Risk Attitude and Portfolio Choice: An Intra-household Perspective*

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Abstract

Using the Household, Income and Labour Dynamics in Australia (HILDA) data, we document that the households whose financial decision-makers are husbands are more attached to the financial market than those whose decision-makers are wives. To explain this fact, we develop a simple intra-household bargaining model of household portfolio choice, in which the couple first collectively decides the household risk preference, which, in turn, determines their portfolio allocations. The bargaining power of each spouse depends on a wide range of economic and non-economic characteristics. Our channel decomposition analysis shows the risk related variables (income, education, cognitive ability and financial literacy) are most important factors in explaining the gender asymmetric associations between the bargaining power and household investment decisions. Incorporating "Big-five" personality traits in the bargaining equation reduces the household risk taking preference and therefore leads to the decrease of stock market participation rates, which is opposite to the effect of gender identify norm.

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1 Introduction

The finance literature has long been interested in the study of how risk attitudes of households affect their portfolio choices. Most of the early studies treat a household as a single decision-making unit to study their financial decisions(see, e.g. (Haliassos and Bertaut, 1995; Heaton and Lucas, 1997; Vissing-Jørgensen, 2002)). A limitation of this approach is that it is unable to analyze the household decision when individual household members hold different preferences. However, the survey studies show that men and women differ in their risk preferences in almost half of the married couples (Barsky et al., 1997; Mazzocco, 2004).

Besides, empirical studies show that the asset allocation outcome of married couples are outcomes of joint decision-making(Arano et al., 2010; Yilmazer and Lyons, 2010) and would be different from the decisions by each spouse individually (Bateman and Munro, 2005). Despite the consensus that the household decision-making often involves many prolonged bargains where each spouse's profile and preferences should be both considered, limited studies aim at understanding this decision process.[1] In this paper, we would like to open this "black-box" regarding how two-person households combine their risk preferences and make their joint portfolio choices.

We develop a tractable model of household portfolio choice using an intra-household bargaining framework, where each spouse differs in their risk preference as well as other economic and non-economic attributes. In the model, the spouses first cooperatively decide a household risk preference, which is a weighted average of each household member's risk preference. And the weight, interpreted as the bargaining power of each side, is assumed to be a function of both household members' characteristics. The couple then decides their portfolio allocations based on this aggregated household risk preference.[2] We show our model has an equivalent expression as a cooperative model in which the household maximizes a weighted sum of two utility functions Chiappori (1988, 1992); Apps and Rees (1997); Browning (2000); Chiappori and Ekeland (2006). The weight on each spouse's utility is the same as the bargaining weight on determining the household risk preference.

[1] Studies about intra-household financial decision making focus primarily on the consumption-saving choice and the transition to retirement (e.g. (Browning, 2000; Lundberg et al., 2003; Mazzocco, 2004; Addoum, 2017)). The studies looking at stock market participation and financial portfolio choices are much less.

[2] They need to both decide whether investing in the stock market (extensive margin) and how much to invest (intensive margin) based on this aggregated household risk preference.

We estimate this model using the Household, Income and Labour Dynamics in Australia (HILDA) survey. HILDA is a comprehensive panel providing detailed information regarding the economic and non-economic characteristics, including the risk attitudes of each individual. More importantly, it offers unusual direct measures the financial decision marker within household, which reveals whose preferences are reflected a greater degree at the household level.[3] Following Flinn et al. (2018), we allow a wide range of economic and non-economic characteristics (income, financial literacy, age, education, personality traits, cognitive ability and gender identity norm) as the potential determinants of household bargaining weight and let the estimation results identify which set of variables are the most important ones in determining the bargaining process. The model is estimated using the maximum likelihood estimation (MLE) method.

In our model, the risk preference of each spouse is designed to affect the household preference through two channels. First, the individual's risk preference appeared directly in the household risk determination equation. We call this channel as "direct effect". Second, the set of factors that determine the bargaining power may also significantly correlated with individual's risk preference. Therefore, the individual's risk preference could also affect the household risk preference thought its association with the bargaining weight. We call the second channel as "indirect effect". The second channel is crucial in explaining the asymmetric association between the bargaining power and household investment decision. Using the group whose finally decisions are equally shared between spouses (called "equal shared" group thereafter) as the reference, we find the households whose financial decision maker are husbands (called "male head" group thereafter) are more probable to participate into the stock market, as well as hold larger share of risky asset. While the portfolio allocation of the household whose decision makers are wives (called "female head" group thereafter) are close to the allocations of the reference group. We attribute this pattern to gender asymmetric association between individual risk preference and bargaining power. As the more risk-taking men are more likely to become the household head, the "indirect effect" would reinforce the "direct effect" on men side. As a result, the households in "male head" group are more risk taking than the "equal shared" group. On the contrary, the more risk-taking women are less likely to be the household head, therefore the "indirect

[3]The Health and Retirement Study (HRS) data also has a similar question reporting whether a husband or wife has "the final say" when making major decisions, which is used by several papers with a similar interpretation Friedberg and Webb (2006); Yilmazer and Lich (2015). However, HRS doesn't contain such a rich set of individual characteristics as HILDA has.

effect" would offset the direct effect. Consequently, the risk taking level of the "female head" group could be close to the "equal shared" group.

Our channel decomposition analysis yields a number of potentially important findings. First, the risk-related variables, including income, cognitive ability, education and financial literacy, are the most important determinants in explaining the gender asymmetric associations between the a spouse's risk preference and his/her bargaining power, which is the main channel in explaining why the households whose financial decision-makers are husbands are more attached to the financial market than those whose decision-makers are wives in the data. Second, When comparing the heterogeneity from both genders, they work on the opposite direction but different magnitudes. The heterogeneity from male side causes risk taking men more powerful. The heterogeneity from female side, however, causes risk taking women more powerful within household. Third, the incorporation of personality traits reduces the household risk taking preference and therefore leads to the decrease of stock market participation rates. Fourth, the incorporation of gender identity attitude increases the household risk taking preference and therefore leads to the increase of stock market participation rates. Its magnitude is close to the effect of personality traits but the sign is opposite.

This paper could potentially contribute to the literature in the following ways. First of all, this paper contributes to the household portfolio choice models with limited stock market participation (Bertaut, 1998; Cocco et al., 2005; Gomes and Michaelides, 2005; Wachter and Yogo, 2010). Most of the existing quantitative studies on household portfolio choice treated household as a single agent and use the entry cost as the main friction to explain the low participation rate(Vissing-Jørgensen, 2002; Cocco et al., 2005; Gomes and Michaelides, 2005; Alan, 2006). Our model departs from the standard unitary household assumption and analyzes whether the friction arising in the bargaining process would be an additional channel in explaining the limited stock market participation. Following the collective bargaining set-up in the literature (Chiappori, 1988, 1992; Browning and Chiappori, 1998; Chiappori and Ekeland, 2006), we model the household risk preference as a weighted average of spouse risk preferences in our framework. That is to say, the household member who holds the "purse strings"(Bertocchi et al., 2014) or who "wears the trousers"(Maurer and Luhrmann, 2008) would have a relatively more substantial weight in determining the household risk attitude. The model closest to ours is perhaps (Yilmazer and Lich, 2015), who also study the household portfolio choice using a cooperative bargaining model where

spouses differ in their risk preference. Our relative contribution is to allow the correlations between a spouse's risk preference and his/her bargaining power.

This paper also contributes to the growing literate studying the determinants of household's stock allocation and participation decisions. Prior studies have documented the importance of age, education, income, wealth, and marital status on portfolio choice (Campbell, 2006; Curcuru et al., 2010). Through the lens of intra-household bargaining model, we show a wide range of factors, which are not considered relevant in the previous studies, may affect the household financial decisions due to their influence on the bargaining position. Although a comprehensive set of candidates variables have been mentioned as potential factors in determining the household financial decision in the literature, including education (Friedberg and Webb (2006)), income (Friedberg and Webb (2006); Bertocchi et al. (2014)), age (Bertocchi et al. (2014)), financial literacy (Elder and Rudolph (2003)), personality traits ("Big-five") (Johnston et al. (2016)), cognitive ability (Smith et al. (2010)) and gender identity role (Ke (2018)), their relative importance has never been evaluated in the same framework. We take advantage of the comprehensive, high-quality HILDA dataset and become the first paper to achieve this goal.

