Life-cycle fund asset allocation and investors' risk appetite

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Abstract

This paper describes how an optimal retirement portfolio should develop over time. This optimal asset mix is then compared with an investment in a life-cycle fund. Two components are of significant influence on the optimal retirement portfolio, being human wealth and an investor's risk appetite. In the analysis of risk appetite several demographics will be distinguished. To collect data on the risk appetite of pension participants a survey is done. This questionnaire contains a multiple price list which should provide a coefficient of relative risk aversion. This coefficient is then used to obtain the optimal asset allocation along the retirement horizon. Furthermore, to make use of human capital in the analyses of optimal asset allocation its value must be determined. This is done by taking the present value of all future payments. In this paper it is assumed human wealth varies in riskiness (i.e. variations in correlation with stock returns). For the analysis of the optimal retirement portfolio I distinguish two types of assets. A risky asset where the MSCI AC Index acts as a proxy and a riskless asset where a 1-month American T-bill serves as a proxy. A long horizon is used ranging from 1988 to 2011. Using these data I find that an investment in a life-cycle fund isn't always an appropriate investment choice regarding retirement. For some investors a life-cycle fund pursues an investment strategy that is too conservative whereas for others it pursues a investment strategy that is too aggressive. Whether or not a life-cycle fund is regarded as an appropriate retirement investment is depend on investors risk appetite and riskiness of human capital.

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1. Introduction

The retirement system in the Netherlands has experienced small change in recent years. The traditional DB pension plan loses popularity. The pension plan in which employees relied on professionally managed retirement portfolios provided by their employers becomes less usual. A growing minority of employees wants to make its own decision on how much to contribute for retirement and make its own investment decisions. In a defined contribution (DC) pension plan, employees save money on individual basis at accounts administered by the plan sponsor. In a DC plan employees are free to decide how much to contribute each month (up to a legally established maximum). Each employee is responsible for its own account and will manage its own retirement portfolio. Thus the benefits they get, and eventually the amount of retirement they receive, depends on their own contributions and investment decisions. The DC plan sponsors are only responsible for the design of the plan and for its administration and record-keeping.

Government regulations grant DC sponsors considerable flexibility in the selection of investment options available. Therefore most investment options offered by plan sponsors are a menu of mutual funds. A couple of years ago the DC plan gained considerable popularity in the US as well. The retirement system already transformed and most of the pension plans offered are DC pension plans. However, Viceira (2007) found that within the US several mutual fund industry executives, pension and investment experts consider the investment choices made by DC plan members are disappointing. Their concern is that because of these disappointing saving and investment decisions the final retirement income at retirement is little. Viceira (2007) states the following:

> *''There is evidence that a large number of DC plan participants, particularly among those with lower levels of education, wealth, and income, show a considerable degree of inertia in their contribution and investing decisions. They tend to adopt the default contribution and investment option chosen by the plan sponsor, which is typically either no contribution or a small contribution that is entirely invested in a money market fund.''*

In response to this concern banks started offering life-cycle funds (LCF's). Plan sponsors started adopting this new type of mutual fund. LCF's are offered as a 'one-size-fits-all' solution. This type of investment option is managed by a professional and is diversified across equity, bonds and cash and gradually tilts the risky investment options towards the riskless options over time. However, recent empirical evidence has shown that these 'one-stop' solutions are not a convenient investment for every DC plan member. Bodie & Treussard (2007) describe that risk aversion and human capital are of significant influence for deciding, whether a standard LCF offered is a suitable investment vehicle. Do LCF's offered by DC plan sponsors reflect the risk appetites of the DC plan members? I.e. do LCF managers consider a correct degree of risk appetite of its investors? To test whether this is true the following hypothesis forms the core of the prevailing research.

H_0 : LCF's consider the correct risk appetite of its investors and translate this appetite into an optimal asset mix.

Furthermore, it is well-known people differ in risk appetite. Weber, Blais, & Betz (2002) researched how people assess risk in five different domains (financial decisions, health/safety, recreational, ethical, and social decisions). In their research they conclude that risk taking behavior is influenced by situational characteristics as well as person-centered characteristics. Where person-centered characteristics include age, gender, culture and personality. Furthermore they conclude women are, in general, more risk averse than men. I'm interested if women also tend to make more risk averse decisions considering their retirement. Therefore the following hypothesis will be tested as well:

H_0 : Men have, concerning retirement investments, a greater risk appetite than women.

Moreover, in the early sixties Wallach & Kogan (1961) researched the relationship between risk tolerance and age. They found that if one ages, risk tolerance decreases. Other researchers find similar results (Morin & Suarez (1983), Zuckerman (1994) and Hallahan, Faff & McKenzie (2003)). On the other hand, there is evidence that suggests otherwise. Bellante & Saba (1986), Grable & Lytton (1999) and Wang & Hanna (1997) all find evidence one becomes more risk tolerant as one ages. I want to examine whether you become truly more risk averse as you age. Therefore the following hypothesis is tested:

H_0: Investors become increasingly risk averse regarding their retirement investment decisions as they age.

To determine the risk appetite for retirement I do a survey. In this questionnaire there are several questions about risk preferences. These questions are based on two theories that try to capture risk aversion. The first method used is the methodology of Holt & Laury (2002) . Participants are faced with ten paired lottery choices about the amount of pension received at retirement. One of the options is the safe choice and the other the risky choice. The menu of paired lottery choices is structured so that the switching point from safe to risky can be used to derive a measure of risk aversion and serves as an indicator of risk appetite. The second method is the methodology of Weber, Blais, & Betz (2002) where several questions are asked regarding risk appetite. Eventually this questionnaire should clarify to what extend the participants are risk averse.

The remainder of this paper will be structured as follows. Section 2 will provide an overview of written literature on LCF's and life-cycle asset allocation. Section 3 is devoted to the methodologies used for this study. Section 4 continuous with the data. Followed by the results of the research in section 5. Finally sections 6 and 7 will focus on the shortcomings of this research and conclusions.

2. Literary review

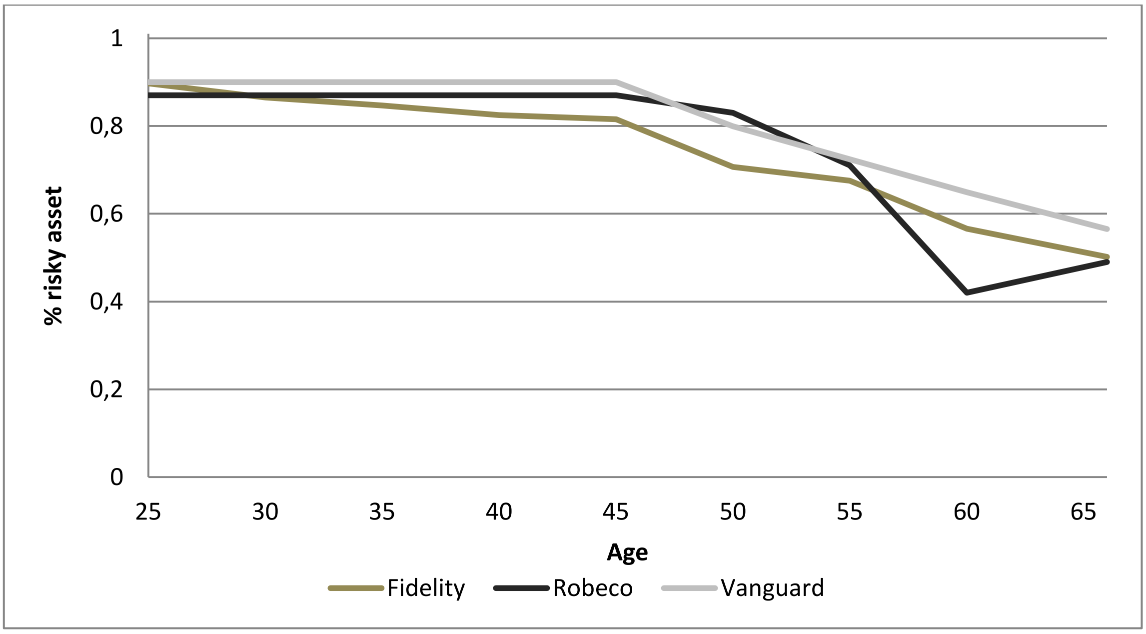
With a slowly changing pension system which switches to a DC pension plan, the responsibility of making investment decisions shifted from a professional towards the individual DC plan participant. In response banks started offering LCF's. This section evaluates and provides an overview of academic research in the field of LCF's and life-cycle investment theory.

2.1 Life-cycle funds

LCF's are a relatively new investment vehicle. This type of investment fund is designed on the idea of age-based investing and can be seen as a suitable investment choice when it comes to retirement. The notion behind age-based investing is that young investors with long retirement horizon should heavily expose themselves to equity when young and gradually reduce their exposure towards equity as retirement approaches.

The convenience of LCF's is that it is managed by a fund manager. Resulting in an automatic rebalance, to keep the overall portfolio composition of the fund in line with the pre-determined target mix. As mentioned, this target mix becomes more conservative over time. The exposure towards equity gradually tilts toward more conservative investment categories like bonds and cash. Figure 1 shows LCF offerings, which indeed show a roll down in exposure towards risky assets.

Figure 1: Asset allocation offerd LCF's



It is remarkable to see that the LCF of Robeco moves back up again in the last five years. The underlying idea is unknown. However, when the factsheets of Robeco (2013) are analyzed one can see they add an additional asset class. Furthermore, within the equity section they choose to reduce the percentage invested in emerging markets and globally diversified mutual funds. They reallocated this towards a conservative investment strategy, causing a broader and less risky diversification. Which makes it possible to hold more of the risky asset.

The main characteristic of an LCF is that it reduces exposure towards the risky assets as the target date approaches. This is, according to Canner, Mankiw, & Weil (1997), in line with the popular advice. However, a different question is whether this asset allocation strategy is supported by academics and scholars.

2.1.2 Life cycle funds' asset allocation in a mean and variance framework

The most fundamental decision in investment management is how to allocate your assets. The mix of different asset classes is dependent on various elements. The mean-variance framework introduced by Markowitz (1952) is by far the most common formulation of portfolio choice. In essence, it aims to garner the same amount of return with a reduced amount of risk. Where portfolio diversification is at the core of asset management. It pertains the need to spread risks and return across different assets and asset classes. An intuitive example is illustrated by two separate islands. Island A produces ice creams. One could earn a lot of money when it is extremely hot the whole year round, but you would gain nothing when the weather is bad. Island B produces raincoats. There it is the other way around. During good weather there is not much to gain and during extremely rainy weather one could gain a lot. However, an investment in both islands could assure a proper gain with any type of weather. The fundamental concept is that one should focus on the interaction among asset. An investor should select the options which provide the best diversification possibilities. To illustrate the effects of diversification in a more mathematical approach, consider a portfolio exciting of two assets, a risky asset (asset x) and a riskless asset (asset y). Each asset has a variance (σ_x^2 ; σ_y^2) and an expected return ($\overline{R}_x$; $\overline{R}_y$). The proportion invested in each asset is denoted by ω_i. The proportion invested in the riskless asset can thus be determined by $\omega_{rf} = 1 - \omega_x$. The expected return of this portfolio is then:

$$\bar{R}_p = \omega\bar{R}_x + (1-\omega)\bar{R}_y = \bar{R}_y + \omega\left(\bar{R}_x - \bar{R}_y\right) \qquad (2.1)$$

The expected return of the portfolio is calculated by the weighted average of the expected return for each asset. In general the portfolio risk is measured by the standard deviation of the portfolio, which is the square root of the portfolio variance. The portfolio variance can be calculated:

$$\sigma_p^2 = \omega_x^2\sigma_x^2 + \omega_y^2\sigma_y^2 + 2\omega_x\omega_y\sigma_x\sigma_y\rho_{xy} \quad (2.2)$$

And the portfolio standard deviation:

$$\sigma_p = (\omega_x^2\sigma_x^2 + \omega_y^2\sigma_y^2 + 2\omega_x\omega_y\sigma_x\sigma_y\rho_{xy})^{1/2} = \sqrt{\sigma_p^2} \quad (2.3)$$

Where ρ is the correlation coefficient. The correlation coefficient gives an indication if diversification is possible and has a value of $-1 \leq \rho \leq 1$. If $\rho < 1$ there are possibilities for diversification. The further ρ differs from 1 the better the diversification possibilities. The coefficient is calculated:

$$\rho_{x,y} = \frac{cov_{x,y}}{\sigma_x\sigma_y} = \frac{\sigma_{xy}}{\sigma_x\sigma_y} \quad (2.4)$$

If all necessary elements are known the optimal weight of each asset can be determined. The optimal weights show the lowest possible variance for a required return. The following equation is used to determine the optimal weights:

$$\omega^* = \frac{e'V^{-1}e\bar{R}_p - \bar{r}'V^{-1}e}{\bar{r}'V^{-1}\bar{r}e'V^{-1}e - (\bar{r}'V^{-1}e)^2}V^{-1}\bar{r} + \frac{\bar{r}'V^{-1}\bar{r} - \bar{r}'V^{-1}e\bar{R}_p}{\bar{r}'V^{-1}\bar{r}e'V^{-1}e - (\bar{r}'V^{-1}e)^2}V^{-1}e \quad (2.5)$$

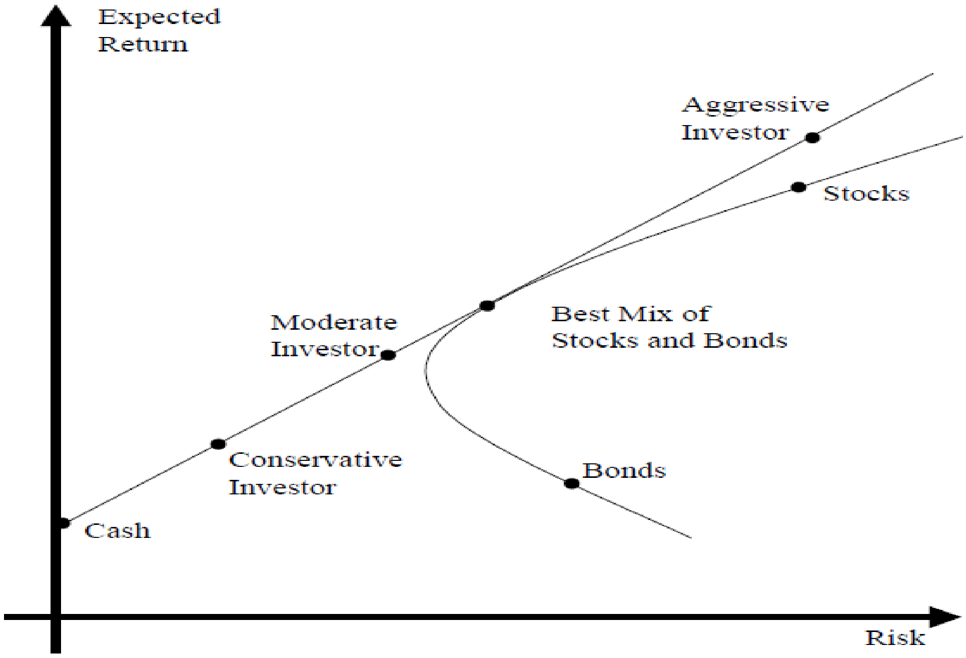
Where:

ω^* = optimal weight of an asset
V = covariance matrix
R_p = desired amount of return
r = average return

All weights of the assets must sum to one. If all optimal weights are combined they will form an optimal portfolio. There are several optimal portfolios, dependent on risk appetite of the investor. All these optimal portfolios can be drawn in an efficient frontier (see figure 2).

A well-known extension to the work of Markowitz is written by Tobin (1958) the mutual fund theorem. He describes that all investors should combine cash with a portfolio consisting of risky assets. The proportion allocated to cash is dependent on the risk appetite of the investor. A conservative investor will prefer to hold more cash where an aggressive investor will allocate more of his wealth towards the risky portfolio, as can be seen in figure 2.

