How will households adjust their consumption and investment decisions under longevity risk

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Abstract

The purpose of this paper is using the experimental methodology to investigate how households will adjust their consumption and investment decisions under longevity risk. Firstly, we find that households prefer changing their asset allocation to cutting their consumption when they face the longevity risk. Then, our results support that households with greater risk aversion, more children and bequest motivation will reduce the proportion of risky asset under longevity risk. Finally, households with higher life expectancy will increase their risky asset holding after retirement. The main results of this paper support households indeed change their behavior to adapt to the longevity risk.

Key words: Longevity risk, Experimental, Consumption Decisions

1. Introduction

In last two decades, with improvement the quality of life, health environment and medical technology, the average human life expectancy has significantly increased. Much evidence can support increasing average life expectation[3]. Population aging is occurring and becoming a serious problem that every country should face and deal with it. According to United Nation World Health Organization (WHO) standard, when the citizens aged over sixty-five years old occupy over 7% percents of the total

[3] Oeppen and Vaupel (2002) find in the U.S. life expectancy is increasing by 2.43 years each decade. Moreover, Turner’s (2006) point out the mortality rate for a 65-year-old U.K. male in 2013 will fall by 46 percent in the twenty years between 1983 and 2003.

population, the country is belonged to an “aged country”. Many Asian or European countries such as Japan, Sweden, and Germany have entered into the aged society. For aged country, the government will encounter an unprecedented demand on social and health care systems due to sharply decreasing number of working age people. In other words, population ageing would make an actual brake on the economic development of countries. Moreover, as the average life expectation is gradually extending, people’s some decisions could be affected by the longevity risk. That is to say, households may adjust their consumption, investment, insurance and house tenure decisions to mitigate the longevity risk. For example, some households will cut down the unnecessary expenditure and reduce the proportion of holding risky asset when they face the longevity risk. Therefore, the purpose of this study is using the questionnaire and experimental methodology to investigate the consumption and investment decisions under longevity risk.

The issue related to the decisions under longevity seems have been more important and popular in recent years. The people may change their consumption decisions when they getting elder. Initially, Modigliani, Brumberg and Ando offer “Life Cycle Hypothesis” in 1950’ and think the households will maintain steady expenditure in their whole life. However, Hamermesh (1984) find the “retirement consumption puzzle” that the households will decrease their expenditure sharply at their retirement. Furthermore, Modigliani (1986) point out that saving should be positive for households in their working span and negative in the retirement, and then wealth should be hump-shaped. Haider and Stephens (2004) find that subjective retirement expectations are predictors of subsequent retirement decisions and still have the conclusion that a consumption decline at retirement with the expectations. Mathieu (2006) uses the family expenditure data in Belgium to explore how aged population affects the aggregate expenditure amount. He finds that increasing the proportion of elder people will reduce the average consumption. Hurst (2008) discovers the decrease of consumption at the retirement period mainly attributes to food expenditure. Base on previous findings, the change of population structure indeed influence the consumption decision.

From the view of investment decision, the improvement in the risk perception of mortality rates could alter the behavior for holding risky asset, and then change the risk premium. By using US data, Bakshi and Chen (1994) find that when the structure of population becomes elder, the demand for financial investment increases and the demand for housing decrease. They also discover there exists a positive relationship with the average age and risk premium. However, contrary to Bakshi and Chen (1994), by utilizing international data, Ang and Maddaloni (2005) find the higher the growth rate of the proportion of the retired group to population will reduce the risk premium. Besides demographic changes, the improvement in the risk perception of the mortality rate can also influence the risk premium in stock market. That is to say, the longevity risk will change the individuals' prediction of their life expectancy, and then further shift their demand for risky assets. Athanasoulis (2006) argued that if people will anticipate living longer, they would like to save more when mortality rate decreases. In other word, the mortality rate is positively correlated to equity premium in his calibration. Huang et al. (2010) propose that the improvement in the risk perception of mortality rates could increase the anxiety from holding risky assets and further change the demand for risky assets. By using G7 countries, they also find no matter short-run and long-run equity premiums are negatively correlated with mortality rates. Therefore, depending on literature, the change of population structure absolutely affects the investment decisions and asset allocation.

Although previous scholars provide many useful inspirations and interesting findings about how the individual or household has proceeded with the decisions under longevity risk, it still remains some questions need to further explore. Firstly, many previous papers only consider the relationship between one-dimension decision and population structure due to the limitation of data. In this paper, we use the experimental method to consider two-dimension decisions jointly under longevity risk. Secondly, most papers use aggregate data to distinguish the longevity impact on risk premium or expenditure amount. It is difficult to track how households proceed with their consumption and investment decision for the long period. To construct the panel data of households under the longevity risk may spend a lot of time and money. Use the experimental economics could provide another way to analyze the households' behavior under longevity risk.

Therefore, the purpose of this study is using the questionnaire and experimental methodology to investigate the consumption and investment decisions under longevity risk. We invite participant who is head of household with qualifies some criterions such as age is around thirty years old and married to join our experiment. During our experiment, we record their consumption and investment decisions respectively with and without longevity risk. Then, we can analyze the relationship between household background, risk aversion and their consumption and investment decisions.

