AIC	**1931**	**1952**
BIC	**2168**	**2190**
Number of observation	1,442	1,442

[a]Demographics include male age and age squared, dummy for large age difference between partners (more than 10 years), dummies of income and wealth quartiles, job market participation of partners, education of partners and the sickness index of partners.

4.3.2 Household portfolio allocation

This Section discusses the results of the empirical estimates that study the determinants of the household portfolio allocation decision.

I estimate two different collective specifications that capture the effects of risk preferences of both partners on household portfolio allocation. Table 12 presents the results of the Heckman first stage: Column (1) uses the measure of husband and wife (financial) risk tolerance separately, while Column (2) uses the household weighted risk measures.
Income and wealth strongly affect the probability of stock market participation: income effects are stable across its quartiles, while wealth effects are increasing in magnitude. These findings are in line with the entry costs assumption in Section 2.3: the higher is the household wealth, the lower is the impact of lump-sum costs on household finances and the probability of being/becoming a stockholder increases. The numeracy of both partners is significant and have a positive effect on the stock market participation[14]. Male numeracy effects are increasing, while female numeracy does

[14]I test the joint significance of the numeracy scores of the male and female partners in each model. The Wald tests reject the null hypothesis of joint non-significance at the 1% significance level.

not show a similar pattern. This difference might be a consequence of the higher bargaining power of males: when the husband has high cognitive skills, he increase the probability of household stock market participation because of the higher (average) influence on portfolio choices. Male job market participation decreases the household probability of being a stockholder. Husbands may hold the "last say" on portfolio decision because of their higher (average) bargaining power. When the husband is working, he has less time to gather and study the necessary information about financial markets and then he decides to not invest in risky assets. Moreover, workers contributing to a Defined Contribution pension plan receive a lump-sum payment which amounts to about 25% of their pension pot when transiting to retirement. Therefore, it is more likely that they have higher liquidity to invest in the stock market at retirement. Male education has positive and significant effects, as largely documented in the literature. Last, there are no significant effects of financial risk tolerance on stock market participation, in line with the theoretical model. Indeed, risk tolerance must affect the share of wealth allocated in risky assets, but not participation, which depends on wealth, stock market entry costs and numeracy.

The outcome equation, in Table 13, estimates a linear model where the dependent variable is α (share of household net financial wealth allocated in risky assets) and the regressors are the same of the probit estimates of the first stage. However, the outcome equation excludes partners numeracy scores and includes the inverse Mills ratio of the first stage. The structure of Table 13 is the same of Table 12.
α increases in net financial wealth, with wealthier households that invest a larger share of their finances in risky assets. The female partner high education increases the portfolio share allocated in risky investments, while the male education has no effects. Notice that the opposite is true in the first stage. This effect might be due to partners sorting into marriage based on education. Therefore, couples participating in the stock market tend to have higher education on average. Once the stockholders are considered, what seems to matter is the high education level of the wife, because a woman with a college degree is rarer than a man with the same title.
Risk tolerance positively affects the share of wealth allocated in risky assets in both cases, when the partners' or the household risk preferences is considered. The difference is in the marginal effects: male and female partner risk show similar coefficients, while the weighted household risk tolerance impact is twice the risk tolerance of the two partners.

The results are in line with the collective portfolio decision model, which describes the household financial decision process as a two-step procedure. In the first step, partners choose the shared degree of risk tolerance and then decide about stock market participation. In the second step, the choice concerns the optimal share of wealth allocated in risky assets, if any. Therefore, the household takes decisions as a system of individuals that combine their preferences, and not as a single unit. The specifications in Table 12 and Table 13 follow this idea: each of them includes the preferences of all the household decision-makers, combined in a unique (weighted) measure or not, and these preferences affect the household portfolio allocation. Last, the inverse Mills ratio presented in Table 13 is non-significant. However, as I will discuss in the robustness section (Section C in the Appendix), controlling for selection remains important in this context.

4.3.3 Collective vs unitary approach

This Section aims to assess whether the collective approach proposed in this paper fits the data significantly better than the standard unitary approach generally used in the literature to study the household portfolio allocation.

Table 12: Household portfolio determinants: household probability of holding risky assets. Heckman selection equation. Partners characteristics by gender.

	Financial risk	
participation	Individual (1)	Baseline (2)
low numeracy: male	0.4519** (0.2249)	0.4569** (0.2247)
mid numeracy: male	0.6237*** (0.2353)	0.6342*** (0.2351)
high numeracy: male	0.6543*** (0.2118)	0.6545*** (0.2116)
low numeracy: female	0.4098** (0.1803)	0.4017** (0.1802)
mid numeracy: female	0.3810** (0.1942)	0.3822** (0.1942)
high numeracy: female	0.4088** (0.1712)	0.4079** (0.1712)
age: male	0.1281** (0.0632)	0.1274** (0.0634)
age^2: male	-0.0009* (0.0005)	-0.0009* (0.0005)
age diff > 10	0.1208 (0.1659)	0.1056 (0.1660)
2^{nd} income quartile	0.2392** (0.1065)	0.2396** (0.1063)
3^{rd} income quartile	0.3556*** (0.1177)	0.3466*** (0.1174)
4^{th} income quartile	0.3508*** (0.1343)	0.3579*** (0.1340)
2^{nd} wealth quartile	0.7364*** (0.1069)	0.7363*** (0.1069)
3^{rd} wealth quartile	0.8943*** (0.1142)	0.8960*** (0.1139)
4^{th} wealth quartile	1.4250*** (0.1448)	1.4210*** (0.1437)
in work: male	-0.2224** (0.1123)	-0.2302** (0.1122)
in work: female	-0.0120 (0.1084)	-0.0193 (0.1078)
mid education: male	0.3024*** (0.0974)	0.3008*** (0.0973)
high education: male	0.3383** (0.1372)	0.3254** (0.1368)
mid education: female	0.0566 (0.0951)	0.0537 (0.0950)
high education: female	0.1433 (0.1454)	0.1471 (0.1451)
sickness: male	-0.0201 (0.0191)	-0.0192 (0.0190)
sickness: female	-0.0128 (0.0182)	-0.0157 (0.0181)
financial risk: male	0.0177 (0.0172)	
financial risk: female	-0.0052 (0.0176)	
financial patience: male	-0.0281 (0.0196)	
financial patience: female	0.0260 (0.0183)	
financial risk: hh		0.0173 (0.0205)
financial patience: hh		-0.0187 (0.0236)
Constant	-6.1690*** (2.2245)	-5.9974*** (2.2331)
Number of observations	1,442	1,442

As stated in the Introduction, the unitary model describes the household as a single decision-making unit that solves the utility maximization problem with well-defined preferences. Empirically, it is common practice to proxy the household behaviour using the husband or the head of the household. In this paper, I represent the unitary household with the risk preferences of the husband. In the Appendix, I present the result obtained using the household head as a proxy of the unitary household, i.e. with the preferences of the partner who hold the last say on the decision (e.g.: Bertocchi et al. (2014)). In this context, I proxy the household head using the financial respondent of the interview, i.e. the partner that answers to the Income & Asset section of the survey.