Figure 2: Mean-Variance efficient frontier



Both theories attempt to maximize expected return for a given amount of risk, or it is trying to minimize risk for a given amount of expected return. The fundamental concept is that an investment portfolio shouldn't be constructed merely on characteristics of a single asset. It is important to know the interaction between an asset and all other assets, so that diversification is possible.

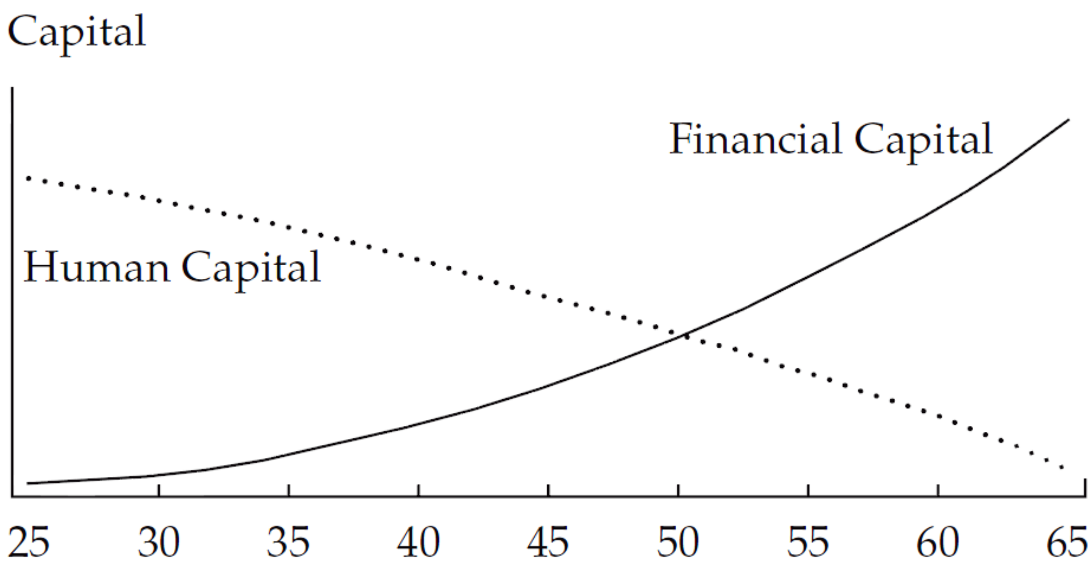
However the result that emerges from the mean-variance analysis is based on the assumption that investors will invest their wealth for one period, meaning the optimal portfolio found will sustain for the full period regardless of the length of this period (month, year, decade). Furthermore, when the period is of considerable length, the mean variance framework neglects the effects of income on the optimal investment portfolio. However, this sets off against recent academic work. In the years that followed after the work of Markowitz, academics analyzed the impact of income (human capital) on the optimal portfolio and came to notion that it is a variable not to omit. According to Bodie, Merton, & Samuelson (1992) omitting human capital even creates a non-optimal portfolio.

2.2 Human capital and asset allocation

As mentioned, standard mean-variance analysis ignores that investors have another sources of wealth in the form of human capital. Human wealth, probably the biggest asset one can own, consist of the discounted value of all future wage payments.

It was Schultz (1961) who first noticed this form of non-physical capital. He describes human capital as a stock of competence, knowledge and creativity embodied in the ability to perform labor and add economic value to a product. It is clear people acquire skills and knowledge as they age. It starts off at school, often followed by a study at a university or another educational provider, and later on the job training programs. It is less conventional that these acquired skills and knowledge are a form of capital. This type of non-physical capital in the Western Societies has grown at a much faster rate than the physical, non-human capital. Furthermore it has increasing rates of return, caused by an increase in productivity due to education and experience. Unlike other types of assets, human capital is non-tradable. Just because human wealth is not tradable, Bodie, Merton, & Samuelson (1992) illustrated that it shouldn't be ignored. In fact they have shown that human capital tilts the asset allocation towards the risky asset at the start of the life-cycle. The main reason is that human wealth is often seen as an equivalent of an investment in a bond. Hence, human capital forms a big part of an investor's total wealth resulting in an enormous exposure towards the riskless asset. In order to come as near as possible to the optimal target mix an investor should, at the start of his career, invest all of his financial wealth in the risky asset in an attempt to come as close as possible to the optimal asset allocation. As an investor grows older human wealth will shrink in value, hence as one ages fewer future wage payments can be expected. On the other hand financial wealth will grow over time (see figure 3). This results in an asset mix that will tilt the investment portfolio towards the riskless asset over time.

Figure 3: Expected financial capital and human capital over the working life-cycle



However, human wealth is not necessarily bond like. There are several elements that influence the risk of human capital. Bodie (2003) describes two reasons that could influence the risk of this type of asset. First there is the job flexibility. The greater the flexibility for making changes in labor supply, the greater the exposure to risky assets can be. Younger workers have greater flexibility in altering their labor supply. It is possible for them to delay retirement and make up for losses. Older investors do not have this privilege, causing a relatively safer human capital for young investors. Due to this relatively safe human capital one has to invest more in risky asset when young so an optimally diversified portfolio will maintain. Second, age is of significant influence on the riskiness of human capital as well. At the start of a career one has a lot of exposure towards human capital and can expect a large amount of future wage payments, making human capital less risky in the early stages of a career. In the wake of this, the amount of capital allocated towards risky asset normally should decline as one ages. Furthermore, Merton (2003) found that the risk profile of human capital is dependent on one's profession as well. A market maker, a nurse, a teacher and a lawyer have very different risk profiles. A market maker for instance is dependent on the stock market. When stock markets decline it is likely there will be fewer jobs available as a market maker.

The optimal asset allocation is highly dependent on the relation of human capital and its correlation with stock market. When an investor knows with certainty what the amount of discounted value of future labor earnings will be and its interaction with the stock market is negligible, the optimal asset mix will consist of a great allocation to stocks when young and gradually tilt this allocation towards the riskless asset as the investor ages. However, when human wealth does show correlation with the stock market it will affect the optimal asset mix. In his study Viceira (2001) shows small correlations reduce the amount invested in equity and with large correlations there will be a tilt towards riskless assets. Meaning that the decline asset allocation toward equity as is seen in life cycle funds is scientifically based only when human capital is riskless. LCF's are a less convenient financial vehicle when human capital is correlated with stock returns. If investors with a correlated human wealth will invest in an LCF as offered by Fidelity, Robeco or Vanguard they are too heavily exposed to stocks, and hold a non-optimal allocated investment portfolio.

However, there is more to consider than just human wealth when it comes to life-cycle investing. As Tobin's the mutual fund theorem suggests, investors differ in risk tolerance. What could be optimal for investor X could be non-optimal for investor Y. Each investor values extra gain or a loss differently. In their paper Bodie & Treussard (2007) do indeed find that risk aversion is of influence on the total welfare extracted from a constructed portfolio. They evaluate total welfare extracted from general LCF's and it appears that when an investor is extremely risk averse and its human wealth has a correlation of one with the stock market, it will suffer an enormous drop in total welfare if he chooses to invest in a general LCF. So in order to find an investment portfolio that is optimal for an investor the definition of risk is an important matter. According to Barberis & Thaler (2003) investors' preferences are an important factor in trying to understand how investors evaluate risky gambles. I.e. how should investors, given their preferences, invest their wealth? In the next subsection I will elaborate on this matter.

2.3 Investors risk tolerance

Investors' preferences are important to understand. Within economics utility is often used as representation of Investors' preferences. In their expected utility theory (EUT) Von Neumann & Morgenstern (1944) used these utility functions in order to understand investors' preferences and understand how investors act when exposed to risky gambles. They conclude when an investor is faced with several risky gambles he will base his choice on expected values of each option. Investors will always prefer the option with the highest expected utility and will only alter their decision if the expected utility of an alternative gamble is higher. Furthermore, EUT takes into account investors might be risk averse. Meaning that the individual would refuse a fair gamble or in the context of portfolio construction, an individual prefers to put his money on a savings account rather than invest in equity which might have a higher expected return. Within the concept of EUT there are two ways to quantify risk attitudes:

- Relative risk aversion
- Absolute risk aversion

Relative risk aversion (RRA)

Is a measure on how investors value upside and downside risk. The relative risk aversion measure assumes risk aversion is reflected in a percentage of wealth, meaning an investor cares about the return in percentage. He will value a loss of -5% equally disappointing regardless the value of its portfolio. A loss of -5% on a portfolio of € 5.000 or € 500.000 is valued the same.

Formula: $RRA = \frac{xU''(x)}{U'(x)} = constant$

Relative risk aversion can be increasing, decreasing or constant. With increasing RRA an investor will hold a smaller percentage in the risky asset as wealth increases. With constant RRA an investor will hold the same percentage in the risky asset as wealth increases. With decreasing RRA an investor will hold a larger percentage in the risky asset as wealth increases.

Absolute risk aversion (ARA)

In contrast to constant relative risk aversion, absolute risk aversion assumes risk aversion is measured by the amount of wealth lost. This means, a billionaire will find it equally disappointing to lose a € 100 as someone in social welfare.

Formula: $ARA = \frac{U''(x)}{U'(x)} = constant$

Absolute risk aversion can be increasing, decreasing or constant. With increasing ARA an investor will hold fewer dollars in the risky asset as wealth increases. With constant ARA an investor will hold the same amount of dollars in the risky asset as wealth increases. With decreasing ARA an investor will hold a larger amount of dollars in the risky asset as wealth increases.

In extension to the expected utility theory several new theories have been written. Regret theory by Bell (1982) and Loomes & Sugden (1982) which states that investors could regret their investment choice. This can have different effects, one could make a more risky choice whereas another person could be more risk averse due to the feeling he may regret his investment choice. Another theory is the rank-dependent utility theories by Quiggin (1982), Yaari (1987) and Segal (1987) Segal (1989). This theory overweighs only unlikely, extreme outcomes rather than all unlikely events (i.e. overweighting low probabilities). Probably the best-known theory is written by Tversky & Kahneman (1979) and Tversky & Kahneman (1992), the prospect theory. Prospect theory is somewhat different from expected utility theory. It is defined over gains and losses rather than final wealth. In addition prospect theory accounts for the fact that individuals do not use objective probabilities. They tend to put more weight on small probabilities (just as the rank-dependent utility theory). Kahneman & Tversky (1979) found that investors are more sensitive to losses than to gains. This means that investors are risk seeking over losses and risk averse over gains.

However, most models still assume the expected utility theory. For instance Holt and Laury (2002) use the EUT in order to quantify the risk tolerance of investors. Although their method of capturing risk aversion is well-known there are several other methods to capture an individuals' risk aversion.

2.3.1 Measuring risk attitudes

Every individual has its own risk appetite. In order to measure to what extent an individual exhibits risk aversion there are different manners in evaluating individual risk aversion. Donkers, Lourenco, & Dellaert (2012) identify two categories towards measuring risk attitudes:

1. Direct attitudinal scales that capture risk preferences
2. Choice-based approaches to infer risk preferences

For direct attitudinal scales Dellaert & Turlings (2011) describe how risk atitudes for pension products are measured in practice. The use of questionnaires is the most commonly used method to evaluate risk tolerance. In these questionaires the core of the questions is formed by five topics:

1. Financial position. Financial situation of an individual (i.e. individual salary).
2. Knowledge and/or experience (investment literacy and experience with investing).
3. Investment horizon (the consumer’s investment horizon, from the start of the pension investment to the actual pension date).
4. Degree of dependence on payment (the degree of dependency of the individual on the return of the pension investment).
5. Willingness to take risks (the individual’s attitude towards investment risks).

In addition Weber, Blais, & Betz (2002) recently constructed measurement scales related to domain-specific risks including a financial domain. However, this method has serious shortcomings. The individuals answering the questions often misinterpret their own actions (e.g. social desirability bias, people often act otherwise than they say they will do). The other category in identifying risk attitudes suffers less malfunction. Here the risk attitude is expressed in choices that are made. The most widely used method for capturing level of risk aversion using lottery choices is the method used by Holt & Laury (2002). Participants of this method are confronted with paired lottery choices. Where option A is less variable than option B. The point where they switch from A to B is key in determining risk appetite. Although this method suffers less malfunction than the direct attitudinal method, it isn’t flawless. A common problem with a methodology of paired lottery choices is that it might encourage respondents to choose one of the options in the middle, independent of their true valuations of this option. Furthermore, Hershey & Schoemaker (1985) found that respondents put too much weight on either the propabilities or the outcome itself.

2.4 General considerations of life-cycle investment

In the previous sections I have explored what popular advice and acedamics have to say about asset allocation along the life-cycle. A general characteristic of an LCF is that it gradually reduces the amount of equity overtime. The rule of thumb often used, described by Canner, Mankiw, & Weil (1997), is that investors should invest (100-age) % in risky asset. Academic research has shown a same pattern. When it concerns long-run investing Bodie, Merton, & Samuelson (1992) show that labor income will tilt the investment portfolio towards the risk asset. As one ages human capital reduces and the optimal asset allocation will slowly tilt towards the riskless asset. However, Merton (2003) shows human capital isn't always riskless and differs per profession. Furtheremore, Bodie (2003) subscribes that job flexibility is of influence as well. The greater the flexibility in making changes in labor supply, the greater the exposure to risky assets can be.

Next to human wealth risk tolerance influences the optimal asset allocation as well. Bodie & Treussard (2007) show in their paper that it is a measure of risk aversion in combination with the riskiness of human capital that can influence the final wealth of an investor. In order to find an investment portfolio that is optimal, the definition of risk is an important matter. According to Barberis & Thaler (2003) investors' preferences are a key factor in trying to understand how investors evaluate risky gambles. Within economics utility is often used as representation of Investors' preferences. In their expected utility theory (EUT) Von Neumann & Morgenstern (1944) used these utility functions in order to understand investors' preferences and understand how investors act when they are exposed to risky gambles. Based on the expected utility theory Holt & Laury (2002) can determine an interval for realtive risk aversion. Next to the method used by Holt & Laury, the choice-based approaches to infer risk preferences , there is a more qualitative way to get an insight in risk appetite for investors, the direct attitudinal scales that capture risk preferences. Typically five topics in these questionnaires form the core (financial position, knowledge and/or experience, degree of dependence on payment, willingness to take risks).

To sum up, there are two key components in determining the asset allocation path during the working life-cycle. They are human capital and relative risk aversion. Where human capital is the present value of all future wage payments. Risk aversion can be determined via the direct attitudinal scales that capture risk preferences method or the choice-based approaches to infer risk preferences method. In the next chapter I will elaborate on which methods are for this thesis.

3. Methodology

This section describes the methods used to analyze risk aversion regarding retirement investments. In this analysis a distinction is made between several demographics. For the analysis of risk aversion there is a questionnaire. In this survey both the direct attitudinal approach and the choice-based approach are utilized. The main focus will be on the development of RRA as one ages and the difference in risk appetite for men and women. The RRA found is then used for the analysis for of the optimal portfolio. In constructing an optmal portfolio Merton (2003) describes several factors that influence the risk of human capital. Meaning human capital isn't bond like perse. Therefore in this paper the analysis of the optimal portfolio is done multiple times where human capital varies in correlation with the stock market.

3.1 A measure of risk aversion

To determine to what extent pension participants exhibit risk aversion both the direct attitudinal approach and the choice-based approach are utilized. For the choice-based approach the methodology of Holt & Laury (2002) is used. All participants of the survey are offered ten paired lottery choices. Option A offers the "safe" gamble. The value of the potential payoffs is less variable(€ 1169 and € 1002) than "risky" option B (€ 668 and € 1503). All paired lottery choices are given in table 1.

