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THE STABILITY OF FINANCIAL RISK PREFERENCES UNDER CHANGING PROBABILITIES: AN EXPERIMENTAL STUDY

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Is your risk preference stable? After Arrow and Pratt defined the method to measure risk aversion, many people try to find out what are their risk preferences. For a rational consumer, his or her risk preference should be stable in similar situations, but some researchers have found out that risk preferences are not stable in many cases. They claimed that risk preferences are diverse between men and women, or between youngsters and elders. And risk preferences are not stable according to the time either. Furthermore, if you use different eliciting method or different survey questions, the risk preferences you get may differ as well.

The problem we are going to solve in this thesis is the stability of risk preferences under different probabilities. We know that people’s risk attitudes vary in different fields, such as financial situations, health decisions and career scenarios, etc. Here we are going to focus on risk preferences in the financial field. To conduct the research, we design an experiment which contains five lotteries whose winning probabilities are different. From the responses of all the subjects, we can estimate their equivalent values for those lotteries and elicit their risk aversion.

According to the experimental results, we find out that people’s risk preferences are unstable in these five lotteries. People show up a significantly different risk attitude when facing the lowest-winning-rate lottery. And this kind of instability is affected by the gender and age as well. We find out that the risk preferences of women and elders are more stable than those of men and youngsters respectively. These results can be applied to the policies about revising the pricing method of financial instruments, marketing strategies of financial companies, designing and selling financial instruments, etc.

Since people’s risk preferences are not stable especially when they face the extreme probabilities, we can guess the reason is that people usually overweight low probabilities. Then in the future research, we can also study the effect of probability distortion in this experiment, to find out how it affects the stability of risk preferences in a gaining situation.

A restriction in this experiment is that the sample cannot necessarily represent the other population groups in the market because students are supposed to be young and bold comparing with others. In the future study, to generalize this research in a real market, we can ask real investors in the financial markets to participate in this experiment. And considering the overconfidence problem in this experiment, in the future, we can still study its effect on people’s risk preferences when people are making financial decisions.
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1 INTRODUCTION

1.1 Introduction to the topic

In the world of financial markets, risk has been one of the most researched topics because it exists everywhere and it influences people’s life and behaviors all the time. Considering that you intend to buy a stock, while the return of the stock is uncertain, which means you have a chance to lose or earn some money in the end. So that you have to make a decision on whether you should buy the stock and how much you would like to invest. It is a very normal example of risk existing in our life. And when people face such risks, their attitudes toward risk are different. Some people will invest more money on it, some people invest less, and some others will not even buy the stock.

We can see that people’s attitude toward risk plays an important role in the decision making process, but we do not know whether their attitudes toward risk are always the same or not. This kind of problem pushes researchers to find out what is the rule influencing people’s financial decisions.

1.2 Why is it an interesting topic?

Casinos and gambling are two words we may think of when we are talking about financial risks. It is true that many people keep losing money in casinos every day and they may be even broken because of it, although they clearly know the high risk of gambling. On the contrary, sometimes we can find an encouraging story that someone wins a one-million-dollar lottery and lives a happier life. Risk can be either silver lining or dark cloud in our life and it makes our life more interesting.

In a financial market, for example stock market, risk means the variance of return of a stock, and risk itself is quite uncertain as well because we cannot predict neither the return of a stock, nor the variance of it. It is like a mystery in the market. What makes it even more obsessing is that it is also uncertain on the way it influences an investor’s behavior, because the investor’s risk attitude is hard to observe and sometimes unstable.
And that is why so many researchers are attracted by this topic and pay so much effort to solve the mysteries in this problem.

Also, studying people’s risky behavior usually accompanies with experimental study, which is interesting to some researchers, because making an economic experiment itself is challenging and interesting.

1.3 Why is it an important topic?

In the financial markets, risk is one of the most important and popular topics. And the risk attitude of an investor is an inevitable problem when we are talking about financial risks.

In the insurance market, risk aversion is the intimate reason why we buy insurances. Risk attitudes determine whether consumers will purchase this insurance policy or not (unless it is a mandatory insurance policy) and how much they will purchase. Also, when insurance companies design and price the insurance contracts, they will consider consumers’ risk attitudes as well.

Situations are similar in other financial markets, because most of assets are risky. An investor’s risk attitude must play an important role when they are making decisions of buying assets or portfolios. For different assets, the returns and the probability distributions of them are different. Thus, if we can find out the relation between the probability distribution and the risk attitude, we can contribute to the research of investor’s decision making problems.

In the general model of risk and information (Gollier, 2004: 319-334), probability, utility function and risk aversion are main variables which determine the results of the model, so the topic of this thesis may also contribute to the information theory to some extent.

The study of risk preferences is important also because it is not only concerned of economic issues, it is also an important topic of psychological study, pedagogical study
and other researches which need to consider problems about risk preferences. So we can do a study to contribute to this topic, it will make a big progress in the society.

The risk preference is like an invisible hand to control people’s behavior and decision making, and we are trying find out the convincible rules of it to make it visible in our life. To find out how risk preference influences human behavior, I think that we should firstly make sure if risk preferences are stable or not, which is an important and interesting topic.

In the next chapter, we are going to discuss the classic theories relating to this topic and some recent researches on this topic. And in chapter 3 we are going to introduce the main theorem and formula we are going to use in this thesis. Then chapter 4 is about how do we design the experiment and how are we going to conduct the experiment. In chapter 5 we are going to analyze the results of the experiment and compare these results with some previous researches. Finally, the chapter 6 is the conclusion of this thesis.
2 PREVIOUS RESEARCH

2.1 Research history

In the beginning, people thought that the expected value affected the results of people’s decisions. It was popular to see the expected value as the true value of a lottery or a stock considering the outcomes and probability distributions of them.

However, Bernoulli (1738), as well as Montmort and Remond (1713), used an example to argue that expected value cannot evaluate a lottery precisely. He set up a lottery in which a player had 2 dollars in the deposit in the beginning, then the casino would keep tossing a fair coin, the deposit would double the money every time the heads showed up, and the game would end when the tail first showed up, then the player got the money in the deposit. The expected value of this lottery is infinite but people rarely pay more than 25 dollars to play this game. This is the famous St. Petersburg paradox.

Then Bernoulli (1738) solved the St. Petersburg paradox using the expected utility theory. He argued that a certain utility function should be used to evaluate how much satisfaction a consumer would get from a certain amount of money. Thus people’s aim is to maximize their utility when making decisions instead of maximizing the expected value of the choice.

Based on expected utility theory, Von Neumann-Morgenstern (1947) has found out cardinal utility theory which claims that the utility can be measured according to a given income when considering the consumer is rational. His theory contributes to find out consumer’s preferences on decision making because it confirms that the utility is measurable, then it becomes reasonable to calculate utility and to make comparisons and orderings.

With a utility function, we can predict the decision a consumer will make when facing risky lotteries, thus we can know the consumer’s preference toward risk. Arrow (1963) and Pratt (1964) have defined absolute risk aversion and relative risk aversion, and they have provided a way to derive consumers’ risk aversion degree from a certain utility function.
According to Arrow (1963), there is a relation between risk aversion and wealth level, which indicates that absolute risk aversion is decreasing with wealth level. Other than wealth level, more and more researchers have found out other variables which can influence the risk aversion.

Kahneman and Tversky (1979) have elaborated prospect theory which claims that people make decisions among several risky choices following some psychological rules. These rules are reference dependence, loss aversion, non-linear probability weighting and diminishing sensitivity to gains and losses. This theory can explain a wide range of situations where people make risky decisions.

Risk preference is also a main topic in behavioral economics which studies people’s economic decisions from the different prospects of psychological effect, social effect, cognitive effect and emotional factors.

2.2 Risk and uncertainty

In the history, some economists used to differentiate uncertainty and risk. Frank H. Knight (1921) has identified risk as a kind of situation in which we can define several consequences and we can also calculate the probability for each consequence. While in another hand, uncertainty is a kind of situation in which we cannot define some definite and objective consequences or outcomes for it.

