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DC Defaults 2.0

An International Framework in order to Improve the Investment Strategy for DC Defaults across Europe

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DC Defaults 2.0: an international framework in order to improve the investment strategy for DC defaults across Europe

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Abstract

The shift from DB to hybrid and DC pension plans shifts the investment risk from the corporate sector to households. This also implies that participants are provided with the option to exercise choice. However, most participants of DC pension plans 'choose not to choose' and, thus, end up in the default investment mix. Most pension providers hold on to a 'one size fits all' life cycle based default investment option. Heterogeneous factors such as the size and design of the first pillar, the wage level and career path, work interruptions and additional personal wealth are often not taken into account when determining the risk preferences of the participant regarding the default investment mix.

In this thesis the influence of differences in the size and design of the first pillar together with different wage levels and career paths on the optimal default investment strategy is researched. This is done by using simulations to predict the development of income and first and second pillar pension accumulation and decumulation, the expected risk return distribution of the replacement rate for different participants is predicted for different life cycle investment options of the DC pension plan, varying from very defensive to very offensive. A mean-variance utility function is used to evaluate this risk-return distribution. The analysis shows that the relative size of the first pillar as a percentage of total pension income is of crucial importance for the optimal default investment option, where the investment mix should be more offensive the larger the relative size of the first pillar. A distinction between different countries and different wage levels and career paths is made to show the effect of these factors on the relative size of the first pillar. All these factors have a significant influence on the relative size of the first pillar, and, thus on the optimal DC default investment option. Therefore, pension providers should take into account these factors when determining the risk preferences of the participant regarding the default asset allocation and acknowledge that there is no ‘one size fits all’ default investment strategy.

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1. Introduction

1.1. Background

In the design of funded pension schemes, traditionally, the distinction can be made between two main types of pension plans, the defined-benefit (DB) and the defined-contribution (DC) plan. In DB plans, the benefits are defined in advance and contributions are set and adjusted to balance the fund. In DC plans, the contributions are defined and the benefits are flexible and dependent on investment performance (Han, Hung, 2012).

Over the past few decades there has been a gradual shift from traditional DB pension plans towards DC and hybrid pensions. In some countries, the majority of invested assets in private sector occupational pension plans are invested in DC pension plans. There is expected that recent and prospective regulatory and accounting reforms in the pension sectors of a number of countries quickens the shift from DB to DC pension plans (Broadbent, Palumbo, Woodman, 2006). The implications of this shift from DB to DC pension plans in private sector pensions is that the investment risk shifts from the corporate sector to households. Retirement income will thus be subject to greater variability than before and households are becoming increasingly exposed to financial markets.

Another reason for the gradual shift from DB to DC arrangements is the increased individualization, which creates heterogeneous preferences between participants. DC pension plans, with the option to exercise choice, are a solution for this social development. However, experience with DC pension plans shows that many people ‘choose not to choose’. For participants in a defined contribution plan who refrain from exercising their option to choose their own investment mix, the pension plan contributions are invested following the default investment option of their respective plans. These default investment options vary widely in terms of their benchmark asset allocation. This benchmark asset allocation is the most important determinant of the investment performance, and, therefore, participants who are enrolled in these default investment options face significantly different wealth outcomes at retirement (Basu, Drew, 2006).

Nowadays, most DC pension plans offer investment strategies based on a life-cycle asset allocation, where the riskiness of the investment strategy is adjusted to the age of the participant, with a more risky strategy for younger participants which is gradually becoming less risky as the participant ages. This life cycle investment strategy is based on the idea that human capital should be taken into account in the determination of total capital and human capital should be perceived as risk-free. Since human capital is decreasing with age, the financial capital should be invested less risky as the participant ages (Bodie, Merton, Samuelson, 1992). Another reason for the gradual shift towards relatively risk-free bonds when the retirement age approaches is the hedge that bonds provide for the conversion risk at retirement when the accumulated pension income should be converted into an annuity. However, there are a lot of other heterogeneous factors, besides age, that might play an important role in the optimal DC default asset allocation and that are not taken into account when the default investment strategy is determined.