Table 1: Ten paired lottery choices

Option A	Option B	Expected Payoff Difference
1/10 of € 1.169 or, 9/10 of € 1.002	1/10 of € 1.503 or, 9/10 of € 668	€ 267,2
2/10 of € 1.169 or, 8/10 of € 1.002	2/10 of € 1.503 or, 8/10 of € 668	€ 200,4
3/10 of € 1.169 or, 7/10 of € 1.002	3/10 of € 1.503 or, 7/10 of € 668	€ 133,6
4/10 of € 1.169 or, 6/10 of € 1.002	4/10 of € 1.503 or, 6/10 of € 668	€ 66,8
5/10 of € 1.169 or, 5/10 of € 1.002	5/10 of € 1.503 or, 5/10 of € 668	€ 0
6/10 of € 1.169 or, 4/10 of € 1.002	6/10 of € 1.503 or, 4/10 of € 668	-€ 66,8
7/10 of € 1.169 or, 3/10 of € 1.002	7/10 of € 1.503 or, 3/10 of € 668	-€ 133,6
8/10 of € 1.169 or, 2/10 of € 1.002	8/10 of € 1.503 or, 2/10 of € 668	-€ 200,4
9/10 of € 1.169 or, 1/10 of € 1.002	9/10 of € 1.503 or, 1/10 of € 668	-€ 267,2
10/10 of € 1.169 or, 0/10 of € 1.002	10/10 of € 1.503 or, 0/10 of € 668	-€ 334

In the most right column the expected payoffs for the choice of option A. A risk neutral person would be indifferent between the safe and the risky option at gamble five. He would definitely switch to the risky option at gamble six. Even the most risk averse person should switch to option B at gamble ten. Hence the payoff is certain and higher than option A. To capture the magnitude of an individual's risk aversion the payoffs for each lottery choice are selected so that the crossover point would provide an interval estimate r of relative risk aversion. In their paper Holt & Laury (2002) assume constant relative risk aversion (CRRA) with utility function $U(x) = \frac{x^{1-\gamma}}{(1-\gamma)}$, where x is the expected payoff for either option A or B and r is relative risk aversion. With $r < 0$ implies someone is risk loving, $r = 0$ implies risk neutrality and $r > 0$ indicates a person is risk averse. If for example one chooses five safe options and switches at at gamble six, we know this person could be indifferent between option A and B at gamble 5 and option A and B at gamble 6. Which means the utility of these option can be seen as equal and r can be derivate. The example below one chooses five safe option:

$$0{,}6 * U(1169) + 0{,}4 * U(1002) = 0{,}6 * U(1503) + 0{,}4 * U(668)$$

$$0{,}6 * \frac{1169^{(1-\gamma)}}{1-\gamma} + 0{,}4 \frac{1002^{(1-\gamma)}}{1-\gamma} = 0{,}6 * \frac{1503^{(1-\gamma)}}{1-\gamma} + 0{,}4 \frac{668^{(1-\gamma)}}{1-\gamma}$$

$$0{,}6 * 1169^{(1-\gamma)} + 0{,}4 * 1002^{(1-\gamma)} = 0{,}6 * 1503^{(1-\gamma)} + 0{,}4 * 668^{(1-\gamma)}$$

A further algebraic solution is not possible. Therefore r has to be estimated from this point. The estimation yields the $\gamma = 0{,}85$. Meaning a person which switches at this point is risk averse. The upper bound of the interval then is 0,85. For the lower bound of the interval the outcome probabilities must be changed to 0,5 yielding $\gamma = 0{,}01$. The true indifference point of each person is unknown. The exact indifference point is somewhere in the middle of both options. For that reason there is an interval for relative risk aversion.

Next to the choice-based approached, the direct attitudinal approach will be used as well. This method will be mainly used complimentary to the choice-based approach of Holt & Laury (2002). In the direct attitudinal approach the questions are derived from Weber, Blais, & Betz (2002) and will test peoples' choices regarding their risk appetite. The questions asked are:

1. My friends describe me as cautious
2. How would you describe your risk appetite regarding your pension investments?
3. How would you describe the risk you're willing to take with your future total retirement income?

In order to test the hypothesis stated in the introduction, relative risk aversion will be linked to several demographics. First the gender of the respondent will be used. This will test whether men have a bigger risk appetite considering their pension investment than women. The same will be done for age. The respondents are divided into three groups segmented by age (early career, midcareer, end of career). This should test whether as one ages risk appetite declines.

Thereafter the outcome of these questions will be tested in SPSS in order to check whether the differences found are indeed significant. Furthermore an ordinal regression is performed in order the analyze the combined influence of different demographics on risk appetite. In ordinal regression, instead of predicting the value of the outcome variable, the probability of the outcome variable is predicted using the odds ratio. The odds ratio is calculated by dividing the probability an event occurs by the probability a event doesn't occur: $odds\ ratio = \left(\frac{p(event)}{1-p(event)}\right)$. The probability of an event occurring is $P(event\ Y) = \frac{1}{1+e^{-(\beta_0+\beta_1 X_{1i}+\ldots+\beta_n X_{ni})}}$.

In this thesis I separate three questions. Each question will be analyzed separately:

1. My friends describe me as cautious. Where the following model is used to analyze the results:

$$prob(score\ cautious\ y) = \frac{1}{1+e^{-(\beta_0+\beta_1 GENDER_i+\beta_2 AGEGROUP_i+\beta_3 INCOME_i)}}$$

2. How would you describe your risk appetite regarding your pension investments? Where the following model is used to analyze the results:

$$prob(score\ retirment\ portfolio\ risk\ y) = \frac{1}{1+e^{-(\beta_0+\beta_1 GENDER_i+\beta_2 AGEGROUP_i+\beta_3 INCOME_i)}}$$

3. How would you describe the risk your willing to take with your future total retirement income? Where the following model is used to analyze the results:

$$prob(score\ retirment\ income\ risk\ y) = \frac{1}{1+e^{-(\beta_0+\beta_1 GENDER_i+\beta_2 AGEGROUP_i+\beta_3 INCOME_i)}}$$

Where GENDER and AGEGROUP are the explanatory variables, whereas INCOME is a continuous explanatory variable. INCOME is added to the model because Hawley & Fujii (1993), Warner & Cramer (1995) and Sung & Hanna (1996) find that income influences risk appetite as well. In performing an ordinal regression there are three important assumptions. First being linearity, it is assumed that the outcome variable has linear relationships with the predictor variables. Second assumption is independence of the errors, this means the data is not related. Third assumptions is multicollinearity, this means the predictor variables shouldn't be highly correlated with one another. These assumptions will be tested prior to the actual regression. The results of both the tested assumptions and the regression will be posted in chapter 5.

3.2 Human capital

Human capital, in most cases, is the biggest asset one can own. Therefore it is important to know what the exact value of this asset type is. To quantify human capital Chen, Ibbotson, Milevsky, & Zhu (2006) use the present value. The present value of wage earned is calculated using the following formula:

$$\sum_{t=1}^{n} \frac{E(h_t)}{(1+r)^t} \tag{3.1}$$

where:

$E(h_t)$ = the expected after tax salary in period t.

n= the number of periods wage which will be discounted

r = the risk free discount rate.

The formula used by Chen, Ibbotson, Milevsky, & Zhu (2006) lacks, in my view, one component, inflation. Over the last 40 years the average inflation was 2,54% per annum. To adjust for inflation wage is multiplied average annual inflation. This yields the following formula:

$$\sum_{t=1}^{n} \frac{E(h_t) \times (1+i)^t}{(1+r)^t} \tag{3.2}$$

To see the effect of human capital on the optimal portfolio there will be multiple assumption regarding the risk characteristics of human capital. As mentioned earlier a financial analyst has a riskier human capital than a kindergarten teacher. Therefore I will allow for different correlations between the stock market and human capital. When human capital is considered (partially) risky, and thus isn't riskless anymore, it cannot be discounted against the risk free rate. Therefore the following formula is just:

$$\sum_{t=1}^{n} \frac{E(h_t) \times (1+i)^t}{(1+r+risk\ premium)^t} \tag{3.3}$$

The risk premium is depend on the characteristics of human capital. The riskier human capital the higher the risk premium.

3.3 Optimal portfolio

As stated in previous chapters there are some components not to omit when constructing a retirement portfolio, being measure of risk aversion and human capital. For convenience two assets are used in this study and implemented in a mean-variance framework. Viceira (2000) describe in their book how to caclulate the proportion that must be invested in the risky assest when one has a given parameter for relative risk aversion (RRA). In determining the correct asset allocation investors are assumed to have power utility and asset returns are log normal:

$$U(W_{t+1}) = \frac{W_{t+1}^{(1-\gamma)}}{1-\gamma}$$

Where W_{t+1} is future wealth and ɣ is a measure of relative risk aversion. Naturally an investor will try to maximize his/hers utility. The problem stated in (3.3) can be rewritten into:

$$maxE(W_{t+1}) = \frac{W_{t+1}^{(1-\gamma)}}{1-\gamma} \tag{3.5}$$

Since future wealth within a mean-variance framework is dependent on the return of the invested portfolio, wealth can be rephrased as an expectation of the portfolio return.

$$max\ \log E_t W_{t+1}^{1-\gamma} = (1-\gamma)\, E_t r_{p,t+1} + w_t + \frac{1}{2}(1-\gamma)^2 \sigma_{wt}^2 \tag{3.6}$$

Where $r_{p,t+1}$ is the log return on the invested portfolio. Dividing equation (3.5) by $(1-\gamma)$ and rewrite the equation it yields:

$$max\ E_t \ln\left(1 + R_{p,t+1}\right) - \frac{1}{2}\gamma\sigma_{pt}^2 \tag{3.7}$$

Where σ_{pt}^2 is the portfolio variance of the expected return. To analyze what the optimal proportion invested in the risky asset should be, the log portfolio returns need to be related to the log returns of the underlying asset. In a two asset model it becomes:

$$E_t r_{p,t+1} - r_{f,t+1} = \omega_t\left(E_t r_{t+1} - r_{f,t+1}\right) + \frac{1}{2}\omega_t(1-\omega_t)\sigma_t^2 \tag{3.8}$$

Now that the log portfolio returns are related to the log returns of the underlying asset equation(3.7) can be substituted in equation(3.6) :

$$\max \omega_t(E_t r_{t+1} - r_{f,t+1}) + \frac{1}{2}\omega_t(1-\omega_t)\sigma_t^2 + \frac{1}{2}(1-\gamma)\omega_t^2\sigma_t^2 \tag{3.9}$$

If this equation is solved to ω_t, the optimal proportion invested in the risky asset can be determined by the following formula:

$$\omega_t = \frac{E_t r_{t+1} - r_{f,t+1} + \frac{\sigma_t^2}{2}}{\gamma\sigma_t^2} \tag{3.10}$$

In the numerator you will find the expected excess log return on the risky asset. The denominator represents the measure of RRA multiplied by the portfolio variance. As ɣ grows the proportion invested in the risky asset will decline. Thus a more risk averse investor will invest less in the risky asset. However human wealth is not considered in equation (3.9) Bagliano, Fugazza & Nicodano (2009) extended the model and added a component for human capital. Adding non-tradable human wealth (i.e. the expected present discounted value of all future payments) is an important step in constructing a retriment portfolio. Hence, it is one of the biggest assets one can own. The simplest case to analyze the effects of human capital on asset allocation is when this non-tradable asset is considered riskless. Because human wealth H_t is riskless, and is equivilent to holding the riskless asset, it will drive up the proportion invested in the risky asset:

$$\omega_t = \frac{E_t r_{t+1} - r_{f,t+1} + \frac{\sigma_t^2}{2}}{\gamma \sigma_t^2}\left(1 + \frac{H_t}{W_t}\right) \geq \widehat{\omega}_t \qquad (3.11)$$

Where $\widehat{\omega}_t$ is the optimal weight of risky asset when human capital is fully tradable, H_t is the amount of human wealth and W_t is the amount of financial wealth. Thus, due to the riskless non-tradable human wealth the investor will invest more in the risky asset. The share invested in the risky asset will increase as the ratio H_t / W_t increases. However human capital isn't always riskless. As mentioned earlier, the risk profile of human capital is dependent on one's profession. A market maker, a nurse, a teacher and a lawyer have very different risk profiles. The correlation of future earnings with the risky asset can serve as a proxy for the riskiness of human wealth. Bagliano, Fugazza & Nicodano (2009) used the following extentions on equation (3.11):

$$\omega_t = \frac{1}{\rho}\left(\frac{E_t r_{t+1} - r_{f,t+1} + \frac{\sigma_t^2}{2}}{\gamma \sigma_t^2}\right) + \left(1 - \frac{1}{\rho}\right)\beta \qquad (3.12)$$

Where $\beta = \left(\frac{\sigma_{l,u}}{\sigma_u^2}\right)$ with $\sigma_{l,u}$ being the covariance of labor income with the risky asset $cov(l_{t+1}, r_{t+1})$ and $\rho = (1 + \overline{H}/\overline{W})^{-1} < 1$. With $\overline{H}/\overline{W}$ being the average human wealth to financial wealth of the simulation of possible outcomes for each year. I however assume this ratio is equal to the ratio used in equation (3.11).

4. Data

The data used in this thesis are twofold. The first part consists of a survey in which the goal is to learn more about the risk tolerance regarding pension investment. The second part focuses on the data used for the analysis regarding optimal asset allocation over the life-cycle.

4.1. Survey data

In order to know more about the risk tolerance of the respondents a survey is done. The survey is intended for multiple studies and is constructed and conducted in collaboration with other students. Family, friends and fellow students (at Erasmus University Rotterdam) are approached. Preferably the selected respondents are employed and possess basic knowledge about their retirement. Respondents are asked to fill out the survey on the internet. 116 respondents have fully completed the survey. 37 of them are female the other 79 respondents are male. The total number ranges between the ages of 22 and 70 with an average age of 40, which is a little less than most comparable studies (Holt & Laury (2002) 175 respondents; Harisson, Lau & Rutström(2004) 253 respondents and Weber, Blais & Betz (2002) performed one study with 121 respondents) but enough to find significant results.

The survey consists of two methods in order to evaluate the risk tolerance of respondents. The core of this survey focuses on the Holt & Laury (2002) methodology of paired lottery choices. Here the switching point from lottery A towards lottery B contains valuable information about the risk tolerance of an investor. An investor is confronted with ten paired lottery choices, the later the switch to option B the more risk averse they are. On average the switching point of these paired lottery choices is 6,83. Since a risk neutral investor would choose 5 safe choices, an average switching point of 6,83 is an indication of risk aversion. Furthermore some direct attitudinal scale questions are conducted as well, using a seven point rating scale from 1 (really disagree) to 7 (really agree). This part of the survey mainly consists of questions in the domain of retirement investments. Main topics within this domain are financial literacy, experience and attitude towards risk regarding pension investments. Similar to the paired lottery choices, respondents reacted so that it seems they tend to be risk averse. A question like “my friends describe me as cautious” is answered positively, 52% of the respondents did at least recognize themselves a little in this statement and 25% didn’t agree nor disagree. When respondents are asked “How would you describe your risk appetite regarding your pension investments?” the answer is a little for 55% of the respondents. The same is true for the question “How would you describe the risk you’re willing to take with your future total retirement income?” 69% of the respondents indicate their risk tolerance regarding their future total retirement income is low. All three questions on how people would describe their risk tolerance are answered so that it seems there is a tendency of risk aversion. Which is important data for the second part where the asset allocation is determined.

4.2. Historical data asset allocation

In order to perform an analysis of asset allocation an important assumption is made. An investor can only choose between two types of investment option, a riskless asset and a risky asset. As a proxy for the riskless asset 1-month American treasury bills are used. As a proxy for the risky asset the MSCI All Country Index is used. In order to determine the average return, standard deviation and variance the monthly return indices are utilized with a time horizon of 24 years. In finance it is common to use monthly data because it is almost independent. According to Estrada (2000) daily data, in contrast, suffer from autocorrelation which makes it hard to recognize rare events. he downside and upside risks are easier approximated using monthly data Versijp (2010). When this dataset is analyzed it yields an average monthly return of 0,566% for the risky asset and an average monthly return of 0,297% for the riskless asset. The corresponding monthly standard deviations are 4,788% for the risky asset and 0,185% for the riskless asset. Although the riskless asset has a standard deviation of 0,185% per month, a standard deviation of 0% is used in the analysis. Hence, otherwise the riskless asset isn't riskless. Reason I find a standard deviation for the riskless asset is because a one month American T-bill is used as a proxy for the riskless asset. Furthermore, Bodie, Merton & Samuelson(1992) showed the importance of human capital in an investment portfolio. As a proxy for human capital the average wages paid in 2011 are used as a starting point. According to the figures of CBS (2012) average end of the year earnings is € 24.700. Per annum the investor wage will be adjusted for inflation which is ,according to the figures of the world bank, 2,55%. Thereafter this labor income is then discounted against a risk free which is, according to the world bank, 3,69% per annum. Dependent on the correlation of human capital with the stock market a risk premium can be added. According to figures of CBS (2012) on average a twenty-five year old will hold approximedly € 7.222 of financial captial. Obviously this financial wealth will grow over time. In this paper I will assume financial wealth will be invested as the life-cycle target mix predicts. The amount invested in equity will grow at a rate of 7% per year (i.e. the yearly return of MSCI All Country Index) and the riskless asset will grow at a rate of 4% per annum. Besides return on invested equity it is assumed investors will save 10% of the wages earned the previous year. This capital will be added to financial wealth and will be invested. Resulting in a decreasing value of human capital and an increasing value of financial capital over time.

