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DC Default 3.0

Optimal Asset Allocations Given a Replacement Rate Target under Different First Pillar Pension Systems across Europe

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DC Default 3.0: Optimal asset allocations given a replacement rate target under different first pillar pension systems across Europe

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Abstract

For individuals in defined contribution schemes that are unable to choose their funding strategy, the default investment allocation is assigned regardless of their differences. Many pension providers often exclude some important factors such as the first pillar system design and human characteristics when determining the default strategy. This thesis investigates the effect of the different first pillar system taking into account realistic human capital characteristics on the optimal asset allocation in defined contribution pension schemes across Europe, if the evaluation is based on the downside risk and tail-related risk metrics.

This thesis shows that different first pillar systems influence the optimal strategy in the funded scheme. Individuals that receive large entitlements from the first pillar are optimal to choose less risky strategies for the second pillar. Moreover, different salary profiles and different starting salary levels also have a significant impact on the optimal strategy. This thesis also finds that a replacement rate target level is an important factor when the risk-reward profile for evaluating the strategies is considered. Increasing the target level requires individuals to choose riskier strategies to obtain the optimal result.

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Chapter 1

Introduction

Traditional occupational defined benefit (DB) schemes offer a pensioner a fixed income without having financial market risks and demographic risks. On the other hand, the individual defined contribution (DC) schemes entrust all the responsibility to the individual such as the amount of contribution, the asset allocation decision and others [Bovenberg and Nijman, 2009]. Despite the flexibilities of DC schemes, DB schemes experience a number of drawbacks, which have resulted in shifting from these schemes to the DC schemes.

Even though pension funds with defined contribution schemes often provide several investment alternatives, most of the participants accept the default arrangements. Evidence from Swedish retirement plans show that only 10% of the participants makes their own portfolio choice [Cronqvist and Thaler, 2004]. And the United States, 80% of the participants in DC schemes choose a default asset allocation [Choi et al., 2001]. These studies indicate the importance of the default allocation to the participants, as the majority will choose this arrangement.

Human capital characteristics should be considered as one of the most important factors for determining the optimal asset allocation. Blake et al. [2007] conclude that different occupations have very distinctive career salary profiles. Furthermore, there should be a distinction between males and females as they have different career salary profiles, even if they have a similar occupation. These facts suggest that pension funds should not implement a one-size-fits-all strategy to all participants.

Pension income comes from different pillars where the first pillar is the basic income that is managed by the government. The first pillar entitlements are different depending on the design of the first pillar in each particular country. According to van der Horst [2013], the size and design of the first pillar have a large influence on the optimal asset allocation

in the defined contribution schemes. Countries with flat-rate first pillar pension systems require the participants to invest depending on their salary levels. Whereas in countries with an earning-related first pillar, the optimal asset allocation does not depend on the salary level of the participants. Therefore, pension funds need to consider the effects of the first pillar entitlement to the optimal asset allocation in the funded schemes.

1.1 Research Question, Motivation and Relevance

The main focus of this thesis is formulated in the following research question:

What is the effect of the first pillar pension system design taking into account realistic human capital characteristics on the optimal asset allocation in defined contribution pension schemes across Europe, if optimality is evaluated with the downside risk and tail-related risk metrics?

The research question is intended to better understand the effect of the first pillar on the optimal DC default asset allocations. This thesis concentrates only on European systems because of the practical reasons such as the accessibility of information on pension system designs. On the other hand, including stochastic human capital can produce a better analysis as it is more resembling reality.

Previously, van der Horst [2013] has investigated the effect of the first pillar on the optimal asset allocation. She makes simplifying assumptions such as that the growth of the first pillar entitlements for all countries only depends on inflation. However, this thesis imposes more realistic assumptions and applies a different evaluation method. Furthermore, more realistic human capital characteristics such as the shape of career salary profiles and a stochastic unemployment rate are included. The motivation of this thesis is to provide a more realistic analysis by implementing more resembling reality first pillar systems and incorporating the uncertainty in human capital.

The analysis of this thesis will be relevant for the pension industry and the regulators. The results can be used to improve the allocation strategies of DC pension plans. Pension funds that provide pension products for different countries may use this analysis to help their pension strategies in the future. Regulators will be able to compare their first pillar system with other countries.

1.2 Approach

There are two sources of pension income that are considered in this thesis. The first source is attained from the first pillar. This benefit calculation is different for each country. The first pillar systems for all countries are investigated and formulated. The entitlement is presented in terms of the replacement rate of the first pillar. The second source is received from the defined contribution schemes, where participants contribute some percentage of their annual salary and invest their contribution in the funded schemes. The investment return will depend on the selected asset allocation. At retirement, the accumulated wealth will be converted into an annuity. This annuity will be presented in terms of the replacement rate of the second pillar.

The total replacement rate, which is the sum of the first pillar and second pillar replacement rate, is the metric for evaluating investment strategies. The Sortino ratio and tail-related risk evaluations are employed to choose the optimal asset allocation. Three different career salary profiles and the unemployment rate, which affects both the first pillar[1] and the second pillar, are investigated.

1.3 Structure

The remainder of this thesis is outlined as follows. The next chapter discusses the literature review on this topic. Chapter 3 outlines the methodologies and assumptions that are applied. In Chapter 4, the data are described and summarized. Subsequently, the results are discussed and sensitivity analysis is performed in Chapter 5. The last chapter concludes and presents some recommendations for future research.

[1]The unemployment rate affects only the first pillar entitlement of a country which has an earning-related scheme such as Poland or Italy.

Chapter 2

Background

Pension is necessary because of three economic motives, which are paternalism, market failures and income redistribution [Barr and Diamond, 2008]. First, paternalism is defined as the behaviour of an individual or institution to give restrictions to someone for their own benefit. Secondly, a pension can generate some protection for an individual against market failures. For example, markets that sell financial products for hedging longevity risk and interest rate risk are very limited. In case of public pension systems, pensions create social solidarity where intergenerational and intragenerational risk sharing can be obtained. Besides these economic motives, there are two important objectives for individuals. First, individuals are able to smooth their consumption over the life cycle. Secondly, pension establishes an insurance for old-age poverty.

Traditionally, pension benefits come from three different sources called pillars. These pillars consist of a basic pension (1^{st} pillar), an occupational pension (2^{nd} pillar) and a private pension (3^{rd} pillar). Mostly, the 1^{st} pillar is based on a Pay-As-You-Go (PAYG) pension scheme, which means that benefits of pensioners are paid directly by the contributions of the working generation. The benefits depend on the design of the first pillar for each country. PAYG pension schemes can be divided into two types, which are flat-rate and earning-related schemes. On the other hand, the 2^{nd} can be divided into DB schemes and DC schemes. These schemes are funded in such a way that the contributions are accumulated and used to provide pension income during retirement [OECD, 2013].

Flat-rate schemes provide pensioners with basic pension income in which benefits depend on years of residency, instead of their salary profiles. Some countries such as the Netherlands and the United Kingdom apply flat-rate schemes. On the other hand, earning-related schemes accommodate the pensioner with a benefit that depends on their salary profile. Inside the earning-related schemes there are some different forms such

as the notional account schemes and the points schemes.[1] Notional account schemes or notional defined contribution (NDC) schemes are established to imitate DC schemes. The difference is that each participant has a notional capital account. The notional capital account grows depending on the notional rate, which is announced by the pension plan annually [Auerbach and Lee, 2006]. At retirement, the accumulated notional account is converted to pension payments. The amount of pension income is calculated differently for each country [Gronchi and Nisticò, 2006]. Sweden is the first country that implemented NDC schemes in 2001 and some countries such as Italy and Poland introduced NDC schemes in the following years.

The 1st pillar entitlements are different depending on the design of each particular country. According to van der Horst [2013], the size and design of the 1st pillar influences the optimal asset allocation in the defined contribution schemes. Countries with flat-rate 1st pillar schemes require the participants to invest depending on their salary level. Whereas in countries with an earning-related 1st pillar, the optimal asset allocation does not depend on the salary level of participants. Therefore, pension funds need to consider the effect of the first pillar entitlements on the optimal asset allocation in the funded schemes.

DB schemes provide employees with a certain annuity payment for the rest of their life starting from the retirement age. The amount depends on the number of working years and the reference salary. The reference salary can be based on a final salary or a career-average scheme. In recent years, there has been a shift from the final salary to the career-average scheme [Bovenberg and Nijman, 2009]. DC schemes require contributions from each participant which are assigned to an individual account. The contribution to this scheme is received from the employee, the employer or both the employee and the employer. The individual account grows depending on the investment performance of the selected investment strategies. The accumulated contribution that grows with investment returns forms the pension income for retirement. This accumulated contribution can be converted to a pension-income stream such as a life annuity or can be used directly by the pensioners [Byrne, 2004].

According to Bovenberg and Nijman [2009], the traditional DB schemes have some deficiencies that result in a shift from DB to DC schemes. Some important deficiencies are the following. Firstly, there is the inability of the company that offers pensions to absorb risk. This drawback brings many companies to not only focus on their core business but also on pension guarantees of pensioners. Therefore, many companies begin to withdraw giving pension guarantees to their workers in order to concentrate on their core business only. Secondly, there is the sub-optimality of tailor-made benefits in

[1] For more information about the design of each pension system, please refer to OECD [2013]

the DB schemes. Traditional DB schemes mostly assume all participants have similar characteristics and preferences, which is not true. Individuals then prefer to follow an arrangement provided by other pension funds that fits them best.

Individual DC schemes also have some drawbacks which should be considered carefully. Many individuals are financial illiterate and affected by behavioural biases. These factors affect the ability of individuals to achieve optimal financial planning for retirement including portfolio selection, contribution levels and pension product decisions (see Lusardi and Mitchell [2007]; and Tapia and Yermo [2007]). Another drawback is inadequate pension product designs by pension funds. Individuals still find it is difficult to handle investment choices even though pension funds already provide a selection of choices. According to Benartzi and Thaler [2007], individuals are unable to deal with excessive portfolio selection decisions and they require some helps for choosing the optimal decisions. They suggest that a sufficient number of adequate default options should be provided and that choices are provided in a structured way.

Given that individuals have uncertain life expectancy, an annuity provides beneficial longevity insurance [Brown, 2003]. This study has shown that it is optimal to convert the retirement savings to an annuity given that fair and complete annuity products are available. According to Bütler and Teppa [2007], many individuals would refuse to convert their accumulated wealth into an annuity if they have the choice to take a lump sum. They argue that if a pension fund gives solid argumentations and recommendations to annuitize, individuals will then choose to do so. The fundamental objectives of pension plans are to provide sufficient retirement income during retirement and to eliminate the risk of pensioners outliving their capital [Blake, 2006]. Therefore, an annuity should be considered by participants in DC schemes instead of a lump sum.

Chapter 3

Methodology and assumptions

3.1 Risk factors

Defined contribution pension schemes produce some risks and problems for the participants. These risks and problems come from several factors such as the return of the accumulated wealth during the accumulation phase, the unforeseen interest rate at the retirement date and the earnings of the individual. This section discusses each risk factor that affects the pension income during retirement. The assumptions will be provided as well.

3.1.1 Asset returns and interest rates

For this thesis, asset returns and interest rates will be simulated with a risk model designed by Van den Goorbergh et al. [2011]. The stochastic variables are generated using a vector autoregressive model with two features. The first feature is to incorporate a regime-switching model which takes into account a crisis period. These stochastic jumps produce an unexpected loss in market confidence, thus resulting in lower interest rates and stock returns. Secondly, time-varying second moments to integrate different characteristics correlated with a crisis will be employed.

Interest rates are required to calculate the annuity factor[1] at the retirement date. Yields on long-term bonds are a common discount rate for valuing the annuity factor [Blake

[1] Annuity factor is a method in actuarial science to calculate the net present value given at the retirement date for getting one unit of income during the retirement age.

et al., 2001]. The annuity factor is given by the following formula:

$$\ddot{a}_T = \sum_{s=0}^{\infty} (1 + y_T^{(s)})^{-s} (1 + i_{T+s})^s {}_sP_T, \tag{3.1}$$

where T is the retirement date, ${}_sP_T$ is the conditional probability that an individual will live to age $T + s$ given that he is alive at age T, $y_T^{(s)}$ is the yield of bonds at time T that mature at time $T + s$ and i_{T+s} is the inflation rate at time $T + s$.

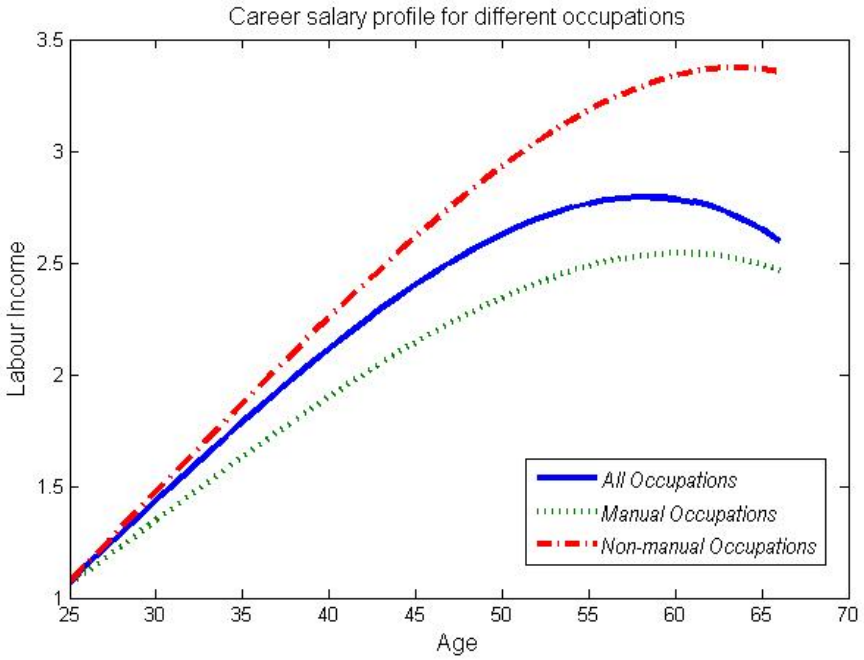
3.1.2 Salary profile

For capturing the career salary profile, Blake et al. [2007] build a model that employs a quadratic function of age. The quadratic function has been chosen such that it fits with the observations from the labour economics literature. The model is given by the following formula:

$$G_x = 1 + h_1 \left[-1 + \frac{x - 20}{45} \right] + h_2 \left[-1 + \frac{4(x - 20)}{45} - \left(\frac{\sqrt{3}(x - 20)}{45} \right)^2 \right], \tag{3.2}$$

where x is age. For this thesis, the parameters of h_1 and h_2 will be retrieved from Blake et al. [2007].