1.2. Research question, motivation and relevance

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

What is the impact of heterogeneous factors on the DC default life cycle that provides the highest utility of total pension income for participants across Europe?

This research goal is chosen because limited research has been done on empirical cases, investigating the influence of heterogeneous factors, besides age, on the risk preferences of the optimal default investment strategy. The decision to focus on Europe is made because of the practical relevance. Pension providers are more likely to offer their product to several European countries than to countries in other continents, because European countries have more characteristics in common. Therefore, similar investment products can be offered across Europe which might not fit the investment preferences of countries outside Europe.

The research is scientifically relevant because former research on this subject is still limited. A considerable amount of research has been done on the traditional life-cycle theory and the default asset allocation according to this theory. This is outlined in section 2.4.2.1. However, limited research has been done on DC default asset allocations that extend beyond basic life-cycle theory and incorporate other important factors that should be taken into account in the determination of the risk preferences of the investment strategy. Particularly, an empirical analysis, using realistic data, of the influence of different first pillars (both in size and design) in combination with different wage levels and career paths on the optimal asset allocation has not been done yet. This research is the start of the development of an international framework that incorporates the most relevant factors in the design of default investment strategies, and which can be extended and tested further in the future.

The research is economically significant because the development of an international framework that can be used to improve the design of DC defaults across Europe might have important applications for existing pension schemes, especially for cross-border pension schemes. This research provides the first evidence that based on characteristics of participants in different countries, different investment strategies might fit these participants better than others and that there is no ‘one size fits all’ optimal investment strategy. Pension providers can apply the conclusions of this research in order to optimize the default investment options of their DC pension plan.

1.3. Approach

In this thesis the extent to which different personal characteristics of participants, such as the wage level and expected career path, and differences in the structure and size of the first pillar lead to different risk preferences regarding the optimal asset allocation of the default investment mix of the funded pension plan is investigated. Simulations are used to predict the mean amount and volatility of total pension income at retirement expressed as a percentage of the final wage. The resulting replacement rates of the first and second pillar are then expressed as a percentage of total pension income in order to determine the relative importance of the second pillar for total pension income. A mean-variance utility function is used to evaluate the risk-return distribution of second pillar pension income in order to determine the optimal investment strategy. Four different countries, with different first pillar systems, together with three different wage levels and expected career paths are analyzed in order to show the influence of the combination of different first pillars with different wage levels and career paths on the optimal default investment strategy.

1.4. Structure

The outline of this thesis is as follows. In chapter 2, the former literature on this topic is discussed. This chapter starts with a general introduction describing why pensions are necessary and a description of the different pillars that form total pension income. After that the behavioural biases causing people to not choose their own investment mix are outlined. Lastly, the framework, showing the different factors that might influence the risk preferences of the default investment mix, is provided and life cycle theory is further explained. In chapter 3, the model and methodology are explained. In this chapter there is explained step by step, how the replacement rate is calculated, how it is converted to the relative allocation and which utility function is used to evaluate the risk return distribution of the replacement rates. In chapter 4, all the different inputs, assumptions and simulations necessary to make the model work are clarified and explained. This chapter includes the assumptions regarding wage levels, career paths, life cycles, first pillars, growth rates, simulations etc. In chapter 5 the results of the model are presented and the underlying theoretical explanations are provided. This chapter is divided in the influence of different first pillar systems, different wage levels and different career paths. In this chapter there is also shortly discussed how the results and underlying explanations could be applied to factors which are not numerically researched in this analysis, and, how the risk-aversion level that fits a participant best should be selected. The last chapter concludes the thesis. First, the thesis is shortly summarized and, thereafter, the thesis is discussed and some recommendations for further research and some policy implications are provided.

2. Literature review: pension systems and the role of DC defaults

In this chapter the theoretical framework of the thesis is developed and explained. The chapter starts with an introduction that explains why pension plans are necessary. Furthermore, the different pillars that form total pension income are outlined. After that, the importance of the default investment option is discussed. Lastly, a framework is developed, which incorporates the different risk factors that are involved with the development of the optimal DC default investment strategy.