Lastly, our paper also advances small literature discussing the effect of bargaining power on observed portfolio choice decisions (Neelakantan et al., 2009; Yilmazer and Lich, 2015; Thörnqvist and Vardardottir, 2014; Addoum et al., 2016; Addoum, 2017). The bargaining theory suggests the heterogeneous bargaining power may due to limited commitment (Addoum et al. (2016)) or the changing of the threat point (Thörnqvist and Vardardottir (2014)). In this paper, our goal is not to distinguish the models in generating asymmetric bargaining power between genders. Our solemn target is to investigate the factors in determining the distribution of bargaining power between spouses. Elder and Rudolph (2003) and Johnston et al. (2016) are two closest paper in this line. However, neither of these two papers further explore how the distribution of bargaining power affects financial outcomes.

The paper proceeds as follows. The next section describes the data and stylized facts. Section 3 presents our baseline model. Section 4 discusses the econometric specification and estimation implementation. Section 5 and 6 present the estimation results and counterfactual experiments. Section 7 concludes.

2 Data

2.1 HILDA survey

We use sample information from the Household Income and Labour Dynamics in Australia (HILDA) data set, which is a nationally representative household survey conducted annually since 2001. All adult household members (aged 15 years and above) answer the face-to-face person questionnaire and additionally fill in a self-completion questionnaire (SCQ). The questionnaires cover a wide range of topics including economic and subjective well-being, labour market dynamics and family dynamics. At the beginning of the survey, 7682 households (19,914 individuals) were in the sample, and this was extended by an additional 2153 households (5477 individuals) in 2011.

A key advantage of the HILDA dataset for this study is that each wave includes special questionnaire modules and have collected information such as household financial decision-maker, stock market participation, financial literacy, personality traits, cognitive ability, and gender norm. However, different information are collected at different waves: (1) Household financial decision-maker (wave 5-14, 16); (2) Stock market participation (wave 2, 6, 10, 14); (3) Financial literacy (wave 16); (4) Personality traits (wave 5, 9, 13); (5) Cognitive ability (wave 12 and 16); (6) Gender norm (wave 1, 5, 8, 11, 15). Financial literacy is only measured in wave 16 (2016), and wave 14 (2014) is the closed wave including information on household financial decision-maker and stock market participation (The other 2 waves are wave 6 and 10). Therefore, we use wave 14 as the baseline sample and merge key variables from other waves. Specifically, we use financial literacy from wave 16 (2016), personality traits from wave 13 (2013), cognitive ability from wave 12 (2012), and gender norm from wave 15 (2015). Here, we assume that these characteristics remain constant between waves. We further restrict our sample to married couple households where both partners are working. After dropping cases for missing information on key variables that we use, we are left with 1304 couples for our main sample specifications.

Table 1 shows the average characteristics of males or females. The average age of males in the sample is 45.41 years, while the average age for females is 43.35 years. Females have slightly higher years of education (13.49) than males (13.36). Males have higher log income (11.15) than females (10.54).

Table 1: Summary statistics

	Male	Female
Age	45.41	43.35
Education	13.36	13.49
Income	69564	37798
Risk-taking	0.652	0.491
Financial literacy	0.917	0.803
Cognitive ability	0.164	0.277
Gender norm	3.040	2.905
Big-five personality		
Extraversion	4.290	4.560
Agreeableness	5.229	5.727
Conscientiousness	5.137	5.415
Emotional stability	5.175	5.185
Openness to experience	4.349	4.195
Observations	1304	1304

2.2 Measuring financial literacy, cognitive ability, personality traits, and gender norm

One of the key benefits of the HILDA survey is the depth of information it collects on the financial literacy, cognitive ability, personality traits, and gender norm of each partner.

Financial literacy. In wave 16 (2016) only, the survey included 5 questions assessing basic competencies in financial concepts such as interest rate, inflation, portfolio diversification, risk versus return, and money illusion.[4] For our variable of financial literacy, an individual is coded as 1 if she correctly answers at least four questions, oth-

[4]Questions include: (1) Suppose you put $100 into a no-fee savings account with a guaranteed interest rate of 2% per year. You don't make any further payments into this account and you don't withdraw any money. How much would be in the account at the end of the first year, once the interest payment is made? (2) Imagine now that the interest rate on your savings account was 1% per year and inflation was 2% per year. After one year, would you be able to buy more than today, exactly the same as today, or less than today with the money in this account? (3) "Buying shares in a single company usually provides a safer return than buying shares in a number of different companies." (True or false?) (4) "An investment with a high return is likely to be high risk." (True or false?) (5) Suppose that by the year 2020 your income has doubled, but the prices of all of the things you buy have also doubled. In 2020, will you be able to buy more than today, exactly the same as today, or less than today with your income?

erwise she is coded as 0. Males have a higher level of financial literacy than females: the average level of financial literacy is 0.917 for the male and 0.803 for the female.

Gender norm. The survey measures gender norms using following three items: (1) It is better for everyone involved if the man earns the money and the woman takes care of the home and children. (2) If both partners in a couple work, they should share equally in the housework and care of children. (3) Whatever career a woman may have, her most important role in life is still that of being a mother. Responses were collected on a scale from 1 (strongly disagree) to 7 (strongly agree). Since questions (1) and (3) are in favor of men and question (2) is in favor of women, we take the reverse value of question (2). Then we use the mean of the three measures as our variable of gender norm. Males have a stronger attitude of traditional gender role: the average level of gender norm is 3.04 for the male and 2.905 for the female.

Personality traits. The Big-5 personality traits were collected from respondents which measure an individual's degree of extraversion, agreeableness, conscientiousness, emotional stability, and openness to experience. Each trait is measured on a scale from 1 to 7. A high score indicates that the personality trait describes the person very well while a low score indicates the personality trait describe you in an opposite way. The measures are constructed by averaging responses to the question, "How well do the following words describe you?", where respondents can answer from 1 (does not describe me at all) to 7 (describes me very well). Several responses are averaged to construct each of the 5 personality types.

Cognitive ability. The survey conducted three tests to measure cognitive ability: (1) the 'Backwards digits span' test (BDS), (2) a 25-item version of the 'National Adult Reading Test' (NART), and (3) the 'Symbol-digit modalities' test (SDM).[5] To derive a summary measure for cognitive ability, we first construct a one-dimensional measure from these three measures. Then, we construct a single measure by first standardizing

[5]The BDS is a traditional sub-component of intelligence tests and measures working memory span. The interviewer reads out a string of digits which the respondent has to repeat in reverse order. NART is a short version of the National Adult Reading Test that measures pre-morbid intelligence. Respondents have to read out loud and pronounce correctly 25 irregularly spelled words. SDM is a test where respondents have to match symbols to numbers according to a printed key. It was originally developed to detect cerebral dysfunction but is now a recognised test for divided attention, visual scanning and motor speed.

each of the three measures and then taking the mean. In our sample, females have higher cognitive scores than males (0.277 vs 0.164).

Risk preference. The survey measure risk preference in the following question in the self-completion questionnaire: Which of the following statements comes closest to describing the amount of financial risk that you are willing to take with your spare cash? That is, cash used for savings or investment.

1. I take substantial financial risks expecting to earn substantial returns
2. I take above-average financial risks expecting to earn above-average returns
3. I take average financial risks expecting average returns
4. I am not willing to take any financial risks
5. I never have any spare cash

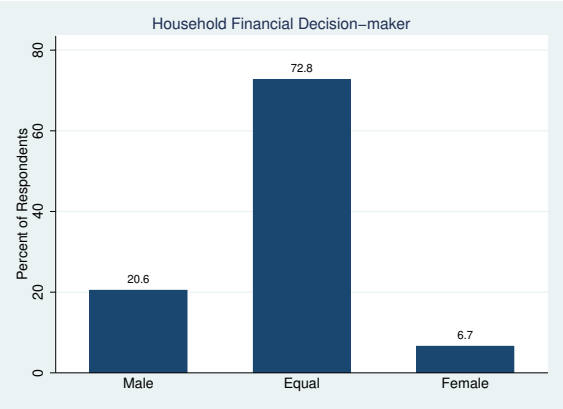
For our variable of risk preference, we classify respondents 1-3 as being 'Risk-taking' and classify 4-5 as being 'Risk Averse'.