Table 13: Household portfolio determinants: household share of net financial wealth allocated in risky assets. Heckman outcome equation. Partners characteristics by gender.

share of risky assets	Financial risk	
	Individual	Baseline
	(1)	(2)
age: male	0.0147	0.0143
	(0.0197)	(0.0197)
age^2: male	-0.0001	-0.0001
	(0.0001)	(0.0001)
age diff > 10	0.0224	0.0145
	(0.0413)	(0.0413)
2^{nd} income quartile	0.0105	0.0075
	(0.0321)	(0.0322)
3^{rd} income quartile	0.0165	0.0146
	(0.0350)	(0.0349)
4^{th} income quartile	0.0028	-0.0001
	(0.0359)	(0.0362)
2^{nd} wealth quartile	0.0744	0.0752
	(0.0650)	(0.0657)
3^{rd} wealth quartile	0.1801**	0.1807**
	(0.0729)	(0.0738)
4^{th} wealth quartile	0.2487***	0.2464***
	(0.0900)	(0.0910)
in work: male	-0.0329	-0.0390
	(0.0283)	(0.0284)
in work: female	-0.0111	-0.0016
	(0.0257)	(0.0256)
mid education: male	0.0298	0.0298
	(0.0301)	(0.0301)
high education: male	0.0267	0.0249
	(0.0358)	(0.0356)
mid education: female	0.0302	0.0282
	(0.0250)	(0.0250)
high education: female	0.1005***	0.1041***
	(0.0324)	(0.0324)
sickness: male	-0.0002	0.0002
	(0.0056)	(0.0056)
sickness: female	-0.0032	-0.0027
	(0.0049)	(0.0049)
financial risk: male	0.0158***	
	(0.0044)	
financial risk: female	0.0187***	
	(0.0045)	
financial patience: male	-0.0018	
	(0.0049)	
financial patience: female	0.0016	
	(0.0048)	
financial risk: hh		0.0307***
		(0.0051)
financial patience: hh		-0.0002
		(0.0060)
Constant	-0.5320	-0.4960
	(0.7598)	(0.7603)
Inverse Mills ratio		
λ	0.0876	0.0849
	(0.1276)	(0.1290)
Number of observations	1,442	1,442
Selection	1,070	1,070

I compare three specifications, two collective models and one unitary model, using the information criteria and the likelihood ratio test. The selection and the outcome equation of each specification are jointly estimated using maximum likelihood, which provides the values of the AIC and BIC to compare the goodness of fit of the models. Last, the likelihood ratio test is constructed by considering the unitary model as a special case of the collective models. Then, the unitary model is the nested (or reduced) model of the test.

In line with the selected baseline specification of Section 4.3.1, the three estimated models use the financial risk preferences of households and partners. The three specifications share the same

first-stage selection equation, which uses the numeracy of both partners as exclusion restriction and includes the household demographics and the risk tolerances of each partner, separately. On the other hand, the specifications have three different outcome equations, whose estimation results are shown in Table 14. In particular, the first collective model (Column (1)) uses the risk tolerance of each partner separately (wife and husband), the second collective model (Column (2)) includes the household weighted risk tolerance and, additionally, the risk preference of the husband, while the unitary model (Column (3)) uses only the husband risk preferences (as a proxy of the household preferences). Therefore, the risk tolerance of the husband appears in each outcome equation, such that the unitary model (Column (3)) becomes a nested model of the two collective specifications (Columns (1) and (2)).
I compare the three specifications using the likelihood ratio test, testing if the risk preferences of wives add information to the collective models and matter in the household portfolio allocation process.

Table 14 shows the likelihood ratio test results between Column (1) and Column (3) and between Column (2) and Column (3), i.e. between the two collective models and the unitary model. The test rejects the null hypothesis in both cases. Thus, the additional variable used in Column (1) and (2), i.e. the risk tolerance of the wives, has an important role in explaining household portfolio allocation.

Last, Table 15 reports the baseline model selected in Section 4.3.1 and compares the AIC and BIC information criteria of the collective and the unitary model. I conclude that the collective approach proposed in this paper fits significantly better the data than the standard unitary approach, where the information about the second partner risk preferences are missing.

Table 14: Collective vs unitary approach - likelihood ratio test. Heckman outcome equation: household share of net financial wealth allocated in risky assets. Partners characteristics by gender.

	Collective models		Unitary model
share of risky assets	Partner risk	Household risk	
	(1)	(2)	(3)
demographics[a]	*	*	*
financial risk: hh		0.0440^{***}	
		(0.0102)	
financial risk: male	0.0157^{***}	-0.0121	0.0190^{***}
	(0.0044)	(0.0084)	(0.0044)
financial risk: female	0.0201^{***}		
	(0.0046)		
Constant	0.1661	0.1682	0.2494
	(0.6681)	(0.6673)	(0.6715)
likelihood ratio test	Col (1) and (3)	Col (1) and (3)	
p-value	0.0001	0.0001	
Number of observations	1,442	1,442	1,442

[a] Demographics include male age and age squared, dummy for large age difference between partners (> 10 years), dummies of income quartile, job market participation of partners, education of partners and the health index of partners.

4.3.4 Household portfolio allocation - under 65 years

This Section presents the results previously described using the subsample of households where at least one partners is aged less than 65 years. Indeed, older agents have a high probability of being retired and may change their investment preferences, financial behaviours and decision-making

Table 15: Collective vs unitary approach - information criteria. Heckman outcome equation: household share of net financial wealth allocated in risky assets. Partners characteristics by gender.

share of risky assets	Collective model (1)	Unitary model (2)
demographics[a]	*	*
financial risk: hh	0.0312***	
	(0.0053)	
financial risk: male		0.0190***
		(0.0044)
Constant	0.1906	0.2525
	(0.6680)	(0.6719)
AIC	**1930**	**1946**
BIC	**2168**	**2184**
Number of observations	1,442	1,442

[a]Demographics include male age and age squared, dummy for large age difference between partners (> 10 years), dummies of income quartile, job market participation of partners, education of partners and the health index of partners.

process. This subsample is composed by 688 households and the stock market participation rate is 73.4%, in line with the overall sample.
Table 16 and 17 compares the collective and the unitary model using the likelihood ratio test and the Bayesian information criteria, following the analysis explained in Section 4.3.3.