For aspect of consumption decision, our empirical results support that it is difficult for all households to reduce their expenditure significantly before retirement and whole life. However, households with higher education will decrease their expenditure to avoid the longevity risk after retirement. It could be due to the households' expenditures such as food, clothes, children education fee, rent or mortgage, transportation are inflexible and hardly change before retirement. After retirement, although some expenditure can be reduced, medical and health-care expense could increase sharply. Therefore, we find that households drastically adjust their consumption decisions even if under longevity risk.

For aspect of investment decision, we find that households with higher risk aversion will take more conservative investment strategies to avoid the longevity risk. Before the retirement, the participants have more children and higher absolute risk aversion will intend to increase the proportion of riskless asset and reduce the proportion of risky asset. After retirement, if the participants qualified the characteristics of female, higher education, more children and lower life expectancy will intend to hold more riskless asset and less risky asset to mitigate the longevity risk. For whole life, we find households with more bequest motivations will reduce the proportion of risky asset. However, participants with higher life expectancy will increase their risky asset holding after retirement. According to above results, we discover that households will actively modify their asset allocation to alleviate the longevity risk by their characteristics. The main result of this paper is finding the households prefer to adjust their investment decision than consumption decision in order to deal with the longevity risk.

The remainder of this paper is organized as follow. In section two, we will explain how we use experiment methodology to investigate the participants' behavior under longevity risk. Section 3 contains variables definition and empirical model. We will show the statistics and empirical results in section 4. We will make the conclusions in last section.

2. Experiment Methodology

Experimental economics is the application of experimental methods to investigate the economics questions. This methodology provides other ways to understand the human behaviors under some specific setting and environment. Economic experiments can be classified into many different topics such as game theory, auctions, bargaining, decision making, coordination, etc. The purpose of this paper is investigating how the household proceed with their consumption and investment decisions under longevity risk by experimental economics methodology.

We recruited nearly one hundred participants who their ages are nearly thirty years old and have married to join our experiment. At the beginning of the experiment, we will introduce the experimental regulations and how to make consumption and investment decisions to the participants. Moreover, we will interview most of participants with their attitudes and thoughts when they face the longevity risk. Although this interview record can't be analyzed by statistics, it still helps us to find reasonable explanations for participants' behavior. Then, the participants are asked to fill in questionnaire related to the characteristics of households. This questionnaire mainly contains three parts including household demographic, health status perception and risk aversion. The demographic part consists of gender of participant, education, number of children, family salary, net wealth and the bequest motivation. The health status perception includes participants' life expectation, health status and health-care expenditure. Some information such as net wealth, monthly salary and life expectation will be used in our experiment. We use Eisenhauer and Ventura (2003) method to measure the risk aversion of participants (described more in next section).

All participants will be asked to join this experiment two times. In the first round, without longevity risk, participants will proceed with their decisions, and live until as their expectation in the questionnaire. In the second round, by telling participants have the opportunity can extend their live age from zero to ten years, the participants proceed with their consumption and investment decision when understanding they could live to longer. The only difference of the first and second round is possible life extension. We use the life extension as the proxy for longevity risk and observe how the households will adjust their consumption and investment decision after incorporating longevity risk in experiment.

In figure 1, we can know the experimental framework more clearly. In the first step, the participants will fill in the questionnaire and be introduced relevant regulations related the experiment. In the second step, participates begin to proceed with their decisions in this stage, which means the thirty years old as the start point in our experiment. For convenient to compare the participants' decisions, no matter how old are they, we assume they begin their decision at thirty years old in our experiment[4]. We can get the information such as salary, net wealth and salary growth expectation from the questionnaire and use these real data in our experiment[5]. Every five years means one turn in our experimental process. Before retirement period, the participants proceed with their consumption and investment decision with salary based on information salary growth and initial month salary[6] at thirty years old filled in their questionnaires. In other word, all participants have seven turns before retirement period.

Since sixty-five years old, the participants retire and have no salary in post-retirement period. They continuously proceed with their consumption and investment decisions without salary. In the first round, the participants will die in their life expectation. For example, if one participant expects he can live until seventy-five years old, he will leave at the ninth turn of experiment. That is to say, there is no longevity risk because people can predict how long they will live. To base on this information, they can choose their consumption and investment in each turn, then to decide how much money to leave to their children.

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[4] We recruit the participant nearly thirty years old and get married. Therefore, the assumption which the start age of our experiment is thirty years old seems reasonable.

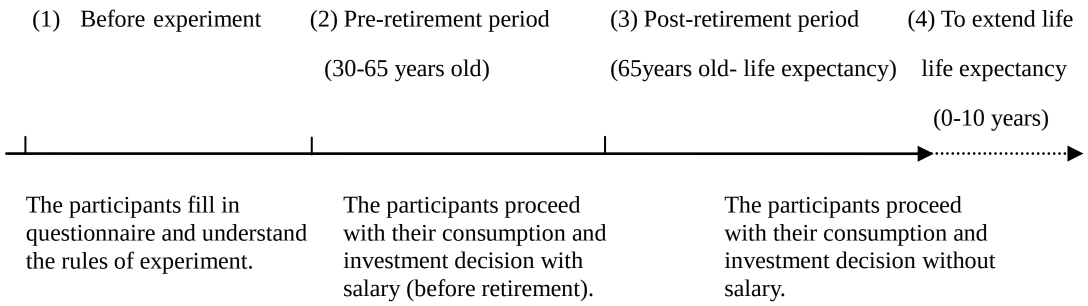
[5] The participants fill in their net wealth, month salary, salary growth and life expectation in the questionnaire. At the beginning of experiment, we use the real information such as net wealth, month salary at thirty years old and salary growth provided by participants