In this thesis, we will look into risk instead of uncertainty according to the classification of Knight, because it is more advisable to focus on situations with predictable outcomes and computable probabilities. Uncertainty is hard to quantify, so it is also very difficult to analyze the economic value of it.

2.3 The elicitation of risk preferences in reality

Utility cannot be observed directly, which makes it difficult to derive the exact utility function for a consumer, thus it is hard to elicit risk aversion as well. Even we know the utility function of a consumer and the risk aversion measure from Arrow (1963)
and Pratt (1964), it is still not easy to elicit risk preferences of consumers in reality, because the real market is complicated and very hard to simulate.

Many researchers have used experimental methodologies to elicit people’s risk preferences through several economic experiments. Charness, Gneezy and Imas (2013) have summarized the most used elicitation methods and experimental methodologies which are utilized to measure people’s risk preferences.

There are several kinds of eliciting methods of risk preferences used frequently by researchers, for example:

- The balloon analogue risk task (Lejuez et al. 2002) is used to elicit risk aversion of self-reported risky behavior.

- Self-reported questionnaires (Maccrimmon & Wehrung 1990; Hunt, Hopko, Bare, Lejuez & Robinson 2005; Bornovalova, Daughters, Hernandez, Richards & Lejuez 2005; Fecteau, Pascual-Leone, Zald, Liguori, Théoret, Boggio & Fregni 2007) are used to examine a wide range of risk taking problems.


- The multiple price list method (Binswanger 1981; Holt & Laury 2002; Reynaud & Couture 2012; von Gaudecker, van Soest & Wengstrom 2011) is the most used method today, especially in the financial decision making problems.
In the paper of Charness et al. (2013), talking about financial risk preferences specifically, there are three popular methods to elicit them. For example, Eckel and Grossman (2002) have set up an experiment in which they ask participants to choose only one lottery from a list of several different lotteries. Dave et al. (2010) have applied Eckel and Grossman’s method and set up a list of six lotteries. All these six lotteries have 50% chance to get a low payoff and 50% chance to get a high payoff, but the values of low payoffs and high payoffs are different among these lotteries. (Table 1)

<table>
<thead>
<tr>
<th>Lottery</th>
<th>Low payoff</th>
<th>High payoff</th>
<th>Expected return</th>
<th>Standard deviation</th>
<th>Implied CRRA range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lottery 1</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>0</td>
<td>3.46&lt;r</td>
</tr>
<tr>
<td>Lottery 2</td>
<td>24</td>
<td>36</td>
<td>30</td>
<td>6</td>
<td>1.16&lt;r&lt;3.46</td>
</tr>
<tr>
<td>Lottery 3</td>
<td>20</td>
<td>44</td>
<td>32</td>
<td>12</td>
<td>0.71&lt;r&lt;1.16</td>
</tr>
<tr>
<td>Lottery 4</td>
<td>16</td>
<td>52</td>
<td>34</td>
<td>18</td>
<td>0.50&lt;r&lt;0.71</td>
</tr>
<tr>
<td>Lottery 5</td>
<td>12</td>
<td>60</td>
<td>36</td>
<td>24</td>
<td>0&lt;r&lt;0.50</td>
</tr>
<tr>
<td>Lottery 6</td>
<td>2</td>
<td>70</td>
<td>36</td>
<td>34</td>
<td>r&lt;0</td>
</tr>
</tbody>
</table>

This method assumes that people have constant relative risk aversion (CRRA), so we can use the utility function $u(x) = x^{1-r}$ to express the preferences. The last column of the table represents the range of the CRRA a participant owns if he or she chooses the corresponding lottery.

This measure can easily elicit the CRRA value of a participant, but the disadvantage of this method is that it cannot measure the range of CRRA very precisely if the participant is a risk-loving person. (As we can see in the last column of the table, r<0 means that the participant is risk-loving.)
Multiple price lists (MPL), which is used by Binswanger (1981) to derive risk preferences of farmers in India, has been largely used to elicit risk preferences nowadays. A popular example is the method used by Holt and Laury (2002). They have provided a list of 10 binary gambles, and the participants are asked to make decisions for each gamble. In each gamble there is a risky lottery and a less risky lottery. And in each gamble the probabilities of getting high payoffs are varied. (Table 2)

<table>
<thead>
<tr>
<th>Option A</th>
<th>Option B</th>
<th>Option A</th>
<th>Option B</th>
<th>Implied CRRA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/10 of $2, 9/10 of $1.6</td>
<td>1/10 of $3.85, 9/10 of $0.1</td>
<td>□</td>
<td>□</td>
<td>r&lt;0.95</td>
</tr>
<tr>
<td>2/10 of $2, 8/10 of $1.6</td>
<td>2/10 of $3.85, 8/10 of $0.1</td>
<td>□</td>
<td>□</td>
<td>r&lt;0.95</td>
</tr>
<tr>
<td>3/10 of $2, 7/10 of $1.6</td>
<td>3/10 of $3.85, 7/10 of $0.1</td>
<td>□</td>
<td>□</td>
<td>-0.95&lt;r&lt;0.49</td>
</tr>
<tr>
<td>4/10 of $2, 6/10 of $1.6</td>
<td>4/10 of $3.85, 6/10 of $0.1</td>
<td>□</td>
<td>□</td>
<td>-0.49&lt;r&lt;0.15</td>
</tr>
<tr>
<td>5/10 of $2, 5/10 of $1.6</td>
<td>5/10 of $3.85, 5/10 of $0.1</td>
<td>□</td>
<td>□</td>
<td>-0.15&lt;r&lt;0.15</td>
</tr>
<tr>
<td>6/10 of $2, 4/10 of $1.6</td>
<td>6/10 of $3.85, 4/10 of $0.1</td>
<td>□</td>
<td>□</td>
<td>0.15&lt;r&lt;0.41</td>
</tr>
<tr>
<td>7/10 of $2, 3/10 of $1.6</td>
<td>7/10 of $3.85, 3/10 of $0.1</td>
<td>□</td>
<td>□</td>
<td>0.41&lt;r&lt;0.68</td>
</tr>
<tr>
<td>8/10 of $2, 2/10 of $1.6</td>
<td>8/10 of $3.85, 2/10 of $0.1</td>
<td>□</td>
<td>□</td>
<td>0.68&lt;r&lt;0.97</td>
</tr>
<tr>
<td>9/10 of $2, 1/10 of $1.6</td>
<td>9/10 of $3.85, 1/10 of $0.1</td>
<td>□</td>
<td>□</td>
<td>0.97&lt;r&lt;1.37</td>
</tr>
<tr>
<td>10/10 of $2, 0/10 of $1.6</td>
<td>10/10 of $3.85, 0/10 of $0.1</td>
<td>□</td>
<td>□</td>
<td>1.37&lt;r</td>
</tr>
</tbody>
</table>

According to Table 2, we can see that the probabilities of high payoffs go higher each time. With higher probability of high payoff, rational people intend to choose option B instead of option A. In the end, when the probability becomes 10/10, people will definitely choose option B. Thus, when will participants begin to choose option B
becomes a critical point. For example, if the participant chooses option B from the first gamble, his or her implied CRRA will be smaller than -0.95. That means he or she is a risk-loving person. And if the participant chooses option B from the fifth gamble, his or her implied CRRA will be around 0, which indicates a risk-neutral character. This method is important when researchers design an experiment concerning risk aversion (Harrison, Johnson, McInnes & Rutström 2005).