2.1. Why are pensions necessary?

According to Barr and Diamond (2008), three economic motives can be distinguished why pension plans are necessary, namely:

- Paternalism: Paternalism can be defined as the behaviour of a person, organization or state which limits some person or group's liberty or autonomy for their own good. In the case of pension plans, it is meant that people are protected against behavioural biases. Most of the behavioural biases that should be considered for retirement planning are further explained in section 2.3.

- Market failures: Market failures refer to the fact that the regular financial markets cannot provide protection against certain risks that are involved with the ability to provide people with an adequate pension. Examples are longevity risk or interest rate risk. The financial markets usually do not offer bonds with a maturity of longer than 30 years, while a pension plan is for a period of much longer than 30 years. Therefore, there is no 'risk-free' product offered by the market for pension provision. Financial markets also do not offer protection against the longevity risk due to an ageing population.

- Equity considerations/income redistribution: Income redistribution refers to the idea that in the case of public pension systems, redistribution between and within generations is possible. This is called intergenerational and intragenerational redistribution. When redistribution between, for example, young and old or rich and poor is socially desirable and cannot be achieved by more efficient policy instruments, a redistribution rationale for public pensions exists.

Besides economic motives, a pension plan also has several objectives. A distinction can be made between objectives for individuals, the government and secondary reasons. For individuals a public pension plan offers the possibility of consumption smoothing. Consumption smoothing means that people have the desire to have a stable path of consumption over the life cycle. Another objective of public pension plans for individuals is that pension plans provide a form of insurance. In most pension plans some kind of minimum pension level is provided for poverty relief. This is also one of the objectives of the government, who wants to provide everyone with a reasonable minimum standard of living. Another objective of the government is redistribution. As discussed before, inter- and intragenerational redistribution can be socially desirable and thus justified as an objective of pension plans. Finally, also some secondary objectives should be taken into account. Pension plans should not disturb economic growth or create disruptions in the labour market (Barr and Diamond, 2008).

2.2. The multi-pillar pension system

In this section, the different pillars out of which the pension system consists are outlined. In general, the pension system consists of three different components, the so called pension pillars. These three pillars are outlined below:

2.2.1. First pillar public pensions

In most countries (part of) the first pillar consists of a Pay-As-You-Go (PAYG) public pension plan. PAYG means that the revenues that are received out of the contributions paid by the working generation are used to provide benefits to the older generation. Or, in other words, the current young pay for the pension income of the current old. In most countries part of the pension system is on a PAYG basis. However, the size varies largely between countries. Within the PAYG public pension two main forms can be distinguished, namely an earnings-related (Bismarckian) benefit and a flat-rate (Beveridgean) benefit. An earnings-related benefit is a benefit which is related to the income of the participant, while a flat-rate benefit is an amount which is independent of the income of the participant. A flat-rate benefit is usually meant to provide everyone with a basic minimum income level at retirement, while an earnings-related benefit aims to provide people with part of the income necessary to maintain their standard-of-living.

Recently, a new form of first pillar public pension known as ‘Notional Defined Contribution’ (NDC) has been created. A NDC pension plan has the objectives of addressing the fiscal instability of traditional plans and mimicking the characteristics of funded DC plans while retaining PAYG finance. In a NDC pension plan, a notional capital account is maintained for each participant, earning a rate of return that is declared by the pension plan each year. Notional payments into the account are made to mirror actual taxes or contributions. The notional payments together with the rate of return determine the value of the account at any point in time (Auerbach and Lee, 2006).

2.2.2. Occupational pensions

The second pillar of the pension system can be referred to as occupational pension. In contrast to the first pillar, this part of the pension income is funded. This means that the contributions employees contribute to the pension provider are invested, and, that their own contributions are used to provide them with a benefit when they retire. Another main characteristic is that, within occupational pension schemes, there is always a link between employment and pension accrual. Participation in these supplementary pension schemes varies largely between countries and depends on whether participation is mandatory or voluntary and on the size of the first pillar public pension scheme in the country. Figure 1 below shows an overview of the participation in supplementary pension schemes as a percentage of workers for different European countries.