2.3 Measuring Household Financial Decision-maker

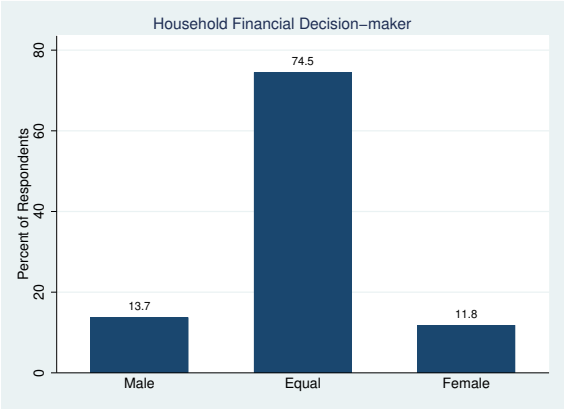
In the self-completion questionnaire both the male and female partner are asked "Who makes the decisions about the savings, investment and borrowing in your household?" Respondents could answer on the scale: 'always me', 'usually me', 'shared equally between partner and self', 'usually partner', 'always partner', 'always/usually other person(s) in house', 'shared equally among household members' and 'always/usually someone not living in house'. We omit couples who report that someone else other than the couple is the decision-maker. For our main measures of financial decision-maker we create variables based on either the male or the female report that are coded: (1) 'always or usually the male', (2) 'shared equally', and (3) 'always or usually the female'. Figure 1 shows the distribution of these responses. Most couples report that they share decisions on finances (more than 70%), which is relatively consistent across the male and female reports. If decision-making is not shared equally, it is more likely that the male is the decision-maker; although, the frequency is not consistently reported across genders: 20.6% of men report they are the decision-maker, whereas 13.7% of women

Figure 1: Household Financial decision-maker reported by males and females

(a) Male Reports



(b) Female Reports



report that the decision-maker is male. Conversely, 6.7% of men and 11.8% of women report that the decision-maker is female.

2.4 Stock Market Participation and Financial Decision-maker

The main objective of this paper is to study the relationship between household financial decision-maker and stock market participation. Table 2 reports the household stock market participation rate broken down by whether the household financial decision-maker is male or female, or if the decision-making is shared equally. The statistics are provided separately for male and female reports. literature

Table 2: Stock market participation rate, based on who is the financial decision-maker

	Male Reports mean/count	Female Reports mean/count
Male(Decision-maker)	0.515	0.587
	(268)	(179)
Equal	0.404	0.400
	(949)	(971)
Female(Decision-maker)	0.391	0.403
	(87)	(154)
Observations	1304	1304

We find that households whose financial decision-maker is male have a higher stock market participation rate than those whose financial decision-maker is female or shared equally by the couple. In addition, households whose financial decision-maker is female or shared equally by the couple have similar stock market participation rate. These findings are consistent across the male and female reports. Friedberg and Webb (2006) use data from the 1992 HRS to show that households where the husband has the "final say" over household decisions exhibit an increased tendency to participate in the stock market and allocate more of their financial wealth to stocks. Yilmazer and Lich (2015) extend this evidence to an HRS sample covering the 1992 to 2006 period. Then, the main question studied by this paper is what contributes to this large difference in the stock market participation rate by household financial decision-makers.

2.5 Stock Market Participation and Risk Preference

Risk preference have long been treated as one of the major determinants of stock market participation in the finance literature. Table 3 shows the stock market participation rate broken down by risk preference of each spouse. We find that household risk preference affects stock market participation: the stock market participation rate of households with one risk-taking spouse is much higher than that of households where both spouses are risk-averse (41% v.s. 24%), and households where both spouses are risk-taking have the highest stock market participation rate (56%). In addition, the risk preference of men and women has the same effect on household stock market participation: for households with one risk-taking spouse, whether the risking-taking spouse is the male or the female, the stock market participation rate is 41%. This is a symmetric result across genders. What's more, there is some degree of sorting on risk preference within couples: households where both spouses are risk-taking are the most common family structure (40% of the population). But there are still a large amount of households where 2 spouses have different risk preferences (35% of the population).

Table 3: Stock market participation rate, based on risk preference of each spouse

	Female(Risk Averse)	Female(Risk-taking)	Obs.
Male(Risk Averse)	0.239	0.411	
	(330)	(124)	(454)
Male(Risk-taking)	0.413	0.556	
	(334)	(516)	(850)
Observations	(664)	(640)	(1304)

2.6 Financial Decision-makers and Risk Preference

We further study the relationship between risk preference and household financial decision-makers. Here we construct a dummy variable, which equals 1 if the respondent is risk-taking, and 0 if she is risk averse. The average of this dummy variable indicates the degree of risk-taking. Table 4 shows the degree of risk-taking of males and females broken down by whether the household financial decision-maker is male or female.

Table 4: Degree of risk-taking, based on who is the financial decision-maker

	Risk-taking(Male)	Risk-taking(Female)
Male(Decision-maker)	0.776	0.598
Equal	0.623	0.478
Female(Decision-maker)	0.586	0.448
Total	0.652	0.491

We find that males are more risk-taking than females (0.652 v.s. 0.491), the difference in the degree of risk-taking is 0.161. However, when they become decision makers, the difference doubles to 0.328: the degree of risk-taking of males in male decision-making households is 0.776, and that of females in female decision-making households is 0.448, which is even lower than the degree of risk-taking than the average females

(0.491). Therefore, the underlining intro-household bargaining process selects risk-taking males and risk-averse females to become the household financial decision-makers, which contributes to the large difference in the stock market participation rate by household financial decision-makers. Table 5 shows the proportion of decision makers broken down by risk preference of each spouse. It shows that risk-taking men are more likely to become the financial decision-maker.

Table 5: Proportion of Decision Makers, based on risk preference of each spouse

	Decision-maker(Male)	Decision-maker(Female)
Male(Risk_Averse)	0.132	
Male(Risk-taking)	0.245	
Female(Risk_Averse)		0.128
Female(Risk-taking)		0.108
Observations	1304	1304

3 Model

3.1 A model of household portfolio choice

In this session, we introduce a household portfolio choice model to explain why spouses would make heterogeneous decisions on stock market participation as well as the amount of asset holdings. The model consists of two parts. In the first part, we describe household portfolio choices with mean-variance utility function.[6] In the second part, we describe how individual preferences aggregate into the household level.

Assume an economy has two assets. One risk-free asset with constant interest return r,

[6]The mean-variance preference is a good approximation to the expected logarithmic value of wealth and therefore widely used in the literature Levy and Markowitz (1979); Aivazian et al. (1983); Kroll et al. (1984). We use the mean-variance utility function because we want to look at the financial wealth as the single outcome, and the other potential household decisions (labor supply, child raising) are isolated. In addition, this specification allows us to solve for the optimal portfolio choice in closed-form because it neutralizes the wealth effect. Appendix A shows the equivalence between CARA utility and mean variance utility.

and a risky asset (from the stock market) with risky return $r+\tilde{x}$. The extra return $\tilde{x}$ is assumed to follows a normal distribution $\tilde{x} \sim N(r_p, \sigma)$. A household has total wealth w and needs to consider the portfolio choice between risky asset holding a and risk-free asset holding $w-a$. However, entering into the stock market requires a lump-sum cost C_h.[7]Given the mean-variance utility preference, the utility maximization problem can be specified as:

$$U_h(a) = \max_a w(1+r) + \left(ar_p - C_h - \frac{1}{2}\gamma_h a^2\sigma^2\right) I(a>0)$$

where $I(a>0)$ is a dummy indicating whether the household participates into the stock market. γ_h is the degree of household risk aversion. Then, the solution of the portfolio choice is:

$$a = \begin{cases} 0 & \gamma_h > \frac{r_p^2}{2\sigma^2 C_h} \\ \frac{r_p}{\gamma_h \sigma^2} & \gamma_h \leq \frac{r_p^2}{2\sigma^2 C_h} \end{cases} \tag{1}$$

where the optimal risky asset holding is independent of initial wealth w but a function of household risk aversion γ_h. The solution predict a clear correlation between the household risk aversion γ_h and risky asset investment both in the extensive margin (stock market participation) and the intensive margin (the amount of risky asset holding). When the household is more risk-taking (γ_h is smaller), it is more likely to participate in the stock market and hold more risky assets. In our model, each household has different portfolio choices because of their heterogeneous γ_h. We then get the household optimal utility level as

$$V_h = \begin{cases} w(1+r) & \gamma_h > \frac{r_p^2}{2\sigma^2 C} \\ w(1+r) + \frac{r_p^2}{2\gamma_h\sigma^2} - C_h & \gamma_h \leq \frac{r_p^2}{2\sigma^2 C} \end{cases}$$