FIGURE 3.1: The career salary profile for different occupations given a constant wage growth starting with one unit labour income at age 25



For each individual of age x, the growth of labour income is the following:

$$I_x = r_x + \frac{G_{x+1} - G_x}{G_x}, \tag{3.3}$$

where r_x is the labour income growth for an individual at age x and G_x is the salary profile of an individual at age x. Then the labour income received at age $(x+1)$ is $Y_{x+1} = Y_x exp(I_x)$.

The development of some career salary profiles is provided in Figure 3.1. All the salary profiles are increasing until a certain age and then gradually decreasing afterwards. Intuitively, workers become more experienced and more productive until they reach the optimal age. Afterwards, they become less productive and less efficient, which will result in lower salary growth. 'Manual' workers have lower salary growth compared to 'non-manual' workers.

3.1.3 Unemployment factor

Unemployment means that the individual was not able to work and thus no contribution to the pension scheme is made during the unemployment period. In this thesis, the unemployment rate is assumed to be constant for all ages and there is no difference between males and females. Different unemployment rates, which will be retrieved from the OECD database, will be applied for each country.

The unemployment rate for each country is provided in Table 3.1. The Netherlands has the smallest unemployment rate of 6.7% whereas Italy has the highest unemployment rate of 12.2%. This factor will not only affect the second pillar pension benefits but also the first pillar entitlements for some countries that implement an earnings-related scheme such as Italy or Poland.

TABLE 3.1: Unemployment rate 2012/2013 for each country

	Unemployment rate
Netherlands	6.7%
United Kingdom	7.5%
Italy	12.2%
Poland	10.3%

Source : http://stats.oecd.org/Index.aspx?DatasetCode=STLABOUR#

3.2 Control variables in the scheme

The pension provider and/or the participant of the scheme are able to decide their own funding strategies. For example, they are allowed to choose their preferred asset allocation, they can decide how much is contributed to the scheme or they can determine the retirement age. However, there are different regulations that determine these privileges for different countries. This section will explain in detail the asset allocation selections, the contribution rate and the assumptions on the retirement age.

3.2.1 Asset allocation selections

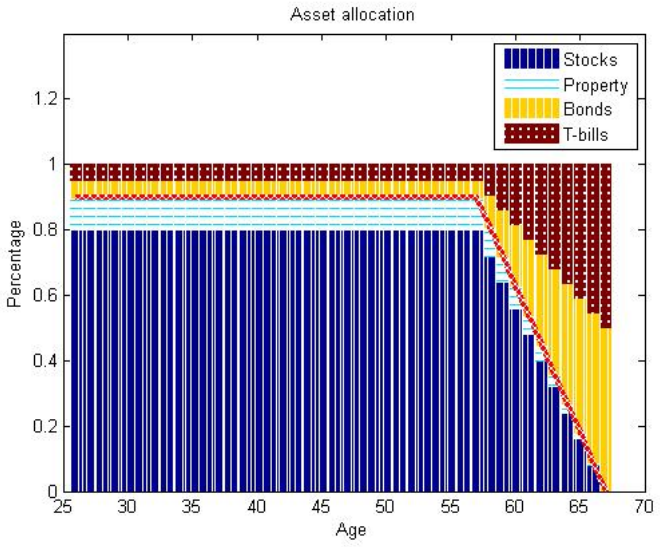
In this thesis, it is assumed that the pension funds invest across four different asset classes: MSCI world index for equities, three-month Euribor for treasury bills, Euro Treasury with 6 years maturity for bonds and US transaction-based index for property. For the default strategies, four different allocations will be investigated. The asset allocation strategies are given below:

- *Bonds-Bills*: This type of allocation consists of 50% bonds and 50% T-bills.
- *Aggressive*: The contributions will be allocated to available risky asset classes, which are equities and property. This strategy consists of 90% equities and 10% property.
- *Pension fund average (PFA)*: The average default asset allocation for defined contribution pension schemes. This strategy consists of 36% equities, 57% bonds, 4% property and 3% T-bills[2].
- *Lifestyle*: This is a deterministic asset allocation where it starts with holding 80% equities, 5% bonds, 5% T-bills and 10% property at younger age. Then, the proportion of equities and property will diminish gradually starting from 10 years before retirement. It decreases 10% of the equities and property holding annually and is converted to 'Bonds-Bills' strategy proportionally[3]. The pattern of this strategy is given in Figure 3.2.

[2]This information retrieved from www.company.info and exported on 8 January 2014. As they also have alternative asset class, this proportion is allocated to equity.

[3]This portfolio composition resembles the proportion of life-cycle fund of ABN AMRO. For more information, please refer to 'Lifecycle 2050' at www.abnamro.nl

FIGURE 3.2: The pattern of the 'lifestyle' strategy



3.2.2 Contribution rates

The contribution rate for the 2nd pillar is different for each country. The size and design of the 1st pillar affects the contribution rate of 2nd pillar. For example, Italy and Poland have the compulsory contribution rate of 32.7%[4] and 16.02% respectively. This contribution to the 1st pillar is already high which results in less consumption and additional saving. Therefore, uniform contribution rates is not appropriate for all countries.

The contribution rate for different countries is given in Table 3.2. It can be seen that participants in the Netherlands and the United Kingdom have zero contribution rate to the 1st pillar. The reason is that these countries implement a flat-rate scheme. Therefore, participants in these countries have the same first pillar pension benefits despite of different salary profiles.

TABLE 3.2: The contribution rate of the 1st and 2nd pillar for different countries

	Contribution rate	
	First pillar	Second pillar
Netherlands	-	16.4%
Poland	16.02%	3.5%
United Kingdom	-	8%
Italy	32.7%	6.91%

[4]For Italy, 1/3 of the contribution rate will be paid by the employee whereas the other 2/3 will be paid by the employer.

The contribution rate of the 2nd pillar depends on the regulation for each country. In the United Kingdom, individuals need to contribute at least 8% of their salary into the DC scheme. In Poland, the government has a requirement of 19.52% contribution of which 3.5% will be invested in the funded scheme. In Italy, there exists a voluntary private pension where the individuals can contribute 6.91% of their gross salary. In the Netherlands, the contribution rate for occupational scheme is 16.4%. The 1st pillar contribution rate will be explained in more detail in Section 3.3.

3.2.3 Retirement age and career length

One key reform in the pension industry around the world is the increase in the retirement age for the participants. This can be seen by increase in the retirement age from 65 to 67 in most OECD countries [OECD, 2013]. Some countries have even increased the retirement age to 68 or 69. For this thesis, it is assumed that the retirement age is 67. However, the retirement age should be treated more carefully if in the future it will be linked with the life expectancy. For example, Italy will link the pension age with the life expectancy from 2015 onwards [OECD, 2011].

In this thesis, a single person will start working at age 25 until the standard pension-qualified age, which is set to 67. Thus, everyone in this economy has a career length of 42 years.

3.3 First pillar pensions

The first pillar income will be expressed as the replacement rate which depends on the individual's final salary. The replacement rate for the first pillar is given by the following formula:

$$RR_I = \frac{FP_T}{S_T}, \tag{3.4}$$

where FP_T is the first pillar income at retirement and S_T is the final salary. Different countries will have different first pillar income. Note that this first pillar is based on PAYG system, which means that the pension benefits of retirees are directly paid by the working generation. This section will explain the size and the design of the first pillar for different countries[5] and the assumptions used to calculate the entitlements from the first pillar.

[5]This information is retrieved from OECD [2013]

3.3.1 Netherlands

The first pillar system in the Netherlands is a flat-rate public scheme[6]. For every year, the accrual rate for this benefit is 1.75% to 2% of the full pension amount. In 2012, the gross monthly pension benefit was €1,079.93 for the first 6 months and €1,085.63 for the other 6 months. Furthermore, there is holiday allowance included which amounts to €720.18 per year. Therefore, the basic pension benefit gives a total of €13,713.54 per year for a single person. This benefit will grow depending on the net minimum wage growth. In this thesis, it is assumed that participants will receive the full amount of AOW. The summary of the characteristics of the basic pension scheme is given in Table 3.3.

TABLE 3.3: Summary characteristics of the first pillar system in the Netherlands

	Netherlands
Pension system	Flat-rate schemes
Gross pension benefit	€13,713.54 per annual
Accrual rate	1.75% - 2% per annual
Indexation rate	Wage growth

The first pillar income at retirement will be given by:

$$FP_T = FP_0 \prod_{i=1}^{T} (1 + \pi_i), \tag{3.5}$$

where FP_0 is the current first pillar pension income and π_i is the indexation rate at time i.

3.3.2 Italy

The first pillar system in Italy is a notional defined contribution scheme. The public and private employees need to contribute 32.7% of their salary annually to the schemes. The contribution increases with the gross domestic product (GDP) growth. At retirement, this accumulated notional contribution will be converted into an annuity. The amount of the benefit will depend on the transformation factor. This transformation factor takes into account the survival probability, the probability of becoming widow or widower and the benefit amount that will be withdrawn. The summary of the pension scheme's characteristics is given in Table 3.4.

To find the income during the retirement for Italy, the formula derived by Gronchi and Nisticò [2006] will be applied. The first pension income at retirement is given by the

[6]The first pillar in the Netherlands is called AOW(Algemene Ouderdomswet)

TABLE 3.4: Summary characteristics of the first pillar system in Italy

	Italy
Pension system	Notional defined contribution schemes
Contribution rate	32.7%
Entitlements regulation	Minimum of 20 years contributions
Indexation rate	GDP growth

following:

$$FP_T = \frac{a \sum_{i=0}^{T-1} S_i(1-e_i) \prod_{j=i+1}^{T} (1+\pi_j^L)}{\sum_{i=1}^{m} (1+\delta)^{1-i}}, \tag{3.6}$$

where a is the contribution rate to the first pillar scheme, S_i is salary at time i, π_j^L is the rate of return for workers at time j, δ is a conversion rate determined by the policy maker, e_i is the dummy of the employment state at time i ($e_i = 1$ if not employed) and m is the life expectancy at the retirement age. Following the assumption by Aben [2011], the conversion rate is assumed to be equal to 1.5%. The rate of return for workers will follow the nominal GDP growth.

3.3.3 United Kingdom

The first pillar in the United Kingdom consists of two tiers, namely a flat-rate basic pension (Basic State Pension or BSP) and an additional earnings-related pension (State Second Pension or S2P). In 2012, a single person received a full basic pension of £107.45 per week, which is £5,587.4 annually. The flat-rate basic pension grows with on the maximum of three rates, which are the wage growth rate, the growth of the consumer price index or 2.5%[7]. In order to have full entitlement of the BSP, individuals need to contribute at least 30 years of national insurance (NI).

TABLE 3.5: Illustration of the employee with annual salary of £20,000

Salary band	Salary	Accrual rate	Benefit
Less than LEL	£5,564	0%	£0
LEL to LET	£9,136	40%	£3,654.4
LET to UET	£5,300	10%	£530
Total salary:	£20,000	**Total S2P:**	£4,184.4

For the additional earnings-related pension, the benefit depends on the thresholds. In 2012/13, if individuals have earnings between £5,564 (Lower earning limit or LEL) and

[7]This information retrieved from https://www.gov.uk/state-pension/overview

£14,700 (Lower earning threshold or LET) annually, they receive 40% accrual rate over the difference between LEL and LET. Individuals with earnings above LET obtain an additional 10% accrual rate over the difference between LET and their earnings. If their earnings are above than an upper earning limit (UEL) of £40,040, then their earnings are put at UEL.[8] An illustration is given in Table 3.5. However, there is a possibility to 'contract-out' which means that the participant can move some proportion of S2P provision to private fund provision. In this thesis, the possibility of contracting-out is excluded in the analysis. The summary of the pension scheme's characteristics is given in Table 3.6.

TABLE 3.6: Summary characteristics of the first pillar system in the United Kingdom

	United Kingdom	
Pension system	Flat-rate schemes	Earning-related schemes
Gross pension benefit	£5,587.4 per year	
Accrual rate		40% (+10% for above LET)
Entitlements regulation	30 years of NI contributions	
Indexation rate	Max of wage growth / inflation / 2.5%	

The first-pillar pension income at retirement will be calculated as the following:

$$FP_T = \begin{cases} BSP_T & \text{if } S_T \in (0, LEL) \\ BSP_T + 0.4(LET - LEL) & \text{if } S_T \in [LEL, LET] \\ BSP_T + 0.4(LET - LEL) + 0.1([S_T, UEL]^- - LET) & \text{otherwise} \end{cases} \tag{3.7}$$

where BSP_T is the basic flat-rate pension at retirement, S_T is the final salary and $[S_T, UEL]^-$ means the minimum between the final salary and the UEL.

3.3.4 Poland

The first-pillar in Poland is an earnings-related pension scheme that consists of PAYG and funded schemes. Workers have to contribute 19.52% of their salary to the pension schemes. This contribution will be divided into three different accounts. The first account is a notional defined contribution scheme (12.22%) with the notional growth depending on the highest rate between the covered wage bill and the CPI growth. The second is the additional sub-account or Social Security Fund (3.8%) that grows with the GDP growth. The last account will be in the form of a funded scheme which consist of 3.5% of the total contribution. The basic pension benefits from the notional DC scheme and the additional sub-account are calculated using the accumulated notional capital divided

[8] The information about the accrual rate is available at www.firstactuarial.co.uk/

by the "g-value" that is the life-expectancy average at retirement. The summary of this pension scheme is given in Table 3.7.

TABLE 3.7: Important key for Polish first pillar system

	Poland
Pension system	Earning-related schemes
Contribution rate	16.02% (12.22% NDC & 3.8% sub-account)
Entitlements regulation	Min of 20 (female) or 25 years contributions
Indexation rate	Max of wage growth / inflation (NDC) & GDP growth (sub-account)

In this thesis, the notional defined contribution scheme and the additional sub-account will be merged into the basic pension. Therefore, the calculation of the first pillar pension benefit at retirement is the following:

$$FP_T = \frac{1}{g}\left[a_{NDC}\sum_{i=0}^{T-1} S_i(1-e_i)\prod_{j=i+1}^{T}(1+\pi_{j,NDC}) + a_{SA}\sum_{i=0}^{T-1} S_i(1-e_i)\prod_{j=i+1}^{T}(1+\pi_{j,SA})\right], \tag{3.8}$$

where $\pi_{j,NDC}$ is the growth rate of the NDC account, $\pi_{j,SA}$ is the growth rate of the sub-account, a_{NDC} is the contribution rate to the NDC account, a_{SA} is the contribution rate to the sub-account and g is the life-expectancy at the retirement age.