Ding, Hartog and Sun (2010), on the other hand, have provided another way to measure individual risk preferences in a survey. In the survey, every participant will be asked to make a choice 20 times, each time the participant should make a choice between a lottery and a certain amount of money. The lotteries are the same, which provides the participant a fair chance (50%) to win 300 yuan, otherwise the participant will get nothing. The certain amount of money increases each time you make a choice. And the participants are told that one of these 20 cases will be randomly chosen to play in the end. If you choose the amount of money in that chosen case, you will get the money; otherwise you should take part in the lottery. (Table 3)

### Table 3. Ding’s survey

<table>
<thead>
<tr>
<th>Choice number</th>
<th>□ I choose 10 yuan</th>
<th>□ I choose to play the game</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>□ I choose 20 yuan</td>
<td>□ I choose to play the game</td>
</tr>
<tr>
<td>2</td>
<td>□ I choose 30 yuan</td>
<td>□ I choose to play the game</td>
</tr>
<tr>
<td>18</td>
<td>□ I choose 180 yuan</td>
<td>□ I choose to play the game</td>
</tr>
<tr>
<td>19</td>
<td>□ I choose 190 yuan</td>
<td>□ I choose to play the game</td>
</tr>
<tr>
<td>20</td>
<td>□ I choose 200 yuan</td>
<td>□ I choose to play the game</td>
</tr>
</tbody>
</table>
A participant should have a reservation price for the lottery. If the amount of money is below that reservation price, they will choose the lottery, and if the amount of money is higher than the reservation price, they will choose the money. In the end, according to the survey, we can find out what the reservation price is for a certain participant.

2.4 Stability of risk preferences

Risk aversion is an economic concept which is related to psychological study as well. It is hard to totally represent a person’s risk attitude in an experiment because people’s psychological thinking is hard to capture. Even though we can elicit consumers’ risk preferences in a way, it is still hard to promise that the risk preferences will keep stable in varied contexts.

Weber, Blais, and Betz (2002) have made the Domain-Specific-Risk-Taking (DOSPERT) test to identify the risk preferences in seven varied domains which are social, recreational, health, safety, gambling, ethical and investments. Financial risk preferences include risk preferences in gambling and investment domains.

Based on this DOSPERT test and the risk aversion measure by both Eckel and Grossman (2002) and Holt and Laury (2002), Reynaud and Couture (2010) have found that French farmers’ risk preferences are varied in different domains (Ethical, financial, health, recreational and social domains). And when using different eliciting techniques in a certain domain, the eliciting risk attitudes vary as well.

It is acceptable that eliciting risk preferences may vary according to different techniques we use, because in different experiments the scenarios are different, thus people’s decisions will be affected. Dave et al. (2010), accordingly, have argued that simple survey produces more precise estimates of risk aversion than complicated ones because the participants’ math abilities may be low sometimes.

However, even using the same experimental methodology, the risk preferences have been proved to be unstable as well, because participants have different genders, ages, education levels, etc.
Gender effect has been proved largely as a variable to influence risk preferences. In the paper of Eckel and Grossman (2008), they have analyzed that women are significantly more risk-averse than men in the domains of gambling, investment and insurance decisions. Hartog, Ferrer-i-Carbonell and Jonker (2002) have used three different surveys to abstract willingness to pay for different lotteries to find out that women’s estimated risk aversion degrees are 10% to 30% larger than men’s. Brinig (1995) has asked her participants to choose one of three lotteries whose probabilities and prizes are varied, and the results show no difference between men and women’s choices. But consider the variables of sex and age in the same time, it shows that women became more risk-averse than men when they are over 30 years old.

Concerning the age effect, in the study of Gardner and Steinberg (2005), 306 adolescents and young adults have been divided into three groups according to their ages, and the result is that people tend to reduce risky decisions when their ages become older, which means people become more risk-averse with age. Meanwhile, in the study of Albert and Duffy (2012), the experimental result shows that risk preferences are varied with age in the loss domain, but there is no evidence to show that age affects risk preferences in the gain domain.

Barseghyan, Prince and Teitelbaum (2011) have used the data of auto and home insurance policies to find out that risk preferences of insurance policy holders are not stable in different decision contexts, which means policy holders show different risk preferences between auto insurance and home insurance.

Thinking about the probability differences, Barseghyan, Molinari, O’Donoghue and Teitelbaum (2013) have also used the insurance data to show that large probability distortions can change households’ deductible choices, which implies that these probability distortions can change insured people’s attitudes toward risk.

Andersen, Harrison, Lau and Rutström (2008) have made an experimental study for Danish adults. These experiments elicit risk and time preferences in the same time. As a result, they find out that the joint elicitation of discount rates are significantly smaller than results from former researches. That means risk preferences may also be unstable, and be affected by time factor.
Risk preferences are unstable and influenced by many variables which are not strict to gender, age, decision contexts and probability distortions etc., there are also other aspects affecting the stability of risk preferences. The more we find out, the better we can understand the consumers’ behavior in decision making.

In this thesis, we will discuss the stability of risk attitudes in the financial domain when the probability is changing. We know that probability distributions and risk preferences both influence people’s decision making directly, but we do not know if the probability also affects the risk preference in some way. It should be an interesting and important point because if there are some effects between probability and risk aversion, the results of decision making problems should be affected as well.
3 THEORETICAL FRAMEWORK

3.1 Preferences and expected utility theorem

Consider a simple lottery L. It is composed of two characteristics which are probabilities and outcomes. We can set X as the outcomes of the lottery. It can be written as $X = \{x_i\}, i = 1, 2, 3, ..., n$. So $x_i$ means the outcome of the lottery in the situation $i$. And we can let $p_i$ be the probability that situation $i$ will happen, which means $p_i$ is the probability of the outcome $x_i$. Also the probabilities should be strict to $\sum_{i=1}^{n} p_i = 1$. (Gollier, 2004: 13)

In a set of this kind of simple lotteries, which we can set as $L = \{L^a, L^b, L^c, ...\}$, there exists a complete and transitive preference relation $\succeq$ or $\sim$ for the consumer. Complete preference relation means that for any two of the lotteries $L^a$ and $L^b$, the consumer either prefers to buy lottery a over lottery b ($L^a \geq L^b$), or prefers to buy lottery b over lottery a ($L^b \geq L^a$). And transitive preference relation means that if the consumer prefers to buy lottery a over lottery b ($L^a \succeq L^b$), meanwhile prefers to buy lottery b over lottery c ($L^b \succeq L^c$), then the lottery a should be preferred to lottery c ($L^a \succeq L^c$) as well. (Von Neumann and Morgenstern, 1944)

Von Neumann and Morgenstern (1944) also define continuity and independence axioms of preference as follow: “(Continuity axiom) The preference relation $\succeq$ on the space of simple lotteries $L$ is such that for all $L^a, L^b, L^c \in L$ such that $L^a \geq L^b \geq L^c$, there exists a scalar $\alpha \in [0,1]$ such that

$$L^b \sim \alpha L^a + (1 - \alpha)L^c.$$"

“(Independence axiom) The preference relation $\succeq$ on the space of simple lotteries $L$ is such that for all $L^a, L^b, L^c \in L$ and for all $\alpha \in [0,1]$:

$$L^a \geq L^b \iff \alpha L^a + (1 - \alpha)L^c \geq \alpha L^b + (1 - \alpha)L^c.$$"

And then the expected utility theorem can be defined as:
“(Expected utility theorem) Suppose that the rationale preference relation \( \succeq \) on the space of simple lotteries \( L \) satisfies the continuity and independence axioms. Then, \( \succeq \) can be represented by a preference functional that is linear. That is, there exists a scalar \( u_i \) associated to each outcome \( x_i \), \( i=1,\ldots,n \), in such a manner that for any two lotteries \( L^a = (p_1^a, \ldots, p_n^a) \) and \( L^b = (p_1^b, \ldots, p_n^b) \), we have

\[
L^a \succeq L^b \iff \sum_{i=1}^{n} p_i^a u_i \geq \sum_{i=1}^{n} p_i^b u_i.
\]

3.2 Measures of risk

Given a utility function \( u(x) \), assuming that this utility function \( u(x) \) is twice differentiable at any wealth level. According to Arrow (1963) and Pratt (1964), we can define the coefficient of absolute risk aversion as

\[
A(x) = -\frac{u''(x)}{u'(x)}
\]  

(1)

In the equation, \( x \) means the wealth level of a consumer, \( u'(x) \) is the first derivative of the utility function respect to wealth level \( x \); and \( u''(x) \) is the second derivative of the utility function respect to the wealth level \( x \). Then \( A(x) \) means the Arrow-Pratt measure of absolute risk-aversion (ARA). The larger value of ARA means the higher level of risk aversion.