We now starts to specify how the household risk aversion γ_h depends on household members' risk aversions $\{\gamma_m, \gamma_f\}$ as well as their other characteristics. Each household has two members, a male (m) and a female (f). We assume the inverse household risk aversion $\frac{1}{\gamma_h}$ as a weighted average of inverse male risk aversion $\frac{1}{\gamma_m}$ and inverse female

[7]It is a fairly common assumption to introduce trading cost C to capture the limited stock market participation of households in the literature. Examples include Vissing-Jørgensen (2002); Gomes and Michaelides (2005); Alan (2006).

risk aversion $\frac{1}{\gamma_f}$

$$\frac{1}{\gamma_h} = \frac{\beta}{\gamma_m} + \frac{(1-\beta)}{\gamma_f} \tag{2}$$

where the weight parameter β captures the bargaining power of the male, and $1-\beta$ is the bargaining power of the female. We make this assumption for two reasons: first, it carries the insight that the household member who "holds the purse-strings" or "who wears the pants" has the greatest weight in the decision-making process. For example, the household preference γ_h only represent the husband preference γ_m when $\beta = 1$. Second, it provides an equivalent expression as the classical collective bargaining model in which the household utility function is a weighted average of individual's utility (Manser and Brown (1980); McElroy and Horney (1981); Chiappori (1988, 1992)). To see this point more clear, let each individual also has a mean-variance utility function

$$U_i(a_i) = \max_{a_i} w_i(1+r) + \left(a_i r_p - C_i - \frac{1}{2}\gamma_i a_i^2 \sigma^2\right) I(a_i > 0), i \in \{m, f\}$$

leads to the optimal individual utility as:

$$V_i = \begin{cases} w_i(1+r) & \gamma_i > \frac{r_p^2}{2\sigma^2 C_i} \\ w_i(1+r) + \frac{r_p^2}{2\gamma_i \sigma^2} - C_i & \gamma_i \leq \frac{r_p^2}{2\sigma^2 C_i} \end{cases}$$

Therefore, we should have $V_h = \beta V_m + (1-\beta)V_f$ when $C_h = \beta C_m + (1-\beta)C_f$.[8]
We further assume the bargaining power β depends on a set of other characteristics from the male side X_m and from the female side X_f following a logistic form

$$\beta(X_m, X_f) = \frac{\exp(\delta_0 + \delta_{xm} X_m)}{\exp(\delta_0 + \delta_{xm} X_m) + \exp(\delta_{xf} X_f)} \tag{3}$$

where δ_{xm} and δ_{xf} are coefficient vectors capture the contribution of each characteristics on the bargaining power, and δ_0 is the constant term capturing the systematic difference of bargaining power between genders.[9] We allow the coefficients δ_m and δ_f to be different to capture potential gender asymmetries on bargaining power.

[8] Our analysis relies on the implicit assumption that couples are fully commit to stay in the marriage. Therefore, $U_i(a_i)$ is not the utility of being single but the part of utility each individual receive from the household investment.

[9] We aware that the initial household matching decision for couples $\{X_m, X_f\}$ is outside the scope of our analysis. Also, we assume individual's characteristics $X_i, i \in \{m, f\}$ are time-invariant. Therefore, the bargaining power β is time-invariant, regardless of the possibility of period-by-period bargaining.

It is worth to mention that the total effect of individual risk preference $\gamma_i, i = \{m, f\}$, on the household risk preference γ_h could be non-linear and ambiguous due to two channels. (1) γ_i appears in the equation 2 and affects γ_h directly. We call this channel as "direct effect" in the analysis thereafter. (2) γ_i also affects γ_h due to its non-zero correlation with individual characteristics X_i. Therefore, γ_i also have indirect associations with β. We call this channel as "indirect effect". The total effect of γ_i on γ_h depends on the sign and magnitude of both channels.

3.2 Econometric Implementation and maximum likelihood function

In this section, we would add more parametric specifications to map the model into the corresponding data. Our goal is to establish a stochastic mapping between the observed characteristics

$$\Omega = (\bar{\gamma}_m, \bar{\gamma}_f, X_m, X_f)$$

where $\{\bar{\gamma}_m, \bar{\gamma}_f\}$ are measured risk aversions, $\{X_m, X_f\}$ is a comprehensive set of candidates variables that determine financial decision-making power ever mentioned in the literature, including education (Friedberg and Webb, 2006), income (Friedberg and Webb, 2006; Bertocchi et al., 2014), age (Bertocchi et al., 2014), financial literacy (Elder and Rudolph, 2003), personality traits ("Big-five") (Johnston et al., 2016), cognitive ability (Smith et al., 2010) and gender identity role (Ke, 2018). Although all these potential factors are analyzed under different context, this is the first time to put them together and compare their relative importance under one framework. And the outcomes

$$O = \{h_m, h_f, I, \bar{a}\}$$

where I is a dummy of stock market participation, $\bar{a}$ is reported risky asset holding. $\{h_m, h_f\}$ are the reported financial decision-maker in the household. They have integer value between 1 to 5, and we would use them as proxy of bargaining power β.[10]

In the next step, we need to introduce a bunch of measurement errors to specify the stochastic relationship between Ω and O. In our paper, the existence of measurement errors can be justified for two reasons. First, while the reported household financial decision-markers $\{h_m, h_f\}$ and measured risk aversion $\{\bar{\gamma}_m, \bar{\gamma}_f\}$ are discrete categories,

[10] We assume the values of (h_m, h_f) to be negative in principle but are positive in all data realizations.

their corresponding preference parameters (γ and β) are continuous variables. Therefore, measurement errors help to map the continuous values into cardinal integers. Second, HILDA collects the financial decision-marker information from both sides but only two-third households agree on who is the household decision marker.[11] The measurement error helps to smooth out the intra-household disagreement while still using the decision making information from both sides.

We assume (h_m, h_f) is a proxy of the financial bargaining power (β_m, β_f) within household with measurement errors (ξ_m, ξ_f) following the equations

$$\begin{aligned} h_m &= \delta_0 + \delta_{1m}\beta_m + \xi_m \\ h_f &= \delta_0 + \delta_{1f}\beta_f + \xi_f \end{aligned} \tag{4}$$

where $\beta_m = \beta$ is the bargaining power of the male, $\beta_f = 1 - \beta$ is the bargaining power of the female. We assume the coefficients $(\delta_{1m}, \delta_{1f})$ are gender-specific, as the same same of bargaining power may generate each gender different changes in their reports. However, the initial reference points δ_0 is assumed to be the same across genders. Measurement errors (ξ_m, ξ_f) follows a joint normal distribution

$$\begin{pmatrix} \xi_m \\ \xi_f \end{pmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_\xi^2 & \rho_\xi \sigma_\xi^2 \\ \rho_\xi \sigma_\xi^2 & \sigma_\xi^2 \end{bmatrix} \right)$$

The risk aversion parameters (γ_m, γ_f) are assumed to be functions of measured risk aversions $(\bar{\gamma}_m, \bar{\gamma}_f)$ with measurement errors (ϵ_m, ϵ_f). Again, we assume the marginal effect parameters $(\delta_{3m}, \delta_{3f})$ to be gender-specific but the level coefficient δ_2 to be shared by genders:

$$\begin{aligned} \log \gamma_m &= \delta_2 + \delta_{3m} \log \bar{\gamma}_m + \epsilon_m \\ \log \gamma_f &= \delta_2 + \delta_{3f} \log \bar{\gamma}_f + \epsilon_f \end{aligned} \tag{5}$$

where measurement errors (ϵ_m, ϵ_f) following a joint normal distribution and ρ_ϵ captures the potential correlation of the measurement errors between spouses.

$$\begin{pmatrix} \epsilon_m \\ \epsilon_f \end{pmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_\epsilon^2 & \rho_\epsilon \sigma_\epsilon^2 \\ \rho_\epsilon \sigma_\epsilon^2 & \sigma_\epsilon^2 \end{bmatrix} \right)$$

[11] This intro-household disagreement is a common phenomenon found in various survey datasets. Examples include Dobbelsteen and Kooreman (1997) using BHPS and Elder and Rudolph (2003) using HRS.