3.4 Second pillar accumulated wealth

This thesis will use the accumulated wealth model proposed by Basu and Drew [2010]. They use the stochastic accumulated wealth where the volatility comes from the asset returns. To determine the accumulated wealth of participants at retirement, the following formula will be used:

$$W = k\sum_{i=0}^{T-1}(1-e_i)S_i\prod_{j=i+1}^{T}(1+r_j), \tag{3.9}$$

where k is the contribution rate, T is number of working years, e_i is the dummy for the employment state at time i ($e_i = 1$ if not employed), S_i is the salary at time i and r_j is the investment return at time i. Because this thesis takes into account the effect of different career salary profiles on the wealth accumulation, the formula from Section 3.1.2 will be incorporated.

The pension income from this pillar will be expressed in term of the replacement rate[9]. Individuals will convert all their accumulated wealth at retirement to a life annuity. Then, the replacement is defined as the proportion of the retirement income relative to the final salary S_T. The replacement rate of the second pillar at retirement will be given by the following formula:

$$RR_{II} = \frac{W}{\ddot{a}_T S_T}. \tag{3.10}$$

3.5 Economic variables

The growth rate of the first pillar pension entitlements for all countries will depend on economic performance measures such as inflation, wage growth, GDP growth, etc. In order to clearly identify the effect of different sizes and designs of the first pillar, a set of defined economic variables will be applied to all countries. In this manner, the comparisons of the sizes and designs of the first pillar system are more coherent. The assumptions of the economic variables are given below.

The growth of GDP is assumed to be fixed at 2%. This assumption is consistent with the projection of advanced economies, such as European countries which have a growth rate of 2% or less[10]. Real earnings growth and inflation are simulated by the Asset and Liability Management department of APG. These two variables are projected for European countries in general.

3.6 Metrics for assessing the asset allocation

The total replacement rate will be the replacement rate of the first and the second pillar together. The total replacement rate is given by:

$$RR = RR_I + RR_{II}. \tag{3.11}$$

Participants do not only choose the highest expected replacement rate. They also may consider the risk driven by the chosen investment strategy. The investment risk can be seen as the potential of having lower target returns (downside risk) and the potential of having big losses (tail-related risk). To account for the riskiness of the investment strategies, there are several metrics that can be employed.

[9]This ratio has been used commonly to evaluate the investment performance of the pension fund internationally [Aldrich, 1982]

[10]This information retrieved from the report of PricewaterhouseCoopers about the world in 2050.

3.6.1 The downside risk

The lower partial moment (LPM) is able to capture the downside risk. LPM, which is introduced by Bawa [1978], measures the downside risk and also takes into account the negative deviation of the target outcome. According to Unser [1998], LPM is suitable for any distribution of asset returns. Therefore, this measure is convenient because there are no assumptions to be made regarding the distribution of the replacement rate. LPM is given by the following formula:

$$LPM_\lambda = \frac{1}{n}\sum_{t=1}^{n} Max[0, (RR_T - RR_t)]^\lambda, \tag{3.12}$$

where λ is the risk tolerance of the participant, RR_T is the replacement rate target and RR_t is the replacement rate of scenario t[11]. When $\lambda = 0$, the participants consider only the probability of shortfall. This type of participants do not have an interest in the size of shortfall. For the investors that take into account the size of the shortfall or the semi-variance, λ will be 1 and 2, respectively.

The performance measure that will be used to assess different asset allocations is the Sortino Ratio (SR) introduced by Sortino and Price [1994]. This ratio is similar to the Sharpe Ratio[12], but the difference is that SR only accounts for the downside standard deviation. Moreover, SR uses a target whereas the Sharpe Ratio uses the risk-free rate. For this thesis, SR will be applied because it is an appropriate metrics for choosing the optimal fund compared to other measures [Chaudhry and Johnson, 2008]. SR is given by the following formula:

$$SR = \frac{RR_M - RR_T}{\sqrt{LPM_2}}, \tag{3.13}$$

where $RR_M = \frac{1}{n}\sum_{t=1}^{n} RR_t$ is the average of all replacement rate scenarios.

3.6.2 The tail-related risk

There is evidence that investors are risk-averse, which means that they put more weight on losses rather than gains [Benartzi and Thaler, 1995]. Furthermore, Basu and Drew [2010] argue that if participants are risk-averse, they will likely choose an asset allocation which has the lowest probability of very bad outcomes. Therefore, it is important to take

[11] Scenarios are similar to "States of the world". For example, n = 500 means that there are 500 independent states of the world.

[12] Sharpe Ratio is a popular measure in finance to evaluate the investment performance. It is the ratio of the excess return divided by the volatility of the returns [Sharpe, 1966]

into account the extreme loss while choosing the optimal asset allocation strategy. The value-at-risk (VaR) will be applied to this thesis. VaR is given by the following formula:

$$VaR = Q_{1-\alpha}, \tag{3.14}$$

where α is the confidence level. For this thesis, α is set to 95%, which specifies that the individual is likely to get an outcome above VaR with probability of 95%.

To complement the VaR, expected tail loss (ETL) is also included. ETL measures the probability weight of all scenarios below VaR level. ETL is given by the following:

$$ETL_\alpha = \frac{1}{1-\alpha} \sum_{p_i}^{\alpha} RR_i.p_i, \tag{3.15}$$

where RR_i is i^{th} outcome and p_i is the probability of outcome i^{th}[13]. In other words, ETL with 95% confidence level is the average of all 5% worst scenarios.

3.6.3 Rules for choosing the optimal asset allocation

There are no studies that discuss how to choose the optimal asset allocation given a target replacement rate. Blake et al. [2001] suggest that the strategy which has the highest VaR is optimal. However, they do not consider the risk-reward profile of the strategies. For instance, a strategy that has the highest VaR does not imply that it also has the highest expected return (reward). On the other hand, Basu and Drew [2010] use similar metrics (downside risk and tail-related risk estimates) for evaluating the asset allocations considering the risk-reward profile. Nevertheless, they give analysis on each evaluation measure without drawing conclusions on how to use all the metrics jointly for determining the optimal asset allocation. Therefore, new rules for choosing the optimal asset allocation are proposed.

The procedures to choose the optimal strategy are the following.

1. Set the target replacement rate to 0.7 or 70% as the base setting.
2. Eliminate all the strategies that have VaR below 0.5 or 50%.
    - In case that all strategies have VaR below 50%, the strategy that has the highest VaR is the optimal strategy.
    - Otherwise, the optimal strategy is chosen in such a way that it has the highest SR.

[13] This formula is retrieved from Basu and Drew [2010].

Many financial advisers suggest that the replacement rates should be between 70% to 85% [Scholz and Seshadri, 2009]. Therefore, it is reasonable to choose the replacement rate target of 70%. On the other hand, there is no consensus for the threshold of VaR. In this thesis, it is assumed that the threshold is 50%, which means that the pension income at retirement is half of the final earnings.

Chapter 4

Data

4.1 Financial market data and economic variables

In this section, the simulations used for this thesis are summarized and discussed.[1] The summary statistics such as mean, standard deviation, minimum, maximum and correlation are provided in Table 4.1 and Table 4.2. Besides the financial markets, some economic variables play an important role in determining the pension entitlements. The inflation rate and wage growth are important in determining the growth of the 1st pillar incomes for different countries and are included as well. Furthermore, the term structure of interest rates is explained afterwards.

TABLE 4.1: Summary statistics of stocks, bonds, property, treasury bills, inflation and wage growth simulations.

		Statistics			
	Variable	Mean	Standard deviation	Minimum	Maximum
(1)	Stocks	0.071	0.169	-0.7441	1.3231
(2)	Bonds	0.0363	0.0484	-0.3538	0.2844
(3)	Property	0.066	0.1738	-0.8509	0.9899
(4)	Treasury bills	0.0125	0.0076	0	0.0732
(5)	Inflation	0.02	0.0099	-0.0197	0.075
(6)	Wage growth	0.025	0.0128	0	0.099

In the simulations, stocks and property have an annual return of 7.1% and 6.6% with a standard deviation of 16.9% and 17.38% respectively. Property has a lower return and a higher standard deviation than stocks which is in line with the findings of Hoevenaars et al. [2008]. Bonds have an annual return and a standard deviation of 3.63% and 4.84%,

[1]The simulations are provided by Asset Liability Management department of APG.

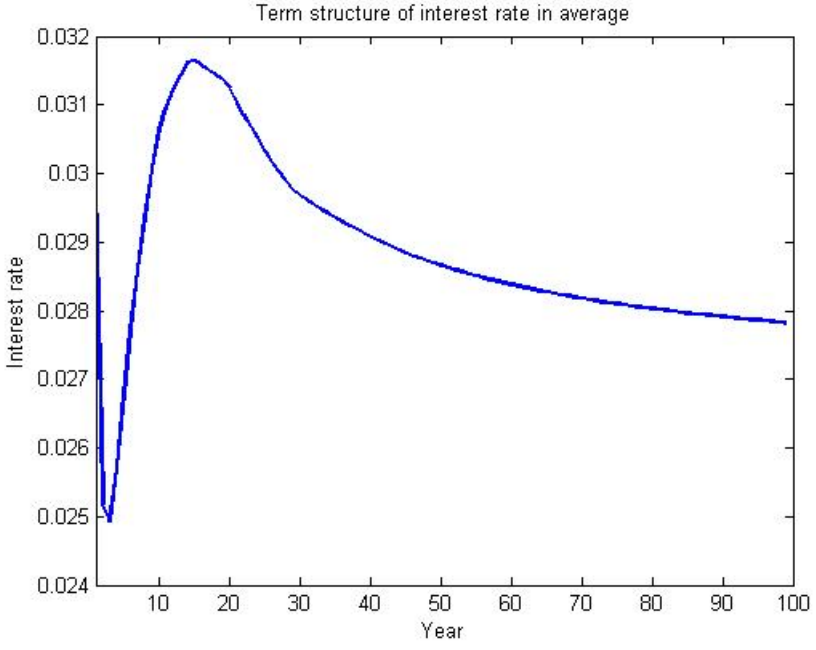
respectively. Treasury bills have the lowest return of 1.25% which corresponds with the lowest standard deviation of 0.76%. Inflation and wage growth have an annual growth rate of 2% and 2.5% with a standard deviation of 0.99% and 1.28% respectively.

TABLE 4.2: Correlation matrix simulation between stocks, bonds, property, treasury bills, inflation and wage growth.

		Correlation matrix					
	Variable	(1)	(2)	(3)	(4)	(5)	(6)
(1)	Stocks	1					
(2)	Bonds	-0.0603	1				
(3)	Property	0.3299	-0.0062	1			
(4)	Treasury bills	-0.0832	-0.2891	0.0197	1		
(5)	Inflation	-0.0036	-0.0584	0.0515	0.4553	1	
(6)	Wage growth	0.0666	-0.0027	0.0445	0.2218	0.3220	1

Table 4.2 shows the correlation between the financial assets and the economic variables. Stocks have positive correlation with property and wage growth. According to Quan and Titman [1997], this strong correlation between stocks and property is caused by the same economic activity that causes these variables to move together. The correlation between bonds and treasury bills is negative at -0.2891. Treasury bills have positive correlation with inflation and wage growth at 0.4553 and 0.2218 respectively. The correlation between inflation and wage growth is also positive at 0.3220.

FIGURE 4.1: The term structure of interest rate at retirement



To evaluate the annuity factor, the term structure of interest rate in the future is simulated. At retirement, the net present value of future pension payments are discounted with

the appropriate interest rate. Figure 4.1 shows the evolution of the interest rate from retirement on average. The term structure starts at a rate of 2.99% then decreases for 3 years. Afterwards, the interest rate begins to increase for the next 12 years to 3.16%. Then the following years, the term structure of interest rates is declining moderately.

4.2 Wage profiles for the different countries

In this section, the starting salary levels in different countries are discussed and the career salary profiles are described. Three different starting levels are provided, namely the low wage, the average wage and the high wage level. The minimum monthly salary in different countries is retrieved from Eurostat (Netherlands and Poland), UK government website (United Kingdom)[2] and www.salaryexplorer.com (Italy)[3]. For the average wage and high wage level, the numbers are retrieved from van der Horst [2013].

The three starting salary levels in different countries are provided in Table 4.3. Because the United Kingdom and Poland have different currencies, the exchange rate at 20 May 2014 is applied. After converting all wages to Euro, all three starting salary levels are the highest in the Netherlands and the lowest in Poland. For the base settings, the average wage level is used.

TABLE 4.3: The starting salary levels for different countries

Country		Starting salary level			
		Low	Average	High	Exchange rate
Netherlands	Euro	17,632.8	28,652	57,304	
United Kingdom	Euro	15,961.78	23,626	47,252	1 GBP = 1.24 EUR
	NCU	(12,872.4)	(19,053.23)	(38,106.45)	
Italy	Euro	9,600	21,424	42,848	
Poland	Euro	4,712.76	8,088	16,176	1 PLN = 0.24 EUR
	NCU	(19,636.5)	(33,700)	(67,400)	

**NCU: National currency units*

For this thesis, three different career salary profiles are considered. These are manual occupations, non-manual occupations and all occupations. These different career salary profiles are investigated later on. For the base analysis, the 'all occupations' career salary profile with an average starting salary level is applied. The development of the three distinct career salary profiles is provided in Figure 3.1.

[2] www.gov.uk/national-minimum-wage-rates

[3] Because Italy does not have a minimum requirement salary,the lowest salary level taken from the observations by www.salaryexplorer.com is assigned for this minimum value.

Chapter 5

Results

This section presents the results for the different countries. Each country is discussed thoroughly in a separate section. Furthermore, sensitivity analysis are performed.

5.1 Netherlands

5.1.1 First pillar and second pillar replacement rates

The distribution of the first pillar replacement rate for the average wave level with the 'all occupations' career salary profile is given in Table 5.1. From the simulations, the average first pillar replacement rate is 40.98%. Because the first pillar entitlements increase with the stochastic wage growth and career growth, this distribution has a standard deviation of 0.59%.