On the other hand, the Arrow-Pratt measure of relative risk-aversion (RRA) is shown as

\[
R(x) = x \cdot A(x) = -x \cdot \frac{u''(x)}{u'(x)}
\]  

(2)

We can find out that the RRA is just the wealth level \( x \) multiples the corresponding ARA. So after taking the wealth level into account, RRA will eliminate the effect of wealth level on consumer’s risk aversion, in case the consumer shows a decreasing absolute risk aversion (DARA). (Arrow, Pratt, 1964)
3.3 Some common utility functions

Utility is always hard to observe and measure, so it is also difficult to regress a certain utility function. However, some mathematical functions are usually used as a utility function because they can well explain consumers’ behavior according to their risk preferences.

Some common utility functions include:

- Constant elasticity of substitution (CES) utility function. (Solow 1956)

- Hyperbolic absolute risk aversion (HARA) utility function (Ingersoll 1987:39; Merton 1971:389; Mossin 1968) which includes isoelastic utility function, exponential utility function and quadratic utility function.

In macroeconomics, CES functions are used to analyze the effects of labor and capital on quantity of production. (Solow 1956; Arrow, Chenery, Minhas and Solow 1961) Similarly, CES utility function can be used to analyze the utility a consumer can acquire from consuming two or more kinds of goods. (Dixit and Stiglitz 1977)

While the CES function is a kind of ordinal utility function which focuses on the utility derived by consuming different goods bundles, it is not the utility function we are going to use in this thesis. A cardinal utility function should be used here because a cardinal utility function is usually used to analyze the preferences on lotteries.

HARA utility functions are such cardinal utility functions we are looking for and they are easier to model mathematically. Isoelastic utility function, exponential utility function and quadratic utility function are three kinds of HARA utility functions which are most used nowadays. The difference is that isoelastic utility function has a constant relative risk aversion (CRRA) coefficient, and exponential utility function has a constant absolute risk aversion (CARA).
3.3.1 CRRA utility function

A CRRA utility function is the function we are going to use in this thesis. It is a kind of HARA utility function, and it can be written as:

\[
\begin{align*}
    u(x) &= \begin{cases} 
        \frac{x^{1-r}}{1-r}, & \text{if } r \neq 1 \\
        \ln(x), & \text{if } r = 1
    \end{cases}.
\end{align*}
\]  

(3)

Where \(x\) is wealth level and \(r\) means the coefficient of relative risk aversion. In this case, the first order derivative is:

\[
\begin{align*}
    u'(x) &= \begin{cases} 
        x^{-r}, & \text{if } r \neq 1 \\
        x^{-1}, & \text{if } r = 1
    \end{cases}.
\end{align*}
\]

And the second order derivative is:

\[
\begin{align*}
    u''(x) &= \begin{cases} 
        (r)x^{-1-r}, & \text{if } r \neq 1 \\
        -x^{-2}, & \text{if } r = 1.
    \end{cases}
\end{align*}
\]

So we have:

\[
RRA = r.
\]  

(4)

We can see that for any level of wealth \(x\), the relative risk aversion is the same, which is equal to a constant coefficient \(r\).

The value of \(r\) also shows the risk preference of the consumer: if \(r > 0\), the consumer shows a risk-averse preference; if \(r < 0\), the consumer shows a risk-loving preference; and if \(r = 0\), then the consumer is a risk-neutral person.

We select CRRA utility function not only because it is easy to model and to derive the coefficient of CRRA in the empirical research, but also we can eliminate the effect of initial wealth on the level of risk aversion of a certain consumer, thus we can focus on the effect of probability on the risk aversion.
3.3.2 An exception of CRRA utility function

Sometimes, researchers may take living expenditure into account when they consider wealth level in the utility function. For example, in Stone-Geary utility function (Geary 1950, Stone 1954), we can let $a$ be the amount of total expenditure, $x$ be the wealth level and $r$ be the relative risk aversion coefficient, then the utility function can be rewritten as:

$$u(x) = \frac{(x-a)^{1-r}}{1-r},$$  \hspace{1cm} (5)

$x > a > 0, r > 0$ and $r \neq 1$

So the first order derivative is

$$u'(x) = (x-a)^{-r}$$

and the second order derivative is

$$u''(x) = -r(x-a)^{-r-1}.$$ 

We can get the equation of RRA as:

$$RRA(x) = \frac{rx}{x-a}$$ \hspace{1cm} (6)

According to this equation, RRA is not constant anymore because it becomes a function of wealth level $x$.

But we will not consider total expenditure in the model of this thesis because total expenditure is not the variable we are going to look into now. We will still use the original CRRA utility function:

$$u(x) = \begin{cases} 
\frac{x^{1-r}}{1-r}, & \text{if } r \neq 1 \\
\ln(x), & \text{if } r = 1
\end{cases}.$$
3.4 Elicitation of relative risk aversion

In those popular methods we just mentioned in chapter 2.3, the main idea of them is to find out the equivalent value of a lottery by comparing two different risky lotteries or by comparing one risky lottery and one risk-free choice. And then use the mathematical method to calculate the coefficient of relative risk aversion or the coefficient of absolute risk aversion.

In this thesis, we are also going to find out the equivalent value of a lottery in the experiment. For example, a subject will be provided a lottery which has 50% of probability to earn 100 euros and 50% of probability to earn nothing, and if the subject shows the equivalent value is 40 euros, then according to the expected utility theorem, we have the equation:

\[ 0.5 \cdot u(w_0 + 100) + 0.5 \cdot u(w_0 + 0) = u(w_0 + 40). \]

In this equation, \( w_0 \) means the initial wealth which the participant has. According to the experiment survey, participants are asked about their monthly expenditure, so we can estimate \( w_0 \) by using the data of monthly expenditure.

Suppose that \( r \neq 1 \), \( w_0 = 800 \), then given the CRRA utility function \( u(x) = \frac{x^{1-r}}{1-r} \), we can calculate the coefficient of CRRA:

\[
0.5 \cdot \frac{(800 + 100)^{1-r}}{1-r} + 0.5 \cdot \frac{(800 + 0)^{1-r}}{1-r} = \frac{(800 + 40)^{1-r}}{1-r}
\]

\[ \Rightarrow r \in (6.94, 6.95) \]

So the value of CRRA falls between 6.94 and 6.95 according to the response of the subject, and the subject shows a risk-averse attitude because the CRRA is larger than 0.
As we assume that the coefficient of CRRA will not equal to 1, so we can simplify the CRRA utility function which we chose in the chapter 3.3.1:

\[
u(x) = \begin{cases} 
\frac{x^{1-r}}{1-r}, & \text{if } r \neq 1 \\
\ln(x), & \text{if } r = 1
\end{cases}
\to u(x) = \frac{x^{1-r}}{1-r}
\]

Generally, if we know the lottery prize money \( V \), the winning probability \( p \), initial wealth level \( w_0 \) and the equivalent value \( \pi \), assuming that the relative risk aversion coefficient \( r \neq 1 \), therefore the CRRA utility function can be written as \( u(x) = \frac{x^{1-r}}{1-r} \), we can always calculate the coefficient of CRRA as follow:

\[
p * u(w_0 + V) + (1 - p) * u(w_0 + 0) = u(w_0 + \pi)
\]

\[
\Rightarrow p * \frac{(w_0+V)^{1-r}}{1-r} + (1 - p) * \frac{(w_0+0)^{1-r}}{1-r} = \frac{(w_0+\pi)^{1-r}}{1-r}
\]

Thus, from the responses of the survey participants, we can always estimate a range of the CRRA coefficient utilizing the CRRA utility function and the lottery information. And based on the value of the CRRA, we can identify if the subject is a risk-averse, risk-loving or risk-neutral person.