Lastly, we assume the reported asset $\bar{a}_s$ is a noisy measure of the true asset value a

$$\log \bar{a} = \log a + \zeta \tag{6}$$

where ζ is the measurement error and follows a normal distribution $\zeta \sim N(0, \sigma_a^2)$.

The parameters for assets are set exogenously. The risk premium $r_p = 0.06$ and the volatility is set to be $\sigma_r = 0.135$.[12]

Based on the above parametric specifications, we are able to establish the likelihood function between the outcome O_i and the observed characteristics Ω_i of household i given the parameter set Θ. The parameter set contains

$$\Theta = (C, \delta_{\gamma m}, \delta_{\gamma f}, \delta_{xm}, \delta_{xf}, \delta_{0m}, \delta_{0f}, \delta_1, \delta_{2m}, \delta_{2f}, \delta_3, \sigma_{\xi k}, \rho_\xi, \sigma_{\epsilon k}, \rho_\epsilon, \sigma_a), k = m, f$$

We can write the likelihood function as

$$\begin{aligned} l(O_i|\Omega_i, \Theta) = \iint_{\epsilon_m \times \epsilon_f} & f_h(h_m, h_f|\beta) f_a(\bar{a}|I, \gamma_h) f_I(I|\gamma_h) f_{\gamma_h}(\gamma_h|\gamma_m, \gamma_f, \beta) \\ & f_\beta(\beta|X_m, X_f, \gamma_m, \gamma_f) f_\gamma(\gamma_m, \gamma_f|\bar{\gamma}_m, \bar{\gamma}_f, \epsilon_m, \epsilon_f) d\epsilon_m d\epsilon_f \end{aligned}$$

where density function f_{γ_h} and f_β are two deterministic functions defined in equation 2 and equation 3. The other two density functions f_h and f_γ are defined in equation 4 and 5, respectively. The investment decision function f_I and and the asset holding function f_a follows the decision rule 1 as well as the asset measurement equation 6. The optimal values of parameters $\hat{\Theta}$ is estimated by maximizing the following likelihood function:

$$\hat{\Theta} = \arg\max_{\Theta} \prod_{i=1} l(O_i|\Omega_i, \Theta)$$

3.3 Identification

To be completed

[12] We use the values consistent with Pojanavatee(2011), in which report the return and standard error of the S&P/ASX 200 are 7.62% and 13.50%, respectively.

4 Estimation Results

4.1 Model estimates

The estimated parameters that determine the bargaining weights are shown in Table 6. We classify all determinants of the bargaining weight on financial decisions into three dimensions: financial ability related characters (financial literacy, cognitive ability, income and education), "Big-five" personality traits and other non-economic characters (age and gender norms). Consistent with previous literature, we find all three parts are important factors in determining bargaining weight.[13] More specifically, the effects of all four financial ability related variables on bargaining weight are positively significant. And their effects are somewhat more significant on men's side. Among the big-five personality traits, emotional stability have a ceteris paribus positive effect on the bargaining weight, whereas agreeableness and conscientiousness have a negative effect. Extraversion increases the bargaining weight for women but decreases it for men. Age increases the bargaining weight for both men and women. But the effect for men are significantly larger than the effect for women. lastly, a belief of gender identity norm favors for men's bargaining weight but not favors for the women's bargaining weight.

The other estimates are reported in table 7. Our estimates show the lump-sum participation cost of stock market is AU$4843. The standard deviation of the measurement error term in asset equation 6 is 0.898. The other estimates are the coefficients associated with the measurement equation 4 and 5. Individuals who reported to be more risk averse tend to have a larger risk aversion level. However, the marginal effect is smaller for male (1.195) than for female (2.148). On the other hand, The spouse who has more bargaining weight in the household are more likely to be the final financial decision market in the household. However, the coefficient is smaller for men (-0.339) than for women (-0.429).[14]

[13] Smith et al. (2010) use the US Health and Retirement Survey (HRS) data and find that numeracy skills are important in determining who makes the financial decisions within a household. Brown and Taylor (2014) uses from the British Household Panel Survey (BHPS) and find the certain personality traits such as extraversion are generally significantly associated with household finances in terms of the levels of debt and assets held. Ke (2018) use gender identity norms to explain why families with a financially sophisticated husband are more likely to participate in the stock market than those with a wife of equal financial sophistication.

[14] The coefficients are negative because a smaller value (=1 or 2) means the respondent is the decision marker while a larger value (= 4 or 5) means his/her partner is the decision marker.

Table 6: Model estimates: coefficients in the bargaining equation 3

	Male		Female	
	Value	S.E.	Value	S.E.
Financial ability characters				
Financial literacy	0.625	0.069	0.142	0.031
Cognitive ability	0.448	0.049	0.021	0.016
Income	0.692	0.069	0.044	0.020
Education	0.560	0.063	0.022	0.023
"Big-five" personality traits				
Extraversion	-0.151	0.032	0.112	0.029
Agreeableness	-0.137	0.032	-0.156	0.035
Conscientiousness	-0.068	0.018	-0.132	0.033
Emotional stability	0.156	0.036	0.217	0.031
Openness	-0.018	0.020	-0.010	0.007
Other non-economic characters				
Age	2.081	0.094	0.114	0.040
Gender norms	0.099	0.022	-0.045	0.015

Table 7: Model estimates: coefficients in measurement equations

Variable	Value	Standard error
σ_ξ	1.349	0.045
ρ_ξ	-0.467	0.029
δ_0	1.193	0.062
δ_{1m}	1.195	0.061
δ_{1f}	2.148	0.060
σ_ϵ	0.644	0.007
ρ_ϵ	-0.380	0.019
δ_2	3.104	0.021
δ_{3m}	-0.339	0.037
δ_{3f}	-0.426	0.059
σ_a	0.633	0.034
C	4843	193.9

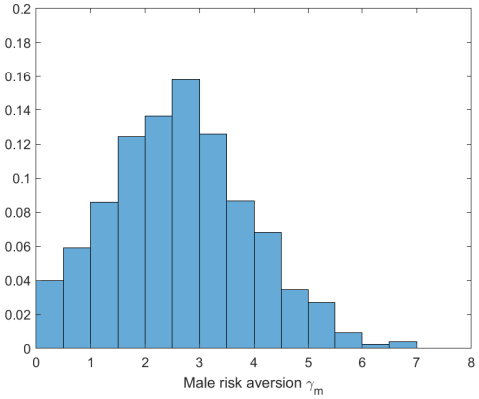
Figure 2 plots the histogram distribution of spousal risk aversion (γ_m and γ_f) in the upper panel and bargaining weight (β_m and β_f) in the lower panel. The distribution of male risk aversion γ_m are more right skewed compared with the distribution of female risk aversion γ_f, which means women are on average more risk averse than men. This finding is consistent with significant empirical evidence in the literature. For example, Powell and Ansic (1997) provide experimental evidence of gender differences in risk behavior in financial decision-making. **?** show survey-based evidence. And Barber and Odean (2001) demonstrate strong gender-based differences in investment preferences. The average gender ratio γ_f/γ_m is 1.484 in our estimation, which is reasonably close to the estimate value 1.67 from Mazzocco (2005) using the Consumer Expenditure Survey (CEX). The lower panel displays the distributions of male bargaining power (subfigure (c)) and female bargaining power (subfigure (d)). Men have relatively larger bargaining weights to their spouses. Subfigure c shows the distribution of male bargaining weight is concentrated toward 1 with half of the males have bargaining powers $\beta_m > 0.9$. While the distribution of female bargaining power is concentrated towards 0 with half of them $\beta_f < 0.1$.