Table 16: Under 65 years: collective vs unitary approach - likelihood ratio test.Heckman outcome equation: household share of net financial wealth allocated in risky assets. Partners characteristics by gender.

Under 65 years			
	Collective models		
share of risky assets	Partner risk (1)	Household risk (2)	Unitary model (3)
demographics[a]	*	*	*
financial risk: hh		0.0368***	
		(0.0130)	
financial risk: male	0.0200***	-0.0018	0.0246***
	(0.0068)	(0.0115)	(0.0067)
financial risk: female	0.0209***		
	(0.0065)		
Constant	3.5903**	3.6785**	3.5431**
	(1.4872)	(1.4916)	(1.4968)
likelihood ratio test	Col (1) and (3)	Col (2) and (3)	
p-value	0.0060	0.0184	
Number of observations	688	688	688

[a]Demographics include male age and age squared, dummy for large age difference between partners (> 10 years), dummies of income quartile, job market participation of partners, education of partners and the health index of partners.

The table show that the results are in line with previous findings, even if somewhat attenuated. In Section C.4 of the Appendix I perform the analysis distinguishing partners characteristics by financial and non-financial respondent, as a robustness check. These estimates confirm the results of Section 4, using the financial respondent partner risk preferences to approximate the unitary household.

Table 17: Under 65 years: collective vs unitary approach - information criteria. Heckman outcome equation: household share of net financial wealth allocated in risky assets. Partners characteristics by gender.

Under 65 years		
share of risky assets	Collective model (1)	Unitary model (2)
demographics[a]	*	*
financial risk: hh	0.0342***	
	(0.0076)	
financial risk: male		0.0245***
		(0.0067)
Constant	3.8137**	3.5890**
	(1.4885)	(1.4952)
AIC	**982**	**990**
BIC	**1186**	**1193**
Number of observations	688	688

[a]Demographics include male age and age squared, dummy for large age difference between partners (> 10 years), dummies of income quartile, job market participation of partners, education of partners and the health index of partners.

5 Conclusion

This paper studies the role of partners risk preferences in the household portfolio choice process. I develop a theoretical model that describes the household portfolio allocation decision following the collective approach proposed by Chiappori (1988). This approach considers the household as a group of agents which combine their preferences through a bargaining process. Formally, the general model assumes that the decision-making process is a weighted combination of individual behaviours, where the weights are the bargaining power of each household's member. Assuming exponential utility, I show how the optimal portfolio allocation depends on a weighted average of the household decision-makers risk preferences, fixed stock market entry costs and stock market returns.

I use the ELSA survey to study the effects of the partners risk preferences on household portfolio allocation, using the share of household income as a proxy of the bargaining powers. The empirical estimate relies on the Heckman selection model, which corrects for the bias produced by non-randomly selected samples. Indeed, the household decision to participate or not in the stock market creates a problem of incidental truncation because the variable of interest is observed or not depending on the stock market participation decision. The exclusion restriction that guarantees non-parametric identification relies on partners' numeracy scores, which I consider a proxy of cognitive ability. I assume that low cognitive skills increase the stock market fixed entry costs because the household needs more time to learn about the stock market and its mechanism. Then, the partners decide to not hold risky assets because of lower potential returns. However, once the household has the minimum knowledge about the stock market and holds stocks, numeracy does not affect the heterogeneity of the portfolio allocation.

The estimates show that stock market participation increases in household income, household wealth, partners numeracy and partners education, while risk tolerance has no effects. On the other hand, a higher risk tolerance increases the share of wealth allocated in risky assets, once the household is a stockholder.
Finally, I compare the collective and the unitary approach estimating three different specifications with maximum likelihood. I use Akaike's and Schwarz's Bayesian information criteria and the

likelihood ratio test to compare their goodness of fit. The results show that the collective approach performs significantly better than the unitary one, and therefore the preferences of both spouses matter in the household portfolio allocation process when the partners manage their finances jointly.

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Additional Material

Households risk preferences and portfolio allocation: a collective approach

Francesco Maura

A Theoretical model

A.1 CARA and mean-variance utility

Household wealth w can be invested in two types of assets: a risk-free asset with constant return (r) and a risky asset with return $\tilde{r} = r + \tilde{s}$ where $\tilde{s} \sim N(\mu_s, \sigma_s^2)$. The household (or agent) i maximizes its own utility u_i, choosing the optimal share of wealth allocated in risky asset, α.
Wealth after the investments is:

$$W_i = (w_h - \alpha)(1 + r) + w_h\alpha(1 + \tilde{r}) = w_h(1 + r + \alpha\tilde{s})$$

Assuming CARA utility with risk aversion parameter ρ_i, we have:

$$u_i(W_h) = -e^{-\rho_i W_h}$$

Because risky asset returns are normally distributed, the value function $V_i(\alpha)$ can be written as:

$$\begin{aligned}
\max_\alpha V_i(\alpha) &= \max_\alpha E[u_i(W_h)] = \max_\alpha E[-e^{-\rho_h W_h}] \\
&= \max_\alpha -E[e^{-\rho_i(w_h[(1+r)+\alpha\tilde{s}])}] = \max_\alpha -ln\ (E[e^{-\rho_i w_h[(1+r)+\alpha\tilde{s}]}]) \\
&= \max_\alpha -(E[-\rho_i w_h[(1 + r) + \alpha\tilde{s}]] + \frac{1}{2}Var[\rho_h w_h[(1 + r) + \alpha\tilde{s}]]) \\
&= \max_\alpha\ \rho_i w_h[(1 + r) + \alpha\mu_s] - \frac{1}{2}[\alpha^2\sigma_s^2\rho_i^2 w_h^2] \\
&= \max_\alpha\ \rho_i w_h[(1 + r) + \alpha\mu_s - \frac{1}{2}\alpha^2\sigma_s^2\rho_i w_h]
\end{aligned} \tag{1}$$