Because of the survey design, the value of prize money \( V \) and winning probability \( p \) are both positive for sure, and the probability is less than 1, which means:

\[
V > 0,
\]

\[
0 < p < 1.
\]

Also the equivalent value \( \pi \) should not be 0 or negative (otherwise it will be deleted as an outlier):

\[
\pi > 0.
\]
In the next chapter, we will talk about the methodology of how to design the experiment and how to get the responses of equivalent values of the lotteries in the experiment.
4 METHODOLOGY

4.1 Sampling

In this experiment, the students in Oulu Business School will be chosen as the subjects of the survey. The reason why we choose Oulu Business School students as our participants is that:

- It is less costly to ask students to do the survey than to ask participants outside the university.

- It is convenient and time-saving to get OBS students into this survey.

- OBS students have some knowledge of relative theories in this thesis, so they can understand the questions well and give reasonable answers.

Although the OBS students cannot represent the whole population, we can still make an experiment on them first and then can we spread this experiment to other people.

The survey was sent to Oulu Business School students, which include all registered bachelor students, master students and doctoral students, via student office’s system. These students got an email with the message and the link of the online survey which would be active for one day. During one day of this online survey, I received 70 responses. According to the last question of the survey, which is asking to what extent the participant understands the questions in the survey (answers range from 1 to 10), I deleted 5 invalid responses whose answers are lower than 5 out of 10. As if the participants cannot understand the questions in a good level, their answers may be biased. So finally we have 65 valid responses.

Among these 65 valid participants, there are 43 male students and 22 female students. And the average age of all valid participants is 27.1 years old. There are 23 bachelor students, 36 master students and 6 doctoral students.
4.2 Experiment design

In the survey, the main task is to find out the participant’s willingness to pay or the equivalent value of the designed lotteries in the experiment, therefore we can calculate the coefficient of the relative risk aversion according to the formula (9) in chapter 3.4.

There are several ways to elicit equivalent value from a survey, for example, we can let the participant to choose a lottery from a price list (Andersen, Harrison, Lau & Rutström 2006), or we can ask the participant to make a choice between two risky lotteries (Camerer 1989).

In this experiment, we are going to design a risky lottery and a risk-free choice, then elicit the risk preferences of the subjects from their decisions between risky lotteries and risk-free choices. For example, we can describe a situation in the survey as follow: “Suppose that you are short of money recently, while you have a chance to choose one of the two options below to gain some money.” This description gives participants the purpose to gain as much money as they can. And then there are two options provided in front of every participant: Option 1 is a risky lottery which has a quite small probability, let’s say 10%, to win a prize money of 1800 euros. So the participant has 90% of probability to get nothing at all. In this lottery, we can find out the expected value of it is 180 euros; and option 2 is a certain amount of money that the participant can get for sure. This amount, let’s say X, will not be clarified in the description. Therefore, the participants are expected to state the value of X which makes the option 2 at least as good as option 1.

The stated value in the survey should be the estimation of the equivalent value of the lottery according to the participant. For example, if the participant writes down “170” in the blank space, it means that the subject will not pay more than 170 euros for this lottery. So 170 euros is approximately the equivalent value of the lottery for this subject.

Because this lottery’s winning rate is 10%, let’s say it is 10%-lottery. In other 4 lotteries, we will change the probability of winning the lottery, and detect the effect of probability on the participant’s risk preference. In the meantime, we will hold the
expected value of these lotteries the same, which means the expected value of all the lotteries in this survey will be 180 euros. Therefore, in the 25%-lottery, 50%-lottery, 75%-lottery and 90%-lottery, the stake prizes will be 720 euros, 360 euros, 240 euros and 200 euros respectively.

4.3 Validity of the survey

This survey is supposed to find out participants’ different responses in five lotteries with different probabilities of winning. As you can find out that the original questionnaire is attached in the Appendices, the survey questions are, apparently, not perfect but quite reasonable. Now we will talk about the validity of this survey in a few points of view.

4.3.1 Allais paradox

Maurice Allais (1953) has designed two similar experiments in which there are two gambles respectively. Participants are asked to make choices in both two experiments. And the results show that many people’s choices violate the predictions of expected utility theory. Sometimes it is used to argue that expected utility theory is not always consistent in some experiments.

However, Allais gets that inconsistent results because he compares the choices from two different experiments. In different experiments, the outcomes and probabilities are different, so that the utility function can change. But Allais assumes that the utility functions are the same when he calculates the results. That is why he gets the inconsistency of choices with expected utility theory.

In this thesis, when we calculate the CRRA value, we will only compare the choices within a certain situation. For different situations with different probabilities, we assume that people’s utility function will change, which is in accordance with the results of Allais’s paper.
4.3.2 Probability distortion

Kahneman and Tversky (1979) have created prospect theory which shows that people could overweight the extremely low probabilities. But this kind of probability distortion is usually related to loss aversion.

In the experiment of this thesis, both the lottery and the certain amount of money option have positive expected values, so people are not supposed to consider losing anything when they do the experiment. In this experiment, we are trying to wipe out the effect of loss aversion, as well as the effect of the probability distortion.

However, in the experiment, the lowest probability is 10%, which is not necessarily an extremely low probability, so probability distortion should not make a big difference in this experiment.

4.3.3 Anchoring effect

Tversky and Kahneman (1974) are the first researchers who find out this cognitive bias which states that people tend to be largely affected by the first information they get when they are making decisions.

In the survey of this thesis, the expected value of each lotteries are given in the text, so it could cause the anchoring effect. However, this anchor will not influence people’s risk preferences toward risk actually. Even though participants could rely on the expected value when they write down their answers, it is still uncertain whether they will write down a number bigger than the anchor value or smaller than the anchor value, or sometimes maybe equal to the expected value. So after all, the responses they give will be determined and representing their own risk preferences.

The reason why the expected values are given in the text is that it will be time-saving and convenient for participants to finish the survey, especially for those who are not good at mathematics. Also, it will reduce the bias caused by the miscalculation and negative moods for mathematics.
5 THE EXPERIMENT AND RESULTS

5.1 The stability of risk preferences in an overall level

In the experiment, every participant has written down their equivalent values for five different lotteries in the survey. The first step is to calculate the mean values of equivalent values for each lottery and calculate their CRRA coefficients. (See Table 4)

Table 4. Overall data summary

<table>
<thead>
<tr>
<th></th>
<th>10% lottery</th>
<th>25% lottery</th>
<th>50% lottery</th>
<th>75% lottery</th>
<th>90% lottery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>241.4462*</td>
<td>192.5385</td>
<td>185.3846</td>
<td>176.0462</td>
<td>173.6154</td>
</tr>
<tr>
<td>Standard</td>
<td>256.0781</td>
<td>119.7985</td>
<td>69.38495</td>
<td>47.10972</td>
<td>32.25615</td>
</tr>
<tr>
<td>CRRA</td>
<td>-0.5--0.49</td>
<td>-0.28--0.27</td>
<td>-0.33--0.32</td>
<td>0.66--0.67</td>
<td>2.77--2.78</td>
</tr>
</tbody>
</table>

*: p<0.10, **: p<0.05, ***: p<0.01 (Comparing with mean value=180)

As we can see in the Table 4, the mean equivalent value of 10%-lottery is the highest, and the mean value goes down when the probability increases. As similar as the mean values, the standard deviation shows a decreasing trend when the probability goes up.

The data show that people tend to be more risk-tolerating when they are facing high returns and high-risk choices, and their choices are more volatile. While they are facing less risky choices, however, their choices become more conservative and stable.