TABLE 5.1: Distribution of the first pillar replacement rate for average worker earnings in the Netherlands

Salary level	Statistics				
	Mean	Median	Standard deviation	Max	Min
All occupations					
Average wage level	0.4098	0.4100	0.0059	0.4245	0.3853

Table 5.2 shows the mean, median, standard deviation (SD), maximum, minimum, coefficient of variation (CV) and interquartile range ratio (IQRR) of the total replacement rate for each different asset-allocation strategy. The last two coefficients are given to measure the dispersion of the replacement rate. Higher CV and IQRR[1] values mean that the spread of the replacement rate is wider.

[1] $CV = \frac{\sigma}{\mu}$ and $IQRR = \frac{Q_{0.75} - Q_{0.25}}{Q_{0.5}}$

TABLE 5.2: Distribution of the replacement rate for every allocation strategy in the Netherlands

	Strategy			
	Bonds/Bills	Aggressive	PFA	Lifestyle
Mean	0.8946	3.3505	1.2379	1.6062
Median	0.8903	2.3775	1.2204	1.4604
SD	0.0737	3.0760	0.2295	0.7153
Max	1.2079	30.7077	2.2237	6.7627
Min	0.6754	0.3845	0.5942	0.5014
CV	0.0824	0.9181	0.1854	0.4453
IQRR	0.1093	1.1894	0.2457	0.5885

The result indicates that strategies with more allocation to risky asset (stocks and property) have a higher mean and median. The 'aggressive' strategy has the highest mean and median whereas the 'bond/bills' strategy has the lowest mean and median. However, the lower expected replacement rate is compensated by a lower standard deviation, which will result in less replacement rate dispersion. The values of the CV and the IQRR tend to increase with the strategies that have a higher proportion in risky assets. For example, the IQRR for the 'aggressive' strategy is 1.1894 while for the 'bonds/bills' strategy is 0.1093. The 'pension fund average' and 'lifestyle' strategies have lower dispersion than the 'aggressive' strategy but higher dispersion than the 'bonds/bills' strategy.

5.1.2 Evaluation of the strategies

As the base setting, the replacement rate target is set at 70%, which is the typical replacement rate in DB schemes in the Netherlands. This target is useful to determine the performance of the different allocation strategies for individuals. Table 5.3 presents the downside risk and the tail-related risk estimates for every allocation strategy.

The results show that the 'bonds/bills' strategy has the lowest LPM_0 of 0.0012, whereas the 'aggressive' strategy has the highest LPM_0 of 0.0372. This means that there is a probability of 0.12% that the 'bonds/bills' strategy will not achieve the target level. LPM_1 and LPM_2 provide the magnitude of the shortfall and the downside semi-variance respectively. Similar results are found for LPM_1 and LPM_2 indicating that the 'bonds/bills' strategy is the lowest and the 'aggressive' strategy is the highest. This means that the 'aggressive' strategy has an expected shortfall of 0.344% with a downside semi-variance of 0.0487%.

All the strategies have VaR estimates above the proposed threshold of 50%. The 'PFA' strategy has the highest VaR and the 'aggressive' strategy has the lowest VaR. It should

be taken into account that the ETL of the other three strategies beside the 'bonds/bills' strategy are significantly different from their VaR estimates. The reason is that the 'bonds/bills' strategy consists of less risky assets compared to the other strategies, which results in less extreme outcomes.

TABLE 5.3: Estimation of downside risk and tail risk for average wave level with 'all occupations' career salary profile in the Netherlands

	Strategy			
	Bonds/Bills	Aggressive	PFA	Lifestyle
Downside risk estimates				
LPM_0	1.20E-03	3.72E-02	2.20E-03	1.34E-02
LPM_1	1.94E-05	3.44E-03	5.67E-05	6.18E-04
LPM_2	3.81E-07	4.87E-04	3.75E-06	4.55E-05
SR	**315.467**	120.328	278.306	103.746
Tail risk estimates				
VaR	0.7794	0.7467	0.8909	0.7913
ETL	0.7564	0.6374	0.8276	0.7237

According to the defined rules, the 'bonds/bills' strategy is optimal as it has the highest SR and the VaR is above 50%. The reason that this strategy is optimal is explained in the following analysis. The first pillar replacement rate for the base setting profile ('all occupations' with average starting salary level) is 40.98%, which means less pension income from the second pillar is needed to achieve the target level. The 'bonds/bills' strategy is the 'safest' strategy to obtain the replacement rate target. It is the 'safest' strategy because it has the lowest probability of shortfall, expected shortfall and downside semi-variance. Even though this strategy has the lowest expected returns compared to other strategies (resulting in a decreasing nominator of the SR), it is compensated by having the lowest downside semi-variance (resulting in a decreasing denominator of the SR).

5.1.3 Sensitivity Analysis

5.1.3.1 Various replacement rate targets

As it was mentioned before, there is no objective way to decide on the target level. In this section, the effect of different replacement rate targets is provided for several target levels as a robustness check. The considered target levels range from 70% to 85%. Table 5.4 shows the downside risk estimates for a replacement rate target of 75%, 80% and 85%.

TABLE 5.4: The downside risk estimates for different replacement rate target levels

	Strategy			
	Bonds/Bills	Aggressive	PFA	Lifestyle
Target level of 75%				
LPM_0	1.54E-02	5.08E-02	5.80E-03	3.06E-02
LPM_1	3.02E-04	5.63E-03	2.37E-04	1.72E-03
LPM_2	1.08E-05	9.35E-04	1.71E-05	1.56E-04
SR	43.982	85.236	**118.089**	52.090
Target level of 80%				
LPM_0	9.12E-02	6.36E-02	1.24E-02	5.58E-02
LPM_1	2.58E-03	8.51E-03	6.34E-04	3.84E-03
LPM_2	1.23E-04	1.64E-03	5.82E-05	4.24E-04
SR	8.563	**63.179**	57.517	29.139
Target level of 85%				
LPM_0	2.77E-01	8.04E-02	2.86E-02	8.44E-02
LPM_1	1.12E-02	1.21E-02	1.59E-03	7.37E-03
LPM_2	7.35E-04	2.66E-03	1.63E-04	9.72E-04
SR	1.653	**48.568**	30.445	17.633

In the previous analysis, the 'bonds/bills' strategy was optimal for the target level of 70%. However, the results show that different replacement rate targets give different optimal strategies. For a target level of 75%, the 'PFA' strategy is the optimal. On the other hand, the 'aggressive' strategy is optimal for target levels of 80% and 85%. These findings are expected because a higher target level requires a riskier strategy in order to have a higher expected replacement rate.

Interestingly, the 'aggressive' strategy is not optimal for the target level of 75%. When the target level is 75%, the 'PFA' strategy generates a lower downside semi-variance (LPM_2) estimate than the 'aggressive' strategy. Moreover, changing the target level to 80% or 85% will certainly bring both strategies to have more replacement rate scenarios below the target level. This is because the magnitude changes of LPM_2 between the 'aggressive' and the 'PFA' strategy is significant. For instance, the LPM_2 of the 'PFA' strategy from the target level of 75% to 80% is 3.4 times higher. On the other hand, the LPM_2 of the 'aggressive' strategy from the target level of 75% to 80% is 1.76 times higher. This difference in magnitude changes results in a higher SR for the 'aggressive' strategy as it has smaller changes in the denominator than the 'PFA' strategy.

5.1.3.2 Different career salary profiles and salary levels

In this section, two different starting salary levels (low and high salary level) and two additional career salary profiles ('manual' and 'non-manual' occupations) are included.

The distribution of the first pillar replacement rate for each different career salary profile and for each starting salary level is given in Table 5.5.

TABLE 5.5: Distribution of the first pillar replacement rate for each different career salary profile and different starting salary level

Salary level	Statistics				
	Mean	Median	SD	Max	Min
All occupations					
Low	0.6658	0.6663	0.0096	0.6897	0.6261
Average	0.4098	0.4100	0.0059	0.4245	0.3853
High	0.2049	0.2050	0.0030	0.2122	0.1927
Manual occupations					
Low	0.7017	0.7022	0.0101	0.7269	0.6599
Average	0.4319	0.4321	0.0062	0.4473	0.4061
High	0.2159	0.2161	0.0031	0.2237	0.2031
Non-manual occupations					
Low	0.5160	0.5163	0.0074	0.5345	0.4852
Average	0.3175	0.3177	0.0046	0.3289	0.2986
High	0.1588	0.1589	0.0023	0.1645	0.1493

Because the Netherlands employ a flat-rate scheme for their first pillar, different career salary profiles and salary levels have a significant impact on the first pillar replacement rate. For every career salary profile, the first pillar replacement rate is decreasing for a higher starting salary level. Intuitively, flat basic pensions received by individuals with a high salary level are relatively low in terms of their pre-retirement income.

Table 5.6 shows the estimation of downside risk and tail-related risk for each different career salary profile and each different starting salary level. The result shows that different career salary profiles and different starting salary levels have a significant impact on the optimal strategy. To make the analysis less complicated, it is better to fixate on each starting level separately.

Focusing firstly on the low wage level, all career salary profiles have a VaR above 50%, which is caused by a high first pillar replacement rate. For 'all occupations' and 'manual occupations', all strategies except the 'aggressive' strategy are optimal. These strategies perform well because they generate all replacement rate scenarios above the target level, which result to LPM_2 being nil. Interestingly, the result is different for the 'non-manual occupations' profile. 'Bonds/bills' is the only optimal strategy that produces all replacement rate scenarios above the target level. As 'non-manual occupations' have a lower first pillar replacement rate (51.6%) caused by higher salary growth, a higher replacement rate from the second pillar is desired. However, the target replacement rate still can be fulfilled by a less volatile strategy, which does not require high returns.

TABLE 5.6: Estimation of downside risk and tail-related risk for each different career salary profile and different starting salary level

	Salary											
	Low wage level Strategy				Average wage level Strategy				High wage level Strategy			
	B/B	A	PFA	L	B/B	A	PFA	L	B/B	A	PFA	L
	All occupations											
Downside risk estimates												
LPM_0	0	6.00E-04	0	0	1.20E-03	3.72E-02	2.20E-03	1.34E-02	5.84E-01	9.92E-02	5.70E-02	1.20E-01
LPM_1	0	1.27E-05	0	0	1.94E-05	3.44E-03	5.67E-05	6.18E-04	3.42E-02	1.71E-02	3.87E-03	1.29E-02
LPM_2	0	5.58E-07	0	0	3.81E-07	4.87E-04	3.75E-06	4.55E-05	3.00E-03	4.26E-03	4.44E-04	2.06E-03
SR	**Inf**	3898.811	**Inf**	**Inf**	**315.467**	120.328	278.306	103.746	-0.184	**37.554**	15.838	10.900
Tail risk estimates												
VaR	1.033	1.003	1.146	1.048	0.779	0.747	0.891	0.791	0.576	0.541	0.689	0.586
ETL	1.008	0.894	1.082	0.979	0.756	0.637	0.828	0.724	0.555	0.432	0.624	0.519
	Manual occupations											
Downside risk estimates												
LPM_0	0	2.00E-04	0	0	8.00E-04	3.38E-02	1.20E-03	1.16E-02	6.23E-01	9.96E-02	6.24E-02	1.25E-01
LPM_1	0	2.85E-06	0	0	7.46E-06	2.88E-03	3.55E-05	4.63E-04	3.78E-02	1.70E-02	4.14E-03	1.33E-02
LPM_2	0	4.05E-08	0	0	8.27E-08	3.78E-04	2.49E-06	3.07E-05	3.34E-03	4.17E-03	4.67E-04	2.11E-03
SR	**Inf**	14307.442	**Inf**	**Inf**	**689.700**	134.218	337.739	124.819	-0.304	**37.087**	14.639	10.361
Tail risk estimates												
VaR	1.055	1.029	1.165	1.070	0.787	0.758	0.896	0.799	0.573	0.541	0.682	0.582
ETL	1.030	0.922	1.103	1.003	0.764	0.652	0.834	0.734	0.552	0.436	0.619	0.518
	Non-manual occupations											
Downside risk estimates												
LPM_0	0	1.92E-02	2.00E-04	2.20E-03	3.11E-01	8.28E-02	3.28E-02	8.78E-02	9.73E-01	1.45E-01	2.10E-01	2.46E-01
LPM_1	0	1.07E-03	7.50E-06	5.82E-05	1.10E-02	1.07E-02	1.55E-03	6.54E-03	1.27E-01	2.88E-02	1.82E-02	3.23E-02
LPM_2	0	9.64E-05	2.81E-07	1.88E-06	6.27E-04	2.01E-03	1.35E-04	7.33E-04	1.97E-02	8.03E-03	2.52E-03	6.21E-03
SR	**Inf**	227.220	967.936	468.629	1.286	**45.327**	27.129	16.376	-0.903	20.899	3.114	3.611
Tail risk estimates												
VaR	0.832	0.807	0.926	0.845	0.635	0.606	0.728	0.645	0.478	0.446	**0.571**	0.488
ETL	0.811	0.714	0.872	0.788	0.616	0.515	0.674	0.590	0.460	0.356	0.516	0.432

B/B : the 'bonds/bills' strategy, A : the 'aggressive' strategy, PFA : the 'pension fund average' strategy, L : the 'lifestyle' strategy

Turning to the average wage level, all career salary profile also have a VaR above 50%. For 'all occupations' and 'manual occupations', the 'bonds/bills' strategy is optimal. The intuition is similar as before, namely that this strategy has sufficient returns to achieve the target level with the smallest downside semi-variance. However, the 'aggressive' strategy is optimal for individuals with the 'non-manual occupations' profile. Because these individuals have a first pillar replacement rate of 31.75%, strategies with higher returns are required to achieve the target level.

Individuals with the high wage level have a low expected replacement rate of the first pillar (20.49% for 'all occupations', 21.59% for 'manual occupations' and 15.88% for 'non-manual occupations'). Intuitively, riskier strategies are needed to meet the required replacement rate. Hence, the 'aggressive' strategy is indeed optimal for 'all occupations' and 'manual occupations'. However, this strategy is not optimal for the 'non-manual occupations' as it has a VaR of 44.6%, which does not meet the requirement. Therefore, 'PFA' is the optimal strategy because it has a VaR above 50%. The reason that this strategy has a VaR above the threshold is because it is a well-diversified portfolio that avoids extreme outcomes.