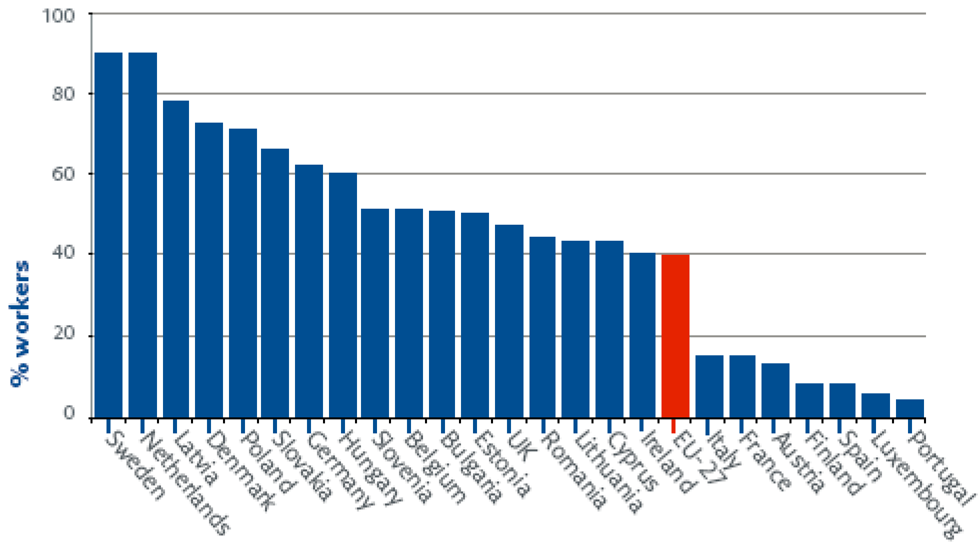

Figure 1. Participation Rates in Supplementary Pension Schemes as a % of Workers. The figure shows the participation rates in supplementary pension schemes expressed as a percentage of current employees. Participation rates vary largely between European countries. The European average is 40%. (Source: de Haan and Mulder, 2012)

Most occupational pension plans are either of a defined benefit (DB) or a defined contribution (DC) type. In a DB plan, the participant of the pension plan will receive an income flow from the employer-sponsored pension scheme from the age of retirement until the age of death. The annual benefit is usually a proportion of either the employee's average or final salary, with the proportion depending on the length of tenure in the pension scheme. In a DC scheme, a defined part of income is paid as contribution to the plan and the employee can usually choose from a range of investment options. The accumulated investment returns of the funds are then available to provide a retirement income, either directly or by purchasing an annuity (Byrne, 2004). In this thesis, only supplementary pension schemes of the DC type are considered, since in DC pension schemes the investment risk is carried by the participant. Therefore, preferences might vary between different participants from different countries. In DB pension schemes other considerations regarding the asset allocation are relevant, but they are not considered in this thesis.

2.2.3. Private individual schemes

The third pillar mainly consists of individual insurances, supplementary DC pension plans or additional pension saving through a bank. This pillar is mainly used by self-employed or employees who work in an industry without an occupational pension plan. Participation in private individual schemes is completely voluntary. However, since the income out of these schemes is used for retirement, it usually has fiscal advantages over regular savings[1]. The magnitude of the third pillar differs between countries and between individuals, based on the other components of the pension system in the country and the industry the participant is working in.