A.2 Household utility as a weighted sum of decision makers utilities

I propose a second model of household portfolio allocation. With respect to Section 2.1, the household maximizes a weighted sum of the two decision-makers utilities. I assume a CARA utility function $u_i(W_h)$ for each decision-maker (a and b), and egoistic preferences of agents (i.e.: their utility does not depends on partners utility). Wealth can be invested in two types of assets: a risk-free asset with constant return (r) and a risky asset with return $(1 + \tilde{r}) = (1 + r + \tilde{s})$ where $\tilde{s} \sim N(\mu_s, \sigma_s^2)$. Therefore, the problem of agent i is to maximize his/her own utility u_i, choosing the optimal share of wealth allocated in risky asset, α.
Wealth is defined as

$$W_h = w_h(1 + r + \alpha\tilde{s})$$

and u_i becomes:

$$u_i(W_h) = -e^{-\rho_i W_h}$$

Individual i maximizes:

$$\begin{aligned}
\max_\alpha V_i(\alpha) &= \max_\alpha E[u_i(W_h)] = \max_\alpha E[-e^{-\rho_h W_h}] \\
&= \max_\alpha\ \rho_i w_h[(1 + r) + \alpha\mu_s - \frac{1}{2}\alpha^2\sigma_s^2\rho_i w_h]
\end{aligned} \tag{2}$$

while household utility $u_h(W_h)$ is:

$$u_h(W_h) = \mu_a u_a(W_h) + \mu_b u_b(W_h) \tag{3}$$

where the weights (μ_a,μ_b) are the bargaining powers of the two individuals. I normalize the weights as follow:

$$\gamma = \frac{\mu_a}{\mu_a + \mu_b} \qquad (1-\gamma) = \frac{\mu_b}{\mu_a + \mu_b} \tag{4}$$

such that $\gamma \in [0, 1]$ represents agent's *a* bargaining power. Thus, the household maximization problem in Equation 3 becomes:

$$u_h(W_h) = \gamma u_a(W_h) + (1-\gamma)u_b(W_h) \tag{5}$$

In terms of the value function $V_h(\alpha)$, the program becomes:

$$\begin{aligned}
\max_{\alpha}\ V_h(\alpha) &= \max_{\alpha} E[u_h(W_h)] \\
&= \max_{\alpha} E[\gamma u_a(W_h) + (1-\gamma)u_b(W_h)] \\
&= \max_{\alpha}\ \gamma E[u_a(W_h)] + (1-\gamma)E[u_b(W_h)] \\
&= \max_{\alpha}\ \gamma \rho_a w_h[(1+r) + \alpha\mu_s - \frac{1}{2}\alpha^2\sigma_s^2 w\rho_a] + \\
&+ (1-\gamma)\rho_b w_h[(1+r) + \alpha\mu_s - \frac{1}{2}\alpha^2\sigma_s^2 w\rho_b]
\end{aligned} \tag{6}$$

Then, solving the first order conditions for α:

$$\alpha = \frac{\mu_s}{\sigma_s^2 w} \cdot \frac{\rho_h}{\phi} \tag{7}$$

where $\rho_h = \gamma\rho_a + (1-\gamma)\rho_b$ and $\phi = \gamma\rho_a^2 + (1-\gamma)\rho_b^2$.

B ELSA dataset

Table 1: Sample selection

Selection	Decrease in observation
Initial sample (individuals)	8445
Individuals in a couple with joint finances	4965
Couple with joint finances (both partners)	2325
Couple with both partners younger than 90s	2304
Couple with both partners self-reported risk valid answers	1582
Couple with positive income	1577
Couple with non-negative net wealth	1465
Couple with risky share of wealth $\in [0, 1]$	1445
sickness index missing values	1442

C Results - robustness check

C.1 Under 65 years - portfolio determinants

Table 2: Under 65 years: baseline model selection: financial and general risk tolerance. Heckman selection equation: household probability of holding risky assets. Partners characteristics by gender.

Under 65 years		
participation	Financial risk measure (1)	General risk measure (2)
low numeracy: male	0.3287	0.3405
	(0.3897)	(0.3881)
mid numeracy: male	0.4603	0.4791
	(0.4008)	(0.3997)
high numeracy: male	0.5796	0.5837
	(0.3686)	(0.3670)
low numeracy: female	0.8346^{***}	0.8267^{***}
	(0.2817)	(0.2799)
mid numeracy: female	0.9825^{***}	0.9888^{***}
	(0.3068)	(0.3049)
high numeracy: female	0.8279^{***}	0.8352^{***}
	(0.2684)	(0.2661)
age: male	0.0855	0.0795
	(0.1346)	(0.1354)
age^2: male	-0.0005	-0.0004
	(0.0011)	(0.0011)
age diff > 10	0.0453	0.0317
	(0.2076)	(0.2077)
2^{nd} income quartile	0.1014	0.1069
	(0.1693)	(0.1686)
3^{rd} income quartile	0.2703	0.2629
	(0.1731)	(0.1719)
4^{th} income quartile	0.2668	0.2623
	(0.1833)	(0.1831)
2^{nd} wealth	0.7760^{***}	0.7802^{***}
	(0.1616)	(0.1612)
3^{rd} wealth quartile	0.8108^{***}	0.8157^{***}
	(0.1596)	(0.1588)
4^{th} wealth quartile	1.2758^{***}	1.2812^{***}
	(0.2040)	(0.2014)
in work: male	-0.1609	-0.1676
	(0.1439)	(0.1440)
in work: female	-0.0106	-0.0254
	(0.1306)	(0.1298)
mid education: male	0.1481	0.1571
	(0.1487)	(0.1485)
high education: male	0.2378	0.2387
	(0.1928)	(0.1924)
mid education: female	0.0388	0.0379
	(0.1537)	(0.1539)
high education: female	0.1064	0.1064
	(0.2060)	(0.2056)
sickness index: male	-0.0194	-0.0170
	(0.0327)	(0.0325)
sickness index: female	-0.0372	-0.0427
	(0.0286)	(0.0284)
financial risk: male	0.0104	
	(0.0263)	
financial patience: male	0.0104	
	(0.0288)	
financial risk: female	-0.0087	
	(0.0251)	
financial patience: female	0.0432	
	(0.0272)	
financial risk: hh		0.0105
		(0.0296)
financial patience: hh		0.0265
		(0.0339)
Constant	-5.4741	-5.1140
	(4.1672)	(4.1851)
Number of observation	688	688

Table 3: Heckman selection equation: household probability of holding risky assets. Baseline model selection: financial and general risk tolerance. Partners characteristics by gender.