[6] The computer use the information provided by participants and automatically calculate the salary in each turn. ((monthly salary*12*(1+salary growth))

In the second round, the participant will have opportunity to live longer from zero to ten years. Therefore, the participants could have more one or two extra turn or still maintain the same turn in the second round experiment. In figure 1, participants attending the second round will have the step 4 (shown as the dotted line). The main difference comparing with the previous round is that the participants do not know when they will die. Thus, they will adjust their consumption and investment decision to avoid the extra life span. We use this uncertainty life span as the proxy variable for longevity risk. As the other conditions are maintained equal to the first round, we will observe how the participants adjust their consumption and investment decision to avoid the longevity risk.

We indeed find some interesting findings from our experiment. We observe that households prefer changing their investment decision to cutting their consumption when they face the longevity risk. Then, our results support that households with some specific characteristics such as greater risk aversion, more children and bequest motivation will reduce the proportion of risky asset under longevity risk. Finally, households with higher life expectancy will increase their risky asset holding after retirement period.

Figure 1 Experiment Frame



The first round contains the step 1, 2 and 3. The participants join the experiment and The second round contains the step 1, 2, 3 and 4.

2.1 The longevity risk

The longevity risk can be briefly defined as that population might live longer, on average, than originally anticipated. How to deal with longevity risk has ultimately become an important question no matter who will face this kind of problem. The problems related to longevity risk should be belongs to the different levels respectively governments, life insurance companies and households be discussed because each level have their own difficulties and possible ways to solved. For country level, the governments will expand the expenditures about social and health care system when the populations live longer than the expectation. On the other hand, due to decreasing number of work-age population, tax income will also be declined at that time. Thus, longevity risk could worsen the budget deficiency, and then make a brake on economics development for one country. One of serious risk confronted by life insurance companies and pension funds is longevity risk. For life insurance companies, life insurers will pay more extra money for the annuitants if they live longer on average than anticipated in the life companies' mortality tables which is used to price annuities. Therefore, the longevity risk will let the insurance companies enhance the probability to become insolvency. For individual, if people live longer than their life expectation, they could face there is no enough money to support unanticipated extending living. The purpose of this paper focuses on individual level and investigates how the households adjust their consumption and investment decision under the longevity risk.

Although previous papers have some findings about how the individual or household has proceeded with the decisions under longevity risk, it still remains some questions need to further explore. Previous papers often use the aggregate data to investigate the one-dimension decision affected by the longevity risk. For example, the relationship between the risk premium and the structure of population has been usually discussed in literature (Bakshi and Chen, 1994; Ang and Maddaloni, 2005; Athanasoulis, 2006). We know the relationships between different decisions are not independent. If we only consider the one-dimension decision affected by the longevity risk, it could ignore the interaction of each decision. Moreover, the aggregate data can't analyze how the characteristics affect the households' decision under the longevity risk. The main advantage of the experimental methodology could provide possible way to analyze the households' multi-dimension decision under longevity risk.

In our paper, we use unexpected life extension as the proxy for the longevity risk. People often have their perception that how long they will live and use this prediction to make their consumption and investment decisions. In our experiment, every five years means one turn in our experimental process. Because we assume the thirty years old as the start point in our experiment, the participants will have seven turn decisions until they become sixty-five years old (see Table 1). All participants will be asked to join this experiment two times. In the first round, all participants will die as their expectation recorded in the questionnaire. For example, if one participant expects he can live until seventy-five years old, he will leave at the ninth turn of experiment (see Table 1). That is to say, there is no longevity risk because people can predict how long they will live.

In the second round, the participants have the opportunity can extend their live age from zero to ten years (zero to two turns), then they proceed with their consumption and investment decision when knowing they could live to longer. For example, if one participant expects he can live until seventy-five years old, he could leave at the ninth, tenth and eleventh turn of experiment in the second round. The only difference of the first and second round is possible life extension. We use this uncertainty life span as the proxy variable for longevity risk. As the other conditions are maintained equal to the first round, we will observe how the participants adjust their consumption and investment decision to avoid the longevity risk.

Table 1 The Experimental Turn Table

Life Expectancy	Under 64	65-69	70-74	75-79	80-84	85-89	Over 90
Experimental Turn	7 turns	8 turns	9 turns	10 turns	11 turns	12 turns	13 turns

2.2 How to evaluate the risk aversion

The utility framework provided by Pratt (1964) and Arrow (1965) is widely used the individual's behavior in uncertainty situation. They use the concave utility function U of wealth to construct measure of absolute risk aversion $A(w) = -\frac{U''(w)}{U'(w)}$, and relative risk aversion $R(w) = -w(\frac{U''(w)}{U'(w)})$. One possible way to estimate of risk aversion is to use the survey questions firstly adopted by Kogan and Wallach (1964). They utilize Choice Dilemma Questionnaire (CDQ) with twelve situations to measure individual risk attitude. Weber et al. (2002) present the psychometric scale that evaluates risk taking by five different domains including financial decisions, health and safety, recreational, ethical and social decisions. Moreschi (2005) uses the questionnaire to discover the relationship between demographics and risk taking. He finds that gender and education both play the prominent role in risk taking. Faff et al. (2008) measure risk aversion from a psychometrically validated survey and find female, lower wealth individual are more risk aversion than male, higher wealth individual.