5.2 United Kingdom

5.2.1 First pillar and second pillar replacement rates

Table 5.7 shows the distribution of the first pillar replacement rate for the average wage level with the 'all occupations' career salary profile in the United Kingdom. From the simulation, the average first pillar replacement rate is 50.26% with a standard deviation of 4.22%. Previous research found that the United Kingdom has a lower basic pension than the Netherlands [van der Horst, 2013]. However, this thesis shows that the United Kingdom has a higher first pillar replacement rate after applying more precise indexation rates and more equitable calculations for the basic pension. It has a higher replacement rate because the first pillar entitlements grow with a more generous indexation rate, which is the maximum of three rates (the wage growth, the growth of the consumer price index or 2.5%).

TABLE 5.7: Distribution of the first pillar replacement rate for average worker earnings in the United Kingdom

Salary level	Statistics				
	Mean	Median	Standard deviation	Max	Min
All occupations					
Average wage level	0.5026	0.4981	0.0422	0.7019	0.3913

The first pillar replacement rate in the United Kingdom is more volatile compared to the replacement rate of the Netherlands' because of the following reasons. The basic pension is obtained from two tiers, which are the flat-rate (BSP) tier and the earning-related (S2P) tier. The entitlements from the flat-rate tier grow depending on three indexation rates which create more volatility. Moreover, the entitlements from the earnings-related tier also create more uncertainty because they depend on the individual's salary level, which is affected by a stochastic variable.

Table 5.8 provides the distribution of the total replacement rate for every allocation strategy in the United Kingdom. Even though the first pillar replacement rate is higher in the United Kingdom, the expected total replacement rate is lower compared to the Netherlands. This can be explained by the fact that individuals in the United Kingdom have a low contribution rate of only 8% to the second pillar[2].

[2]The contribution rate of 8% is set in such a way that resembles the minimum requirement contribution rate to the DC schemes in the United Kingdom

TABLE 5.8: Distribution of the replacement rate for every allocation strategy in the United Kingdom

	Strategy			
	Bonds/Bills	Aggressive	PFA	Lifestyle
Mean	0.7372	1.9263	0.9035	0.9813
Median	0.7336	1.4551	0.8937	0.9372
SD	0.0677	1.4935	0.1283	0.2399
Max	0.9953	16.6119	1.4693	2.8082
Min	0.5538	0.4538	0.5633	0.5341
CV	0.0918	0.7753	0.1420	0.2445
IQRR	0.1259	0.9429	0.1872	0.3208

5.2.2 Evaluation of the strategies

Table 5.9 shows the downside risk and the tail-related risk estimates for every strategy in the United Kingdom. The result shows that the 'bonds/bills' strategy has the highest probability of failing to achieve the target level (31.2%) and the 'PFA' strategy has the lowest probability (4.02%). Similar results are found for the expected shortfall (LPM_1) and the downside semi-variance (LPM_2) indicating that the 'PFA' strategy still has the lowest moments and the 'bonds/bills' strategy still has the highest moments. This means that the 'bonds/bills' strategy has the highest expected shortfall of 1.16% with the highest downside semi-variance of 0.0659%.

TABLE 5.9: Estimation of downside risk and tail risk for every allocation strategy in the United Kingdom

	Strategy			
	Bonds/Bills	Aggressive	PFA	Lifestyle
Downside risk estimates				
LPM_0	3.12E-01	7.02E-02	4.02E-02	7.74E-02
LPM_1	1.16E-02	4.95E-03	1.27E-03	3.51E-03
LPM_2	6.59E-04	5.22E-04	6.97E-05	2.51E-04
SR	1.450	**53.672**	24.367	17.765
Tail risk estimates				
VaR	0.6363	0.6628	0.7100	0.6754
ETL	0.6157	0.6078	0.6756	0.6363

All strategies have VaR estimates above the threshold of 50%. The 'PFA' strategy has the highest VaR and the 'bonds/bills' strategy has the lowest VaR. However, the ETL estimate should also be considered. The 'aggressive' strategy has the lowest ETL because it has more extreme outcomes compared to the other strategies. On the other hand, the 'PFA' strategy has the highest ETL because of its diversification benefits.

The 'aggressive' strategy appears to be the best strategy because it has the highest SR with a VaR above 50%. It seems a surprise because this strategy does not stand out when considering its lower partial moments. This can be explained by the following reasons. The 'aggressive' strategy has a higher expected replacement rate compared to the 'PFA' strategy, which creates a higher numerator of the SR given the target level. Even though the 'aggressive' strategy is more volatile, its higher expected replacement rate outweighs its downside semi-variance. To say it in other words, the 'aggressive' strategy has a higher reward that offsets its downside risk.

5.2.3 Sensitivity Analysis

5.2.3.1 Various replacement rate targets and contribution rates

TABLE 5.10: The downside risk estimates for different replacement rate target levels

	Strategy			
	Bonds/Bills	Aggressive	PFA	Lifestyle
Target level of 75%				
LPM_0	5.95E-01	1.05E-01	1.09E-01	1.44E-01
LPM_1	3.41E-02	9.32E-03	4.75E-03	9.07E-03
LPM_2	2.82E-03	1.22E-03	3.42E-04	8.53E-04
SR	-0.241	**33.663**	8.293	7.921
Target level of 80%				
LPM_0	8.29E-01	1.36E-01	2.12E-01	2.35E-01
LPM_1	7.03E-02	1.54E-02	1.25E-02	1.85E-02
LPM_2	7.95E-03	2.44E-03	1.16E-03	2.19E-03
SR	-0.704	**22.785**	3.037	3.872
Target level of 85%				
LPM_0	9.42E-01	1.69E-01	3.62E-01	3.32E-01
LPM_1	1.15E-01	2.31E-02	2.68E-02	3.28E-02
LPM_2	1.72E-02	4.35E-03	3.06E-03	4.72E-03
SR	-0.861	**16.316**	0.966	1.912

Similarly to the Netherlands, robustness checks for different target levels are performed. Table 5.10 shows the downside risk estimates for target levels of 75%, 80% and 85%. The result shows that different target levels do not change the optimal strategy. It is expected that the 'aggressive' strategy will dominate for these different target levels because of the following explanation. As the target level is set higher, more riskier strategies are needed to achieve it. Because the 'aggressive' strategy is the most risky strategy that is available in this analysis, other strategies definitely will not be optimal.

It is mentioned above that individuals in the United Kingdom can choose their own contribution rate with a minimum rate of 8%. This section provides the analysis for different contribution rates in the United Kingdom. Table 5.11 provides the estimation of the downside risk and tail-related risk for contribution rates of 12% and 16%. The result shows that different contribution rates affect the optimal strategy. The 'PFA' strategy is optimal for the contribution rate of 12% and both 'bonds/bills' and 'PFA' are the optimal strategy for the contribution rate of 16%.

TABLE 5.11: Estimation of the downside risk and tail-related risk for each different contribution rate

	Strategy							
	Bonds/Bills	Aggressive	PFA	Lifestyle	Bonds/Bills	Aggressive	PFA	Lifestyle
	Contribution rate of 12%				*Contribution rate of 16%*			
	Downside risk estimates				*Downside risk estimates*			
LPM_0	1.58E-02	3.22E-02	3.60E-03	1.54E-02	0	1.78E-02	0	2.60E-03
LPM_1	2.76E-04	2.15E-03	8.26E-05	5.28E-04	0	1.13E-03	0	6.76E-05
LPM_2	9.99E-06	2.23E-04	3.25E-06	2.71E-05	0	1.23E-04	0	3.04E-06
SR	48.877	129.931	**224.233**	100.039	**Inf**	239.326	**Inf**	435.901
	Tail risk estimates				*Tail risk estimates*			
VaR	0.7292	0.7524	0.8340	0.7696	0.8212	0.8343	0.9537	0.8619
ETL	0.7051	0.6662	0.7833	0.7170	0.7930	0.7235	0.8881	0.7955

When the contribution rate is increased, all strategies produce more replacement rate scenarios above the target level. Then, the optimal strategy is chosen in such a way that it is a safer investment strategy instead of one with higher replacement rates. Interestingly, the 'bonds/bills' strategy is also optimal for the contribution rate of 16% because this strategy generates all replacement rate scenarios above the target level. Therefore, increasing the contribution rate will result in shifting into a strategy that is less risky.

5.2.3.2 Different career salary profiles and salary levels

Table 5.12 shows the distribution of the first pillar replacement rate for each different career salary profile and each different starting salary level. Even though some parts of the first pillar entitlements come from the earning-related schemes, different starting salary levels and different career salary profiles will still significantly affect the first pillar replacement rate. The entitlements from the flat-rate tier (BSP) are the same for all individuals with different career salary profiles and starting salary levels. On the other hand, the entitlement from the earning-related tier (S2P) should be accrued depending on the individual salary level and profile. However, this entitlement does not fully follow the individual's salary because of the threshold.

TABLE 5.12: Distribution of the first pillar replacement rate for each different career salary profiles and different starting salary levels

Salary level	Statistics				
	Mean	Median	SD	Max	Min
All occupations					
Low	0.6964	0.6893	0.0634	1.0038	0.5444
Average	0.5026	0.4981	0.0422	0.7019	0.3913
High	0.2757	0.2731	0.0311	0.4010	0.1956
Manual occupations					
Low	0.7290	0.7211	0.0677	1.0579	0.5683
Average	0.5243	0.5196	0.0444	0.7344	0.4124
High	0.2904	0.2878	0.0324	0.4172	0.2062
Non-manual occupations					
Low	0.5618	0.5567	0.0483	0.7904	0.4443
Average	0.4107	0.4085	0.0347	0.5664	0.3032
High	0.2137	0.2116	0.0243	0.3137	0.1516

Table 5.13 shows the estimation of downside risk and tail-related risk in the United Kingdom. Individuals with a low wage level have a relatively high expected replacement rate from the first pillar. As it is expected, a less risky strategy is optimal for the 'all occupations' and the 'manual occupations' career salary profile. However, it is not the case for the 'non-manual occupations', where the 'aggressive' strategy is optimal. This can be explained as follows. For the 'non-manual' career salary profile, all simulated individuals earnings are located far above the LET, where they get accrual of 10% of the difference of their earnings and LET[3]. On the other hand, individuals with the 'manual occupations' and 'all occupations' have earnings that are close to the LET. Hence, the 10% accrual rate is less significant for the 'manual occupations' and the 'all occupations' than for the 'non-manual occupations' career salary profile. Similarly, the 'aggressive' strategy is optimal for all career salary profiles with the average wage level.

Interestingly, 'PFA' is the optimal strategy for individuals with the high wage level for all career salary profiles because it has the highest VaR. The result shows that all strategies have a VaR below 50%. These low replacement rate scenarios might be caused by the following reasons. In most of the scenarios, individuals with a high wage level have earnings above the UEL[4]. All individuals with earnings above the UEL receive the same entitlements from the earning-related tier, which is about 40% of the difference between LET and UEL. Hence, the difference of their earnings and the UEL are not considered for the calculation of the entitlements. Moreover, a low contribution rate of

[3]Remember that the United Kingdom has the threshold system for their earning-related scheme. LET stands for the lower earning threshold

[4]UEL stands for the upper earning limit

8% to the second pillar might be insufficient for these individuals to achieve a VaR above the threshold.

TABLE 5.13: Estimation of downside risk and tail risk for each different career salary profiles and different starting salary levels

	Salary											
	Low wage level Strategy				Average wage level Strategy				High wage level Strategy			
	B/B	A	PFA	L	B/B	A	PFA	L	B/B	A	PFA	L
	All occupations											
Downside risk estimates												
LPM_0	0	2.00E-03	0	4.00E-04	3.12E-01	7.02E-02	4.02E-02	7.74E-02	9.98E-01	2.20E-01	6.04E-01	4.80E-01
LPM_1	0	8.41E-05	0	7.29E-07	1.16E-02	4.95E-03	1.27E-03	3.51E-03	1.90E-01	3.82E-02	6.21E-02	6.33E-02
LPM_2	0	4.48E-06	0	2.47E-09	6.59E-04	5.22E-04	6.97E-05	2.51E-04	3.93E-02	8.99E-03	9.18E-03	1.17E-02
SR	**Inf**	670.961	**Inf**	9565.930	1.450	**53.672**	24.367	17.765	-0.957	10.540	-0.245	0.503
Tail risk estimates												
VaR	0.803	0.854	0.882	0.857	0.636	0.663	0.710	0.675	0.423	0.439	**0.493**	0.451
ETL	0.778	0.792	0.848	0.812	0.616	0.608	0.676	0.636	0.404	0.383	0.458	0.415
	Manual occupations											
Downside risk estimates												
LPM_0	0	1.60E-03	0	0	2.51E-01	5.98E-02	3.00E-02	6.14E-02	9.98E-01	2.19E-01	6.02E-01	4.79E-01
LPM_1	0	3.48E-05	0	0	8.32E-03	3.89E-03	8.54E-04	2.56E-03	1.84E-01	3.68E-02	6.05E-02	6.14E-02
LPM_2	0	1.43E-06	0	0	4.29E-04	3.72E-04	4.31E-05	1.67E-04	3.72E-02	8.39E-03	8.74E-03	1.10E-02
SR	**Inf**	1187.796	**Inf**	**Inf**	2.412	**62.993**	32.212	22.292	-0.954	10.714	-0.240	0.518
Tail risk estimates												
VaR	0.823	0.879	0.901	0.879	0.648	0.678	0.721	0.689	0.428	0.446	**0.498**	0.458
ETL	0.798	0.818	0.868	0.835	0.627	0.624	0.687	0.650	0.410	0.393	0.464	0.423
	Non-manual occupations											
Downside risk estimates												
LPM_0	1.92E-01	5.14E-02	2.28E-02	4.56E-02	9.37E-01	1.66E-01	3.45E-01	3.24E-01	1.00E+00	3.15E-01	9.20E-01	7.28E-01
LPM_1	5.47E-03	2.61E-03	5.51E-04	1.64E-03	9.06E-02	1.86E-02	2.09E-02	2.59E-02	2.86E-01	6.66E-02	1.54E-01	1.32E-01
LPM_2	2.49E-04	2.10E-04	2.49E-05	8.83E-05	1.09E-02	2.88E-03	1.99E-03	3.04E-03	8.38E-02	1.86E-02	3.19E-02	3.11E-02
SR	3.953	**71.044**	39.897	27.795	-0.849	**16.349**	1.077	1.993	-0.987	4.985	-0.834	-0.494
Tail risk estimates												
VaR	0.661	0.697	0.726	0.704	0.525	0.550	0.586	0.560	0.343	0.354	**0.400**	0.366
ETL	0.641	0.648	0.696	0.667	0.504	0.502	0.557	0.526	0.328	0.308	0.372	0.337

5.3 Italy

The analysis for Italy is different because it has a surprising outcome. After several simulations are performed, the optimal strategy cannot be defined as it does not converge to one particular strategy. This thesis finds that the timing of the unemployment is a crucial factor while determining the optimal strategy. This section provides two cases with respect to the unemployment period occurs one at the younger age and one at the older age, consecutively[5].