5. Results

In this section the results of the analysis will be posed. It starts with the analysis for a measure of relative risk aversion. Here the focus will be on different demographics, being age and gender. In the search for a coefficient of risk aversion, there will be a comparison if women are more risk averse than men and whether risk appetite decreases as one ages. In addition there is the analysis on how asset should be allocated. The analysis will be done in a mean-variance framework. Human capital and relative risk aversion will be important in the decision of allocation. The effects of these two variables will become apparent.

5.1 A measure of risk aversion

As mentioned in chapter three, there are two methods used in the analysis of investors risk aversion. Same as in the survey a choice-based method and a direct attitudinal method can be distinguished.

5.1.1 Choice based results

For all of the retirement gambles offered the majority of the respondents preferred the safe option at the start. As the payout probabilities of the risky option increase, the option gets more attractive and the subject will value the risky option better. After the seventh gamble more than half of the respondents switched to the risky option. At the tenth gamble everyone will switch to the "risky" option, hence the payoff at the tenth gamble is much higher with certainty. None of the respondents switched back to the safe option after they crossed over to the risky option.

Figure 4: Number of safe choices

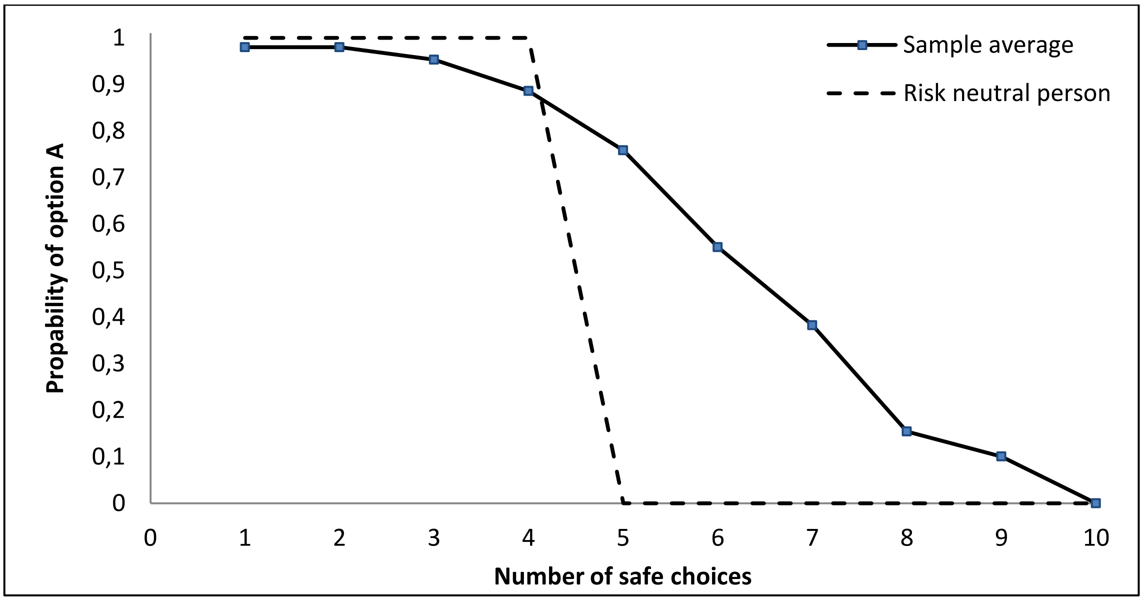
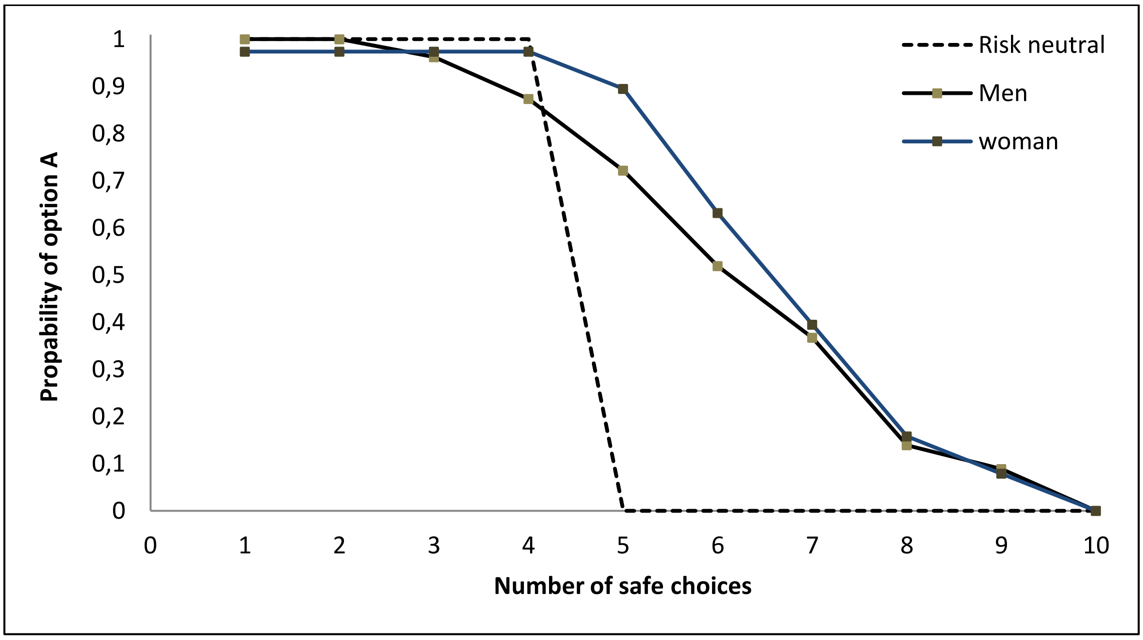


Figure 4 shows the proportion of choice for option A. The vertical axis the proportion of the sample that choose option A. The horizontal axis displays the number of safe options. The dashed line in the figure shows the proportion of choice under the assumption a person is risk neutral. This means a risk neutral respondent would choose four safe option followed by six risky option. The thick line shown in figure 4 is the proportion of choice for the whole sample. What can be seen is that the majority of respondents tends to go for more than four safe choices. Which means that when it comes to their retirement these people tend to make risk averse choices. Similarly the average switching point is at 6,83, indicating a tendency of risk aversion as well. However, there are some respondents that immediately went for the risky option (the thick line starts below the dashed line), indicating that some of the participants, on individual basis, are showing a tendency of risk seeking behavior. When this is translated to investment decisions, these particular individuals will prefer a portfolio that is heavily exposed towards equity for the entire investment horizon.

Figure 5 shows the results by gender. The blue line displays the proportion of the safe option for women and the black solid line for men. At first sight one can see that the blue line is on the right-hand side of the black solid line. This indicates a slightly higher level of risk aversion for women.

Figure 5: Proportion of choice by gender

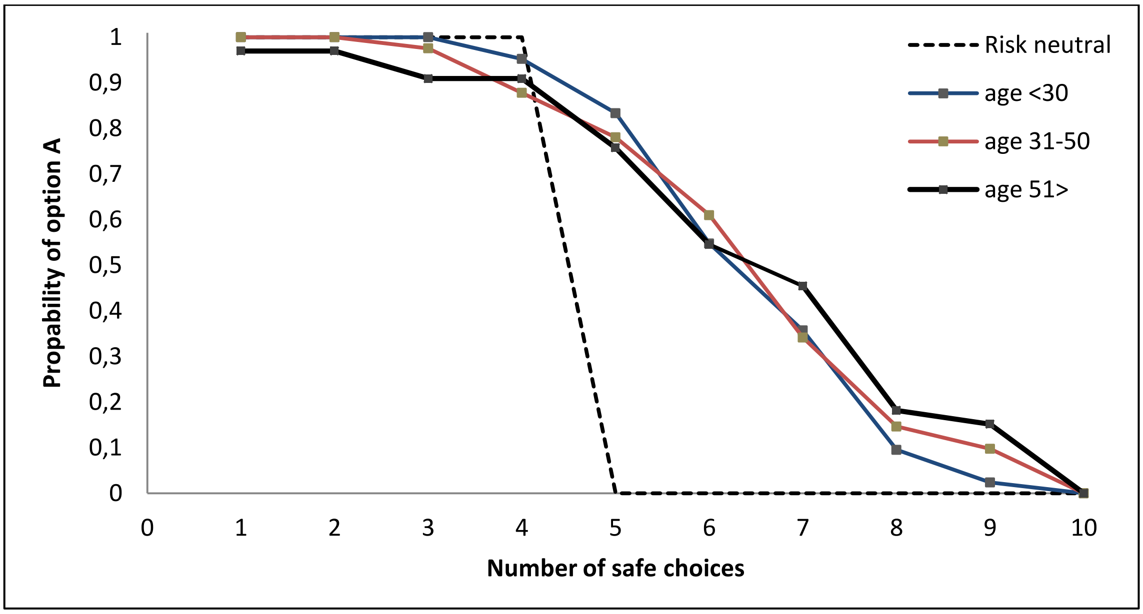


The same outcome can be found for the percentage of women that made a choice which indicates risk averse behavior. For men the proportion of risk averse choices is 87% and for women 97%. Considering the average number of safe choices, women have a higher average.

The average switching point for men is 6,67, where women on average choose 7,0 safe choices. Again an indication that women tend to behave slightly more risk averse than men. However, the difference between men and women is insignificant. A Mann-Whitney U test is performed to test for significance with null hypothesis that there is no significant difference between men and women. The resulting p-value is 0,406 which exceeds the standard level of significance, this means H_0 cannot be rejected.

Figure 6 shows the results by age. The blue line is for the respondents younger than thirty-one, the red line is for the participants ranging between the ages of 31-50. The black solid line represents participants older than fifty. When looking at figure 6, the three lines intersect one another at least once, making none of the three groups more risk averse than the other. Even if the exact proportion of choice is analyzed it is hard to conclude that risk appetite decreases over time. Remarkable is that the youngest group has the highest proportion of safe choices, 95%. For the second group it is 88% that choose a risk averse option. This result implies the middle group has a higher risk tolerance then the youngest group (i.e. an increasing risk tolerance as one ages). However, the last group shows a small increase considering risk averse choices, 91% (see table 2 next page). This is however less risk averse than the youngest participants in the survey. On the other hand, the average switching point of the different groups shows a very small but slightly more risk averse behavior as one ages. The average switching point for respondents younger than thirty is 6,81. The average switching point for respondents between the ages of 31-50 lies at 6,83 and the average switching point for respondents older than fifty is 6,85.

Figure 6: Proportion of safe choices by age



As can be seen the average increases, which indicates that on average as one ages one tends to choose more risk averse option. Again these results are tested for significance. To test whether the results are significant a Kruskal-Wallis test is performed with null hypothesis that there is no significant difference between the different groups. The resulting p-value is 0,927 which exceeds the standard level of significance, this means H_0 cannot be rejected.

As mentioned earlier the switching point of the respondent contains valuable information. With the switching point the interval for RRA can be computed with utility function $U(x) = \frac{x^{1-r}}{(1-r)}$. x is the expected payoff for either option A or B and r is relative risk aversion. With $r < 0$ implies someone is risk loving, $r = 0$ implies risk neutrality and $r > 0$ indicates a person is risk averse. The table below presents all intervals for all possible switching points.

Table 2: Risk aversion classification by age

Number of Safe Choices	Range of RRA for $\boldsymbol{U(x) = x^{1-r}/(1-r)}$	Risk Preference Classification	Proportion of Choice		
			Age < 30	Age 31-50	Age 51 >
0-1	$r < -3$	Highly risk loving	0,00	0,00	0,03
2	$-3{,}00 < r < -1{,}82$	Very risk loving	0,00	0,00	0,00
3	$-1{,}81 < r < -0{,}86$	Risk loving	0,00	0,02	0,06
4	$-0{,}85 < r < 0{,}00$	Risk neutral	0,05	0,10	0,00
5	$0{,}01 < r < 0{,}84$	Slightly risk averse	0,12	0,10	0,15
6	$0{,}85 < r < 1{,}75$	Risk averse	0,29	0,17	0,21
7	$1{,}76 < r < 2{,}85$	Very risk averse	0,19	0,27	0,09
8	$2{,}86 < r < 4{,}45$	Highly risk averse	0,26	0,19	0,29
9-10	$r > 4{,}46$	Stay in bed	0,09	0,15	0,17

In the analysis of risk appetite I found that the majority of the respondents has a coefficient of relative risk aversion that ranges between 0,88 and 1,75, with a sample average of 1,60. These results are in line with the results found by Holt & Laury (2002). However, when these results are compared with academic work the coefficient found is rather low. In most research the coefficient for RRA usually varies between 2-10. Likewise Bodie & Treussard (2007), Hanna & Chen (1998) and Viceira (2007) make this assumption for RRA. This makes me doubt whether the results found are useful in determining the optimal asset allocation over the life-cycle. In chapter 5.2 I will further discuss the consequences of this low coefficient of relative risk aversion.

5.1.2. Direct attitudinal results

The analysis of the attitudinal method is twofold. First I will analyze each question separately . Thereafter I will perform an ordinal regression.

In the analysis of the direct attitudinal methods comparable answers are seen. Most of the respondents answered these questions in a way that it seems they tend to be risk averse. For instance the majority of the respondents, 52%, indicated that their friends describe them as cautious. When the results for this specific question are separated for gender, women are described, on average, more cautious than men. To test for significance a Chi-square test is performed to test the null hypothesis that there is no significant difference between men and women. The standard level of significance isn't exceeded (see table 3), which means that men and women significantly differ in answering this question. Where the answer of women indicates a more risk averse behavior.

Table 3: Test for equal means by gender (described as cautious)

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% C.I. Lower	95% C.I. Upper
Equal variances assumed	2.844	.094	-2.073	119	.040	-.593	.286	-1.159	-.027
Equal variances not assumed			-2.177	84.81	.032	-.593	.272	-1.134	-.051

When the results are segmented by age it seems that your friends will describe you more cautious as you age. The group of respondents aged 30 years or less are described less cautious than the group of respondents aged between 31- 50. Which in their turn are less cautious than the respondents that are aged 51 years or older. To test for significance a one-way ANOVA test is performed to test the null hypothesis that there is no significant difference between the different age cohorts. The standard level of significance isn't exceeded, which means that there is a significant difference in the answers the different groups gave. However, when the groups are compared to each other, on an individual basis, it turns out that only the youngest and the oldest groups significantly differ in answering this question (See table 4).

Table 4: Multiple comparisons of equal means by age group(described as cautious)

(I) Age	(J) Age	Mean Difference (I-J)	Std. Error	Sig.	95% C.I. Lower	95% C.I. Upper
1	2	-.325	.316	.559	-1.08	.42
	3	-.857	.332	.030	-1.65	-.07
2	1	.325	.316	.559	-.42	1.08
	3	-.532	.337	.260	-1.33	.27
3	1	.857	.332	.030	.07	1.65
	2	.532	.337	.260	-.27	1.33

Considering the question "how would you describe your risk appetite regarding your pension investments", the results are similar. The majority of the respondents, 55%, indicated that their willingness to take on risk with their retirement investments is low. When this specific question separates the results for gender, women are described, on average, more cautious concerning their pension investments than man. To test for significance a Chi-square test is performed to test the null hypothesis that there is no significant difference between men and women. The standard level of significance isn't exceeded (see table 5).