Although above previous papers provide a possible way to measure the risk aversion, the main disadvantage is they use many questions to get participants' risk aversion. Eisenhauer and Ventura (2003) use the only question posed by the Bank of

Italy in its 1995 Survey of Italian Households' Income and Wealth. The methodology can avoid that spending much time to consider questions induces the basis of estimation. Therefore, we adopt the method provided by Eisenhauer and Ventura (2003) to measure the participants' risk aversion and adjust this question in our questionnaire as follow.

You are offered an opportunity of acquiring a risky security permitting you, with same probabilities (50% versus 50%), either to gain ten millions NT dollars or to lose all the capital invested. What is the most amount you are willing to pay this security?

We can get the participant's answer to this question, which can be denoted by z, is the reservation price, above which the participant rejects put money on this risky security. The w is denoted as net wealth (total asset minus total liability). We can describe the participant's utility function as follow.

$$U(w) = 0.5U(w-z) + 0.5U(w-z+10) \qquad (2)$$

If the individual gain, the outcome of favorable state results in income of $w-z+10$, otherwise an unfavorable state results in $w-z$; the expected income is $w-z+5$, and the standard deviation is 5. Therefore, in this question, risk averter will establish a reservation price of $z<5$ in order to let his expected income will be positive. In contrast, risk lover will pretend a reservation price of $z>5$. If the individual risk neutral will set a reservation price equals to 5.

The equation (2) can be rewritten as equation (3).

$$2U(w) = U(w-z) + U(w-z+10) \qquad (3)$$

A Taylor series expansion of the right-hand side of equation (3) can extend around an income of w. Then, we can get the formula (4).

$$\begin{aligned} 2U(w) = {} & U(w) - zU'(w) + 0.5z^2U''(w) + U(w) \\ & + (10-z)U'(w) + 0.5(10-z)^2U''(w) \end{aligned} \qquad (4)$$

After rearranging the equation (4), the Pratt-Arrow measure of absolute risk aversion can be derived as the follow.

$$ARA = -U''(w)/U'(w) = \frac{10-2z}{50-10z+z^2} \qquad (5)$$

And multiply the wealth in equation (5), the measure of relative risk aversion can be shown as the equation (6).

$$RRA = -wU''(w)/U'(w) = \frac{2w(5-z)}{50-10z+z^2} \qquad (6)$$

Based above description, we can calculate the absolute and relative risk aversion of participants by their response to this question. Then, we can investigate the participants with different risk aversion how to proceed with their consumption and investment decisions under longevity risk.

2.3 Consumption and investment decisions

The participant will proceed with the consumption and investment decisions in each turn of our experiment. The initial age in the experiment is setting at thirty years old. Every five years means one turn in our experiment. Before retirement period, we assume the households have the salary in each turn. However, after retirement, the households only decide their consumption and investment decisions. In the first round, the households proceed with their decisions without longevity risk because the participants can live until their age perceptions written in questionnaire. In the second round, the households will have zero to ten years (zero to two rounds) life extension. As the other conditions are maintained equal to the first round, we will investigate how the households adjust their consumption and investment decision to under longevity risk. The participants must decide how much money will his (her) family spend in one turn. Then, participants will judge how many percents of rest money respectively invest on risk-free asset and risky asset. We assume the risk-free return is three percent. The average and standard deviation of risky asset return are respectively

6% and 7.5%. The risk-free return is public information, but the risky asset return is the random variable for the participants. The process of wealth accumulated before retirement period is shown as the equation (7).

$$W_{t+1} = (W_t + S_t - C_t)[\alpha_t(1+r_f) + (1-\alpha_t)(1+\tilde{r}_t)] \qquad (7)$$

$t = 1,2,3,4,5,6,7$ (Pre-retirement: thirty years old to sixty-five years old)

W_{t+1} and W_t are respectively the household wealth at turn t and t+1. S_t is salary at turn t. We can get information about the month salary and salary growth from the questionnaire. C_t is the consumption amount at turn t. r_f and $\tilde{r}_t$ are respectively risk-free return and risky asset return. The households choice how much money will they spend in the beginning of that turn. Then, the households should proceed with how many percentages α and $1-\alpha$ invest on the risk-less asset and risky asset. The process of wealth accumulated after retirement period is shown as the equation (8) and (9). Similar to the pre-retirement period, the households should proceed with the consumption and investment decisions, but there is no salary income after retirement.

After retirement without longevity risk

$$W_{t+1} = (W_t - C_t)[\alpha_t(1+r_f) + (1-\alpha_t)(1+\tilde{r}_t)] \qquad (8)$$

$t = 8,9,...,n$ (Post-retirement: sixty-five years old to the participants' expectation)

After retirement with longevity risk

$$W_{t+1} = (W_t - C_t)[\alpha_t(1+r_f) + (1-\alpha_t)(1+\tilde{r}_t)] \qquad (9)$$

$t = 8,9,...,n,n+1,n+2$ (To extend the participants' life from zero to two turns)

In the first round, the participants proceed with their decisions without the longevity risk was described as the equation (8). n is participants' expectation. The participants make the decisions with clearly know how long they will live. In the second round, the household will extend their life extension from zero to two turns. Under longevity risk, how the household proceed with their consumption and investment decisions after retirement was described as equation (9).