5.3.1 First pillar and second pillar replacement rates

Table 5.14 provides the distribution of the first pillar replacement rate for two cases with an 'all occupations' career salary profile. Remember that Italy has a NDC system for the first pillar, which means that the entitlements received at retirement are significantly affected by the contributions of the individuals. When individuals are unemployed, they do not contribute to their NDC account. The result shows that the replacement rate is lower when the unemployment period occurs in the older age. Even though the length of the unemployment period is the same, individuals that are unemployed at a younger age will benefit from the wage growth received at the older age. Although, the individuals that are unemployed when older will receive higher cumulative returns on contribution, it will not compensate for the cumulative wage growth.

TABLE 5.14: Distribution of the first pillar replacement rate for 'all occupations' career salary level

Career salary profile	Statistics				
	Mean	Median	Standard deviation	Max	Min
Unemployment period in younger age					
All occupations	0.7807	0.7780	0.0643	1.0213	0.5914
Unemployment period in older age					
All occupations	0.7544	0.7505	0.0718	1.0248	0.5402

Individuals can voluntarily contribute 6.91% of their salary to the second pillar. Tabel 5.15 shows the total replacement rate from the first and the second pillar for two cases in Italy. The result shows that the 'aggressive' and the 'lifestyle' strategy are significantly higher for the individuals that are unemployed in older age compared to individuals that are unemployed in younger age. The individuals that are unemployed in the older age

[5]Italy has unemployment rate of 12.2%, which means on average 5 unemployment years given 42 working years. When the unemployment period occurs at the younger period, the individuals will work at age 30 instead of 25. Similarly to the other case, the individuals will be unemployed for 5 years before retirement.

will accrue their wealth in earlier age compared to the other case. This gives them the advantage of receiving higher cumulative returns on investment.

TABLE 5.15: Distribution of the replacement rate for every allocation strategy in Italy

	Strategy								
	Bonds/Bills	Aggressive	PFA	Lifestyle		Bonds/Bills	Aggressive	PFA	Lifestyle
Unemployment period in younger age					*Unemployment period in older age*				
Mean	0.980	1.773	1.104	1.151	Mean	0.950	2.055	1.103	1.178
Median	0.977	1.485	1.096	1.123	Median	0.947	1.617	1.093	1.138
SD	0.083	0.971	0.123	0.187	SD	0.092	1.397	0.143	0.24
Max	1.273	10.426	1.607	2.365	Max	1.282	14.729	1.685	2.946
Min	0.728	0.665	0.743	0.721	Min	0.673	0.610	0.692	0.661
CV	0.084	0.547	0.111	0.163	CV	0.097	0.680	0.129	0.204
IQRR	0.115	0.641	0.151	0.215	IQRR	0.133	0.798	0.175	0.267

5.3.2 Evaluation of the strategies

Table 5.16 presents the downside risk and the tail-related risk estimates for two cases in Italy. The result shows that 'aggressive' is the only strategy that has a probability of failing to achieve the target level for the individuals that are unemployed in younger age. The other strategies perform well because of the following reasons. The expected replacement rate of the first pillar is already adequate to reach the target level. Hence, the 'aggressive' strategy is not appropriate because it creates more volatility, which can result in more extreme outcomes. Similarly for the individuals that are unemployed in older age, the replacement rate from the first pillar is high enough to achieve the target level. This results in choosing a strategy that is safer and more diversified to avoid extreme outcomes.

TABLE 5.16: Estimation of downside risk and tail-related risk in Italy

	Strategy								
	Bonds/Bills	Aggressive	PFA	Lifestyle		Bonds/Bills	Aggressive	PFA	Lifestyle
Unemployment period in younger age					*Unemployment period in older age*				
Downside risk estimates					Downside risk estimates				
LPM_0	0	4.00E-04	0	0	LPM_0	1.20E-03	1.60E-03	2.00E-04	6.00E-04
LPM_1	0	1.06E-05	0	0	LPM_1	1.51E-05	6.31E-05	1.67E-06	1.43E-05
LPM_2	0	3.11E-07	0	0	LPM_2	3.07E-07	3.63E-06	1.40E-08	4.49E-07
SR	**Inf**	1926.127	**Inf**	**Inf**	SR	451.184	711.206	**3415.242**	713.128
Tail risk estimates					Tail risk estimates				
VaR	0.848	0.892	0.916	0.896	VaR	0.803	0.863	0.886	0.861
ETL	0.819	0.840	0.878	0.856	ETL	0.772	0.803	0.846	0.816

The result shows that all strategies except the 'aggressive' strategy are optimal for the individuals that are unemployed in younger age. On the other hand, 'PFA' is the only optimal strategy for the individuals that are unemployed in older age. The individuals with the unemployment period in younger age have more than one optimal strategy

because they have a higher replacement rate from the first pillar. Thus, not only the 'PFA' strategy is optimal, but also two other strategies ('bonds/bills' and 'lifestyle') are optimal as these strategies generate all replacement rate scenarios above the target level.

5.3.3 Different career salary profiles and salary levels

Similar to the findings of van der Horst [2013], different starting salary levels have no impact on countries that apply entirely earnings-related schemes (for instance, Italy and Poland). However, different career salary profiles have a significant impact on choosing the optimal strategy. Table 5.17 presents the distribution of the first pillar replacement rate for two cases in Italy.

TABLE 5.17: Distribution of the first pillar replacement rate for each different career salary profile in Italy

Career salary profile	Statistics				
	Mean	Median	Standard deviation	Max	Min
Unemployment period in younger age					
Manual occupations	0.7457	0.7431	0.0613	0.9750	0.5652
Non-manual occupations	0.6749	0.6728	0.0542	0.8783	0.5157
Unemployment period in older age					
Manual occupations	0.7235	0.7196	0.0691	0.9834	0.5172
Non-manual occupations	0.6370	0.6339	0.0597	0.8616	0.4586

Individuals with the 'manual occupations' career salary profile have a higher expected replacement rate from the first pillar compared to the non-manual workers. This can be explained by the fact that non-manual workers have a more diminishing final salary compared to the manual workers. Individuals with 'manual occupations' are referred to individuals working more physically. Intuitively, the productivity of these workers will decrease more quicker when they are older compared to the non-manual workers. Therefore, the salary of the manual workers at retirement will be much lower compared to the working period before retirement.

Table 5.18 presents the estimation of downside risk and tail-related risk for two cases in Italy. The results show that the 'PFA' strategy is optimal in all categories except for the non-manual workers that are unemployed in older age. These individuals have 'aggressive' as their optimal strategy because of the following explanation. As they receive the smallest expected replacement rate of the first pillar, they need to compensate this with higher pension income from the second pillar. Because the contribution is only 6.91% for the second pillar, a more aggressive strategy is needed to achieve the target level. Therefore, the 'aggressive' strategy is appropriate for these individuals.

TABLE 5.18: Estimation of downside risk and tail-related risk for each different career salary profile

	Career salary profile							
	Manual occupations Strategy				Non-manual occupations Strategy			
	B/B	A	PFA	L	B/B	A	PFA	L
Unemployment period in younger age								
Downside risk estimates								
LPM_0	2.00E-04	1.20E-03	0	4.00E-04	1.36E-02	1.02E-02	1.60E-03	4.00E-03
LPM_1	9.15E-07	3.63E-05	0	2.78E-06	2.56E-04	3.03E-04	4.25E-05	9.10E-05
LPM_2	4.18E-09	1.60E-06	0	2.46E-08	7.72E-06	1.73E-05	1.55E-06	3.77E-06
SR	3646.012	788.117	**Inf**	2548.874	52.725	192.290	**200.626**	148.039
Tail risk estimates								
VaR	0.810	0.852	0.875	0.856	0.736	0.772	0.792	0.776
ETL	0.783	0.803	0.839	0.818	0.711	0.728	0.760	0.743
Unemployment period in older age								
Downside risk estimates								
LPM_0	4.20E-03	4.00E-03	6.00E-04	1.40E-03	8.90E-02	3.10E-02	1.32E-02	2.70E-02
LPM_1	8.85E-05	1.38E-04	1.13E-05	4.32E-05	2.69E-03	1.36E-03	3.41E-04	8.33E-04
LPM_2	2.87E-06	8.77E-06	3.46E-07	1.94E-06	1.38E-04	9.66E-05	1.75E-05	4.55E-05
SR	124.829	437.209	**612.455**	311.054	8.669	**101.668**	54.473	42.539
Tail risk estimates								
VaR	0.770	0.827	0.850	0.825	0.680	0.729	0.748	0.727
ETL	0.740	0.770	0.811	0.782	0.654	0.679	0.714	0.690

5.4 Poland

5.4.1 First pillar and second pillar replacement rates

Even though Poland has a similar NDC system for the first pillar as Italy, the timing of unemployment is insignificant for determining the optimal strategy. This can be explained by the fact that Poland has a lower contribution rate to the first pillar compared to Italy. Thus, the expected replacement rate from the first pillar is lower in Poland, which is about 50.42%. If the timing of the unemployment period is different, it will still not result in a different optimal strategy because of the low first pillar entitlements. Table 5.19 provides the distribution of the first pillar replacement rate in Poland.

TABLE 5.19: Distribution of the first pillar replacement rate for average worker earnings in Poland

Salary level	Statistics				
	Mean	Median	Standard deviation	Max	Min
All occupations					
Average wage level	0.5042	0.5024	0.0315	0.6293	0.3713

Individuals who are living in Poland need to contribute 3.5% of their salary to the funded schemes. The contribution to the second pillar in Poland is the lowest compared to the other countries. Hence, the replacement rate from the second pillar is also low in Poland. Table 5.20 provides the distribution of the replacement rate for all strategies in Poland. The result shows that the 'bonds/bills' strategy has the lowest expected replacement rate and the 'aggressive' strategy has the highest expected replacement rate.

TABLE 5.20: Distribution of the replacement rate for every allocation strategy in Poland

	Strategy			
	Bonds/Bills	Aggressive	PFA	Lifestyle
Mean	0.6095	1.1445	0.6842	0.7192
Median	0.6077	0.9324	0.6792	0.6996
SD	0.0423	0.6757	0.0676	0.1151
Max	0.7705	7.3323	0.9735	1.6397
Min	0.4369	0.4598	0.5017	0.4797
CV	0.0694	0.5904	0.0989	0.1600
IQRR	0.0930	0.6724	0.1308	0.2077

5.4.2 Evaluation of the strategies

Table 5.21 presents the estimation of downside risk and tail-related risk for the 'all occupations' career salary profile in Poland. The results show that the 'bonds/bills' strategy has the highest probability of failing to reach the target level (97.7%) and the 'aggressive' strategy has the lowest (23%). Other moments, LPM_1 and LPM_2, also support these findings. The 'bonds/bills' strategy performs poor in Poland because of low basic pensions and a low contribution rate.

TABLE 5.21: Estimation of downside risk and tail-related risk for every allocation strategy in Poland

	Strategy			
	Bonds/Bills	Aggressive	PFA	Lifestyle
Downside risk estimates				
LPM_0	9.77E-01	2.30E-01	6.17E-01	5.01E-01
LPM_1	9.09E-02	1.97E-02	3.58E-02	3.42E-02
LPM_2	9.96E-03	2.33E-03	3.00E-03	3.34E-03
SR	-0.906	**9.219**	-0.288	0.333
Tail risk estimates				
VaR	0.5428	0.5668	0.5809	0.5675
ETL	0.5270	0.5384	0.5614	0.5467

The result shows that the 'aggressive' strategy is optimal for these individuals. A more aggressive strategy is needed because of the following reasons. The first pillar replacement rate is not high enough to help these individuals to achieve the target level. Moreover, the contribution to the second pillar is only 3.5%. A strategy that gives a higher expected replacement rate is more appropriate to achieve the target level. Thus, the 'aggressive' strategy is the best choice for these individuals.

5.4.3 Sensitivity Analysis

5.4.3.1 Various replacement rate targets

As it is expected, increasing the replacement rate target will not change the optimal strategy. Previously, the 'aggressive' strategy was optimal for the target level of 70%. Therefore, increasing the replacement rate target will result in shifting to a strategy that is more risky for acquiring a higher expected replacement rate. As 'aggressive' is the most aggressive strategy, this strategy is still optimal. Table 5.22 presents the downside risk estimates for different target levels.

TABLE 5.22: The downside risk estimates for different replacement rate target levels

	Strategy			
	Bonds/Bills	Aggressive	PFA	Lifestyle
Target level of 75%				
LPM_0	9.99E-01	3.00E-01	8.37E-01	6.64E-01
LPM_1	1.41E-01	3.29E-02	7.28E-02	6.37E-02
LPM_2	2.15E-02	4.92E-03	8.34E-03	8.16E-03
SR	-0.958	**5.622**	-0.720	-0.340
Target level of 80%				
LPM_0	1.00E+00	3.60E-01	9.45E-01	7.91E-01
LPM_1	1.90E-01	4.94E-02	1.18E-01	1.00E-01
LPM_2	3.81E-02	9.01E-03	1.78E-02	1.63E-02
SR	-0.976	**3.629**	-0.867	-0.633
Target level of 85%				
LPM_0	1.00E+00	4.16E-01	9.84E-01	8.75E-01
LPM_1	2.40E-01	6.88E-02	1.66E-01	1.42E-01
LPM_2	5.96E-02	1.49E-02	3.20E-02	2.84E-02
SR	-0.985	**2.413**	-0.926	-0.776

5.4.3.2 Different career salary profiles and salary levels

Table 5.23 provides the distribution of the first pillar replacement rate for each career salary profile in Poland. The result shows that the expected replacement rates of the first

pillar are 48.55% and 42.91% for individuals with the 'manual occupations' and 'non-manual occupations' career salary profile, respectively. Similar to Italy, the individuals with the 'manual occupations' career salary profile have a higher expected replacement rate from the first pillar caused by the relative difference between the salary at retirement and before retirement. In other words, the salary level close to retirement declines more rapidly for the manual workers than for the non-manual workers.