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[1] Source: www.pensioenfederatie.nl

2.3. The importance of default investment options

Saving for retirement is a highly complex task and the stakes are high. The move from DB to DC pension plans creates much more responsibility for the individual participants, because they have to decide how much to save and how to invest the resulting funds (Byrne, 2004). If participants would behave as standard economic theory predicts then they would hold a portfolio with a risk-return combination that is consistent with their investment horizon, degree of risk aversion and the portfolio of other assets they hold including their human capital, and, where relevant, their home. However, behavioural economists and empirical researches have shown that in reality members are not very good at handling their retirement savings, because of behavioural biases (Tapia, Yermo, 2007). The following behavioural biases that clarify the importance of default investment options can be distinguished:

- Financial Illiteracy*:* One of the reasons that explains why so many people end up in the default investment option is that participants do not have enough knowledge to make a well-considered decision about the way their retirement savings should be invested themselves. This is referred to as financial illiteracy. In 2007, Lusardi and Mitchell find that many households are unfamiliar with even the most basic economic concepts needed to make saving and investment decisions, with serious implications for saving, retirement planning, mortgages, and other decisions. In another research, in 2011, Lusardi and Mitchell report that financial illiteracy is widespread among older Americans, women, minorities and the least educated.

- Choice and information overload: Contrary to popular belief, more choice is not always better, because it might lead to choice overload. Several researches have shown that too many investment options can cause information overload, resulting in greater use of the default option and declines in participation rates (Tapia, Yermo, 2007). For example, Iyengar, Jiang and Huberman (2003), who find that participation rates in the US 401(k) plans decline as the number of fund options increases, or, Benartizi and Thaler (2002), who find that plan participants are likely to have difficulty coping with a large number of investment alternatives.

- Unstable and undefined preferences: There are incoherent preferences for making investment decisions. This leads to participants not arriving at the decision with firm preferences in mind, but with individual preferences to risk and time (Tapia, Yermo, 2007). For example, Benartzi and Thaler (2002) find that participants have relatively weak preferences for the portfolio they select. They seem to be happier holding the mean or median portfolio than the portfolio they themselves had selected.

- Heuristic decision-making: Heuristics are experience-based techniques for problem solving, learning and discovery that give a solution which is not guaranteed to be optimal (e.g. rule of thumb). So, instead of a strictly rational decision making process where all relevant information is collected and objectively evaluated, heuristics are used. For example, Benartzi and Thaler (2001) find that when participants have to decide in how many funds to invest they apply the '1/n' strategy, which means splitting contribution equally amongst ‘n’ funds offered by the plan, or they apply other naïve diversification strategies.

- <u>Procrastination and inertia:</u> Much research has shown that when participants face complex choices, required to make investment decisions, both inertia (keep the things as they are) and procrastination (put the decision off until tomorrow) affect the active decision making (Tapia, Yermo, 2007). For example, Benartzi and Thaler (2002) show that participants rarely rebalance their investment portfolios after joining plans, which is a clear example of inertia. Procrastination can be defined as part of the problem of bounded self-control, which means that people are limited in their capacity or desire to execute intentions (Mullainathan and Thaler, 2000). So, even though people might want to make an active investment decision, they delay this decision and, therefore, end up in the default investment option of the pension provider.

Because of the behavioural biases explained above, most participants accept the default arrangements in the plan (Basu, Drew, 2006). To illustrate, Choi et al. (2003) find that up to 80% of the assets in the different pension plans are invested in the default pension plan in the USA. Also in the UK about 80% accepts the default option, which is set by the pension fund (Bridgeland, 2002). In Sweden, around 50% accepts the default option of their pension fund (APRA, 2008).

Thus, default investment strategies offer a solution for the human lack of capacity and/or willingness to make adequate investment decisions, caused by the behavioural biases mentioned above. However, defaults only offer a solution when they are designed properly and, thus, help participants who are not able or willing to make this investment decision themselves, with a choice that matches their preferences. This creates a large responsibility for pension funds to design the default investment mix properly. As mentioned before, there is no ‘one size fits all’ optimal investment strategy and, therefore, the pension plan’s default investment mix should incorporate heterogeneous factors between participants in order to fulfil this duty to the participants.

2.4. The framework

In order to identify the factors that might influence the optimal investment strategy, a framework is developed, which graphically shows these factors. In this framework, all possible forms of income for retirement are taken into account, because they should all be considered together in order to determine the risk preferences of the investment mix of the DC pension plan. This framework is shown in figure 2 below.