3. Variable Definitions and Statistics

3.1 Variable Definitions

The purpose of this paper is investigating how the household change their behavior to avoid the longevity risk by the experiment methodology. At the beginning of experiment, the participants are asked to fill in questionnaire related to their background including household demographic, health status perception and risk aversion. The household demographic part includes gender of participant, education, number of children, family salary, net wealth and bequest motivation. The health status perception includes participants' life expectation, health status and health-care expenditure. How to estimate risk aversion of participants is described in last section. These valuables in the questionnaire could be used to analyze how the households with different characteristics adjust their decisions response to the longevity risk. The definition variables used in the questionnaire are described as follow.

(a) Gender:

The gender plays the significant role in human risk taking behavior. Faff et al. (2008) find the female have more risk aversion than the male. There seems to exist the positive relationship between female and risk aversion. Moreover, the average life expectancy of female is larger than male. Thus, it is possible female and male will take different decisions to mitigate the longevity risk. In our regression, gender is the dummy variable with value 1 if the head of the household is male, and 0 otherwise.

(b) Education:

Moreschi (2005) find people with higher education have the lower risk aversion. It is could be due to education gives people knowledge to evaluate the tradeoff between risk and return. The participants select they belong to which education degree including junior high school or under, senior high school, university, and the graduated school in our questionnaire. It may exist the negative or positive relationship between education years and risk aversion. However, it is hard to predict how participants with higher education to adjust their decisions under longevity risk.

(c) Salary:

The month salary is the aggregate of all members in one family. Because target participants in our experiments focus on the age is round thirty-years old and married. Therefore, in general, salary in our questionnaire is defined as the aggregate of wife and husband month salary. In the questionnaire, we can collect information about how much money the household earn in one month and annual salary growth rate. Before retirement, households can get salary income in each turn. We calculate the salary in each turn by month salary times sixty after adjusting real salary growth rate (nominal growth rate minus inflation). There is no salary income after retirement. There may exists the negative relationship between risk aversion and salary. The household with more salary could put more money on risky asset to avoid longevity risk.

(d) Net Wealth:

Net wealth is defined as the value of total asset minus the value of total liability of the household. Previous papers point out that people with more net wealth have more willingness to take risk. We directly quote the information that net wealth of household at thirty years old in the questionnaire because the initial age of our experiment starts at thirty years old. The household with more net wealth could have more resource to mitigate longevity risk. Therefore, net wealth may affect the household's decisions under longevity risk.

(e) House:

House expenditure has been an important decision in human life. To choose buying the houses in the life will squeeze out other spending and affect the households' consumption and investment decision. People intend to buy the houses could have the pressure and reduce other expenditures because they often should afford the mortgage loans. On the other hand, people who choose rent the house have more money to proceed with their investment decision. Whether buy the house or not could play the significant role in household's decisions under longevity risk.

(f) Number of children:

This variable means how many children under 18 years old does household have. Numbers of children will crowd out other expenditures because the household with more children need higher cost to raise their children. However, children could give some financial feedback to their parents when they grow up. The households could reduce their expenditure while getting older. Numbers of children could play the prominent role in household's decisions under longevity risk.

(g) Bequest Motivation:

Individual without bequest motivation will maximize his utility function by constraint condition which income is equal to consumption in his whole life. However, after incorporating the bequest motivation, individual could have the willingness to transfer part of his wealth to his children. Therefore, the bequest motivation will influence the households' consumption and investment decisions. For example, the households with higher bequest motivation will reduce consumption amount in order to leave more money to their children.

(h) Life expectancy:

People can't expect exactly when they will die in their life. However, people can use some relevant information such as average life expectation in society, living habit and their own health status to expect the life expectancy approximately. People live longer than their expectation could generate the longevity risk. In our experiment, we invite participants who their age is nearly thirty years old and have got married. The experiment design the thirty years old is the initial age and one game turn indicates five years in real life. The participants live as long as their life expectation in questionnaire in the first round of experiment. That is to say, there is no longevity risk because they drop out the experiment based on their own perception. However, in the second round, the participants could live longer than their expectation. They may extend their live age from zero to two turns. In other words, they live with longevity risk. The perception of life expectation will affect the consumption and investment decision because people with longer life expectation could have more time to proceed with their decisions.

(i) Health-Care Expenditure:

We define the health-care expenditure is the direct and indirect cost of spending on health precaution such as attending health club, purchasing health medicine and taking the health testing. The information about how much money do individuals spend on health-care expenditure will be record in the questionnaire of experiment. We assume the there exists the positive relationship between the risk aversion and health-care expenditure.

(j) Risk Attitude

Risk attitude plays a significant role on human behavior when they should take the decisions in the uncertain environment. The utility framework provided by Pratt (1964) and Arrow (1965) is often used to explain individual’s risk attitude in uncertainty situation. In this paper, we use the absolute risk aversion (ARA) and relative risk aversion (RRA) to be proxies for risk attitude. We follow Eisenhauer and Ventura (2003) methodology to use the only question to measure ARA and RRA of household. Many previous papers have been provides the empirical findings that risk aversion will affect human’s behaviors. Therefore, we predict that different types of risk-aversions will have distinct reactions to alleviate the longevity risk.