Under 65 years		
share of risky assets	Financial risk measure (1)	General risk measure (2)
age: male	-0.0876*	-0.0904*
	(0.0469)	(0.0470)
age^2: male	0.0007*	0.0007**
	(0.0004)	(0.0004)
age diff > 10	-0.0580	-0.0741
	(0.0531)	(0.0532)
2^{nd} income quartile	0.0590	0.0586
	(0.0463)	(0.0463)
3^{rd} income quartile	0.0008	-0.0006
	(0.0479)	(0.0473)
4^{th} income quartile	0.0243	0.0254
	(0.0484)	(0.0477)
2^{nd} wealth quartile	0.0810	0.0773
	(0.0800)	(0.0804)
3^{rd} wealth quartile	0.1532*	0.1566*
	(0.0805)	(0.0811)
4^{th} wealth quartile	0.2027**	0.1956*
	(0.0999)	(0.1008)
in work: male	-0.0426	-0.0503
	(0.0353)	(0.0351)
in work: female	-0.0050	0.0036
	(0.0315)	(0.0314)
mid education: male	0.0220	0.0228
	(0.0413)	(0.0416)
high education: male	0.0163	0.0150
	(0.0494)	(0.0495)
mid education: female	-0.0454	-0.0574
	(0.0423)	(0.0425)
high education: female	0.0749	0.0662
	(0.0499)	(0.0501)
sickness index: male	0.0149	0.0157*
	(0.0095)	(0.0095)
sickness index: female	-0.0028	-0.0027
	(0.0087)	(0.0088)
financial risk: male	0.0201***	
	(0.0067)	
financial patience: male	-0.0043	
	(0.0072)	
financial risk: female	0.0186***	
	(0.0064)	
financial patience: female	0.0039	
	(0.0072)	
financial risk: hh		0.0333***
		(0.0073)
financial patience: hh		-0.0022
		(0.0087)
Constant	2.7789*	2.9300*
	(1.5173)	(1.5183)
Inverse Mills Ratio		
λ	0.0384	0.0250
	(0.1467)	(0.1462)
Number of observation	688	688

C.2 Male and female - exclusion restriction

The Heckman methodology shows to be sensible to the exclusion restriction. This Section provides evidence that the results are robust even when using different exclusion restriction: in particular, here only the numeracy of the husband plays the role of the exclusion restriction. The results are consistent (even if sometimes attenuated) and the Invers Mills Ratio become significant in one case, confirming the relevance of controlling for incidentally truncated variables bias.

Table 4: Household portfolio determinants - collective approach. Heckman selection equation: household probability of holding risky assets. Partners characteristics by gender.

participation	Individual risk (1)	Weighted risk (2)
low numeracy: male	0.2240	0.5016**
	(0.3885)	(0.2227)
mid numeracy: male	0.4221	0.6777***
	(0.4005)	(0.2329)
high numeracy: male	0.5185	0.7059***
	(0.3684)	(0.2092)
age: male	0.0779	0.1279**
	(0.1348)	(0.0633)
age^2: male	-0.0004	-0.0009*
	(0.0011)	(0.0005)
age diff > 10	0.0424	0.1065
	(0.2040)	(0.1649)
2^{nd} income quartile	0.1313	0.2381**
	(0.1667)	(0.1058)
3^{rd} income quartile	0.2727	0.3451***
	(0.1711)	(0.1171)
4^{th} income quartile	0.2784	0.3567***
	(0.1819)	(0.1337)
2^{nd} wealth quartile	0.7739***	0.7516***
	(0.1600)	(0.1065)
3^{rd} wealth quartile	0.8059***	0.9090***
	(0.1578)	(0.1135)
4^{th} wealth quartile	1.2966***	1.4444***
	(0.2024)	(0.1432)
in work: male	-0.1389	-0.2144*
	(0.1423)	(0.1118)
in work: female	0.0092	-0.0105
	(0.1296)	(0.1075)
mid education: male	0.1420	0.2856***
	(0.1468)	(0.0967)
high education: male	0.2235	0.3110**
	(0.1906)	(0.1359)
mid education: female	0.0380	0.0656
	(0.1516)	(0.0945)
high education: female	0.1267	0.1585
	(0.2029)	(0.1439)
sickness index: male	-0.0113	-0.0178
	(0.0322)	(0.0190)
sickness index: female	-0.0519*	-0.0214
	(0.0276)	(0.0177)
financial risk: male	0.0180	
	(0.0258)	
financial patience: male	0.0141	
	(0.0284)	
financial risk: female	-0.0191	
	(0.0246)	
financial patience: female	0.0375	
	(0.0269)	
financial risk: hh		0.0162
		(0.0204)
financial patience: hh		-0.0203
		(0.0235)
Constant	-4.4250	-5.7125**
	(4.1657)	(2.2274)
Number of observations	1,442	1,442

Table 5: Household portfolio determinants - collective approach. Heckman outcome equation: household probability of holding risky assets. Partners characteristics by gender.

share of risky assets	Individual risk (1)	Weighted risk (2)
age: male	-0.0835*	0.0234
	(0.0477)	(0.0206)
age^2: male	0.0007*	-0.0001
	(0.0004)	(0.0001)
age diff > 10	-0.0558	0.0201
	(0.0540)	(0.0433)
2^{nd} income quartile	0.0649	0.0248
	(0.0482)	(0.0342)
3^{rd} income quartile	0.0128	0.0379
	(0.0536)	(0.0373)
4^{th} income quartile	0.0366	0.0227
	(0.0545)	(0.0388)
2^{nd} wealth quartile	0.1217	0.1416**
	(0.1115)	(0.0703)
3^{rd} wealth quartile	0.1948*	0.2575***
	(0.1134)	(0.0792)
4^{th} wealth quartile	0.2575*	0.3451***
	(0.1447)	(0.0983)
in work: male	-0.0474	-0.0500*
	(0.0369)	(0.0300)
in work: female	-0.0041	-0.0019
	(0.0321)	(0.0270)
mid education: male	0.0294	0.0493
	(0.0443)	(0.0319)
high education: male	0.0255	0.0451
	(0.0533)	(0.0378)
mid education: female	-0.0434	0.0328
	(0.0430)	(0.0262)
high education. female	0.0793	0.1117***
	(0.0513)	(0.0344)
sickness index. male	0.0143	-0.0016
	(0.0097)	(0.0058)
sickness index: female	-0.0055	-0.0043
	(0.0103)	(0.0052)
financial risk: male	0.0209***	
	(0.0069)	
financial patience: male	-0.0037	
	(0.0075)	
financial risk: female	0.0178***	
	(0.0066)	
financial patience: female	0.0050	
	(0.0076)	
financial risk: hh		0.0316***
		(0.0054)
financial patience: hh		-0.0011
		(0.0063)
Constant	2.5169	-0.9818
	(1.5973)	(0.7989)
Inverse Mills Ratio		
λ	0.1277	0.2365*
	(0.2232)	(0.1398)
Number of observations	1,442	1,442