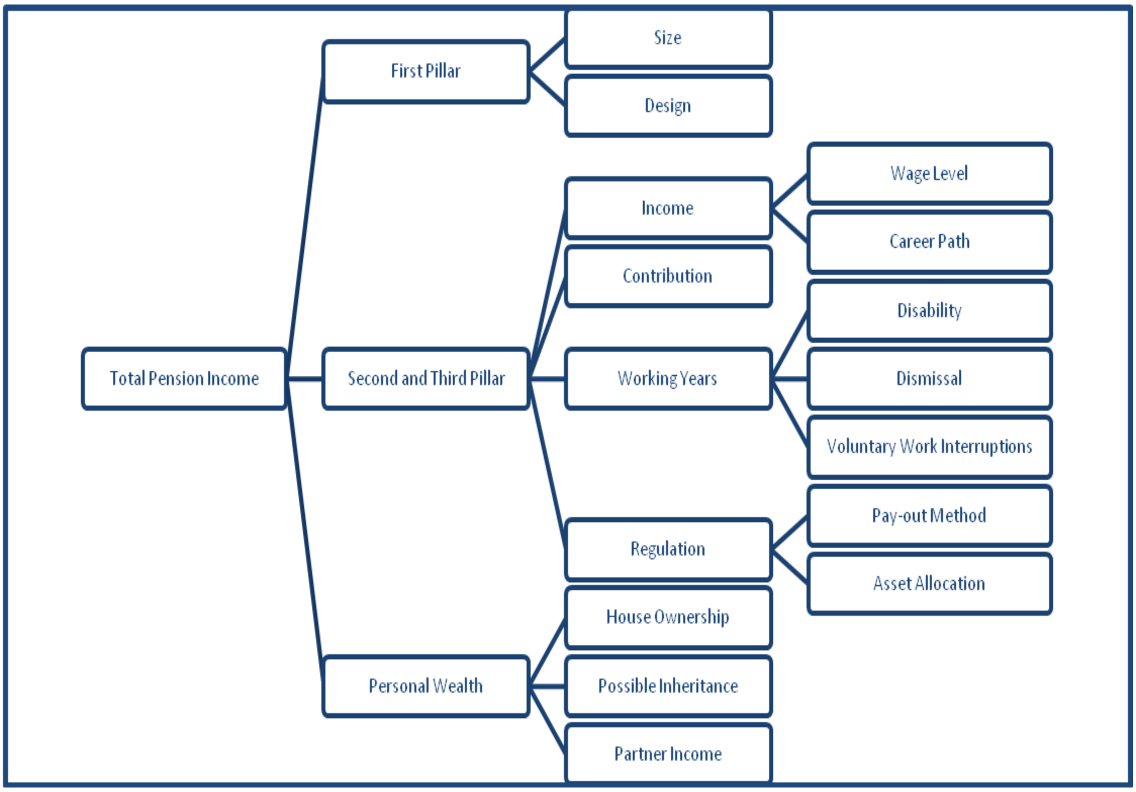

Figure 2. Framework of Factors that Influence Optimal DC Default Design. The figure shows the factors that influence the optimal asset allocation of DC defaults between and within countries. The factors are divided in the different possible pillars of pension income.

The factors within the framework shown in figure 2 can be divided in three different categories. Firstly, country specific factors, which can only differ between countries. Secondly, Human capital related factors, which are all related to the human capital of the participants. Lastly, personal wealth factors, which are related to possible other sources of income in retirement besides the income out of the different pension plans. In the next three sections these factors are shortly discussed.

2.4.1. Country specific factors

The country specific factors are the size and design of the first pillar, the regulation regarding the pay-out phase (lump-sum vs. annuity) and the regulation regarding asset allocation.