Table 1 Variable Definitions and Expected Results

Variable Names	Variable Definitions	Abbreviation
Demographic		
Gender	Gender is the dummy variable with value 1 if the head of the household is male, and 0 otherwise.	*Sex*
Education	The education years of the head of the household. We translate the rank into education years by the following rules. The education years are 9, 12, 16, and 18 years if education level is respectively junior high school or under, senior high school, university and graduated school.	*Edu*
Salary	The variable is the total amount of family salary in one turn of experiment.	*S*
Net Wealth	The net wealth of household at the thirty years old.	*NW*
House	House is the dummy variable with value 1 if the	*H*

	households have their own houses, and 0 if the households rent the houses.	
Children	This variable means how many children under 18 years old does household have.	*Chi*
Bequest Motivation	How much money does the household have the willingness to left to their children.	*B*
Health Situation Perception		
Life Expectancy	The participant predicts how long they will live.	*LE*
Health Status	The participant thinks personal health status based on his own historical medicine record. This variable can be divided into several categories including excellent, good, mediocre, illness and serious illness.	*HS*
Health-Care Expenditure	The average amount of health expenditures is spent by the household per year.	*HE*
Risk Attitude		
Absolute Risk Aversion	The variable is defined as Arrow-Pratt measure of absolute risk-aversion (ARA). We calculate the absolute risk aversion by Eisenhauer and Ventura (2003) methodology.	*ARA*
Relative Risk Aversion	The variable is defined as Arrow-Pratt measure of relative risk-aversion (RRA). We use the ARA timing wealth to calculate this variable.	*RRA*

3.2 Statistics

The table 3 and Table 4 represent the statistics. In Table 3, we can know male and female are respectively 60% and 40%. That is to say, male has still has higher probability to be the head of household in our experiment. The percentage of participants graduated from university or college is nearly 60%. The percentage of education above the university or college is nearly 26%. Most participants do not have any children and 23.3% of them have one or two children. It also reveals that low birth rate in Taiwan. Nearly seventy percentages of household have bought or the willingness to purchase the house. It implies that the house purchase decision still plays an important role in human’s life. However, buying the houses in the life could squeeze out other spending and affect the households' other consumption and investment decisions. The percentages of participants think their health status to be excellent and good are respectively 23.3% and 38.3%. Moreover, nearly thirty-five percentages of participants think their health status is mediocre. Most of participants are risk aversions. Only twenty percentages are risk neutral.

Table 3 The Percentages of Participants

Variable		**Percentage**
Gender	Male	60.0%
	Female	40.0%
Education	Junior high school or under	0.0%
	Senior high school	13.3%
	University or college	60.0%
	Master degree	21.7%
	PHD degree	5.0%
Number of Children	None	51.7%
	One	23.3%
	Two	23.3%
	Three	1.7%
House	Purchase	70.0%
	Rent	30.0%
Health Status	Excellent	23.3%
	Good	38.3%
	Mediocre	35.0%
	Illness	3.3%
	Serious illness	0.0%
Risk Attitude	Risk aversion	80.0%
	Risk neutral	20.0%
	Risk lover	0.0%

The statistics of quantitative variables is described in Table 4. The average of participants' life expectancy is 72.58 years old. The average age of our experiment is slightly below the average age (77 years old) in Taiwan. The average of month household salary is nearly eighty thousands NT dollars. However, maximum and minimum of household are respectively 200,000 and 30,000. There exists a huge salary difference between the households. The average net wealth and health expenditure of household is 872,083 and 15,133. The bequest motivation measures how much money the parents will leave to their offspring. The average of bequest motivation is nearly 2,725,000. Therefore, the bequest motivation seems to be an important factor of financial decision in Taiwan. By following Eisenhauer and Ventura (2003) methodology, we find the average absolute risk aversion and average relative risk aversion are respectively 0.1502 and 1.1417.

Table 4 Statistics

	Mean	Standard Deviation	Median	Max	Min
Life Expectancy	72.58	7.73	75	90	60
Salary	79667	32245	70000	200000	30000
Net Wealth	872083	867750	625000	4500000	200000
Health Expenditure	15133	13548	10000	60000	0
Bequest Motivation	2725000	2622305	1500000	10000000	0
Absolute Risk Aversion	0.1502	0.0777	0.195	0.2000	0
Relative Risk Aversion	1.1417	1.3939	0.5983	6.9986	0

4. Empirical Model and Results

4.1 Empirical model

The purpose of this paper is adopting the experimental methodology to investigate how households will adjust their consumption and investment decisions under longevity risk. We use the records by participant's response to the longevity risk in our experiment and use the regression to analyze how the households change their behavior when they face the longevity risk.

In model 1, we investigate the relationship between the risk aversion and background of household. Based on Faff, Mulino and Chai (2008) model, we exclude two variables, age and marital status from the regression because our participants are nearly thirty years old and get married. The model 1 is described as follow.