4.2 The goodness of model fit

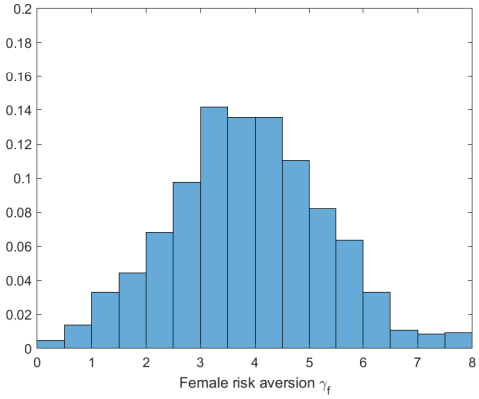
The goodness of model fit are shown in table 8, figure 3 and figure 4. Table 8 show the proportion of households participating into the stock market (upper panel) and the average log value of risky asset conditioning on entering into stock market (lower panel). All mean values are conditional on the financial decision marker categories and risk aversion categories. The first two columns under name “male" are based on reported categories from male side. And the last two columns under name "female" based on reported categories from female side. The model capture well the monotonic patterns across financial decision marker categories and across different risk aversion levels. The subgroup whose final decision markers are husbands are more involved into the stock market. The average participation rate is higher and the average stock assert conditioning on participating into the stock marker are larger. On the other hand, the opposite subgroup whose financial heads are wives are detached from stock market. It displays lower stock participation rate and lower asset values. In the dimension of risk aversion, the less risk averse group (reported risk aversion ≤ 3) are systematically more attached to the stock market compared with the more risk averse group (reported risk aversion > 3). Both their stock participation rate and asset holding values are

Figure 2: Histograms of spousal risk aversion and bargaining weight

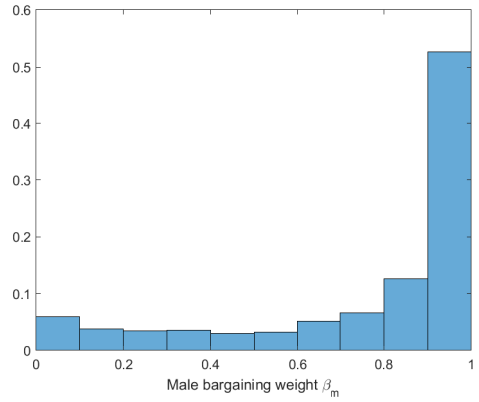
(a) Male risk aversion γ_m



(b) Female risk aversion γ_f



(c) Male bargaining weight β_m



(d) Female bargaining weight β_f

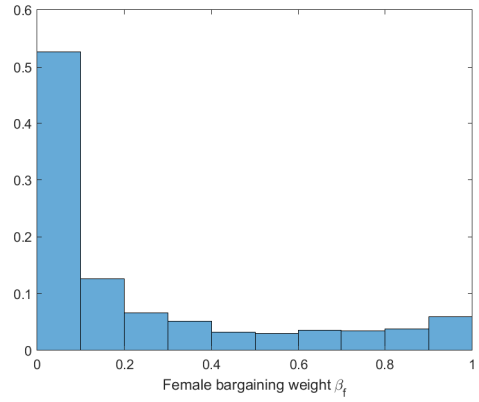


Table 8: The marginal distribution of portfolio choices

	Male		Female	
	Sim	Data	Sim	Data
The proportion of stock market participation				
Financial decision marker				
Male	0.549	0.515	0.598	0.587
Equal	0.410	0.404	0.416	0.400
Female	0.391	0.391	0.383	0.403
Risk aversion levels				
Less risk averse	0.526	0.500	0.545	0.528
More risk averse	0.271	0.286	0.333	0.327
The log of average amount of risky asset (Unit: AU$)				
Financial decision marker				
Male	13.014	13.176	13.057	13.115
Equal	12.837	12.752	12.845	12.819
Female	12.861	12.677	12.837	12.621
Risk aversion levels				
Less risk averse	12.909	12.967	12.901	12.997
More risk averse	12.793	12.481	12.857	12.629

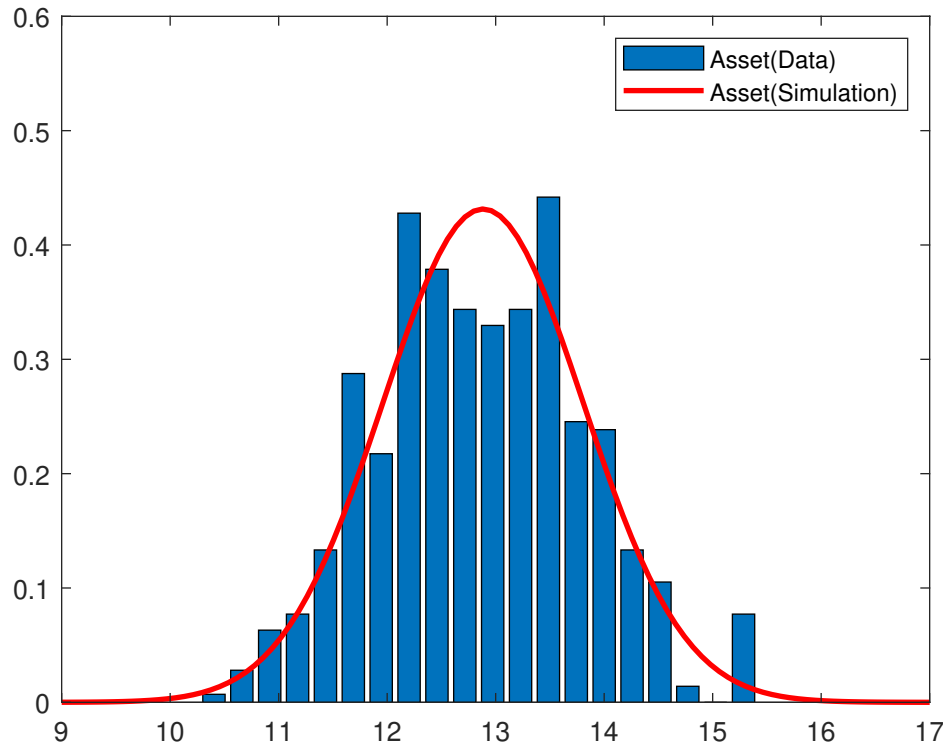
higher. Figure 3 displays a close fit between the asset distribution in the data and the distribution simulated by our model.

Figure 4 shows the distribution of the final financial decision maker in subgroups with different risk aversion levels. The upper panel (subfigure (a) and (b)) demonstrates the decision marker reported from male side and the lower panel (subfigure (a) and (b)) demonstrates the decision marker reported from the female side. Our simulation results replicate two features in the data. First, the reports from each side are both more likely to report male as financial decision makers than females as the financial decision market. Secondly, less risk averse group are more likely to mark males as the financial decision maker compared with their corresponding high risk averse subgroup. However, this difference between groups with different risk averse levels are less in the simulation compared with the difference in the data.

5 Counterfactual Analysis

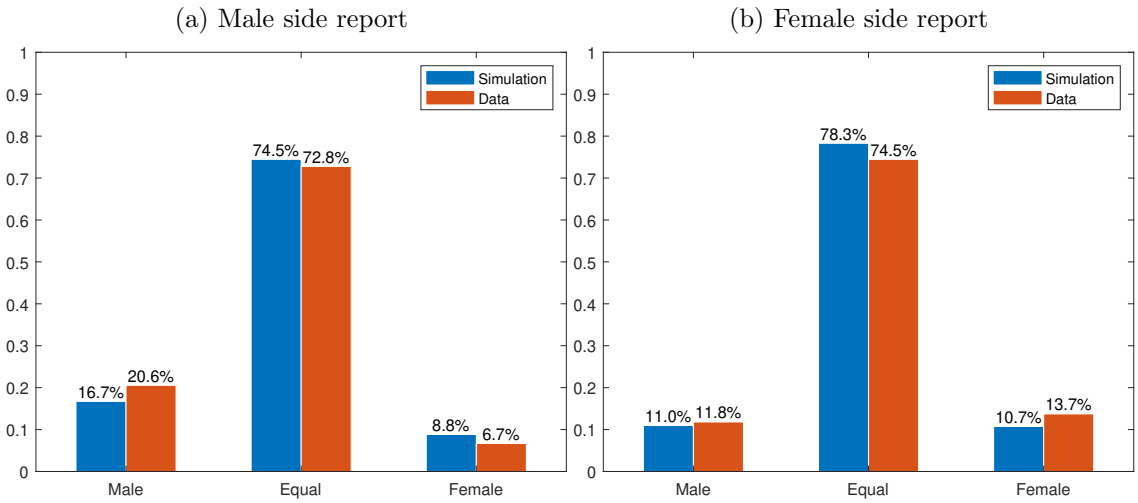
Table 9 compares the simulation results when we only allow for a subset of individual heterogeneity to affect the bargaining power. The symmetric scenario (row 1) assumes

Figure 3: The distribution of risky asset $\log(a)$



Note: The asset value is top-coded in the HILDA data by substituting an average value for all the cases that are equal to or exceed a given threshold, which explains the abnormal high value at the right end of the histogram distribution.