Table 5 : Test for equal means by gender (risk appetite retirement investments)

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% C.I. Lower	95% C.I. Upper
Equal variances assumed	3.105	.081	3.22	119	.002	.758	.235	.293	1.223
Equal variances not assumed			3.53	94.96	.001	.758	.214	.333	1.183

This means men and women significantly differ in answering this question. Where women tend to be more risk averse. When the results are segmented by age a hump-shaped development can be distinguished. The willingness of the group with the respondents aged 30 years or less for taking on risk considering their retirement portfolio is low. The willingness of the group of respondents aged between 31- 50 is in their turn a bit higher, indicating this group is less risk averse than the younger group. The respondents that are aged 51 years or older are less willing to take on risk than the second group but slightly more willing to take on risk than the youngest group. The results extracted from this particular question do not indicate that investors get more risk averse as they age. Regarding this question the opposite is true. The youngest group of respondents reacted most conservatively to this question. To test whether these results are significant a one-way ANOVA test is performed to test the null hypothesis that there is no significant difference between the different age cohorts. The standard level of significance is exceeded (see table 6). This means there is no significant difference in the answers given and you cannot conclude that one age cohort is more risk averse than the other.

Table 6: Multiple comparisons of equal means by age group (risk appetite retirement investments)

(I) Age	(J) Age	Mean Difference (I-J)	Std. Error	Sig.	95% C.I. Lower	95% C.I. Upper
1	2	-.328	.271	.450	-.97	.32
	3	-.064	.285	.973	-.74	.61
2	1	.328	.271	.450	-.32	.97
	3	.264	.290	.635	-.42	.95
3	1	.064	.285	.973	-.61	.74
	2	-.264	.290	.635	-.95	.42

Considering the final question, how would you describe the risk you're willing to take with your future total retirement income, again the results are alike, the majority of the respondents, 69%, indicated that their willingness to take a chance with their future retirement income is low. When the respondents are sorted by gender, women are less willing to take risks with their total future retirement income. To test for significance a Chi-square test is performed to test the null hypothesis that there is no significant difference between men and women. The standard level of significance isn't exceeded (see table 7). When tested for significance these results are significant as well. Indicating women are less willing to risk their future retirement income.

Table 7: Test for equal means by gender (risk appetite retirement income)

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% C.I. Lower	95% C.I. Upper
Equal variances assumed	3.473	.065	2.48	119	.015	.661	.267	.133	1.189
Equal variances not assumed			2.61	85.56	.011	.661	.253	.158	1.164

This means that men and women significantly differ in answering this question. Women tend to be more risk averse. When the respondents are separated by age the outcome is similar to the previous question. The willingness of the group with the respondents aged 30 years or less for taking on risk considering their retirement portfolio is low. The willingness of the group of respondents aged between 31- 50 is in their turn a bit higher, indicating this group is less risk averse than the younger group. The respondents that are aged 51 years or older are less willing to take on risk than the second group but slightly more willing to take on risk than the youngest group. The results extracted from this particular question do not indicate that investors get more risk averse as they age. Regarding this question the opposite is true. The youngest group of respondents reacted most conservatively to this question. However, the results that are found are not significantly different from each other. To test for significance a one-way ANOVA test is performed to test the null hypothesis that there is no significant difference between the different age cohorts. The standard level of significance is exceeded (see table 8). This means there is no significant difference in the answers given and you cannot conclude that one age cohort is more risk averse than the other.

Table 8: Multiple comparisons of equal means by age group(risk appetite retirement income)

(I) Age	(J) Age	Mean Difference (I-J)	Std. Error	Sig.	95% C.I. Lower	95% C.I. Upper
1	2	-.542	.302	.177	-1.26	.18
	3	-.432	.318	.367	-1.19	.32
2	1	.542	.302	.177	-.18	1.26
	3	.110	.323	.938	-.66	.88
3	1	.432	.318	.367	-.32	1.19
	2	-.110	.323	.938	-.88	.66

Ordinal regression

In addition to looking at the effect of age and gender on risk appetite in isolation an ordinal regression is performed in order to analyze the combined influence of different demographics on risk appetite. Prior to performing the regression the corresponding assumptions have to be tested (linearity, Independent errors and multicollinearity). Figure 7 shows the scatter plots residuals versus predicted values for each model(different dependent variable). By eyeballing these scatter plots one can assume linearity. If the dots are symmetrically distributed around the horizontal line linearity can be assumed. The outcome shows that the variability around 0 is approximately the same. Indicating that I can assume linearity.

Figure 7 Scatter plot of residuals vs. Predicted values for each dependent variable

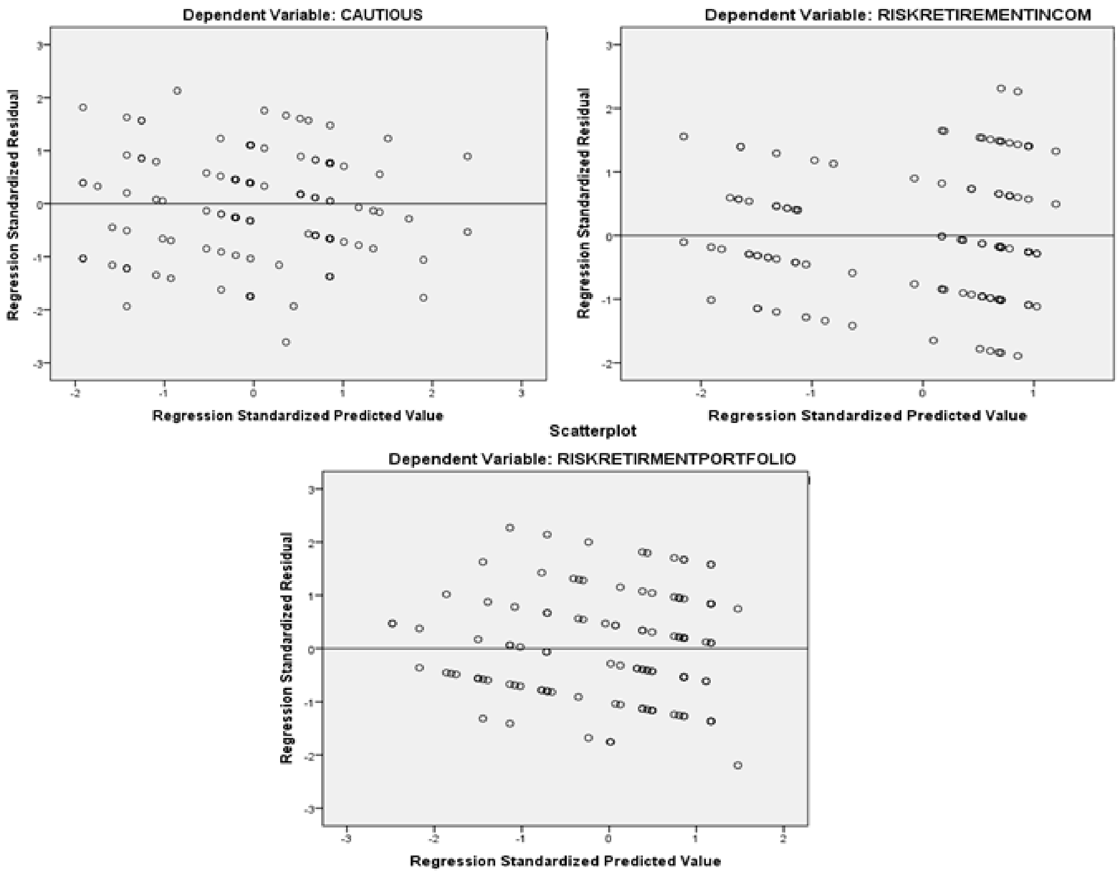


Figure 8 shows the results for the test of independent errors. The Durbin-Watson output will tell whether I can assume independence of errors. The two critical values of 1.5 < d < 2.5, for all three models the Durbin-Watson statistic lies in this interval. So, I can assume independent errors.

Figure 8: Test results independent errors test

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	,360	,129	,107	1,402	2,017

b. Dependent Variable: CAUTIOUS

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	,306	,094	,070	1,203	2,065

b. Dependent Variable: RISKRETIREMENTINCOM

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	,292	,085	,062	1,358	1,944

b. Dependent Variable: RISKRETIRMENTPORTFOLIO

Regarding the last assumption of mulitcollinearity, the outcome is displayed in table 9. The VIF value will indicate whether or not there is mulitcollinearity. When the VIF value is above 3 that means there probably is mulitcollinearity. As can been seen in the output the VIF values for are the predictor variables is below 3 indicating there is no mulitcollinearity.

Table 9: Coefficients(test of multicollinearity)

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	3,538	,615		5,749	,000		
GENDER	-,473	,286	-,158	-1,652	,101	,870	1,149
GROUPEDAGE	-,127	,172	-,072	-,737	,463	,822	1,217
INCOME	,149	,071	,218	2,102	,038	,736	1,358

In performing an ordinal regression three questions are separated. Each question will be analyzed separately:

1. My friends describe me as cautious.
2. How would you describe your risk appetite regarding your pension investments?
3. How would you describe the risk you´re willing to take with your future total retirement?

<u>My friends describe me as cautious</u>

First of all I will check whether adding independent variables to the model improves the ability to predict the outcome. The null hypothesis that all coefficients of the independent variables are zero is tested. When the p-value is less than the standard level of significance the null hypothesis can be rejected. Which means that adding variables improves the ability of predicting the outcome. I do find that adding variables improve the ability to predict the outcome. I found a p-value of 0,005 which is smaller than 0,05 (see table 10).

Table 10: Model Fitting Information (Cautious)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	265,482			
Final	250,803	14,679	4	,005

Furthermore I would like to know if the regression coefficients found are the same for all possible categories. This is to say, if change my reference variable will the outcome still be the same. The null hypothesis tested is that the location parameters (slope coefficients) are the same across response categories. If the assumption of parallel lines is rejected I should estimate all coefficients separately per category. For the test of parallel lines a p-value higher than 0,05 indicates there isn't enough evidence to reject the null hypothesis. Here I find a p-value of 0,236 indicating I can assume parallel lines, (see table 11).

Table 11:Test of Parallel Lines (Cautious)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	250,803			
General	226,646	24,157	20	,236

In table 12 all estimates are shown. The model confirms there are significant effects regarding gender and age. The corresponding estimates give the linear combination of the explanatory variables that predict the log odds. To convert these estimates to normal odds the exponent of this coefficient. For gender the estimate is -1,020. To find the odds ratio the exponent of this coefficient must be calculated: exp(-1,020) = 0,361. This indicates that odd of being described cautious decreases if you are a male (gender is coded as follows 1=male, 2= female), given that all of the other variables in the model are held constant. Regarding age the estimate for group 1 is -1,122 and group two is -0,576. When the exponent of these coefficients are calculated I find the following corresponding odds: for group 1 exp(-1,112) = 0,326 and group 2 exp(-0,551) = 0,576. This indicates that, relative to the oldest group (group 3), the odds of being described less cautious is 0,326 when you're in the youngest group (group 1) and 0,576 when you're in the middle group (group 2). Which is an indication of the middle group being described less cautious than groups 1 and 3. However, only the coefficient of group 1 is significant. Regarding group 3, there is not enough evidence the coefficient found significantly differs from zero.

Table 12: Parameter Estimates(Cautious)

		Estimate	Std. Error	Wald	df	Sig.	95% C.I. Lower	95% C.I. Upper
Threshold	[CAUTIOUS = 1]	-5,001	,944	28,076	1	,000	-6,851	-3,151
	[CAUTIOUS = 2]	-2,699	,664	16,507	1	,000	-4,001	-1,397
	[CAUTIOUS = 3]	-1,947	,641	9,230	1	,002	-3,204	-,691
	[CAUTIOUS = 4]	-,719	,620	1,344	1	,246	-1,935	,497
	[CAUTIOUS = 5]	,346	,616	,316	1	,574	-,862	1,554
	[CAUTIOUS = 6]	2,075	,675	9,454	1	,002	,752	3,398
Location	INCOME	,126	,094	1,803	1	,179	-,058	,310
	[GENDER=1]	-1,020	,384	7,036	1	,008	-1,773	-,266
	[GENDER=2]	0	.	.	0	.	.	.
	[GROUPEDAGE=1]	-1,122	,460	5,953	1	,015	-2,023	-,221
	[GROUPEDAGE=2]	-,551	,421	1,709	1	,191	-1,376	,275
	[GROUPEDAGE=3]	0	.	.	0	.	.	.

How would you describe the risk you’re willing to take with your future total retirement income?

For the question “How would you describe the risk you’re willing to take with your future total retirement income” I do not find evidence that adding variables improves the ability to predict the outcome. The result can be seen in table 13. The null hypothesis is that the model does improve the ability to predict the outcome cannot be rejected (0,05>0,037). The model improves the ability to predict the outcome.

Table 13: Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	234,685			
Final	224,493	10,192	4	,037

Furthermore I test the null hypothesis the location parameters (slope coefficients) are the same across response categories. This means I will test if the regression coefficients are the same for all seven categories. When the significant level of 0,05 is exceeded it means that the lines are parallel. Resulting that the odds found are the same over the different levels of responses. I find a p-value of 0,094 indicating I can assume parallel lines, see table 14.

Table 14: Test of Parallel Lines

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	224,493			
General	200,680	23,813	16	,094

In table 15 all estimates are shown. There is a positive significant effect for gender. The estimate is 0,965. To find the odds ratio the exponent of this coefficient must be calculated: exp(0,965) = 2,625. So, the odds for men answering this question with a higher threshold (i.e. willing to take on more risk with your retirement income) is 2,625 times bigger relative to women. Regarding age the estimate for group 1 is 0,317 and group two is 0,150. When the exponent of these coefficients are calculated I find the following corresponding odds: for group 1 exp(0,317) = 1,373 and group 2 exp(0,150) = 1,162. This indicates that, relative to the oldest group (group 3), the odds of answering this question with a higher threshold is 1,373 times bigger for the youngest group and 1,162 times bigger for the middle group. So, regarding this question the youngest group indeed has the biggest risk tolerance. However, the estimate are insignificant. Which means there isn’t sufficient evidence to reject the null hypothesis that the estimate differs from zero.

Table 15: Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% C.I. Lower	Upper
Threshold	[RETIREINCOM = 1]	-,944	,640	2,174	1	,140	-2,198	,311
	[RETIREINCOM = 2]	,842	,626	1,807	1	,179	-,386	2,070
	[RETIREINCOM = 3]	2,136	,651	10,751	1	,001	,859	3,412
	[RETIREINCOM = 4]	3,136	,682	21,119	1	,000	1,798	4,473
	[RETIREINCOM = 5]	5,460	,958	32,481	1	,000	3,583	7,338
Location	INCOME	,094	,095	,990	1	,320	-,091	,280
	[GENDER=1]	,965	,388	6,178	1	,013	,204	1,725
	[GENDER=2]	0	.	.	0	.	.	.
	[GROUPEDAGE=1]	,317	,455	,485	1	,486	-,575	1,209
	[GROUPEDAGE=2]	,150	,422	,126	1	,723	-,677	,976
	[GROUPEDAGE=3]	0	.	.	0	.	.	.

How would you describe your risk appetite regarding your pension investments?

For the question “How would you describe your risk appetite regarding your pension investments” the null hypothesis that the model improves the ability to predict the outcome by adding variables cannot be rejected. The result can be seen in table 16 (0,05<0,033). The model ability to predict the outcome is thus improved by adding variables.

Table 16: Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	242,129			
Final	231,611	10,518	4	,033

Again the null hypothesis the location parameters are the same across response categories is tested. The significant level of 0,05 is exceeded, which means that the odds found are the same over the different level of responses. I find a p-value of 0,833 indicating I can assume parallel lines, see table 17.