After calculating the CRRA coefficients, we find out that the CRRA coefficients for these five lotteries are quite different. The CRRA is increasing with the winning probability. It means that the participants become less risk-loving when the probability increases, and then they become risk-averse when the probability is over 50%. In
general, the participants present a risk-loving attitude when they are considering 10%-lottery, 25%-lottery and 50%-lottery, while they present a risk-averse attitude when they are facing 75%-lottery and 90%-lottery.

It seems like that people’s risk preferences are not stable with the changing probabilities. People seem to become more and more risk-averse when the winning probability becomes higher. But this is not necessarily true because we can also find out in the Table 4 that, only in 10%-lottery, the mean value of equivalent values is significantly different from the expected value which is 180 euros (p-value= 0.057). And in other 4 lotteries, we cannot reject that the equivalent value is equal to 180 (p-value is 0.40, 0.53, 0.50 and 0.12 respectively), which means that it is possible that people may show a kind of risk-neutral attitude for these four lotteries.

At least we can argue that the participants show a significant risk-loving attitude when they are making a choice in 10%-lottery, and this kind of risk preference is not in accordance with those in 25%-lottery, 50%-lottery, 75%-lottery and 90%-lottery. To prove this argument, we can do several T-tests to check out whether the mean values of these 5 lotteries are the same with each other or not. The results of the T-test are in Table 5.

We can see that the equivalent value of 10%-lottery is significantly different from those of 50%-lottery, 75%-lottery and 90%-lottery. But for other lotteries’ comparison, there exists no significant difference. It seems that 10%-lottery does make a difference in this experiment. Because people show a significant risk-loving attitude in this situation, and this risk-loving preference is significantly varied from the risk preferences in other 4 lotteries.

Why do people’s risk preferences become unstable when the winning probability is low? Maybe the reason is that overconfidence effect influences people’s decision making process. (Lichtenstein, Fischhoff & Phillips 1982; Pallier, Wilkinson, Danthiir, Kleitman, Knezevic, Stankov & Roberts 2002; Moore & Healy 2008) Thus the participants may overweight the winning rate of the lottery (Kahneman & Tversky 1979), and then they overrate the value of the lottery, which makes them present an unexpected risk-loving attitude.
Table 5. T-test results

<table>
<thead>
<tr>
<th>p-value</th>
<th>10% lottery</th>
<th>25% lottery</th>
<th>50% lottery</th>
<th>75% lottery</th>
<th>90% lottery</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% lottery</td>
<td></td>
<td>0.1665</td>
<td>0.09269*</td>
<td>0.04677**</td>
<td>0.03787**</td>
</tr>
<tr>
<td>25% lottery</td>
<td>0.1665</td>
<td></td>
<td>0.6778</td>
<td>0.3046</td>
<td>0.2227</td>
</tr>
<tr>
<td>50% lottery</td>
<td>0.09269*</td>
<td>0.6778</td>
<td></td>
<td>0.3712</td>
<td>0.2182</td>
</tr>
<tr>
<td>75% lottery</td>
<td>0.04677**</td>
<td>0.3046</td>
<td>0.3712</td>
<td></td>
<td>0.732</td>
</tr>
<tr>
<td>90% lottery</td>
<td>0.03787**</td>
<td>0.2227</td>
<td>0.2182</td>
<td>0.732</td>
<td></td>
</tr>
</tbody>
</table>

*: p<0.10, **: p<0.05, ***: p<0.01

This explains why many people buy insurances while they would like to buy lotteries as well. Because they are not very sensitive to relative low probabilities, then they cannot exactly perceive how low the winning rate is, which leads them to behave risky and to show a risk-loving preference. Thus they become a kind of complicated person with two sides of risk preferences.

5.2 Gender effect on the stability of risk preferences

In the 65 valid participants, there are 43 male students and 22 female students. In many researches on risk preferences, gender effect is usually considered as a variable causing different levels of risk aversion among people. In this paper we are also going to find out if the stability of risk preferences varies between male participants and female participants.

In Table 6 we can see that the mean equivalent values from male participants are higher than those from female subjects. From the results of CRRA coefficients, we can also see that male participants are more risk-loving in the first three lotteries, and they are less risk-averse in the last two lotteries. It shows that, generally, male participants
behave more aggressively when they are making financial decisions. On the other hand, women are less risk-loving and more risk-averse in corresponding situations.

Table 6. Data summary (Gender comparison)

<table>
<thead>
<tr>
<th></th>
<th>10% lottery</th>
<th>25% lottery</th>
<th>50% lottery</th>
<th>75% lottery</th>
<th>90% lottery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (male)</td>
<td>242.3*</td>
<td>197.3</td>
<td>181.7</td>
<td>179.0</td>
<td>175.3</td>
</tr>
<tr>
<td>Mean (female)</td>
<td>239.9</td>
<td>183.2</td>
<td>192.7</td>
<td>170.2</td>
<td>170.3</td>
</tr>
<tr>
<td>SD (male)</td>
<td>223.5932</td>
<td>113.5653</td>
<td>58.96322</td>
<td>42.21992</td>
<td>31.8759</td>
</tr>
<tr>
<td>SD (female)</td>
<td>316.0044</td>
<td>133.443</td>
<td>87.37516</td>
<td>56.07277</td>
<td>33.48971</td>
</tr>
<tr>
<td>CRRA (male)</td>
<td>-0.51~0.5</td>
<td>-0.38~0.37</td>
<td>-0.11~0.1</td>
<td>0.17~0.18</td>
<td>2.12~2.13</td>
</tr>
<tr>
<td>CRRA (female)</td>
<td>-0.49~0.48</td>
<td>-0.08~0.07</td>
<td>-0.78~0.77</td>
<td>1.58~1.59</td>
<td>3.93~3.94</td>
</tr>
<tr>
<td>Risk attitude</td>
<td>Risk-loving</td>
<td>Risk-loving</td>
<td>Risk-loving</td>
<td>Risk-averse</td>
<td>Risk-averse</td>
</tr>
</tbody>
</table>

*: p<0.10, **: p<0.05, ***: p<0.01 (Comparing with mean value=180)

According to the results of male participants, we find it similar with the overall results whose mean value in 10%-lottery is significantly different from the expected value. On contrary, mean values of female participants show no significant difference comparing with 180 euros. It means that, when facing the 10%-lottery, male participants show up a significant risk-loving attitude, but female participants are possible to be more or less risk-neutral for all the lotteries.

So it is evidential that men usually play aggressively in financial decision making compared with women. Especially in the low-winning-rate lottery, men’s risk-loving attitude becomes apparent, which may be due to overconfidence of them.
Table 7 reveals the t-test results for male participants. It shows that the male participants’ risk preferences for 10%-lottery are significantly unstable with those for 50%-lottery, 75%-lottery and 90%-lottery. This is quite similar with the overall results, which indicates people tend to overweight the low probabilities when making financial decisions, and to present a risk-loving attitude. Apparently, male participants show this tendency too, at least in the 10%-lottery.

Table 7. T-test results (Male)

<table>
<thead>
<tr>
<th>p-value</th>
<th>10% lottery</th>
<th>25% lottery</th>
<th>50% lottery</th>
<th>75% lottery</th>
<th>90% lottery</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% lottery</td>
<td></td>
<td>0.2443</td>
<td>0.09215*</td>
<td>0.07517*</td>
<td>0.05836*</td>
</tr>
<tr>
<td>25% lottery</td>
<td>0.2443</td>
<td></td>
<td>0.4255</td>
<td>0.3276</td>
<td>0.2272</td>
</tr>
<tr>
<td>50% lottery</td>
<td>0.09215*</td>
<td>0.4255</td>
<td></td>
<td>0.8144</td>
<td>0.5367</td>
</tr>
<tr>
<td>75% lottery</td>
<td>0.07517*</td>
<td>0.3276</td>
<td>0.8144</td>
<td></td>
<td>0.6439</td>
</tr>
<tr>
<td>90% lottery</td>
<td>0.05836*</td>
<td>0.2272</td>
<td>0.5367</td>
<td>0.6439</td>
<td></td>
</tr>
</tbody>
</table>

*: p<0.10, **: p<0.05, ***: p<0.01

Comparing with the instability of male participants’ risk preferences, female participants show up to be possibly stable when they are considering these five lotteries with varied probabilities.