Model 1:

$$RA_i = \alpha_0 + \beta_1 Sex_i + \beta_2 S_i + \beta_3 Edu_i + \beta_4 Chi_i + \beta_5 NW_i + \beta_6 B_i + \beta_7 HE_i + \beta_8 LE_i + \varepsilon_i$$

where RA means risk aversion of the participants. We will use the different risk aversion, respectively are absolute risk aversion and relative risk aversion, as proxies for dependent variables. Sex_i is the participant's gender. S_i is the household's salary. Edu_i is the participant's education. Chi_i is the children number of household. NW_i is net wealth of households. B_i is the bequest motivation of participant. In other word, how much money the participant will leave to their offspring. HE_i is health expenditure of LE_i is the participant's life expectation. ε_i is the regression disturbance. More detail about variables is described as above section.

The main purpose of this paper is how households will adjust their consumption and investment decisions under longevity risk. In the first round, the household proceed with their decisions without longevity risk. However, in the second round, the household make their decisions with longevity risk when other conditions are same. We observe the differences of consumption and investment decisions in two rounds.

Model 2:

$$\partial C_j = \alpha_0 + \beta_1 Sex + \beta_2 S + \beta_3 Edu + \beta_4 Chi + \beta_5 W + \beta_6 Life + \beta_7 HE + \beta_8 B + \beta_9 ARA$$

$$\partial Save_j = \alpha_0 + \beta_1 Sex + \beta_2 S + \beta_3 Edu + \beta_4 Chi + \beta_5 W + \beta_6 Life + \beta_7 HE + \beta_8 B + \beta_9 ARA$$

$$\partial Stock_j = \alpha_0 + \beta_1 Sex + \beta_2 S + \beta_3 Edu + \beta_4 Chi + \beta_5 W + \beta_6 Life + \beta_7 HE + \beta_8 B + \beta_9 ARA$$

where C_j the ratio of average consumption to average salary in period j (j =1,2,3) The period j respectively means all period, pre-retirement period and post-retirement period). ∂C_j means the differences of consumption-to-salary ratio in the first round (without longevity risk) and the second round (with longevity risk). In other word, we use the consumption-to-salary ratio with longevity risk minus same ratio without longevity risk. Therefore, by using ∂C_j as dependent variable, we can investigate how the household adjust their consumption decision when they face longevity risk.

$Save_j$ means average percentages that household put money on risk-free asset in each turn. $Stock_j$ means average percentages that household put money on risky asset in each turn. Similarly, $\partial Save_j$ and $\partial Stock_j$ respectively means the differences of risk-free and risky asset ratio in the first round (without longevity risk) and the second round (with longevity risk). That is to say, we use this deviation between with and without longevity risk to measure the household's adjust behavior for avoid longevity risk. To utilize these two variables as dependent variable, we can investigate how the household adjust their asset allocation under longevity risk. Other independent variables are described as above descriptions.

4.2 Empirical Results

We use the experimental methodology to investigate how the household adjust their consumption and investment decision. We invite the head of household with nearly thirty years old as the participants and record their decisions in the experiment. The empirical results about relationship between risk aversion and background of households are shown as Table 5. In left columns, the absolute risk aversion is regarded as dependent variable. There exists the negative relationship between

Education and ARA. This result is consistent with previous papers that people with higher education intend to have lower absolute risk aversion because they have better knowledge to alleviate the risk. In right columns, it is obvious there exist a positive relationship between salary (net wealth) and relative risk aversion because RRA is calculated by the net wealth. Previous papers point out that age and marital play a prominent role in risk taking behavior. However, we recruit the participants qualified the age is approximately thirty year olds and married. Therefore, it is a pity that we can't further discover how the variable age or marital status affects the absolute risk aversion.

Table 5 Relationship between Risk Aversion and Background of Households

	Absolute Risk Aversion		Relative Risk Aversion	
Variables	**Coefficients**	**p-value**	**Coefficients**	**p-value**
Intercept	0.175	0.104	-1.040	0.508
Gender	-0.021	0.336	0.214	0.499
Salary	5.93E-007	0.139	2.04E-005***	0.001
Education	-0.036**	0.013	-0.313	0.138
Children	-0.004	0.750	0.100	0.544
Net Wealth	-2.90E-008**	0.033	5.22E-007**	0.010
Bequest	-1.47E-009	0.721	-3.49E-008	0.566
Health-care	-8.31E-007	0.242	-1.46E-005	0.164
Life Expectancy	-0.021	0.336	0.214	0.499
Adjust R-square	0.146		0.421	

No matter in pre-retirement, post-retirement and whole life, there is nearly no variables except education will affect consumption decision. People with lower education will consume less after retirement to alleviative longevity risk. However, they still maintain the same consumption level before retirement. For most households, it is difficult to cut off same necessary expenditures such as diet, clothes, transportation, mortgage loan, education and raising children fee before retirement.

Even if some expenditure such as transportation, mortgage and raising children fee can be reduced after retirement, health care and medical spending will increase significantly at this moment. That is to say, the consumption decision has its own rigid and inelastic characteristics. Based on our empirical results, it is difficult for households to reduce their consumption to avoid the longevity risk.

The variables such as gender, income, net wealth and health-care expenditure almost have no impact on households' investment decision. No matter which periods, households with more children intend to increase proportion of risk-less asset to avoid longevity risk. Moreover, households with more bequest motivation will also put more money in risk-less asset in their whole life. Our empirical results show the parents in Asia still regard their offspring as an important factor of making investment decisions even if they face longevity risk. Another reason to explain this phenomenon is people with more children could have financial supports from their offspring and reduce their risky asset proportion. The household with higher education will take more conservative investment decision after retirement. Furthermore, the household with larger absolute risk aversion intend to reduce the proportion of risky asset to alleviate longevity risk. If households were high absolute risk aversion, it means they have less willingness to take risk and shift their money from risky asset to risk-less asset.