TABLE 5.23: Distribution of the first pillar replacement rate for each different career salary profile

Salary profile	Statistics				
	Mean	Median	Standard deviation	Max	Min
Manual occupations	0.4855	0.4836	0.0304	0.6063	0.3573
Non-manual occupations	0.4291	0.4276	0.0263	0.5328	0.3136

Table 5.24 presents the estimation of downside risk and tail-related risk for the 'manual occupations' and 'non-manual occupations' career salary profile in Poland. For the 'manual occupations' career salary profile, all strategies have a VaR above the threshold. The result shows that the 'aggressive' strategy is optimal for these individuals as it has the highest SR. Because of the low entitlements from the first pillar, an aggressive strategy is required to have a higher probability of reaching the target level.

On the other hand, none of the strategies reaches a VaR threshold of 50% for individuals with the 'non-manual occupations' career salary profile. Therefore, the 'PFA' strategy turns out as the optimal strategy because it has the highest VaR. The result is expected as these individuals have a lower replacement rate from the first pillar. Furthermore, the small contribution rate to the second pillar is unable to compensate for these low entitlements from the first pillar.

TABLE 5.24: Estimation of downside risk and tail-related risk for each different career salary profile

	Salary Profile							
	Manual occupations Strategy				Non-manual occupations Strategy			
	B/B	A	PFA	L	B/B	A	PFA	L
Downside risk estimates								
LPM_0	9.93E-01	2.66E-01	7.52E-01	5.95E-01	1.00E+00	3.92E-01	9.72E-01	8.46E-01
LPM_1	1.13E-01	2.53E-02	5.22E-02	4.70E-02	1.81E-01	4.99E-02	1.20E-01	1.03E-01
LPM_2	1.45E-02	3.29E-03	5.00E-03	5.14E-03	3.40E-02	8.34E-03	1.74E-02	1.56E-02
SR	-0.941	**7.174**	-0.575	-0.085	-0.981	2.780	-0.906	-0.733
Tail risk estimates								
VaR	0.523	0.546	0.560	0.546	0.463	0.483	**0.496**	0.483
ETL	0.507	0.519	0.541	0.526	0.450	0.459	0.478	0.467

5.4.3.3 An appropriate contribution rate for having a less risky strategy

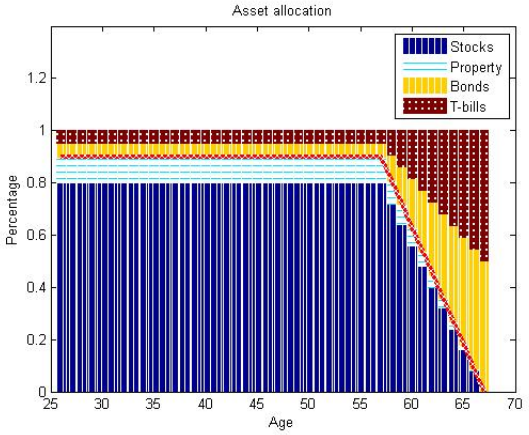
The analysis in the previous section shows that most individuals in Poland have the 'aggressive' strategy as their optimal strategy. This is because they have the lowest replacement rate from the first pillar and the lowest contribution rate to the second pillar compared to the other countries. It appears that individuals living in Poland need to contribute more for having a less risky strategy. In this section, a proper contribution rate is investigated in such a way that other strategies except the 'aggressive' strategy are optimal.

After several simulations with different contribution rates are performed, the results show that a contribution rate of 9.45% is sufficient to have the 'PFA' strategy as the optimal strategy. Moreover, increasing the contribution rate to 14.31% results in the 'bonds/bills' strategy as the optimal strategy. Because the 'aggressive' strategy is really risky, increasing the contribution to the second pillar might be appropriate for the individuals living in Poland. The estimations of downside risk and tail-related risk for the different contribution rates can be found in Appendix D in Table D.2.

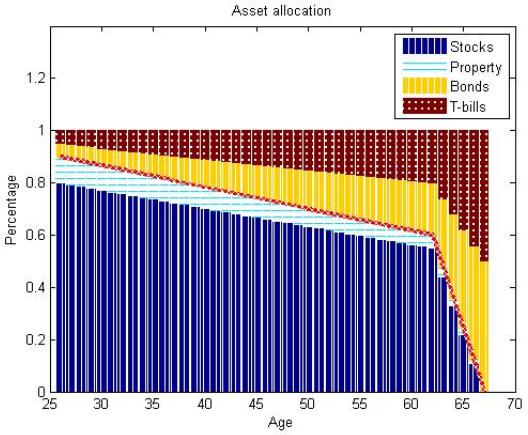
5.5 Why is the lifestyle strategy not optimal?

Lifestyle strategies are the standard strategies for many DC pension schemes. However, it can be seen from the results above that the 'lifestyle' strategy is always outperformed by the other strategies. Therefore, two different types of lifestyle are constructed for a robustness check. The patterns of the previous and different lifestyle strategies are given in Figure 5.1. The Netherlands is used for the analysis in this section.

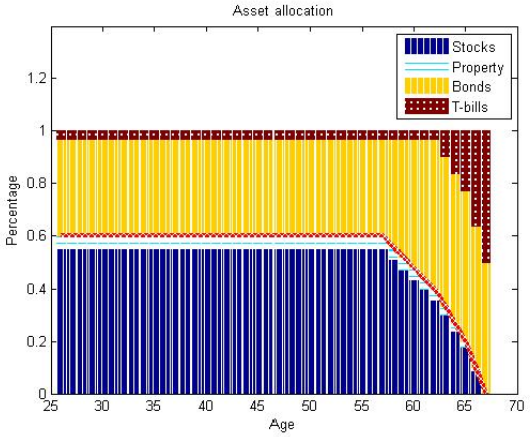
FIGURE 5.1: Different lifestyle patterns



(A) Lifestyle



(B) Lifestyle B



(C) Lifestyle C

The 'lifestyle B' strategy starts with holding 80% equities, 5% bonds, 5% T-bills and 10% property, which is similar to the previous lifestyle strategy. However, the 'lifestyle B' strategy begins to derisk the proportion of risky assets gradually from 90% (80% stocks and 10% property) to 60% (55% stocks and 5% property) during the first 37 working years. Afterwards, it switches into the 'bonds/bills' strategy during the remaining 5 years before retirement. The 'lifestyle C' strategy starts with holding 55% equities, 37% bonds, 3% T-bills and 5% property, which is less risky than two other lifestyle strategies.

Then, the proportion of equities and property will diminish gradually starting from 10 years before retirement to the 'bonds/bills' strategy.

Table 5.25 shows the distribution of the replacement rate for three different lifestyle strategies and the 'PFA' strategy. The 'PFA' strategy is included for a comparison as it is the most diversified strategy in this thesis. The result shows that both new lifestyle strategies have a lower expected replacement rate than the previous lifestyle strategy. However, this 'lifestyle' strategy has the highest standard deviation, which means that it is the most volatile strategy of the three lifestyle strategies.

TABLE 5.25: Distribution of the replacement rate for every strategy

	Strategy			
	Lifestyle	Lifestyle B	Lifestyle C	PFA
Mean	1.400	1.301	1.275	1.239
Median	1.314	1.246	1.241	1.221
SD	0.479	0.358	0.286	0.231
Max	5.028	3.495	2.875	2.280
Min	0.558	0.555	0.616	0.581
CV	0.342	0.275	0.225	0.186
IQRR	0.458	0.371	0.308	0.247

Table 5.26 presents the estimation of the downside risk and the tail-related risk for three different lifestyle strategies and the 'PFA' strategy. The result shows that the 'PFA' strategy outperforms all three lifestyle strategies. Lifestyle strategies decrease gradually the proportion of risky to less risky assets such as bonds and bills as the participants approach retirement. Derisking the pension schemes close to retirement that gives up considerable upside potential might be the reason that the lifestyle strategy is outperformed by the other strategies. Moreover, the lifestyle strategies are more volatile compared to the 'PFA' strategy, which will harm the risk-reward profile valuation. This finding supports the conclusion of Blake et al. [2001]. They also find that the dynamic strategies have been outperformed by static asset-allocation strategies such as a well-diversified strategy with a high equity exposure.

TABLE 5.26: The estimations of the downside risk and tail-related risk for every strategy

	Strategy			
	Lifestyle	Lifestyle B	Lifestyle C	PFA
Downside risk estimates				
LPM_0	1.34E-02	7.80E-03	3.00E-03	2.20E-03
LPM_1	6.18E-04	3.21E-04	1.17E-04	5.67E-05
LPM_2	4.55E-05	2.25E-05	6.44E-06	3.75E-06
SR	103.746	126.708	226.454	**278.306**
Tail risk estimates				
VaR	0.791	0.818	0.864	0.891
ETL	0.724	0.751	0.800	0.828

5.6 Individuals with full employment

In the base setting, individuals face a probability of unemployment depending on the rate of unemployment in each country. Work interruptions will certainly affect the replacement rate. For countries applying the flat-rate scheme, the entitlements from the first pillar of the individuals will not change as it does not depend on the individuals earnings. However, this is not the case for countries with an earning-related scheme, such as the NDC system. This section will discuss the effect of work interruptions caused by unemployment on the first pillar replacement rate for Italy and Poland.

Table 5.27 presents the distribution of the first pillar replacement rate for individuals with full employment for Italy and Poland. The result shows that the individuals that are fully employed between the entire age of 25 and 67 have an expected replacement rate from the first pillar of 85.29% and 53.09% for Italy and Poland, respectively. The expected replacement rate of the first pillar with unemployment increases more than 9% (5%) relative to the base setting case in Italy (Poland).

TABLE 5.27: Distribution of the first pillar replacement rate for the 'all occupations' career salary profile for Italy and Poland

Career salary profile	Statistics				
	Mean	Median	Standard deviation	Max	Min
Italy					
All occupations	0.8529	0.8492	0.0733	1.1256	0.6362
Poland					
All occupations	0.5309	0.5280	0.0274	0.6528	0.4647

This result is expected because more contribution is invested into the NDC account as the effect of full employment. Italy has higher increments because of a higher contribution

rate to the first pillar. As mentioned before, Italy has an contribution rate of 32.7% to the first pillar. This is two times higher than the contribution rate in Poland. Furthermore the unemployment rate in Italy is also larger compared to Poland, which causes a larger difference in employment years compared to the base case with unemployment. Therefore, the unemployment factor must be included in the analysis because it has a significant impact on the replacement rate of the first pillar.

The results for Italy show that all the strategies have all replacement rate scenarios above the target, which results in zero downside semi-deviation. Hence, all strategies have an infinity SR. Therefore, individuals with full employment living in Italy are able to choose any strategy for the second pillar because the first pillar provides an adequate replacement rate to reach the target. On the other hand, the optimal strategy for the second pillar is unaffected in Poland because the contribution rates from the first and second pillar are low. Hence, having full employment does not change the optimal asset allocation for the second pillar in Poland.[6]

[6]The distribution of the replacement rate and the estimation of downside risk for this analysis can be found in Appendix C in Table C.2

Chapter 6

Conclusion

6.1 Summary

This thesis is conducted for the purpose of investigating the effect of first pillar system design taking into account realistic human capital characteristics on the optimal asset allocation in DC pension schemes across Europe. Four different countries, namely the Netherlands, the United Kingdom, Italy and Poland, are chosen because of their distinctive first pillar system. Different career salary profiles and an unemployment factor are implemented to generate more realistic analysis. The downside risk and tail-related risk metrics are applied to find the optimal strategy.

Two sources of pension income are considered. The first source is attained from the first pillar for which the benefit calculation is different for each country. The calculation of this entitlement is presented in terms of the replacement rate of the first pillar. The second source is received from a defined contribution scheme, in which participants contribute some percentage of their salary and invest these contributions in a funded scheme. The investment returns depend on the selected asset allocation. At retirement, the accumulated wealth is converted into an annuity. This annuity is presented in terms of the replacement rate of the second pillar. The total replacement rate from both pillars is the metric for evaluating investment strategies. The Sortino ratio and the value-at-risk are employed to choose the optimal asset allocation. Three different career salary profiles and the unemployment rate, which affects both the first and the second pillar, are investigated.

The results show that different first pillar systems affect the optimal default strategy of the funded scheme. For individuals that receive large entitlements from the first pillar, it is optimal to choose a less risky strategy for the DC pension scheme. Moreover, different

salary profiles and different starting salary levels also have a significant impact on the optimal strategy. In countries where the first pillar is not an earning-related scheme, workers with a high starting salary and high income growth obtain small first pillar entitlements relative to their final salary. Thus, riskier strategies are optimal for these individuals to increase the probability to reach the target level. On the other hand, only the different career salary profiles have an impact on the first pillar replacement rate in countries with an earning-related first pillar. Because the risk-reward profile is considered for evaluating the strategies, the replacement rate target is an important factor. Increasing the target level requires the individuals to choose riskier strategies to obtain a higher probability to reach the target.

To conclude, this thesis shows that the effect of the different first pillar systems taking into account realistic human capital characteristics is significant for the optimal default asset allocation if the evaluation is based on the downside risk and tail-related risk metrics. Human capital characteristics such as the type of occupation, the salary level and unemployment are some important factors that influence the optimal asset allocation for the second pillar. Therefore, different default strategies must be designed to match the characteristics of the individuals living in a particular country.

6.2 Discussion and recommendations for future research

For this thesis, only single individuals are considered for the analysis. According to Scholz and Seshadri [2009], there should be differentiation between couples and singles for finding appropriate retirement income. Even though it will be more complex, investigating optimal asset allocations for couples will be an interesting feature for future research.

In this thesis, longevity risk is not taken into account. However, an unexpected increase in life expectancy could have a significant impact on the pension arrangement. For example, individuals that have a higher probability to live longer need to pay higher contributions to the pension company. Therefore, it will also be compelling to investigate the effect of longevity risk on determining the optimal allocation in defined contribution pension schemes.

The rules for determining the optimal asset allocation are not well defined. There is no literature discussing the combination of different evaluation methods or selecting the appropriate target level and the VaR threshold. It will be interesting to research the preferences of individuals regarding minimum and target pension income for individuals in a particular country. The observation can be created in a such way that asking questions to the individuals. For example by using a questionnaire. An example of a

question could be what percentage of your wage do you expect to get after retirement and what is your minimum acceptable level of retirement income?