Table 17: Test of Parallel Lines

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	231,611			
General	220,999	10,611	16	,833

In table 18 all estimates are shown. For gender I find a estimate of 0,566. This indicates that the odds of men answering this question with a higher threshold (i.e. are more willing to take risk with their retirement portfolio) is exp(0,566) = 1,761 times bigger relative to women. Regarding age the estimate for group 1 is 0,298 and group two is 0,138. When the exponent of these coefficients are calculated I find the following corresponding odds: for group 1 exp(0,298) = 1,347 and group 2 exp(0,138) = 1,148. This indicates that, relative to the oldest group (group 3), the odds of answering this question with a higher threshold is 1,347 times bigger for the youngest group and 1,148 times bigger for the middle group. So, regarding this question the youngest group indeed has the biggest risk tolerance. However, as can be seen these results are insignificant. Meaning there is not enough evidence to reject the null hypothesis that the estimate differs from zero.

Table 18: Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% C.I. Lower	95% C.I. Upper
Threshold	[RETIREPORTF = 1]	-1,569	,697	5,063	1	,024	-2,936	-,202
	[RETIREPORTF = 2]	,805	,625	1,656	1	,198	-,421	2,031
	[RETIREPORTF = 3]	1,736	,642	7,322	1	,007	,479	2,993
	[RETIREPORTF = 4]	2,715	,667	16,593	1	,000	1,409	4,022
	[RETIREPORTF = 5]	4,014	,724	30,754	1	,000	2,595	5,432
Location	INCOME	,204	,096	4,549	1	,033	,017	,392
	[GENDER=1]	,566	,380	2,217	1	,137	-,179	1,312
	[GENDER=2]	0	.	.	0	.	.	.
	[GROUPEDAGE=1]	,298	,454	,432	1	,511	-,591	1,188
	[GROUPEDAGE=2]	,138	,419	,108	1	,742	-,684	,960
	[GROUPEDAGE=3]	0	.	.	0	.	.	.

This subsection explored the risk appetite for a small sample regarding their future pension income and pension investments. Overall I can conclude respondents tend to be risk averse when it comes to their pension investments and future pension income. When a distinction is made for gender it seems women, on average, tend to be more risk averse. When this is translated into investment decisions regarding retirement, women will choose to hold more of the riskless asset than men. When this sample is separated for age it is hard to conclude that when one ages one becomes more risk averse. For some of the questions there seems to be a connection between age and rising risk aversion. However, the results are insignificant. Except for one of the questions, where the older respondents are described more cautious than their younger counterparts, indicating that when investors are at the end of their working life-cycle they will prefer a conservative investment strategy (i.e. they will favor more riskless assets in their investment portfolio). Other results however, sketch a different development for risk aversion over time. In most cases there is a hump-shaped development of risk aversion, resulting in a hump-shaped preference for the risky asset over time. This means when investors are young they tend to be more risk averse and will prefer the riskless asset more than their slightly older counterparts. The group of respondents between the ages of 31-50 is less risk averse and will prefer a slightly more aggressive investment strategy (i.e. more risky assets in their investment portfolio). The oldest group of respondents, in their turn, is more risk averse than the previous group, but less risk averse than the youngest group of respondents. When this is translated to investments decisions it means that the oldest group of respondents will prefer more of the riskless asset compared to the respondents aged between 31-50 years, but prefer less of the risky asset than the youngest group of respondents. However, the results gathered from the survey regarding age were insignificant. Which makes it hard to draw a solid conclusion about the development of risk aversion and implicitly their preferences regarding asset allocation.

5.2 Asset allocation for a pension portfolio.

In chapter 5.1.1. I found a coefficient of RRA that substantially deviates from the RRA used in academic literature. In this section the impact of this low RRA coefficient on the optimal asset mix over time is discussed. This section is structured in such a way that it starts with the RRA used by other researchers. Thereafter the results using the RRA subtracted from the questionnaire are analyzed.

In determining the optimal portfolio regarding retirement there are several components of significant importance. In the literary review I found that human wealth and an investor's risk appetite are of significant influence on the optimal portfolio. For the analysis of the optimal asset mix a couple of assumptions are made. There are only two assets (a risky and a riskless asset). At the start of his career an investor will earn € 24.700 a year. This salary will be corrected for inflation each year and be discounted against the risk free rate. Furthermore, he will save 10% of his income. The return on his portfolio is 7% per annum for equity and 4% per annum for bonds.

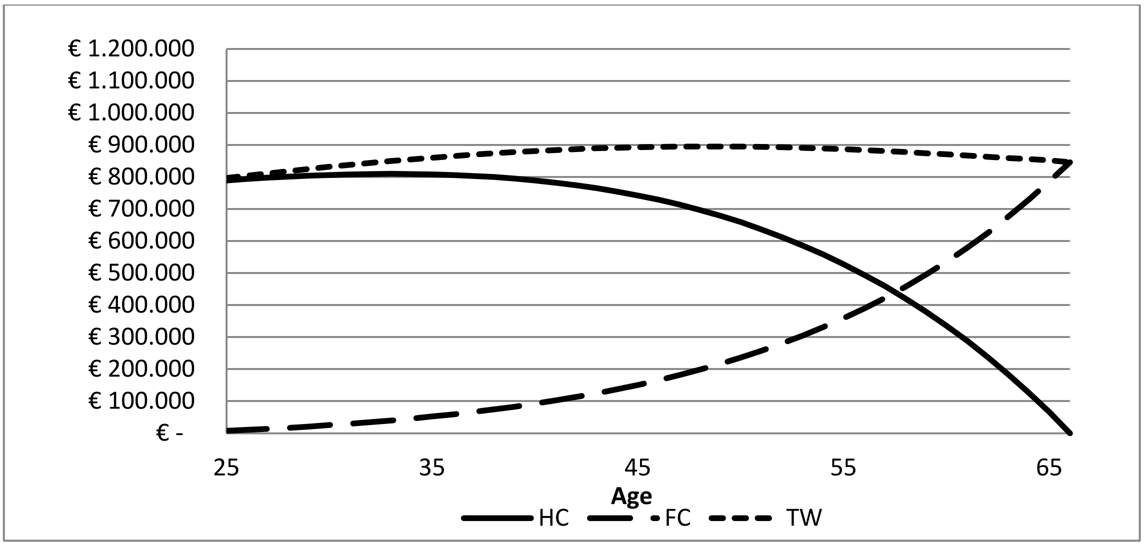
5.2.1 Optimal allocation with RRA from literature

As mentioned human capital and an **investor's** risk appetite are of influence on the optimal portfolio. First I will focus on human capital. In determining the optimal glide path of the asset mix it is important to know the risk characteristics of human capital. First I will consider a riskless human capital. Thereafter I will allow for different risk measures for human capital.

5.2.2. Riskless human capital

In this section human capital is assumed to be riskless. Figure 9 shows the development of human capital, financial wealth and total wealth.

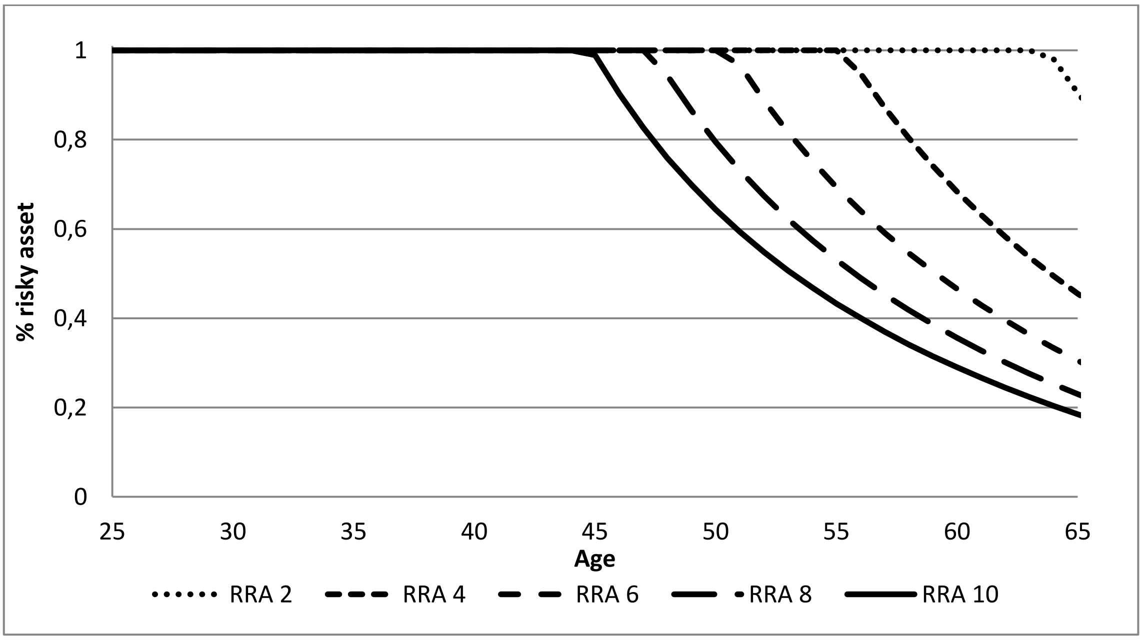
Figure 9: Development of human capital, financial capital and total wealth



Human wealth at the start of the life-cycle forms by far the biggest asset the investor owns. Assuming one starts working at age 25, human capital barely changes in the first ten years. Thereafter a rapid decline is seen. This development is influenced by two factors. First of all the decline nature is explained by the number of future payments. As one ages the number of future wage payments decreases, causing a decline in value of human capital. Second, the delayed decline is explained by the salary at the beginning of each year. Each year the wage payment is corrected for inflation, causing an increase of 2,54% each year until retirement. Because of this increase the value of human capital practically remains unchanged. However, time until retirement decreased by one year. Which means human capital must be discounted for a shorter horizon. Until age 33 it even causes a small increase in value. Thereafter the number of wage payments are too few in order to keep increasing. A rapid decline is seen after age 33 as one grows older. Regarding financial wealth the growth path is the other way around. In the first 10 years there is a slow increase which is followed by a convex-like increase. The curvature of the increase of financial wealth is influenced by three factors. First it is assumed an investor will save money at the end of each year. In this paper this is 10% of his income at time T-1. Since wages are corrected for inflations this amount is increasing over time. Second, the portfolio composition is of influence. It is assumed that an investor will determine the optimal portfolio composition at the start of each year. According to his portfolio choice it is assumed equity will give a return of 7% per annum and bonds will give a return of 4% per annum. Where bonds are considered riskless. So the portfolio allocation determines to a large extent the steepness of the curvature. When the portfolio is heavily allocated towards equity it is likely the curve will become steeper. The last factor that influences the steepness of the curve is closely related to portfolio allocation, namely the risk appetite of an investor. Since a risk averse investor is likely to invest less in equity the curvature of financial wealth over the total life-cycle will be less steep than a risk seeking investor.

The development of human capital related to financial forms an important matter in determining the optimal asset allocation. In formula 3.11 can be seen that the bigger the ratio becomes the more an investor wants to invest in the risky asset. Which makes sense. I assume it is comparable to an investment in a bond (non-tradable however). Thus at the start of the life-cycle an investor is exposed to an enormous investment in the riskless asset. In order to come as close as possible to the optimal asset allocation, the investor will have to invest all of his financial wealth in the risky asset. Since the ratio human wealth to financial wealth is decreasing over time, an investor will eventually invest some of his financial wealth in the riskless asset as well. The risk appetite of an investor determines how long one should be fully exposed to the risky asset with their financial wealth. Figure 10 shows different glide paths for several coefficients for relative risk aversion.

Figure 10: Optimal allocation to risky asset with riskless human capital

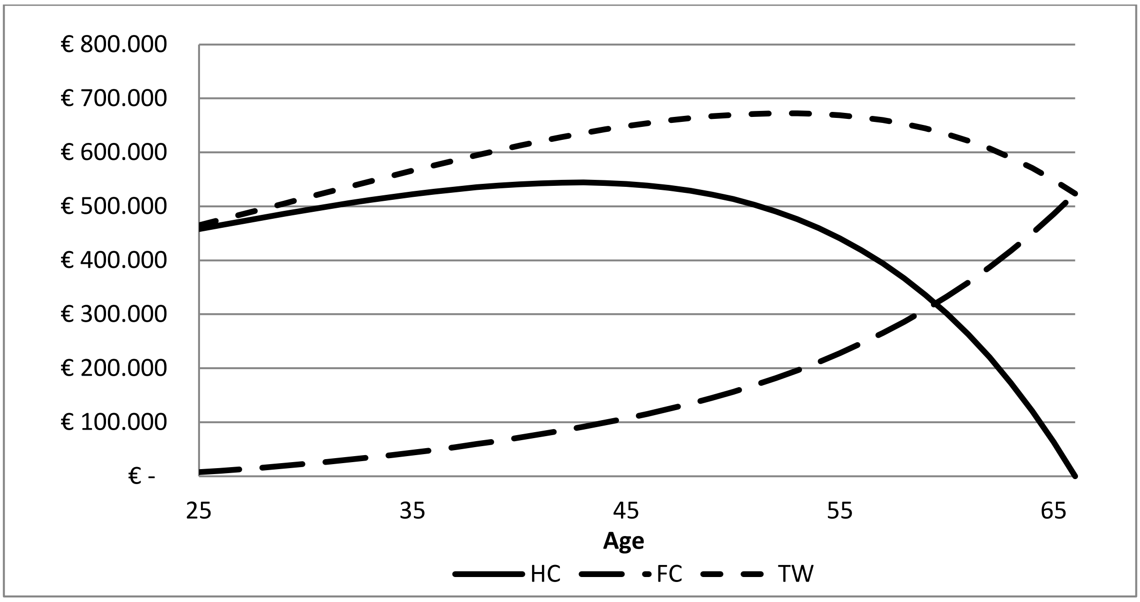


Even the most risk averse investor will choose to invest all of his wealth in the risky asset. At age 44 he slowly starts to invest in the riskless asset as well. The less risk averse an investor the longer he will invest all of his wealth in the risky asset. Eventually even the most risk averse investors will invest some of their financial wealth in the riskless asset at the end of the life-cycle.

5.2.3 Optimal allocation with risky labor income

In this section human capital is assumed to be risky. Furthermore, one will hold financial wealth as well. Financial wealth is increasing over time. Its curvature is influenced by the amount saved at time T-1, the return on the invested portfolio and the risk appetite of the investor. Human capital**,** however, is regarded as risky. In contrast to the previous section human capital is now assumed equivalent to an investment in equity. Since, human capital is equity-like the development of human capital is somewhat different than when it is assumed riskless**,** see figure 11.

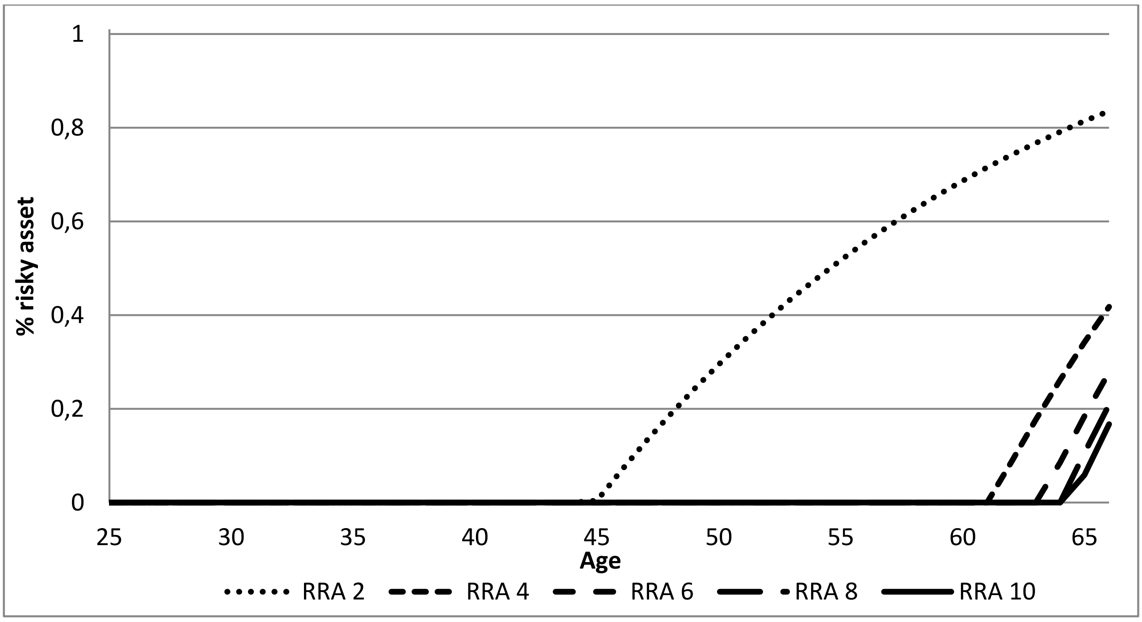
Figure 11: Development of human capital, financial capital and total wealth



First of all the value of human capital is substantially less when it is compared to the value in figure 9. This is because of the assumption that human capital is equity like. When the present value of equity is calculated one cannot use the risk free rate. It must be discounted against the risk free rate plus a risk premium. This results in a higher discount rate, causing a drop in total value of risky human capital relative to riskless human capital. The development of human wealth is slightly hump shaped which is caused by the high discounting rate. The discount rate has an exponential growth over time. The longer the period the steeper the curvature at the end of the period. However, in the life-cycle the period shortens after the years pass by. This means the development of the discount rate is now reversed. There is a steep decline in the discount rate. Because the discount rate will rapidly decrease, wage is corrected for inflation and total value of human capital will increase at the start of the life cycle. As the curvature of the discount rate flattens human capital will grow less and eventually decrease.