We can see in the Table 8 that there is no evidence to prove that female participants behave differently in all five lotteries. Their equivalent values for all lotteries are generally around the expected value which is 180 euros. So we can argue that women players in this experiment show a relatively sensible and stable mind comparing with men players. It is maybe partially because women are considered to be less aggressive, then they are not going to show a risk-loving preferences usually, which makes them more stable in risk preferences.
Table 8. T-test results (Female)

<table>
<thead>
<tr>
<th>p-value</th>
<th>10% lottery</th>
<th>25% lottery</th>
<th>50% lottery</th>
<th>75% lottery</th>
<th>90% lottery</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% lottery</td>
<td></td>
<td>0.4451</td>
<td>0.5061</td>
<td>0.3194</td>
<td>0.3161</td>
</tr>
<tr>
<td>25% lottery</td>
<td>0.4451</td>
<td></td>
<td>0.7826</td>
<td>0.6757</td>
<td>0.6639</td>
</tr>
<tr>
<td>50% lottery</td>
<td>0.5061</td>
<td>0.7826</td>
<td></td>
<td>0.3162</td>
<td>0.2721</td>
</tr>
<tr>
<td>75% lottery</td>
<td>0.3194</td>
<td>0.6757</td>
<td>0.3162</td>
<td></td>
<td>0.9922</td>
</tr>
<tr>
<td>90% lottery</td>
<td>0.3161</td>
<td>0.6639</td>
<td>0.2721</td>
<td>0.9922</td>
<td></td>
</tr>
</tbody>
</table>

*: p<0.10, **: p<0.05, ***: p<0.01

5.3 Age effect on the stability of risk preferences

In this part, we will discuss if the stability of financial risk preferences is influenced by people’s age. In the experiment, we have 65 valid subjects whose ages are varied from 18 years old to 50 years old. There are 35 participants whose ages range from 18 to 25 years old, and there are 30 participants whose ages range from 25 to 50 years old. So we can divide the participants into two groups to make analysis.

The first group is including participants from 18 years old to 25 years old, and the second group consists of participants over 25 years old. From the Table 9 we can find out that the mean equivalent values of the first group are higher than those of the second group. It means that younger people would like to pay more money on the lotteries, which shows a more risk-loving attitude of them. On the contrary, elder people would like to pay less money on those lotteries, which indicates a less risk-loving or more risk-averse preference.
Young people present a more risk-loving preference even comparing with the overall results. We can see that young participants even present a slightly risk-loving preference in 75%-lottery, which is distinct from all other groups’ results. This may attribute to recklessness of young students.

According to Table 10, young people’s risk preferences are significantly unstable between 10%-lottery and 90%-lottery. But from the results in Table 11, we can see that the elder group does not show any significant instability in the five different lotteries. So we can say that the stability of risk preferences among young students is worse than that among elder students. Young people tend to make risky choices and their risk attitudes are changing evidently when they are dealing with very low probabilities and very high probabilities.
Table 10. T-test results (18-25 years old)

<table>
<thead>
<tr>
<th>p-value</th>
<th>10% lottery</th>
<th>25% lottery</th>
<th>50% lottery</th>
<th>75% lottery</th>
<th>90% lottery</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% lottery</td>
<td></td>
<td>0.3514</td>
<td>0.1241</td>
<td>0.1113</td>
<td>0.0858*</td>
</tr>
<tr>
<td>25% lottery</td>
<td>0.3514</td>
<td></td>
<td>0.2823</td>
<td>0.2321</td>
<td>0.1411</td>
</tr>
<tr>
<td>50% lottery</td>
<td>0.1241</td>
<td>0.2823</td>
<td></td>
<td>0.8522</td>
<td>0.465</td>
</tr>
<tr>
<td>75% lottery</td>
<td>0.1113</td>
<td>0.2321</td>
<td>0.8522</td>
<td></td>
<td>0.5547</td>
</tr>
<tr>
<td>90% lottery</td>
<td>0.0858*</td>
<td>0.1411</td>
<td>0.465</td>
<td>0.5547</td>
<td></td>
</tr>
</tbody>
</table>

*: p<0.10, **: p<0.05, ***: p<0.01

Table 11. T-test results (>25 years old)

<table>
<thead>
<tr>
<th>p-value</th>
<th>10% lottery</th>
<th>25% lottery</th>
<th>50% lottery</th>
<th>75% lottery</th>
<th>90% lottery</th>
</tr>
</thead>
<tbody>
<tr>
<td>10% lottery</td>
<td></td>
<td>0.2922</td>
<td>0.4656</td>
<td>0.2458</td>
<td>0.2565</td>
</tr>
<tr>
<td>25% lottery</td>
<td>0.2922</td>
<td></td>
<td>0.5058</td>
<td>0.9327</td>
<td>0.9972</td>
</tr>
<tr>
<td>50% lottery</td>
<td>0.4656</td>
<td>0.5058</td>
<td></td>
<td>0.3148</td>
<td>0.3293</td>
</tr>
<tr>
<td>75% lottery</td>
<td>0.2458</td>
<td>0.9327</td>
<td>0.3148</td>
<td></td>
<td>0.8725</td>
</tr>
<tr>
<td>90% lottery</td>
<td>0.2565</td>
<td>0.9972</td>
<td>0.3293</td>
<td>0.8725</td>
<td></td>
</tr>
</tbody>
</table>

*: p<0.10, **: p<0.05, ***: p<0.01
5.4 Expenditure effect on the stability of risk preferences

In the survey, the participants are also asked about their monthly expenditure which includes housing rent, food, clothes and entertainment, etc. There are five options which are ‘under 400 euros’ (chose by 3 participants), ‘400-600 euros’ (chose by 16 participants), ‘600-800 euros’ (chose by 15 participants), ‘800-1000 euros’ (chose by 15 participants) and ‘over 1000 euros’ (chose by 16 participants).

In this part, we are going to analyze if the amount of monthly expenditure has an effect on the stability of subjects’ risk preferences. So we can divide the participants into 4 different groups according to their monthly expenditure. Group 1 includes participants whose monthly expenditure is lower than 600 euros; group 2 includes participants whose monthly expenditure is between 600 to 800 euros; group 3 includes participants whose monthly expenditure is between 800 to 1000 euros; and group 4 consists of participants whose monthly expenditure is over 1000 euros.

In Table 12 we can find out the mean equivalent values for these 4 groups and corresponding CRRA coefficient values. From the data, we can see that the CRRA values of group 3 (800-1000 euros) and group 4 (over 1000 euros) are, in general, higher than those of group 1 (under 600 euros) and group 2 (600-800 euros). And the participants in group 1 and group 2 show a risk-loving attitude in most of the lotteries. On the other hand, the participants from group 3 and group 4 show a risk-averse attitude in most of the lotteries.