Figure 4: The distribution of the final financial decision maker within household



Note: we need to discretize the continuous simulated variable $h_k, k = m, f$ so it could be comparable with its corresponding discrete categories in the data. Specifically, we assume individual would report themselves as the single financial decision maker when $h_k \leq 2.2$; report the financial decision is shared if $h_k \in (2.2, 3.8)$; report their spouses as the single financial decision maker when $h_k \geq 3.8$.

men and women are homogeneous and have equal weights ($\alpha = 0.5$). In the subsequent rows (row 2-8), we present various simulated outcomes when incorporating a certain subset of heterogeneous characteristics on the determination of bargaining weights: the bargaining weights are homogeneous but unequal between genders (row 2); the bargaining weights are heterogeneous only due to variables significantly associated with risk preference (row 3); a combination of heterogeneity in row 2 and row 3 (row 4); the heterogeneous bargaining weights caused by men side heterogeneity (row 5); the heterogeneous bargaining weights caused by women side heterogeneity (row 6); the heterogeneous bargaining weights caused by only Big-five personality traits (row 7); the heterogeneous bargaining weights caused by only gender identity norm (row 8). The simulation outcomes including all heterogeneity are reported in the last row (row 9).

We first consider the situation when men and women are totally homogeneous (except their risk preference) and therefore have equal weights. Compared with our baseline case with full heterogeneity (row 9), the average stock market participation rate is lower (22.4 versus 43.7 percent) due to the households are on average less risk taking in such scenario (-3.780 vs. -3.232). In our following exercise, we plan to turn on one

channel each time to understand how a certain dimension of individual heterogeneity may affect the risk preference and stock market participation in the household level.

Row 2 reports the outcomes when allowing the bargaining power to be different by genders. More specifically, we achieve it by setting the constant term δ_0 as its estimated value 0.9242 but remain other coefficients to be 0. As a result, the bargaining power of men β equals to 0.716 while the bargaining power of women $1-\beta$ equals to 0.284. Compared with the case of equal weights (row 1), the average stock market participation rate is relatively higher (0.276 vs 0.224) as the households become more risk taking (-3.610 vs. -3.780). This change is mainly driven by the fact that men are on average more risk taking than women. Therefore, the households become more risk taking as the bargaining weights of men increases. We call this change as the "direct effect" of spouse's risk preferences on household risk preference.

Row 3 reports the effects of a set of risk-related variables, including education, cognitive ability, literacy and income on the bargaining power.[15] Specifically, we turn on the estimated associations between this set of variables and bargaining weight but remain the other coefficients to be 0. The purpose of this exercise is to show an indirect connection between individual risk preference and household risk preference through the bargaining weight channel. A certain set of variables, including education, cognitive ability, literacy and income, are highly correlated with risk preference and are also important determinants of the bargaining power of spouses. We call this changes as the "indirect effect" of spouse's risk preferences on household risk preference. Due to the effects of these variables, risk-taking men are more likely to have higher bargaining power ($\rho(\alpha_m, -\bar{\gamma}_m) = 0.285$), while risk-taking women are less likely to have higher bargaining power ($\rho(\alpha_f, -\bar{\gamma}_f) = -0.241$). As a result, the stock market participation rate increases from 0.224 (row1) to 0.316 and the household risk preference increase from -3.780 (row 1) to -3.604.

Row 4 reports the outcomes when combining the heterogeneity in row 2 and 3 together. We perform this exercise to have a relatively completed evaluation on how the spouse's individual risk preferences aggregate into the household risk preference. The combination of "direct" effect and "indirect" effect increase the stock market participation rate from 0.224 to 0.390, which accounts for almost the whole gap between the case without any gender heterogeneity (row 1) and the case with full heterogeneity (row 9).

We explore the importance of the heterogeneity from each gender by allowing for the

[15] These are all variables which are significantly correlated ($\rho > 0.15$) with risk preferences.

heterogeneity from men side in row 5 and the heterogeneity from female side in row 6 separately. By comparing the outcomes in row 5 and 6, we find that the heterogeneity from male side and the one from female side work on the opposite direction but different magnitudes. While the heterogeneity from male side causes risk taking men more powerful, the heterogeneity from female side, on the other hand, causes risk taking women more powerful within household. When comparing their magnitudes, the effect generated by men's heterogeneity dominates the effect generated by female's heterogeneity.

Row 7 reports the effect of personality traits on the bargaining power. Incorporating personality traits generates two offsetting effects on household risk preference. On one hand, it increases the average male bargaining weights, which increases the household risk taking preference. On the other hand, it decreases the probability of risk-taking men to be the the financial decreasing maker, which discourages the household risk taking attitude. The latter effect dominates the former effect. As a result, the incorporation of personality traits reduces the household risk taking preference (-3.795 vs. -3.780) and therefore leads to the decrease of stock market participation rates (0.217 vs. 0.224).

Lastly, row 8 reports the effects of gender identity attitude on the bargaining power. The incorporation of gender identity norm also generate two offsetting effects on household risk preference. The "direct effect" increases the household risk preference but the "indirect effect" decreases the household risk preference. Unlike the case of personality traits, the "direct" effect dominates the "indirect" effect when discussing the effects of gender identity attitude. As a result, the incorporation of personality traits increases the household risk taking preference (-3.724 vs. -3.780) and therefore leads to the increase of stock market participation rates (0.231 vs. 0.224).

Table 9: Decomposition the effects from different characteristics

	Stock market rates	Bargaining power (male)	Corr(weight,risk) $\rho(\alpha_m, -\bar{\gamma}_m)$	Corr(weight,risk) $\rho(\alpha_f, -\bar{\gamma}_f)$	Household risk $-\gamma_h$ [b]
(1) Equal weight ($\alpha = 0.5$)	0.224	0.500	0.000	0.000	-3.780
(2) Homogeneous within gender	0.276	0.716	0.000	0.000	-3.610
(3) Full heterogeneity (baseline model)	0.437	0.764	0.164	-0.127	-3.233
(4) Financial ability characters	0.390	0.726	0.271	-0.233	-3.407
(5) Only "Big-5" personality traits	0.290	0.737	-0.072	0.057	-3.571
(6) Only gender identity norm	0.311	0.794	-0.045	0.138	-3.498
(7) Only male side heterogeneity	0.407	0.734	0.175	-0.151	-3.317
(8) Only female side heterogeneity	0.297	0.756	-0.106	0.195	-3.535

[a] The risk-related variables include education, cognitive ability, literacy and income, which are all variables which have have significant associations ($\rho > 0.15$) with individual's risk preference.

[b] In our raw data, $\gamma = 1$ is the group reporting most risk taking while $\gamma = 5$ is the group reporting most risk averse. Therefore, we use the revered value $-\gamma$ to represent the level of risk taking.

References

Addoum, J. M. (2017). Household portfolio choice and retirement. *Review of Economics and Statistics*, 99(5):870–883.

Addoum, J. M., Kung, H., and Morales, G. (2016). Limited marital commitment and household portfolios. *Available at SSRN 2871296*.

Aivazian, V. A., Callen, J. L., Krinsky, I., and Kwan, C. C. (1983). Mean-variance utility functions and the demand for risky assets: An empirical analysis using flexible functional forms. *Journal of Financial and Quantitative Analysis*, 18(4):411–424.