The development of human capital relative to financial capital is important in determining the optimal glide path. It is the average ratio human capital to financial capital that is important, as can be seen in formula 3.12. The bigger the ratio the smaller the proportion invested in the risky asset. Theory even predicts a reverse tilt when human capital is considered risky. The main reason is that human capital is seen as an equivalent of an investment in equity. Since human capital is the biggest asset one can hold, one has an enormous exposure to the risky asset. An investor will thus choose to invest his total financial wealth in the riskless asset to come as close as possible to the optimal asset allocation. Figure 12 shows the optimal glide path when human capital is considered risky.

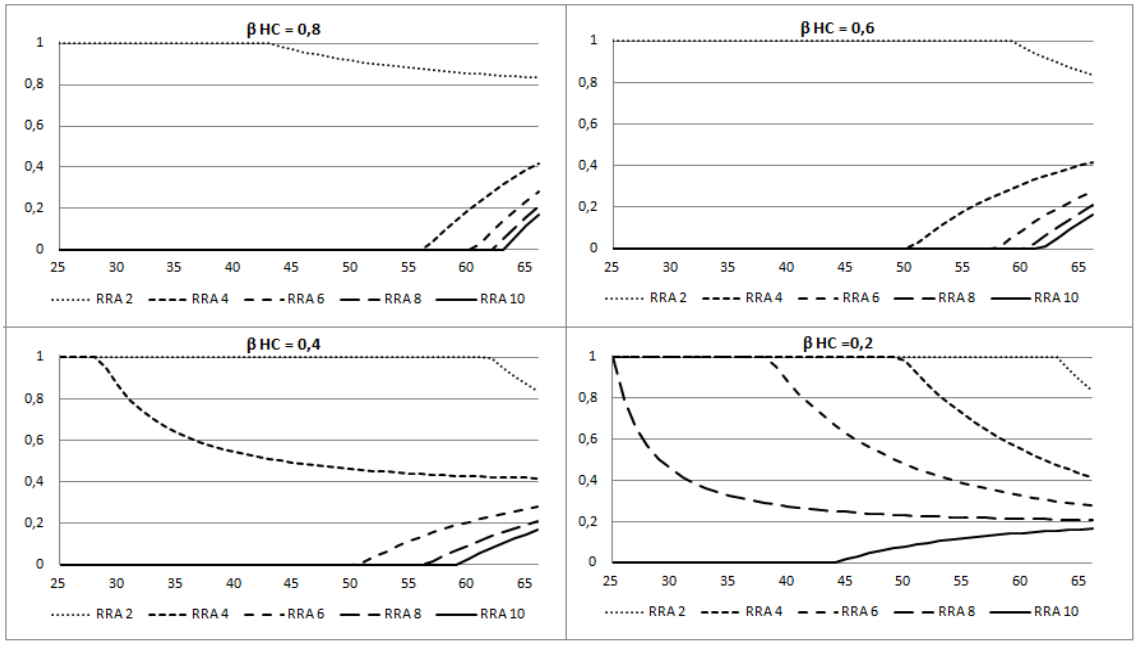
Figure 12: Optimal allocation to risky asset with risky human capital



As expected there is a reverse tilt, which makes sense. Human capital is now considered risky and equivalent to an investment in equity. Thus in order to achieve an optimally diversified portfolio one will have to invest all of his financial wealth in the riskless asset. Even the most risk seeking investor will invest in the riskless asset at the start of the working life cycle.

Until now I analyzed the extreme outcomes, human capital is either riskless or risky. It is more likely that human capital is partially risky. Human capital is thus a combination of the risky as well as the riskless asset. Figure 13 displays the optimal glide path when human capital is partially risky and has a β that varies between 0 and 1

Figure 13 optimal glide path for different beta's for human capital

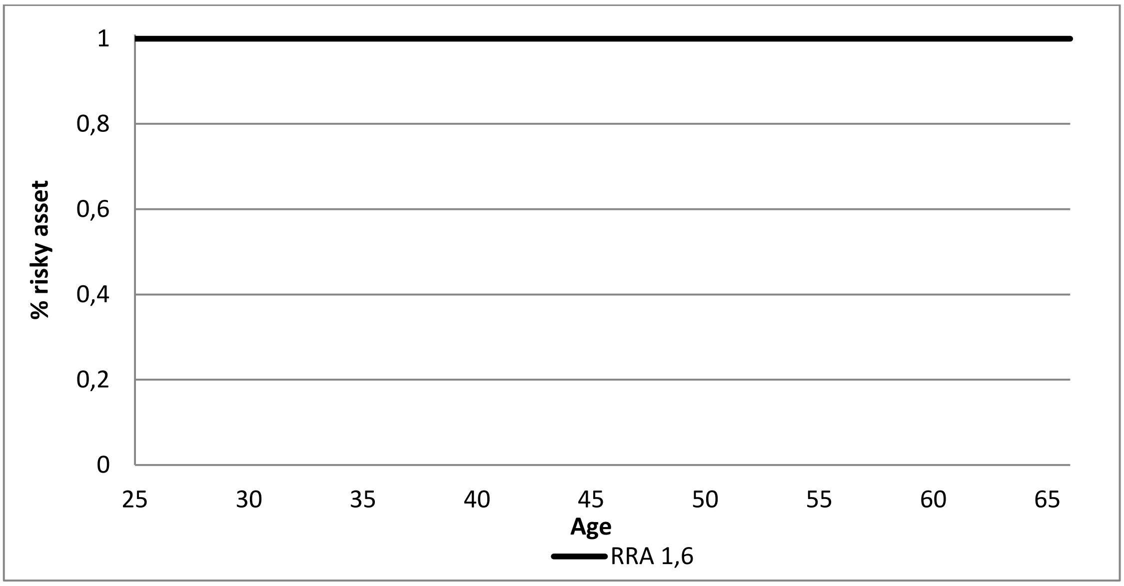


The higher the β with the stock market the less an investor is willing to invest in the risky asset with his financial wealth. This is explained by the fact that the higher the β of human capital the more equity-like it becomes. In the case where β=0.8, 80% of human capital is seen as an investment in stocks. An investor thus holds a substantial amount of the risky asset. Furthermore at the end of the life-cycle the optimal asset allocation per RRA coefficient is equal regardless of the β of human capital. Hence, at the end of the life-cycle human capital is equal to zero. An investor will thus invest all his financial wealth in such a way that he holds the optimal portfolio corresponding to his risk appetite.

5.3.1. Optimal allocation with RRA from questionnaire

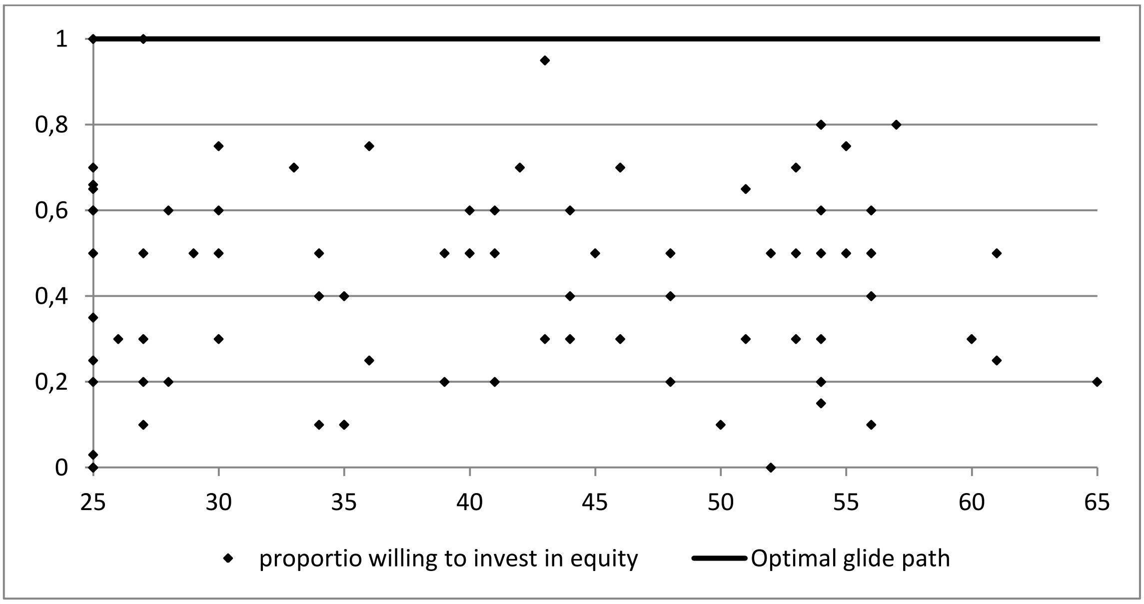
This section will focus on the results from the questionnaire regarding the RRA coefficients and its corresponding optimal asset mix over the life cycle. From the multiple choice list conducted I extracted a coefficient of relative risk aversion. The average switching point is 6,83 resulting in an RRA of 1,6. This measure is used to calculate the optimal glide path for the respondents as displayed in figure 14. An investor will invest all his wealth in the risky asset. This is remarkable since an investor with an RRA of 2 will invest all of its wealth in the riskless asset until he is 45.

Figure 14 optimal asset allocation RRA = 1,6 and β HC = 1



This optimal glide path found with a RRA of 1,6 is at odds with the results from the questionnaire. The survey indicates that the respondents, in general, are risk averse, whereas the resulting investment strategy is extremely aggressive. This result confirms the doubt described in chapter 5.1.1. Furthermore, other academic research that uses an RRA between 2-10 (as in the previous section) displays results that are more likely. In addition one of the questions in the questionnaire tested which proportion of their financial wealth respondents are willing to invest in the risky asset. The results are shown in figure 15.

Figure 15: optimal glide path vs. preferred asset allocation by respondents

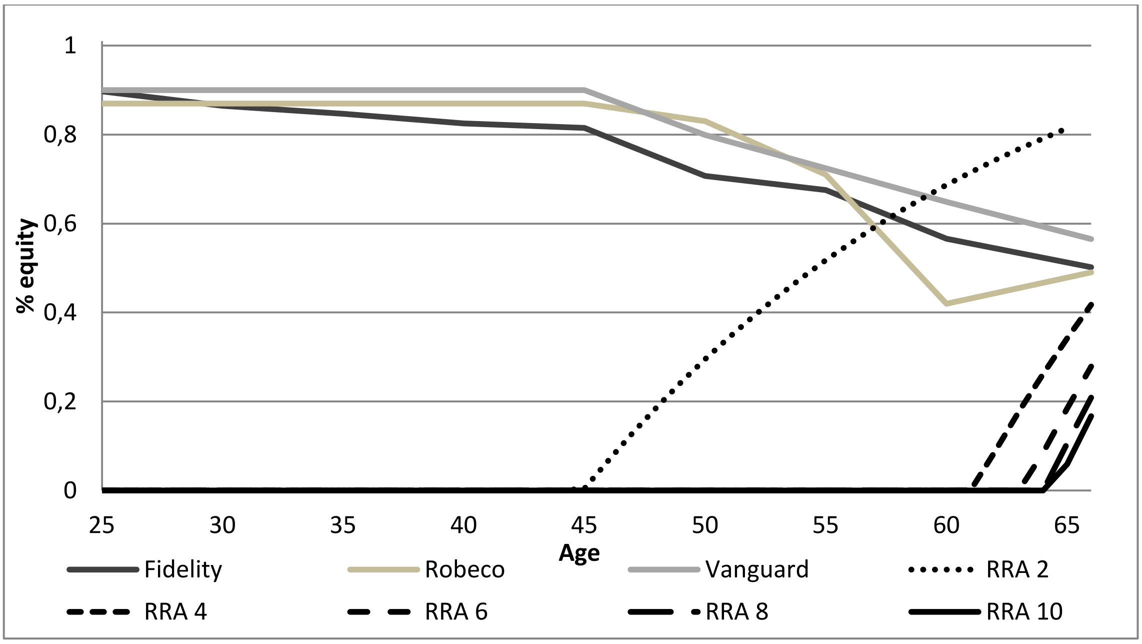


The results show that the optimal glide path compared to the proportion each individual respondent is willing to invest in equity is far too aggressive. Almost none of the respondents are willing to invest all financial wealth in the risky asset. Again this is a confirmation of my doubts described earlier. So this result combined with the result from the direct attitudinal method and academic literature on this subject, makes me believe the results regarding the RRA extracted from the survey and the corresponding investment strategy are unrealistic. So, to determine the optimal glide path and test whether LCF's are a good investment choice I will use the RRA coefficients described in academic literature.

5.4.1. Optimal glide path vs. LCF's

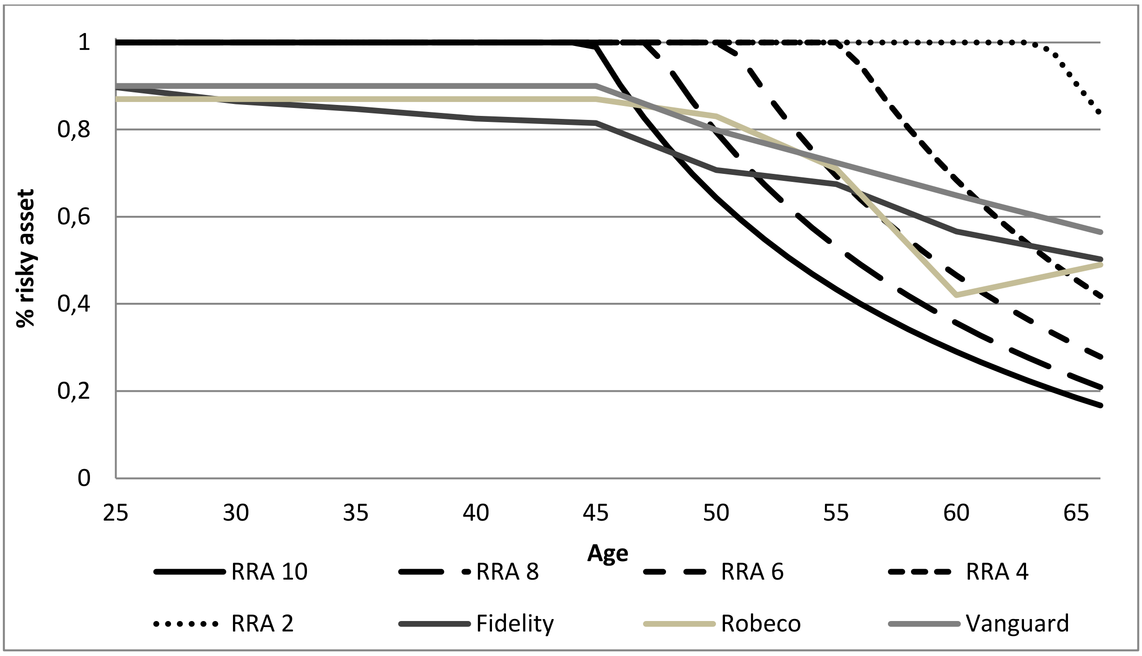
In the pension system DC pension plans are gaining popularity. However, Viceira (2007) found that within the US several mutual fund industry executives, pension and investment experts consider the investment decisions made by DC plan members disappointing(i.e. a naïve diversification strategy or investing their entire contribution in a money market fund). The concern of the professionals is that because of these disappointing investment decisions retirement income at retirement is low. In response banks started offering LCF's and plan sponsors started adopting this new type of mutual fund. Recent empirical evidence however, has shown that these 'one-stop' solutions are not a convenient investment for every DC plan member. In this section I will check which investors do benefit from this 'one-stop' solution. In figure 16 the LCF's of Fidelity, Robeco and Vanguard are compared to the optimal glide path with either risky or riskless human capital.