- Size and design of the first pillar: The size and design of the first pillar are important determinants of the share of total pension income that is provided by the DC pension plan. A different relative division between the first and second pillar might lead to a different optimal investment strategy for the DC pension plan. The design (flat-rate vs. earnings related) influences the replacement rate of first pillar pension income for different participants within the country. If the first pillar is flat-rate the replacement rate differs between different wage levels and career paths. If the first pillar is earnings-related the replacement rate only differs between different career paths. The influence of the size and design of the first pillar on the optimal investment strategy of the DC pension plan is one of the main research goals of this thesis, and, therefore, is explained further in later sections.

- Pay-out method (lump-sum vs. annuity): Whether to encourage annuities or lump-sum pension payments is a key issue. There are a number of reasons why lump-sums are not desirable, such as the fact that the money may be dissipated and not used for pensions. Furthermore, individuals may be myopic about their prospective life expectancy, which justifies mandating annuities. On the other hand, compulsory annuity purchase at the moment of retirement for defined contribution funds exposes the retiree to market timing risk (conversion risk). However, such risks can be reduced by allowing staggered purchase, variable annuities or defined benefit pensions (Davis, 2003). The regulation regarding the way pension income should be paid out varies across countries. In general, countries that tax-exempt pension savings restrict lump-sums. Lunnon (2002) notes that annuities are compulsory for all defined contribution funds in Austria, Brazil, France, Germany, the Netherlands and Sweden, while a mix of annuity and lump sum is permitted in Canada, Denmark, Ireland, Israel, Italy, Norway, Portugal, South Africa, Spain, Switzerland and the United Kingdom. Only Australia, Belgium and the United States are countries which tax-exempt contributions and interest income and where pay-outs are mainly or entirely lump-sum. In table 1 below a summary of practices of DC pension funds in selected OECD countries is shown (Yerno, 2001).

Country	Occupational Pension Funds	Tax Treatment
Canada	No specific regulations-lump sums and annuities possible	EET
Finland	Annuities most common - lump sums subject to tax penalties	EET
Germany	No specific regulations	TET/EET
Italy	Annuitisation required of at least 50% of the balance	EET
Japan	No regulations, DC funds just being introduced	ETT
Netherlands	Full annuitisation at retirement mandatory	EET
Sweden	Full annuitisation at retirement mandatory	ETT
UK	Pension fund must be annuitised by age 75, subject to 25% tax free lump sum and scheduled withdrawals from retirement till 75	EET
US	Lump sums as well as annuities possible	EET

Table 1. Regulation Regarding Pay-Out Method of Selected OECD Countries. The table shows information about the regulation regarding the pay-out method of pension accruals (annuity vs. lump sum) for selected OECD countries. Also the tax treatment is provided, where EET means that benefits are taxed, ETT means that accrued interest and benefits (net of accrued interest) are taxed and TTE means that contributions and accrued interest are taxed. (Source: Yerno, 2001)

The pay-out method is particularly relevant for the maturity of the bonds that are selected for the portfolio. If all the pension income has to be converted into an annuity, bonds with a longer maturity are better because they partly hedge the interest rate risk considered with the conversion. However, when it is allowed to keep part of the pension income lump-sum, short-term bonds and cash are better investment vehicles in order to hedge inflation risk.

- Regulation: In some countries there are strict investment rules for pension funds. There can be maximums regarding the percentage that can be allocated to, for example, risky assets or real estate. A possible reason for these regulations is to protect participants against overexposure to certain asset categories. Table 2 below, provides information on domestic and foreign asset restrictions for pension funds for selected OECD countries. These regulations should be taken into account while determining the optimal investment strategy of the DC pension plan (Davis, 2001).