The reason for this difference may be that people hate to do risky choices when they have to spend a lot of money per month. Especially when the risky choices turn out to be a loss, they will not have enough money to pay the bills. But the story is different if people only spend a low amount of money every month to make them satisfied, because they do not worry that their life will be much worse even if the bad outcome happens to them.
Table 12. Data summary (Expenditure effect)

<table>
<thead>
<tr>
<th></th>
<th>10% lottery</th>
<th>25% lottery</th>
<th>50% lottery</th>
<th>75% lottery</th>
<th>90% lottery</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;600</td>
<td>268.8</td>
<td>218.2</td>
<td>191</td>
<td>173.1</td>
<td>170.3</td>
</tr>
<tr>
<td>CRRA</td>
<td>-0.69~0.68</td>
<td>-0.8~0.79</td>
<td>-0.67~0.66</td>
<td>1.13~1.14</td>
<td>3.93~3.94</td>
</tr>
<tr>
<td>600-800</td>
<td>167.5</td>
<td>181.1</td>
<td>199.4</td>
<td>191.6</td>
<td>185.7*</td>
</tr>
<tr>
<td>CRRA</td>
<td>0.12~0.13</td>
<td>-0.03~0.02</td>
<td>-1.2~1.1</td>
<td>-2.3~2.2</td>
<td>-3.7~3.6</td>
</tr>
<tr>
<td>800-1000</td>
<td>266.7</td>
<td>167</td>
<td>174.5</td>
<td>168.7</td>
<td>173.5</td>
</tr>
<tr>
<td>CRRA</td>
<td>-0.68~0.67</td>
<td>0.29~0.3</td>
<td>0.33~0.34</td>
<td>1.81~1.82</td>
<td>2.81~2.82</td>
</tr>
<tr>
<td>&gt;1000</td>
<td>254.6</td>
<td>196.8</td>
<td>175.8</td>
<td>171.8</td>
<td>166.3</td>
</tr>
<tr>
<td>CRRA</td>
<td>-0.6~0.59</td>
<td>-0.37~0.36</td>
<td>0.25~0.26</td>
<td>1.34~1.35</td>
<td>5.17~5.18</td>
</tr>
</tbody>
</table>

*: p<0.10, **: p<0.05, ***: p<0.01 (Comparing with mean value=180)

5.5 Comparison with results from previous researches

In the prospect theory, Kahneman and Tversky (1979) have stated that people can overweight the extremely low probabilities. And Barseghyan, Molinari, O’Donoghue and Teitelbaum (2013) have found out that large probability distortions can influence household’s risk attitude, which means that probability distortions of low probabilities can evidently change insured people’s preferences toward risk. We cannot make sure that if the participants really overweight the low probabilities or not, but it is evidently that people show up to be more risk-loving in 10%-lotteries and it makes them present an unstable risk preferences in an overall view. Although previous theories focus on the distortion of loss probabilities’ distortion, we still believe that people can distort winning probabilities too, and this distortion should explain the results of the experiment in this thesis.
About gender effect on the stability of risk preferences, Eckel and Grossman (2008) have done a research to find out that women are significantly more risk-averse than men in the domain of financial decisions. And Hartog, Ferrer-i-Carbonell and Jonker (2002) have also asserted that women’s estimated risk aversion is significantly larger than men’s. Many other researches show similar results as well. In the experiment of this thesis, women participants do present to be more risk-averse than men participants, and in the meantime, women players have more stable risk preferences compared with men players.

Considering the age effect on the stability of risk attitudes, Gardner and Steinberg (2005), Albert and Duffy (2012), as well as other researchers, have made experimental empirical researches to assert that risk preferences vary in different age groups. They have found out that younger subjects are more likely to behave riskily. This argument has been confirmed in this thesis’s experiment too. And also, we have found that young participants’ risk preferences are unstable when they are facing extremely low and extremely high winning rates.
6 CONCLUSIONS

In this thesis, we are looking into the problem about stability of people’s financial risk preferences in different lotteries. In our experiment, five lotteries have different probabilities of winning, and accordingly, with different winning prizes. For rational consumers, they should show the same or similar risk preferences in these five lotteries when using the same eliciting method of risk preferences. But the experiment results show that the participants’ risk preferences are not stable.

According to the experimental results, subjects’ risk preferences change largely when the winning rates change. Their risk attitudes can change from risk-loving to risk-averse in these five different lotteries. Generally, when the winning rate is small, people tend to show more risk-loving attitude, and on the other hand, they are likely to show a risk-averse attitude in a high winning probability lottery. This is diverse from some previous researches which asserted that people are risk-averse in a gain situation and risk-chasing in a loss situation.

In the experiment of this thesis, people’s risk preferences are unstable, and this instability of risk attitudes is affected by gender effect and age effect. That is, male participants’ risk preferences are more likely to be unstable when facing these five lotteries than female participants’ risk attitudes are. Meanwhile, young participants’ risk preferences tend to be more unstable in these five different lotteries than elder participants’ risk preferences do. Additionally, women participants show more risk-averse than men participants, and elder participants present to be more risk-averse than younger participants. The result of gender effect supports previous researches which claim women are more risk-averse than men, while age effect reflects a few previous researches as well.

Although there is no clear evidence showing that monthly expenditure affects the stability of risk preferences in this experiment, we still find out that people who have high monthly expenditure are more risk-averse. In the future, maybe the expenditure effect should be considered with the wealth level, because both expenditure and wealth level influence the outcomes of a risky decision.
The results are reliable to this research problem because the experimental questions are well designed and distributed. The five lotteries can simulate the real financial instruments and derivatives whose risk is high when the outcome is high. So the behavior of the participants in this experiment can reflect the behavior they will make in the real financial markets.

One problem is that the sample of this experiment is the students in Oulu Business School, and it cannot necessarily represent the investors in the financial markets. So in the future study, we can generalize this experiment to the real participants in the financial markets. And then we can know more about their risk preferences when facing different financial instruments, which is helpful to revise pricing method, marketing strategy and other policies about designing and selling financial instruments.

We also guess that people show such risk-loving attitude in a super low winning rate lottery because they usually overweight low probabilities. So in the future study, we can also apply the prospect theory into this kind of research, to find out its effect on the stability of risk preferences in a gaining situation.
REFERENCES


APPENDICES

The survey questions of the experiment:

Dear participants, this survey is about people’s attitudes toward risk. There is no right or wrong answers for these questions, and your information is totally confidential, so you could just write down your answers which fit your thinking best. It will take only 3-5 minutes to finish this survey. Thank you for your time!

Suppose that you are short of money recently, while you have a chance to choose one of the two options below to gain some money.

Option 1: You can participate in a lottery and have a very small chance (10%) to win 1800 euros, otherwise you will get nothing. (The expected value is 180 euros)

Option 2: You can get X euros for sure.

If X is at least ________€, you will choose option 2 instead of option 1.

Consider the situation again,

Option 1: You can participate in a lottery and have a small chance (25%) to win 720 euros, otherwise you will get nothing. (The expected value is 180 euros)

Option 2: You can get X euros for sure.

If X is at least ________€, you will choose option 2 instead of option 1.

Consider the situation again,

Option 1: You can participate in a lottery and have a fair chance (50%) to win 360 euros, otherwise you will get nothing. (The expected value is 180 euros)
Option 2: You can get X euros for sure.

If X is at least ________€, you will choose option 2 instead of option 1.

Consider the situation again,

Option 1: You can participate in a lottery and have a big chance (75%) to win 240 euros, otherwise you will get nothing. (The expected value is 180 euros)

Option 2: You can get X euros for sure.

If X is at least ________€, you will choose option 2 instead of option 1.

Consider the situation again,

Option 1: You can participate in a lottery and have a very big chance (90%) to win 200 euros, otherwise you will get nothing. (The expected value is 180 euros)

Option 2: You can get X euros for sure.

If X is at least ________€, you will choose option 2 instead of option 1.

Your age: ______

Your gender: ○ Male ○ Female

Estimated total expense per month (€): (including housing, food, entertainment, etc.)

○ under 400 ○ 400-600 ○ 600-800 ○ 800-1000 ○ over 1000

Your education level: ○ Bachelor student ○ Master student ○ Ph.D. student ○ other: ______
Your major: ____________

To what extent do you understand the questions in this survey:

Not at all       Totally understand

1  2  3  4  5  6  7  8  9  10
Participants' gender distribution:

- Male: 66%
- Female: 34%

Participants' monthly expenditure (€):

- <400: 23%
- 400~600: 25%
- 600~800: 25%
- 800~1000: 23%
- >1000: 4%