C.3 General risk preferences

Table 6: Household portfolio determinants - collective approach. Heckman selection equation: household probability of holding risky assets. Partners characteristics by gender.

participation	Individual risk (1)	Weighted risk (2)
low numeracy: male	0.4519^{**}	0.4569^{**}
	(0.2249)	(0.2247)
mid numeracy: male	0.6237^{***}	0.6342^{***}
	(0.2353)	(0.2351)
high numeracy: male	0.6543^{***}	0.6545^{***}
	(0.2118)	(0.2116)
low numeracy: female	0.4098^{**}	0.4017^{**}
	(0.1803)	(0.1802)
mid numeracy: female	0.3810^{**}	0.3822^{**}
	(0.1942)	(0.1942)
high numeracy: female	0.4088^{**}	0.4079^{**}
	(0.1712)	(0.1712)
age: male	0.1281^{**}	0.1274^{**}
	(0.0632)	(0.0634)
age^2: male	-0.0009^{*}	-0.0009^{*}
	(0.0005)	(0.0005)
age diff > 10	0.1208	0.1056
	(0.1659)	(0.1660)
2^{nd} income quartile	0.2392^{**}	0.2396^{**}
	(0.1065)	(0.1063)
3^{rd} income quartile	0.3556^{***}	0.3466^{***}
	(0.1177)	(0.1174)
4^{th} income quartile	0.3508^{***}	0.3579^{***}
	(0.1343)	(0.1340)
2^{nd} wealth quartile	0.7364^{***}	0.7363^{***}
	(0.1069)	(0.1069)
3^{rd} wealth quartile	0.8943^{***}	0.8960^{***}
	(0.1142)	(0.1139)
4^{th} wealth quartile	1.4250^{***}	1.4210^{***}
	(0.1448)	(0.1437)
in work: male	-0.2224^{**}	-0.2302^{**}
	(0.1123)	(0.1122)
in work: female	-0.0120	-0.0193
	(0.1084)	(0.1078)
mid education: male	0.3024^{***}	0.3008^{***}
	(0.0974)	(0.0973)
high education: male	0.3383^{**}	0.3254^{**}
	(0.1372)	(0.1368)
mid education: female	0.0566	0.0537
	(0.0951)	(0.0950)
high education: female	0.1433	0.1471
	(0.1454)	(0.1451)
sickness index: male	-0.0201	-0.0192
	(0.0191)	(0.0190)
sickness index: female	-0.0128	-0.0157
	(0.0182)	(0.0181)
general risk: male	0.0177	
	(0.0172)	
general patience: male	-0.0281	
	(0.0196)	
general risk: female	-0.0052	
	(0.0176)	
general patience: female	0.0260	
	(0.0183)	
general risk: hh		0.0173
		(0.0205)
general patience: hh		-0.0187
		(0.0236)
Constant	-6.1690^{***}	-5.9974^{***}
	(2.2245)	(2.2331)
Number of observations	1,442	1,442

Table 7: Household portfolio determinants - collective approach. Heckman outcome equation: household probability of holding risky assets. Partners characteristics by gender.

share of risky asset	Individual risk (1)	Weighted risk (2)
age: male	0.0147	0.0143
	(0.0197)	(0.0197)
age^2: male	-0.0001	-0.0001
	(0.0001)	(0.0001)
age diff > 10	0.0224	0.0145
	(0.0413)	(0.0413)
2^{nd} income quartile	0.0105	0.0075
	(0.0321)	(0.0322)
3^{rd} income quartile	0.0165	0.0146
	(0.0350)	(0.0349)
4^{th} income quartile	0.0028	-0.0001
	(0.0359)	(0.0362)
2^{nd} wealth quartile	0.0744	0.0752
	(0.0650)	(0.0657)
3^{rd} wealth quartile	0.1801^{**}	0.1807^{**}
	(0.0729)	(0.0738)
4^{th} wealth quartile	0.2487^{***}	0.2464^{***}
	(0.0900)	(0.0910)
in work: male	-0.0329	-0.0390
	(0.0283)	(0.0284)
in work: male	-0.0111	-0.0016
	(0.0257)	(0.0256)
mid education: male	0.0298	0.0298
	(0.0301)	(0.0301)
high education: male	0.0267	0.0249
	(0.0358)	(0.0356)
mid education: female	0.0302	0.0282
	(0.0250)	(0.0250)
high education: female	0.1005^{***}	0.1041^{***}
	(0.0324)	(0.0324)
sickness index: male	-0.0002	0.0002
	(0.0056)	(0.0056)
sickness index: female	-0.0032	-0.0027
	(0.0049)	(0.0049)
general risk: male	0.0158^{***}	
	(0.0044)	
general patience: male	-0.0018	
	(0.0049)	
general risk: female	0.0187^{***}	
	(0.0045)	
general patience: female	0.0016	
	(0.0048)	
general risk: hh		0.0307^{***}
		(0.0051)
general patience: hh		-0.0002
		(0.0060)
Constant	-0.5320	-0.4960
	(0.7598)	(0.7603)
Inverse Mills Ratio		
λ	0.0876	0.0849
	(0.1276)	(0.1290)
Number of observations	1,442	1,442

C.4 Partners characteristics by financial respondent

In this Section, I identify the (unitary) household risk preferences with the one of the household head, where the household head is the financial respondent of the survey. Moreover, I distinguish the partners demographics by financial and non-financial respondent.

C.4.1 All sample

Table 8: Household portfolio determinants - collective approach. Heckman outcome equation: household probability of holding risky assets. Partners characteristics by financial respondent.