To sum up, we find that households prefer changing their asset allocation to reducing their consumption when they face the longevity risk. Our results empirical support that households with greater risk aversion, more children and bequest motivation will decrease the proportion of risky asset under longevity risk. Finally, households with higher life expectancy will increase their risky asset holding after retirement. The main results of this paper support households truly adjust their behavior to avoid the longevity risk.

Table 6 The Relationship between Decisions and Background of Households

	Before Retirement		After Retirement		Whole Life	
	Consumption	**Saving**	**Consumption**	**Saving**	**Consumption**	**Saving**
Intercept	0.065	-0.060	0.315	0.150	0.241	0.037
	(0.699)	(0.693)	(0.363)	(0.546)	(0.167)	(0.806)
Gender	0.029	-0.033	-.031	-0.057	0.036	-0.043
	(0.392)	(0.275)	(0.646)	(0.250)	(0.292)	(0.159)
Income	6.16E-007	-3.17E-008	1.00E-006	-5.58E-007	6.00E-007	-3.06E-007
	(0.326)	(0.955)	(0.434)	(0.547)	(0.353)	(0.589)
Education	-0.024	0.016	-0.107	0.060	-0.047	0.011
	(0.305)	(0.431)	(0.028)**	(0.087)*	(0.051)*	(0.585)
Children	-0.003	0.066	-0.018	0.049	-0.023	0.064
	(0.864)	(0.000)***	(0.607)	(0.058)*	(0.209)	(0.000)***
Net Wealth	-3.87E-011	9.15E-009	1.09E-010	2.98E-008	4.11E-009	6.98E-009
	(0.999)	(0.636)	(0.998)	(0.349)	(0.852)	(0.719)
Bequest	-2.41E-009	5,43E-009	-1.12E-008	1.44E-008	-4.98E-009	1.35E-008
	(0.704)	(0.344)	(0.392)	(0.130)	(0.447)	(0.022)**
Health-care	-2.83E-007	5.34E-700	-1.80E-006	1.41E-006	-3.94E-007	4.69E-007
	(0.797)	(0.591)	(0.427)	(0.390)	(0.728)	(0.639)
Life Expectancy	-0.001	-0.003	0.001	-0.007	-0.001	-0.004
	(0.802)	(0.158)	(0.848)	(0.031)**	(0.525)	(0.071)*
Absolute Risk	0.044	0.329	-0.447	0.735	-0.104	0.343
Aversion	(0.841)	(0.097)*	(0.318)	(0.026)**	(0.642)	(0.086)*

Note1: The number in ( ) indicates P-value.

Note2: 0.1 < P-value < 0.05 →*, 0.01 < P-value ≦ 0.05 →**,P-value ≦ 0.01 →***.

5. Conclusion

Due to the average human life expectancy has significantly increased, to investigate the human's decisions under longevity risk has became an important and interesting topic recently. Although previous papers have some findings about how the individual or household has proceeded with the decisions under longevity risk, these papers still confine to one-dimensional decision and aggregate data. In this paper, we adopt the experimental methodology to investigate how the household proceed with their consumption and investment decisions under longevity risk. We recruit the head of household as the participants in our experiment. All participants will be asked to join this experiment two times. Every five years means one turn in our experimental process. In the first round, we assume there is no longevity risk because the household will proceed with their decisions, and live until as their expectation. In the second round, by telling participants have the opportunity can extend their live age from zero to ten years (one to two turns), they proceed with their consumption and investment decision if they can live longer. The only difference of the first and second round is possible life extension. Other condition maintain same, we utilize this life extension as the proxy for longevity risk. We can observe how the households will adjust their consumption and investment decision after incorporating longevity risk in the experiment.

The main empirical results can described as follow. First of all, we observe that households prefer changing their investment decision to reducing their consumption when they face the longevity risk. It could due to the consumption decision is too rigid to reduce significantly. It is difficult to cut off same necessary expenditures such as diet, clothes, transportation, mortgage loan, education and raising children fee before retirement. Even if after retirement, households' health care and medical spending will increase significantly at this moment. Therefore, households reluctantly to change their consumption decisions to deal with longevity risk. They prefer adjust their investment decision when they face longevity risk.

Secondly, our empirical results support that households with some specific characteristics such as greater risk aversion, more children and bequest motivation will reduce the proportion of risky asset under longevity risk. Our empirical results show the parents in Asia still regard the bequest motivation as an important factor of investment decision when they face longevity risk. The households with higher ARA and RRA will be more conservative when they face longevity risk. Finally, we find that households with higher life expectancy will put more money on risky asset after retirement period. It could be that they know average return of risky asset is larger than return of risk-less asset in longer period. They enhance the proportion of risky asset because they predict they have higher probability to live longer.

The contribution of this paper is providing some evidence about how the households adjust their consumption and investment decision. Although the data is collected by experiment methodology not by real data, we still believe that we can get the initial pictures that how the households avoid longevity risk through adjusting their consumption and investment decisions. Moreover, if we can collect the panel data related to households consumption and investment decisions, it will be more useful to analyze the human behavior under longevity risk.

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