Figure 16 offered LCF's vs. Optimal glide path with β HC=1



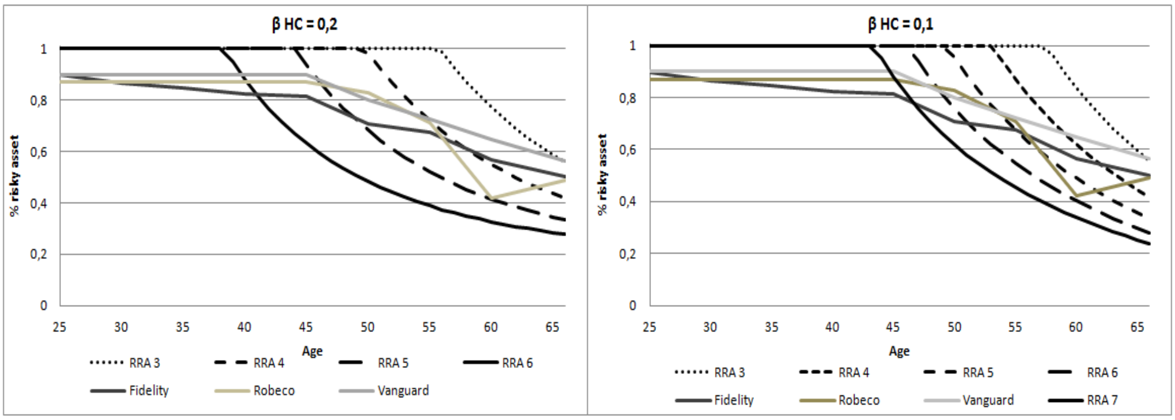
When the optimal glide path is compared to the offered LCF's one can see that, when human capital is considered risky, the investment strategy of the offered LCF's is too aggressive, even for the most risk seeking investor. Which makes, if human capital is risky, an investment in an LCF a non-optimal investment choice. However, it is not likely to assume one has a human capital that is fully correlated with the stock market and probably doesn't occur very often. Figure 17 shows the offered LCF's and the optimal glide path when human capital is considered riskless.

Figure 17 offered LCF's vs. Optimal glide path with β HC=0



When human capital is considered riskless it seems that LCF's could be a suitable decision for certain RRA coefficients. Only for the most risk seeking investor an LCF pursues an investment strategy that is too conservative. However, assuming that human capital is an extreme assumption and probably doesn't occur very often. It is recognized by several academics (Becker (1962), Levhari & Weiss (1974) and Krebs (2003)) that investment in human capital is subject to a risk. A more realistic assumption would thus be that human capital is partially correlated with the stock market. Figure 18 shows the optimal glide path when human capital is considered partially risky.

Figure 18 offered LCF's vs. Optimal glide path with β HC=0,1 & β HC=0,2



The figure shows that when the β ≤ 0,2 and the RRA coefficient ranges between 3-7(3-6 for β =0,2) an investment in an LCF could be a convenient investment strategy. If β > 0,2 the investment strategy followed by LCF is too aggressive. Only for a risk seeking investor LCF's will then be an option. But are these results realistic ? In his research Merton (2003) argues there are several degrees in which human capital can be correlated to the stock market. A stockbroker has a human capital that is heavily correlated with the stock market whereas a nurse or a kindergarden teacher has correlation with the stock market that is neglectable. However, a completely riskfree human capital is unlikely. Hence, due to the economic crisis, companies cut cost leaving a lot of jobs at risk. Therefore I allow for a small risk in human capital.

So LCF's are an appropriate investment decision according to life-cycle theory when the human capital β ≤ 0,2 and RRA is between 3-7. A better asset mix along the life cycle is possible by managing the retirement portfolio yourself. However, one has to possess sufficient financial literacy and must have sufficient time to manage the retirement portfolio.

6. Discussion

Other than other papers, this thesis examines the optimal glide path making use of real data concerning risk appetite of pension investors. Furthermore I make a distinction for several demographics and their preferences regarding the optimal asset allocation along the life-cycle. To learn more about this risk appetite a survey is done. The survey uses a multiple price list in order to evaluate the preferences of an investor when faced with a list of risky gambles. The method of Holt and Laury (2002) provides a guideline in determining a coefficient of relative risk aversion. In the analysis of risk appetite I found that the majority of the respondents have a coefficient of relative risk aversion that range between 0,88 and 1,75. With a sample average of 1,60. These results are in line with the results found by Holt & Laury (2002). Furthermore, in analyzing the results from the survey several demographics are distinguished. First I made a distinction of gender. Where the outcome suggests that men are willing to take more risk. This is in line with the findings of Weber, Blais & Betz (2002). When I make a distinction for age I get somewhat different results. I cannot find a significant difference regarding age, where Weber, Blais & Betz (2002) do find significant difference as age varies. The same is true for the research of Morin & Suarez (1983), Zuckerman (1994) and Hallahan, Faff & McKenzie (2003). They find that risk tolerance decreases with age. Note however, I chose to group the age variable following the different stages in the life cycle described by Bodie, Treussard, & Willen (2007).

Remarkable though is that when the coefficient of RRA found, using the survey, is used for the determination of the optimal glide path, the optimal glide path differs substantially from other papers. The asset allocation strategy in my analysis yields a more aggressive investment strategy. The main difference lies in the coefficient of RRA. Other researchers that examine the optimal glide path make a different assumption regarding relative risk aversion. In most research the coefficient for RRA usually varies between 2-10. Likewise Bodie & Treussard (2007) and Hanna & Chen (1998) make this assumption for RRA. This raises questions. The results found by me, which are in line with Holt & Laury (2002), are inconsisent with other research. According to methodology of Holt & Laury (2002) most respondents tend to make risk averse decisions regarding retirement. However, when the resulting RRA is put in context (i.e. implemented in formula 3.11 and 3.12) it turns out these respondents are extremely risk seeking. This makes me doubt whether the methodology used to extract a measure of relative risk aversion is the correct method. The doubt is twofold. First of all, the investment strategy pursued with the coefficient of RRA form the Holt & Laury (2002) methodology is really aggressive. This is at odds with the results from the questionnaire where almost all respondents indicated to be risk averse. This in combination with other papers written on this subject makes me believe that the outcome is not desirable.

6.1 Future research

This paper researched the risk appetite of pension members. Thereafter this risk appetite is then compared with the risk coefficient to which an investor is exposed when he decides to invest in an LCF. However, this paper suffers from several shortcomings. For instance, the methodology used to obtain a measure of relative risk aversion. The results found are at odds with other academic research. Furthermore, when measure of RRA that is found is used to determine the optimal glide path it results in a rather aggressive investment strategy. When another methodology is used it may find a different RRA and thereby influence the optimal asset allocation along the life-cycle. Furthermore, this research used just two asset classes: a risky asset in the form of equity (with MSCI AC index as a proxy) and a riskless asset in the form of a short-term treasury bill (with a 1-month American T-bill as a proxy). When additional asset classes are added idiosyncratic risk can be further reduced, probably resulting in a bigger proportion invested in risky assets. Besides the assets used for the analysis, there is a limitation concerning human capital as well. In this paper I assume present value of human capital is decreasing over time until nothing is left at retirement age. However, in the Netherlands one will receive a social pension, provided by the government, as one reaches retirement age and will receive this regular payment until his death. This social pension can be seen as a risk less bond. Hence, it is a regular payment and quite certain since it is provided by the government. Because this social pension can be seen as some sort of human capital it will influence the optimal asset mix over time. Furthermore, in my analysis of the optimal asset allocation over an investor’s life-cycle concerns development of human capital over time. As mentioned above I assume a decreasing human capital. However, recent research by Cocco, Gomes, & Maenhout (2005) found empirical evidence that labor income over the life-cycle is hump shaped. Since human capital is one of the biggests assets one can own, it wil probably influence the optimal allocation. Another implication is that I neglect that investors consume part of their wealth. To maximize expected utility over the life-cycle an investor needs to decide how much of his wealth to consume.

7. Concluding remarks

The Dutch pension system experienced considerable change. A growing minority favors the relatively new DC pension plan above the traditional DB pension plan. By choosing a DC pension plan, pension participants chose to take matters in their own hands. Participants decide on individual basis how much to contribute and how this contribution is invested. However, Viceira (2007) found evidence that a large number of DC plan participants, particularly among those with lower levels of education, wealth, and income, show a considerable degree of inertia in their contribution and investing decisions. In response to this concern banks started offering LCF's. This paper explored whether a LCF is a suitable investment choice when it comes to retirement investments.

Prior to determine the optimal asset allocation and compare this with LCF's, it is necessary to know to what extent investor are risk averse. In this analysis, a distinction is made for gender and age. As expected and described in academic literature, it seems that women are less risk tolerant regarding their pension. In the tests women had a tendency to choose a more risk averse respond than men. This means that in constructing a portfolio women will prefer more of the riskless asset relative to their counterparts (provided that the value of human capital and the correlation of human capital in the stock market are equal). Regarding age I find a mixed picture. Out of the five tests only three tests did indeed find risk tolerance had a decreasing nature. However, just one of the test result is significant. Overall I didn't find sufficient evidence to conclude that one gets more risk averse as one ages.

For the determination of a coefficient of RRA I find unsatisfactory results using the Holt & Laury (2002) methodology. On average respondents made 6,83 safe choices. When this is translated in to a measure of risk relative risk aversion the coefficient of RRA is 1,6. Which is noteworthy. The RRA of 1,6 obtained from the questionnaire yield a extremely aggressive investment strategy. Whereas respondents are risk averse. Thus the results found using the Holt & Laury (2002) methodology is at odds with the results obtained from the questionnaire. Therefore RRA coefficients ranging from 2-10 are used, just as in academic literature. Furthermore, in the analysis of the optimal asset allocation several β for human capital are used. When $\beta > 0,2$ a LCF would be a suitable investment decision only for risk seeking investors only. When $\beta > 0,85$ a LCF pursues a investment strategy that is too aggressive, even for risk seeking investors. When human capital has a $\beta \leq 0,2$ and RRA is between 3-7 a LCF can be a suitable investment vehicle. However, when an investor manages his own investment portfolio there are better diversification possibilities. On the other hand LCF's are investment vehicles developed for investor with little financial literacy or investors who don't have time to pay attention to their investment portfolio. In that case a LCF serves its cause.

To summarize. I did find enough evidence to conclude that gender influences risk appetite. It seems women tend to be more risk averse regarding retirement investment decisions. Regarding age I didn't find sufficient evidence to conclude that risk appetite decreases over time. Furthermore, I find contradicting results regarding a coefficient of RRA and the results from the survey. In the survey respondents indicate they are risk averse. However, the coefficient for RRA indicates otherwise and yield a extremely aggressive investment strategy. Other researchers make an assumption regarding RRA and usually ranges between 2-10. Using these coefficients it turns out an LCF could be a suitable investment strategy if $\beta \leq 0,2$ and RRA ranges between 3-7. The one size fits all investment solution offered by commercial banks is thus an investment vehicle that could be a good investment decision. However, when an investor would manage his investment portfolio himself a better diversified portfolio is possible.

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Appendix A

Non-paramatic test reuslts

Mann-Whitney U test

Test Statistics[a]

	switching point
Mann-Whitney U	1360.500
Wilcoxon W	4520.500
Z	-.831
Asymp. Sig. (2-tailed)	.406

a. Grouping Variable: Gender

Kruskal-wallis test

Ranks

	Age	N	Mean Rank
Switchingpoint	1.00	41	56.73
	2.00	41	57.89
	3.00	33	59.71
	Total	115	

Test Statistics[a,b]

	Switchingpoint
Chi-Square	.152
df	2
Asymp. Sig.	.927

a. Kruskal Wallis Test
b. Grouping Variable: Age

Ordinal regression per question

My friends describe me as cautious

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	238,679	200	,032
Deviance	169,655	200	,942

Pseudo R-Square

Cox and Snell	,116
Nagelkerke	,120
McFadden	,035

"How would you describe your willingness to take risk with your future retirement income?"

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	171,563	166	,368
Deviance	152,794	166	,761

Pseudo R-Square

Cox and Snell	,082
Nagelkerke	,086
McFadden	,027

"How would you describe your risk appetite regarding your pension investments?"

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	192,684	166	,077
Deviance	153,284	166	,752

Pseudo R-Square

Cox and Snell	,085
Nagelkerke	,088
McFadden	,027

Appendix B

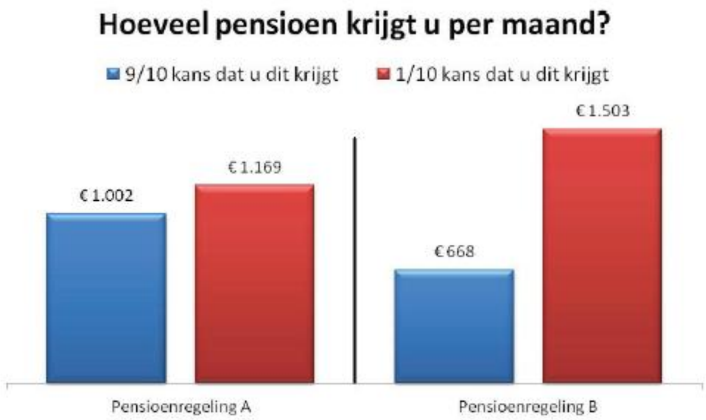
Stelt u zich voor dat u 1.670 euro per maand verdient. Uw pensioenfonds vernieuwt. Pensioenopbrengsten worden minder zeker en u wordt gevraagd een nieuwe regeling te kiezen. Hieronder ziet u steeds twee mogelijke regelingen die verschillen in hoeveel pensioen u krijgt met welke waarschijnlijkheid. U krijgt een aantal keuzes voorgelegd waarbij steeds de kans op de verschillende pensioenuitkomsten anders zijn. Kiest u per vraag welke pensioenregeling voor u het meest aantrekkelijk is (eerste twee vragen uit enquête staan hieronder weergegeven.)

KEUZE 1

Bij pensioenregeling A krijgt u 1002 euro per maand of 1169 euro per maand als totaal pensioen (inclusief AOW). De kans dat u 1002 euro per maand krijgt is 9/10 en de kans dat u 1169 euro per maand krijgt is 1/10. Bij pensioenregeling B krijgt u 668 euro per maand of 1503 euro per maand als totaal pensioen (inclusief AOW). De kans dat u 668 euro per maand krijgt is 9/10 en de kans dat u 1503 euro per maand krijgt is 1/10. Onderstaand ziet u beide regelingen in een grafiek.

Welke pensioenregeling kiest u?

- ○ Pensioenregeling A
- ○ Pensioenregeling B



KEUZE 2

Bij pensioenregeling A krijgt u 1002 euro per maand of 1169 euro per maand als totaal pensioen (inclusief AOW). De kans dat u 1002 euro per maand krijgt is 8/10 en de kans dat u 1169 euro per maand krijgt is 2/10. Bij pensioenregeling B krijgt u 668 euro per maand of 1503 euro per maand als totaal pensioen (inclusief AOW). De kans dat u 668 euro per maand krijgt is 8/10 en de kans dat u 1503 euro per maand krijgt is 2/10. Onderstaand ziet u beide regelingen in een grafiek.

Welke pensioenregeling kiest u?

- ○ Pensioenregeling A
- ○ Pensioenregeling B