participation	Individual risk (1)	Weighted risk (2)
low numeracy: respondent	0.5381**	0.5464**
	(0.2535)	(0.2529)
mid numeracy: respondent	0.5567**	0.5623**
	(0.2646)	(0.2640)
high numeracy: respondent	0.5856**	0.5923**
	(0.2437)	(0.2432)
low numeracy: non-respondent	0.3739**	0.3675**
	(0.1716)	(0.1711)
mid numeracy: non-respondent	0.4324**	0.4329**
	(0.1830)	(0.1826)
high numeracy: non-respondent	0.4843***	0.4845***
	(0.1600)	(0.1594)
age: respondent	0.0477	0.0468
	(0.0610)	(0.0608)
age^2: respondent	-0.0004	-0.0003
	(0.0004)	(0.0004)
age difference > 10	0.0547	0.0546
	(0.1634)	(0.1634)
2^{nd} hh income quartile	0.2573**	0.2563**
	(0.1064)	(0.1061)
3^{rd} hh income quartile	0.3895***	0.3896***
	(0.1167)	(0.1166)
4^{th} hh income quartile	0.3914***	0.3933***
	(0.1335)	(0.1335)
2^{nd} hh wealth quartile	0.7172***	0.7258***
	(0.1068)	(0.1067)
3^{rd} hh wealth quartile	0.9035***	0.9099***
	(0.1151)	(0.1149)
4^{th} hh wealth quartile	1.4201***	1.4290***
	(0.1452)	(0.1451)
in work: male: respondent	-0.1655	-0.1678
	(0.1094)	(0.1095)
in work: male: non-respondent	-0.2034*	-0.2077*
	(0.1079)	(0.1077)
mid education: respondent	0.2719***	0.2694***
	(0.0965)	(0.0965)
high education: respondent	0.3466**	0.3418**
	(0.1376)	(0.1375)
mid education: non-respondent	0.0514	0.0501
	(0.0960)	(0.0960)
high education: non-respondent	0.1159	0.1209
	(0.1457)	(0.1455)
sickness: respondent	-0.0389*	-0.0387*
	(0.0205)	(0.0204)
sickness: non-respondent	-0.0010	-0.0017
	(0.0173)	(0.0173)
female financial respondent	0.0905	0.0811
	(0.0880)	(0.0867)
financial risk: respondent	0.0168	
	(0.0174)	
financial risk: non-respondent	0.0018	
	(0.0175)	
financial patience: respondent	-0.0072	
	(0.0193)	
financial patience: non-respondent	0.0099	
	(0.0183)	
financial risk: hh		0.0198
		(0.0205)
financial patience: hh		-0.0141
		(0.0235)
Constant	-3.1486	-2.9982
	(2.1313)	(2.1256)
Number of observations	1,442	1,442

Table 9: Household portfolio determinants - collective approach. Heckman outcome equation: household probability of holding risky assets. Partners characteristics by financial respondent.

share of risky assets	Individual risk (1)	Weighted risk (2)
age: respondent	-0.0061	-0.0059
	(0.0163)	(0.0163)
age^2: respondent	0.0001	0.0001
	(0.0001)	(0.0001)
age difference > 10	0.0266	0.0218
	(0.0409)	(0.0409)
2^{nd} hh income quartile	-0.0041	-0.0052
	(0.0328)	(0.0327)
3^{rd} hh income quartile	-0.0046	-0.0027
	(0.0364)	(0.0363)
4^{th} hh income quartile	-0.0184	-0.0183
	(0.0373)	(0.0374)
2^{nd} hh wealth quartile	0.0138	0.0301
	(0.0681)	(0.0685)
3^{rd} hh wealth quartile	0.1105	0.1301*
	(0.0780)	(0.0784)
4^{th} hh wealth quartile	0.1594*	0.1809*
	(0.0962)	(0.0967)
in work: male: respondent	-0.0061	-0.0067
	(0.0269)	(0.0269)
in work: male: non-respondent	-0.0380	-0.0372
	(0.0271)	(0.0272)
mid education: respondent	0.0065	0.0092
	(0.0309)	(0.0308)
high education: respondent	0.0403	0.0452
	(0.0365)	(0.0363)
mid education: non-respondent	0.0270	0.0284
	(0.0245)	(0.0244)
high education: non-respondent	0.0521	0.0557*
	(0.0320)	(0.0320)
sickness: respondent	-0.0030	-0.0034
	(0.0062)	(0.0062)
sickness: non-respondent	0.0012	0.0016
	(0.0046)	(0.0046)
female financial respondent	-0.0087	-0.0096
	(0.0218)	(0.0210)
financial risk: respondent	0.0197***	
	(0.0043)	
financial risk: non-respondent	0.0139***	
	(0.0044)	
financial patience: respondent	-0.0001	
	(0.0047)	
financial patience: non-respondent	-0.0010	
	(0.0047)	
financial risk: hh		0.0294***
		(0.0052)
financial patience: hh		-0.0006
		(0.0059)
Constant	0.3664	0.3473
	(0.6045)	(0.6012)
Inverse Mills ratio		
λ	-0.0449	-0.0168
	(0.1356)	(0.1359)
Number of observations	1,442	1,442
Selection	1,070	1,070

Table 10: Collective vs unitary approach - likelihood ratio test. Heckman outcome equation: household probability of holding risky assets. Partners characteristics by financial respondent.

share of risky assets	Collective models		Unitary model
	Partner risk	Household risk	
	(1)	(2)	(3)
demographics[a]	*	*	*
financial risk: hh		0.0229***	
		(0.0078)	
financial risk: respondent	0.0199***	0.0082	0.0223***
	(0.0045)	(0.0065)	(0.0044)
financial risk: non-respondent	0.0149***		
	(0.0046)		
Constant	0.1695	0.1721	0.2531
	(0.6673)	(0.6665)	(0.6707)
likelihood ratio test	Col (1) and (3)	Col (2) and (3)	
p-value	0.0043	0.0122	
Number of observations	1,442	1,442	1,442

[a]Demographics include male age and age squared, dummy for large age difference between partners ($>$ 10 years), dummies of income quartile, job market participation of partners, education of partners and the sickness index of partners.

Table 11: Collective vs unitary approach - information criteria. Heckman outcome equation: household probability of holding risky assets. Partners characteristics by financial respondent.

share of risky assets	Collective model	Unitary model
	(1)	(2)
demographics[a]	*	*
financial risk: hh	0.0293***	
	(0.0052)	
financial risk: respondent		0.0219***
		(0.0043)
Constant	0.3705	0.3381
	(0.6069)	(0.5897)
AIC	**1926**	**1933**
BIC	**2190**	**2197**
Number of observations	1,442	1,442

[a]Demographics include male age and age squared, dummy for large age difference between partners ($>$ 10 years), dummies of income quartile, job market participation of partners, education of partners and the sickness index of partners.

C.4.2 Under 65 years

Table 12: Under 65 years: household portfolio determinants - collective approach. Heckman selection equation: household probability of holding risky assets. Partners characteristics by financial respondent.