In some cases, this thesis is unable to select an optimal asset allocation. For example, individuals living in the Netherlands with the 'manual occupation' career salary profile and the low wage level have three optimal strategies, namely the 'bonds/bills', the 'PFA' and the 'lifestyle' strategy. This is because that these strategies have all replacement rate scenarios above the target, which result to an infinity SR. There are other methods for choosing one optimal strategy. For example, given the strategies with an infinity SR, the strategy that has the highest VaR is optimal.

Besides using the tail-related risk and downside risk metrics, there are other methods for determining the optimal asset allocation. For example, the Epstein-Zin or the loss aversion utility function could be employed for finding the optimal strategy. On top of that, this thesis uses predefined asset allocations for simplicity. It might also be intriguing to find the optimal proportion of risky assets by using the dynamic programming method.

6.3 Policy implications

The analysis of this thesis is relevant for the pension industry and the regulators. The results can be used to improve the pension strategies especially in determining the optimal asset allocation for participants. Pension funds that provide pension products in different countries can use this analysis to improve their pension strategies in the future. Because of this analysis regulators are able to compare the basic pension system with other countries. Some practical findings that are useful for pension providers and regulators are discussed in this section.

The results show that different first pillar system have a significant influence on the optimal asset allocation. Pension companies that have participants in different countries should certainly consider using distinct default strategies. Moreover, they also need to contemplate the appropriate default strategy for individuals with different career salary profiles or different starting salaries, as these components affect the choice of the optimal strategy. Furthermore, the target level is an important factor that affects the optimal asset allocation. Pension providers should take this into account for individuals participating in a defined contribution scheme.

From the perspective of the regulators, they need to realize the importance of the first pillar entitlements. This thesis finds that the first pillar entitlements influence the optimal strategy for the second pillar. For example, individuals that receive a high replacement rate from the first pillar have a less risky strategy as their optimal choice.

Therefore, some regulators need to think seriously about the effect of reforming the first pillar system. For instance, decreasing the amount of basic pension results in shifts to a more risky strategy. Therefore, the consequence of lower basic pension should be accompanied by imposing higher compulsory contributions to the second pillar in order to have appropriate retirement income.

After examining the effect of first pillar pension design on optimal default asset allocations, some findings and recommendations for the current system are outlined below.

- Because the first pillar in the Netherlands is a flat-rate scheme, all individuals have the same entitlements regardless of their salary level and growth. If the occupational pension scheme in the Netherlands is shifted to a funded scheme, the regulators should consider different compulsory contribution rates for individuals with different characteristics.
- Individuals in the United Kingdom must contribute at least 8% of their salary to the funded scheme. However, a contribution rate of 8% is inadequate for some individuals with a higher salary level and/or higher salary growth. Therefore, the regulators should reform the S2P, for example, by increasing the accrual rate or by increasing the minimum contribution rate.
- For individuals who receive most of their pension income from the first pillar based on an earnings-related scheme, such as Italy, the timing of unemployment is a crucial factor for determining the optimal investment strategy. The regulators should consider the effect of unemployment, as this factor influences the pension income from both pillars.
- Poland has the smallest replacement rate compared to the other countries. Thus, individuals living in Poland need to invest more risky to compensate for the low replacement rate from the first pillar and the small contribution rate to the second pillar. Therefore, the regulators need to improve the first pillar system by increasing the mandatory contribution for the first pillar or the second pillar.

Appendix A

Table for the Netherlands

TABLE A.1: Distribution of the replacement rate for each different career salary profile and different starting salary level

	Salary											
	Low wage level Strategy				Average wage level Strategy				High wage level Strategy			
	B/B	A	PFA	L	B/B	A	PFA	L	B/B	A	PFA	L
	All occupations											
Mean	1.151	3.607	1.494	1.862	0.895	3.350	1.238	1.606	0.690	3.146	1.033	1.401
Median	1.147	2.633	1.476	1.717	0.890	2.377	1.220	1.460	0.685	2.172	1.015	1.254
SD	0.075	3.076	0.230	0.715	0.074	3.076	0.230	0.715	0.072	3.076	0.229	0.715
Max	1.467	30.962	2.483	7.019	1.208	30.708	2.224	6.763	1.000	30.505	2.016	6.558
Min	0.917	0.642	0.850	0.760	0.675	0.385	0.594	0.501	0.482	0.178	0.390	0.294
CV	0.066	0.853	0.154	0.384	0.082	0.918	0.185	0.445	0.105	0.978	0.222	0.510
IQRR	0.088	1.074	0.204	0.501	0.109	1.189	0.246	0.589	0.139	1.302	0.295	0.686
	Manual occupations											
Mean	1.168	3.575	1.502	1.861	0.898	3.305	1.232	1.591	0.682	3.089	1.016	1.376
Median	1.164	2.618	1.484	1.718	0.894	2.351	1.214	1.448	0.678	2.135	0.999	1.231
SD	0.073	3.026	0.223	0.698	0.071	3.026	0.223	0.697	0.070	3.026	0.222	0.697
Max	1.475	30.529	*2.468*	6.939	1.201	30.261	2.192	6.670	0.982	30.047	1.973	6.454
Min	0.940	0.679	0.879	0.793	0.685	0.408	0.610	0.520	0.482	0.190	0.394	0.302
CV	0.063	0.847	0.149	0.375	0.079	0.916	0.181	0.438	0.102	0.980	0.219	0.507
IQRR	0.084	1.058	0.197	0.489	0.106	1.177	0.239	0.580	0.136	1.295	0.290	0.682
	Non-manual occupations											
Mean	0.930	2.926	1.213	1.513	0.732	2.727	1.014	1.314	0.573	2.569	0.856	1.156
Median	0.927	2.141	1.198	1.395	0.729	1.945	1.000	1.197	0.570	1.786	0.841	1.038
SD	0.063	2.485	0.190	0.585	0.062	2.485	0.189	0.584	0.061	2.485	0.189	0.584
Max	1.193	24.948	2.022	5.659	0.992	24.751	1.821	5.461	0.831	24.594	1.661	5.302
Min	0.736	0.505	0.674	0.599	0.549	0.305	0.476	0.399	0.399	0.146	0.317	0.238
CV	0.068	0.849	0.157	0.386	0.084	0.911	0.187	0.445	0.106	0.967	0.221	0.506
IQRR	0.091	1.076	0.208	0.506	0.112	1.185	0.248	0.589	0.140	1.292	0.294	0.678

Appendix B

Table for the United Kingdom

TABLE B.1: Distribution of the replacement rate for each different career salary profile and different starting salary level

	Salary											
	Low wage level Strategy				Average wage level Strategy				High wage level Strategy			
	B/B	A	PFA	L	B/B	A	PFA	L	B/B	A	PFA	L
	All occupations											
Mean	0.931	2.120	1.097	1.175	0.737	1.926	0.903	0.981	0.510	1.699	0.677	0.754
Median	0.926	1.643	1.086	1.132	0.734	1.455	0.894	0.937	0.507	1.227	0.668	0.712
SD	0.087	1.495	0.141	0.247	0.068	1.493	0.128	0.240	0.058	1.494	0.123	0.238
Max	1.297	16.795	1.729	3.027	0.995	16.612	1.469	2.808	0.724	16.385	1.229	2.566
Min	0.710	0.618	0.714	0.696	0.554	0.454	0.563	0.534	0.352	0.238	0.358	0.322
CV	0.094	0.705	0.129	0.210	0.092	0.775	0.142	0.244	0.113	0.879	0.182	0.315
IQRR	0.128	0.840	0.170	0.272	0.126	0.943	0.187	0.321	0.153	1.117	0.243	0.418
	Manual occupations											
Mean	0.955	2.120	1.116	1.193	0.750	1.915	0.911	0.988	0.516	1.682	0.678	0.754
Median	0.948	1.650	1.104	1.150	0.747	1.446	0.902	0.945	0.513	1.212	0.669	0.713
SD	0.090	1.471	0.141	0.243	0.069	1.470	0.126	0.235	0.058	1.470	0.121	0.233
Max	1.341	16.687	1.755	3.022	1.018	16.494	1.476	2.792	0.729	16.260	1.219	2.542
Min	0.729	0.641	0.732	0.716	0.570	0.474	0.576	0.549	0.357	0.252	0.365	0.331
CV	0.095	0.694	0.126	0.204	0.092	0.767	0.139	0.238	0.112	0.874	0.178	0.309
IQRR	0.129	0.815	0.166	0.263	0.126	0.931	0.183	0.313	0.152	1.106	0.236	0.406
	Non-manual occupations											
Mean	0.762	1.729	0.899	0.961	0.611	1.577	0.748	0.810	0.414	1.380	0.551	0.613
Median	0.759	1.348	0.890	0.927	0.609	1.198	0.741	0.775	0.412	1.003	0.544	0.579
SD	0.069	1.207	0.114	0.199	0.056	1.207	0.106	0.195	0.047	1.207	0.101	0.193
Max	1.038	13.488	1.397	2.450	0.817	13.344	1.211	2.281	0.587	13.147	1.004	2.071
Min	0.587	0.508	0.589	0.575	0.443	0.369	0.450	0.436	0.287	0.189	0.284	0.259
CV	0.090	0.698	0.126	0.207	0.092	0.765	0.142	0.241	0.113	0.874	0.183	0.315
IQRR	0.124	0.829	0.168	0.271	0.123	0.928	0.186	0.318	0.153	1.111	0.245	0.419

Appendix C

Tables for Italy

TABLE C.1: Distribution of the replacement rate for each different career salary profile

	Salary Profile											
	All occupations Strategy				Manual occupations Strategy				Non-manual occupations Strategy			
	B/B	A	PFA	L	B/B	A	PFA	L	B/B	A	PFA	L
Mean	0.941	1.921	1.077	1.142	0.905	1.865	1.037	1.100	0.806	1.602	0.919	0.970
Median	0.937	1.531	1.068	1.110	0.900	1.480	1.027	1.069	0.803	1.288	0.911	0.945
SD	0.100	1.260	0.143	0.225	0.096	1.240	0.138	0.219	0.084	1.018	0.119	0.184
Max	1.351	14.549	1.741	2.899	1.298	14.407	1.681	2.831	1.151	11.713	1.467	2.380
Min	0.604	0.609	0.651	0.645	0.580	0.586	0.625	0.620	0.511	0.524	0.549	0.555
CV	0.106	0.656	0.132	0.197	0.106	0.665	0.133	0.199	0.104	0.635	0.129	0.190
IQRR	0.143	0.738	0.180	0.254	0.143	0.744	0.181	0.255	0.141	0.715	0.176	0.244

TABLE C.2: Distribution of the replacement rate and the downside risk estimate for the full employment case in Italy and Poland

	Italy Strategy				**Poland** Strategy			
	B/B	A	PFA	L	B/B	A	PFA	L
Mean	1.072	2.183	1.227	1.300	0.642	1.205	0.720	0.757
Median	1.069	1.744	1.217	1.261	0.639	0.981	0.715	0.737
SD	0.094	1.401	0.145	0.242	0.038	0.708	0.066	0.118
Max	1.411	14.869	1.815	3.063	0.790	7.636	1.001	1.664
Min	0.784	0.719	0.805	0.784	0.537	0.498	0.542	0.534
CV	0.088	0.642	0.118	0.186	0.060	0.588	0.092	0.155
IQRR	0.121	0.741	0.160	0.242	0.081	0.668	0.123	0.201
Downside risk estimates								
LPM_0	0.000	0.000	0.000	0.000	9.27E-01	1.79E-01	4.07E-01	3.58E-01
LPM_1	0.000	0.000	0.000	0.000	5.98E-02	1.26E-02	1.66E-02	1.88E-02
LPM_2	0.000	0.000	0.000	0.000	4.79E-03	1.22E-03	1.03E-03	1.43E-03
SR	**Inf**	**Inf**	**Inf**	**Inf**	-0.841	**14.431**	0.637	1.514
Tail risk estimates								
VaR	0.922	0.985	1.007	0.981	0.584	0.602	0.621	0.605
ETL	0.890	0.921	0.964	0.935	0.573	0.574	0.604	0.586

Appendix D

Tables for Poland

TABLE D.1: Distribution of the replacement rate for each different career salary profile

	Salary profile											
	All occupations Strategy				Manual occupations Strategy				Non-manual occupations Strategy			
	B/B	A	PFA	L	B/B	A	PFA	L	B/B	A	PFA	L
Mean	0.610	1.145	0.684	0.719	0.587	1.111	0.659	0.694	0.519	0.954	0.581	0.608
Median	0.608	0.932	0.679	0.700	0.585	0.901	0.654	0.675	0.518	0.783	0.577	0.593
SD	0.042	0.676	0.068	0.115	0.041	0.665	0.065	0.112	0.035	0.546	0.056	0.094
Max	0.771	7.332	0.974	1.640	0.742	7.256	0.942	1.599	0.653	5.917	0.819	1.351
Min	0.437	0.460	0.502	0.480	0.420	0.443	0.484	0.463	0.369	0.392	0.427	0.410
CV	0.069	0.590	0.099	0.160	0.070	0.598	0.099	0.162	0.068	0.572	0.097	0.154
IQRR	0.093	0.672	0.131	0.208	0.093	0.681	0.131	0.210	0.091	0.650	0.128	0.201

TABLE D.2: Estimation of downside risk and tail-related risk for different contribution rate of 9.45% and 14.31%

	Strategy								
	Bonds/Bills	Aggressive	PFA	Lifestyle		Bonds/Bills	Aggressive	PFA	Lifestyle
	Contribution rate of 9.45%					*Contribution rate of 14.31%*			
Downside risk estimates					*Downside risk estimates*				
LPM_0	7.52E-02	5.10E-02	1.06E-02	3.76E-02	LPM_0	2.00E-04	2.12E-02	2.00E-04	4.80E-03
LPM_1	1.89E-03	3.39E-03	2.64E-04	1.43E-03	LPM_1	7.39E-07	1.43E-03	2.82E-06	1.12E-04
LPM_2	8.05E-05	3.53E-04	1.16E-05	8.71E-05	LPM_2	2.73E-09	1.48E-04	3.99E-08	3.91E-06
SR	9.931	81.560	**85.347**	41.303	SR	**4508.946**	199.183	2709.118	346.141
Tail risk estimates					*Tail risk estimates*				
VaR	0.6888	0.6975	0.7663	0.7149	VaR	0.8043	0.8038	0.9129	0.8314
ETL	0.6650	0.6322	0.7269	0.6734	ETL	0.7744	0.7035	0.8566	0.7709

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