Alan, S. (2006). Entry costs and stock market participation over the life cycle. *Review of Economic Dynamics*, 9(4):588–611.

Apps, P. F. and Rees, R. (1997). Collective labor supply and household production. *Journal of political Economy*, 105(1):178–190.

Arano, K., Parker, C., and Terry, R. (2010). Gender-based risk aversion and retirement asset allocation. *Economic Inquiry*, 48(1):147–155.

Barber, B. M. and Odean, T. (2001). Boys will be boys: Gender, overconfidence, and common stock investment. *The quarterly journal of economics*, 116(1):261–292.

Barsky, R. B., Juster, F. T., Kimball, M. S., and Shapiro, M. D. (1997). Preference parameters and behavioral heterogeneity: An experimental approach in the health and retirement study. *The Quarterly Journal of Economics*, 112(2):537–579.

Bateman, I. and Munro, A. (2005). An experiment on risky choice amongst households. *The Economic Journal*, 115(502):C176–C189.

Bertaut, C. C. (1998). Stockholding behavior of us households: Evidence from the 1983–1989 survey of consumer finances. *Review of Economics and Statistics*, 80(2):263–275.

Bertocchi, G., Brunetti, M., and Torricelli, C. (2014). Who holds the purse strings within the household? the determinants of intra-family decision making. *Journal of Economic Behavior & Organization*, 101:65–86.

Brown, S. and Taylor, K. (2014). Household finances and the 'big five' personality traits. *Journal of Economic Psychology*, 45:197–212.

Browning, M. (2000). The saving behaviour of a two-person household. *scandinavian Journal of Economics*, 102(2):235–251.

Browning, M. and Chiappori, P.-A. (1998). Efficient intra-household allocations: A general characterization and empirical tests. *Econometrica*, pages 1241–1278.

Campbell, J. Y. (2006). Household finance. *The journal of finance*, 61(4):1553–1604.

Chiappori, P.-A. (1988). Nash-bargained households decisions: a comment. *International Economic Review*, 29(4):791–796.

Chiappori, P.-A. (1992). Collective labor supply and welfare. *Journal of political Economy*, 100(3):437–467.

Chiappori, P.-A. and Ekeland, I. (2006). The micro economics of group behavior: general characterization. *Journal of Economic Theory*, 130(1):1–26.

Cocco, J. F., Gomes, F. J., and Maenhout, P. J. (2005). Consumption and portfolio choice over the life cycle. *The Review of Financial Studies*, 18(2):491–533.

Curcuru, S., Heaton, J., Lucas, D., and Moore, D. (2010). Heterogeneity and portfolio choice: Theory and evidence. In *Handbook of Financial Econometrics: Tools and Techniques*, pages 337–382. Elsevier.

Dobbelsteen, S. and Kooreman, P. (1997). Financial management, bargaining and efficiency within the household; an empirical analysis. *De Economist*, 145(3):345–366.

Elder, H. W. and Rudolph, P. M. (2003). Who makes the financial decisions in the households of older americans? *Financial Services Review*, 12(4).

Flinn, C. J., Todd, P. E., and Zhang, W. (2018). Personality traits, intra-household allocation and the gender wage gap. *European Economic Review*, 109:191–220.

Friedberg, L. and Webb, A. (2006). Determinants and consequences of bargaining power in households. Technical report, National Bureau of Economic Research.

Gomes, F. and Michaelides, A. (2005). Optimal life-cycle asset allocation: Understanding the empirical evidence. *The Journal of Finance*, 60(2):869–904.

Haliassos, M. and Bertaut, C. C. (1995). Why do so few hold stocks? *the economic Journal*, 105(432):1110–1129.

Heaton, J. and Lucas, D. (1997). Market frictions, savings behavior, and portfolio choice. *Macroeconomic Dynamics*, 1(1):76–101.

Johnston, D. W., Kassenboehmer, S. C., and Shields, M. A. (2016). Financial decision-making in the household: Exploring the importance of survey respondent, health, cognitive ability and personality. *Journal of Economic Behavior & Organization*, 132:42–61.

Ke, D. (2018). Who wears the pants? gender identity norms and intra-household financial decision making. *Gender Identity Norms and Intra-Household Financial Decision Making (August 4, 2018)*.

Kroll, Y., Levy, H., and Markowitz, H. M. (1984). Mean-variance versus direct utility maximization. *The Journal of Finance*, 39(1):47–61.

Levy, H. and Markowitz, H. M. (1979). Approximating expected utility by a function of mean and variance. *The American Economic Review*, 69(3):308–317.

Lundberg, S., Startz, R., and Stillman, S. (2003). The retirement-consumption puzzle: a marital bargaining approach. *Journal of public Economics*, 87(5-6):1199–1218.

Manser, M. and Brown, M. (1980). Marriage and household decision-making: A bargaining analysis. *International economic review*, pages 31–44.

Maurer, J. and Luhrmann, M. (2008). Who wears the trousers? a semiparametric analysis of decision power in couples.

Mazzocco, M. (2004). Saving, risk sharing, and preferences for risk. *American Economic Review*, 94(4):1169–1182.

Mazzocco, M. (2005). Individual rather than household euler equations: Identification and estimation of individual preferences using household data. *Available at SSRN 695285*.

McElroy, M. B. and Horney, M. J. (1981). Nash-bargained household decisions: Toward a generalization of the theory of demand. *International economic review*, pages 333–349.

Neelakantan, U., Lyons, A., and Nelson, C. (2009). Household bargaining and portfolio choice. *Unpublished Manuscript. http://www. acrobatplanet. com/go/Household_Bargaining_and_ Portfolio_Choice. pdf.*

Powell, M. and Ansic, D. (1997). Gender differences in risk behaviour in financial decision-making: An experimental analysis. *Journal of economic psychology*, 18(6):605–628.

Smith, J. P., McArdle, J. J., and Willis, R. (2010). Financial decision making and cognition in a family context. *The Economic Journal*, 120(548):F363–F380.

Thörnqvist, T. and Vardardottir, A. (2014). Bargaining over risk: The impact of decision power on household portfolios.

Vissing-Jørgensen, A. (2002). Limited asset market participation and the elasticity of intertemporal substitution. *Journal of political Economy*, 110(4):825–853.

Wachter, J. A. and Yogo, M. (2010). Why do household portfolio shares rise in wealth? *The Review of Financial Studies*, 23(11):3929–3965.

Yilmazer, T. and Lich, S. (2015). Portfolio choice and risk attitudes: a household bargaining approach. *Review of Economics of the Household*, 13(2):219–241.

Yilmazer, T. and Lyons, A. C. (2010). Marriage and the allocation of assets in women's defined contribution plans. *Journal of Family and Economic Issues*, 31(2):121–137.

A CARA and Mean-Variance Utility

Assuming a CARA utility with risk aversion parameter γ_h, the portfolio choice is

$$V_h = \max_a Eu\left(a\right) = \max_a E\left\{-\exp\left\{-\gamma_h\left[w\left(1+r\right)+\left(a\tilde{x}-C_h\right)I\left(a>0\right)\right]\right\}\right\}$$

where a is the amount of asset the household chooses to invest into the stock market, and $I(a>0)$ is a dummy indicator for the stock market participation. Assume the risky return follows a normal distribution $\tilde{x} \sim N(r_p, \sigma)$, then the utility is lognormally distributed when the stock asset $a > 0$. Therefore, the portfolio choice problem is equivalent to

$$\begin{aligned}&\min_a \log E\left\{\exp\left\{-\gamma_h\left[w\left(1+r\right)+\left(a\tilde{x}-C_h\right)I\left(a>0\right)\right]\right\}\right\}\\ =&\min_a\left\{-\gamma_h\left[w\left(1+r\right)+\left(ar_p-C_h-\tfrac{1}{2}\gamma_h a^2\sigma^2\right)I\left(a>0\right)\right]\right\}\end{aligned}$$

Then, we can rewrite the problem using mean-variance utility

$$U_h\left(a\right) = \max_a w(1+r) + \left(ar_p - C_h - \frac{1}{2}\gamma_h a^2\sigma^2\right) I(a>0)$$