Under 65 years		
participation	Financial risk measure (1)	General risk measure (2)
low numeracy: respondent	1.5660***	1.5861***
	(0.5447)	(0.5372)
mid numeracy: respondent	1.5498***	1.5842***
	(0.5577)	(0.5501)
high numeracy: respondent	1.5636***	1.5766***
	(0.5329)	(0.5257)
low numeracy: non-respondent	0.4851*	0.4776*
	(0.2609)	(0.2601)
mid numeracy: non-respondent	0.6216**	0.6308**
	(0.2844)	(0.2834)
high numeracy: non-respondent	0.6550***	0.6633***
	(0.2467)	(0.2453)
age: respondent	-0.0658	-0.0630
	(0.1523)	(0.1516)
age^2: respondent	0.0006	0.0006
	(0.0013)	(0.0013)
age difference > 10	-0.0102	-0.0034
	(0.2083)	(0.2083)
2^{nd} income quartile	0.0844	0.0845
	(0.1716)	(0.1708)
3^{rd} income quartile	0.2582	0.2616
	(0.1746)	(0.1742)
4^{th} income quartile	0.2337	0.2348
	(0.1843)	(0.1842)
2^{nd} wealth quartile	0.8295***	0.8288***
	(0.1614)	(0.1609)
3^{rd} wealth quartile	0.8495***	0.8573***
	(0.1612)	(0.1603)
4^{th} wealth quartile	1.3504***	1.3612***
	(0.2058)	(0.2051)
in work: male: respondent	-0.0938	-0.0976
	(0.1378)	(0.1376)
in work: male: non-respondent	-0.1488	-0.1611
	(0.1328)	(0.1322)
mid education: respondent	0.2233	0.2355
	(0.1534)	(0.1530)
high education: respondent	0.3714*	0.3691*
	(0.1984)	(0.1980)
mid education: non-respondent	-0.1326	-0.1169
	(0.1536)	(0.1523)
high education: non-respondent	-0.0951	-0.0711
	(0.2075)	(0.2056)
sickness index: respondent	-0.0707**	-0.0695**
	(0.0327)	(0.0323)
sickness index: non-respondent	-0.0011	-0.0040
	(0.0284)	(0.0283)
female respondent	0.1558	0.1315
	(0.1301)	(0.1274)
financial risk: respondent	0.0172	
	(0.0259)	
financial risk: non-respondent	-0.0061	
	(0.0253)	
financial patience: respondent	0.0054	
	(0.0288)	
financial patience: non-respondent	0.0500*	
	(0.0274)	
financial risk: hh		0.0158
		(0.0296)
financial patience: hh		0.0313
		(0.0337)
Constant	-1.0774	-1.0133
	(4.6057)	(4.5937)
Number of observations	688	688

Table 13: Under 65 years: household portfolio determinants - collective approach. Heckman outcome equation: household probability of holding risky assets. Partners characteristics by financial respondent.

Under 65 years		
participation	Financial risk measure (1)	General risk measure (2)
age: respondent	-0.0221	-0.0189
	(0.0404)	(0.0404)
age^2: respondent	0.0002	0.0001
	(0.0003)	(0.0003)
age difference > 10	-0.0071	-0.0160
	(0.0510)	(0.0513)
2^{nd} income quartile	0.0495	0.0487
	(0.0464)	(0.0463)
3^{rd} income quartile	-0.0078	-0.0048
	(0.0477)	(0.0477)
4^{th} income quartile	0.0074	0.0109
	(0.0477)	(0.0478)
2^{nd} wealth quartile	0.0499	0.0500
	(0.0877)	(0.0873)
3^{rd} wealth quartile	0.1462*	0.1527*
	(0.0881)	(0.0881)
4^{th} wealth quartile	0.1770	0.1775
	(0.1118)	(0.1121)
in work: male: respondent	0.0253	0.0255
	(0.0334)	(0.0335)
in work: male: non-respondent	-0.0750**	-0.0737**
	(0.0331)	(0.0333)
mid education: respondent	0.0132	0.0022
	(0.0471)	(0.0477)
high education: respondent	0.0710	0.0610
	(0.0554)	(0.0557)
mid education: non-respondent	-0.0234	-0.0208
	(0.0405)	(0.0405)
high education: non-respondent	0.0167	0.0213
	(0.0477)	(0.0477)
sickness index: respondent	0.0069	0.0064
	(0.0112)	(0.0111)
sickness index: non-respondent	0.0071	0.0082
	(0.0080)	(0.0080)
female respondent	-0.0263	-0.0237
	(0.0331)	(0.0318)
financial risk: respondent	0.0191***	
	(0.0063)	
financial risk: non-respondent	0.0176***	
	(0.0065)	
financial patience: respondent	-0.0014	
	(0.0072)	
financial patience: non-respondent	-0.0018	
	(0.0077)	
financial risk: hh		0.0296***
		(0.0073)
financial patience: hh		-0.0051
		(0.0088)
Constant	0.9267	0.8873
	(1.2007)	(1.2033)
Inverse Mills Ratio		
λ	-0.0096	-0.0130
	(0.1577)	(0.1572)
Number of observations	688	688

Table 14: Under 65 years: collective vs unitary approach - likelihood ratio test. Heckman outcome equation: household share of net financial wealth allocated in risky assets. Partners characteristics by financial respondent.

Under 65 years

share of risky assets	Collective models		Unitary model
	Partner risk	Household risk	
	(1)	(2)	(3)
demographics[a]	*	*	*
financial risk: hh		0.0225**	
		(0.0111)	
financial risk: respondent	0.0196***	0.0029	0.0235***
	(0.0066)	(0.0104)	(0.0065)
financial risk: non-respondent	0.0188***		
	(0.0068)		
Constant	0.9647	0.9172	0.7430
	(1.2533)	(1.2572)	(1.2592)
likelihood ratio test	Col (1) and (3)	Col (2) and (3)	
p-value	0.0133	0.0679	
Number of observations	688	688	688

[a]Demographics include male age and age squared, dummy for large age difference between partners (> 10 years), dummies of income quartile, job market participation of partners, education of partners and the sickness index of partners.

Table 15: Under 65 years: collective vs unitary approach - information criteria. Heckman outcome equation: household share of net financial wealth allocated in risky assets. Partners characteristics by financial respondent.

Under 65 years

share of risky assets	Collective model	Unitary model
	(1)	(2)
demographics[a]	*	*
financial risk: hh	0.0293***	
	(0.0074)	
financial risk: respondent		0.0225***
		(0.0063)
Constant	0.8925	0.7187
	(1.2085)	(1.2102)
AIC	**991**	**995**
BIC	**1218**	**1223**
Number of observations	688	688

[a]Demographics include male age and age squared, dummy for large age difference between partners (> 10 years), dummies of income quartile, job market participation of partners, education of partners and the sickness index of partners.