Country	Quantitative Restrictions on Domestic Assets	Foreign Asset Restrictions
Canada	Rel estate limit to 5%	foreign assets maximum of 20% of fund
Finland	Maximum 30% in shares, 5% unquoted shares, 50% mortgage loans, 40% real estate	80% currency matching limit, 5% in foreign currency, 20% in other EU states
Germany	20-25% in equities, and 15-25% in property	80% currency matching limit, 5% of premium reserve, 20% of other restricted assets, 6% limit on non-EU investment
Italy	Maximum 20% liquidity and 20% in closed end funds	Minimum 33% matching. Securities of OECD countries not traded in regulated markets limited to 50%; non OECD securities traded in regulated markets limited to 5% (forbidden for non regulated markets)
Japan	None	None
Netherlands	None	None
Sweden	Maximum 60% to be held in shares	Currency matching required. Foreign assets limited to 5-10% of the fund
United Kingdom	Maximum 10% in any one mutual fund and 25% in funds run by one manager	None
United States	None	None

Table 2. Regulation Regarding Domestic and Foreign Asset Allocation for Selected OECD Countries. The table shows an overview of the quantitative restrictions on domestic assets and the foreign asset restriction for selected OECD countries.

2.4.2. Human capital related factors

The human capital related factors are age, the wage level and career path (income growth profile), the probability of disability or dismissal and voluntary work interruptions. First the life-cycle theory is explained which adjusts the asset allocation based on the age of the participants.

2.4.2.1. Age based asset allocation: life cycle theory

The idea of life cycle based asset allocation is to adjust the asset allocation based on the age of the participant in order to reach more optimal outcomes. The optimal asset allocation is different for different ages because the ratio between human capital and financial capital changes when the participant ages. Two views on human capital and the corresponding optimal life cycle of investment planning can be distinguished. Bodie, Merton and Samuelson (1992) developed a theory which can be referred to as 'the risk-free human capital view' and Benzoni, Collin-Dufresne and Goldstein (2007) developed a theory which can be referred to as 'the risky human capital view'.

Bodie, Merton and Samuelson (1992) use the basic result of mean-variance optimization to determine the optimal investment in risky assets of a cohort (x) and add human capital as risk-free asset in order to determine the optimal share of risky assets as % of financial capital. This results in formula 1 below.

$$a_x = \left(\frac{\mu_r - r_f}{\gamma \sigma_r^2}\right)\left(\frac{HC_x + FC_x}{FC_x}\right) \tag{1}$$

Where:

a_x = optimal investments in risky assets of cohort x as % of financial capital

μ_r = mean portfolio return

σ_r^2 = standard deviation of portfolio

r_f = risk-free interest rate

γ = coefficient of relative risk-aversion

HC_x = human capital of cohort x

FC_x = financial capital of cohort x

In this case the development of the optimal investment in risky assets as % of financial capital looks like in figure 3 below.

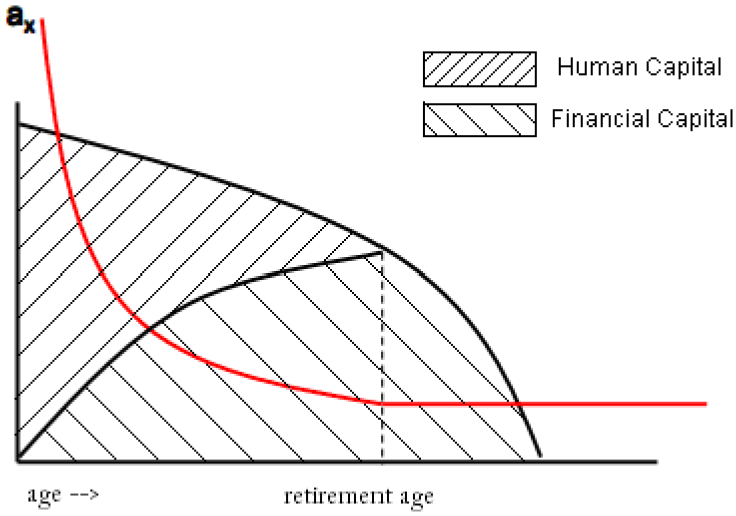

Figure 3. Graphical Representation of the Development of HC, FC and a_x. The figure shows the development of human capital, financial capital and the optimal share of risky assets as defined by Bodie, Merton and Samuelson (1992).

Figure 3 shows that because human capital declines over time and financial capital increases until the retirement age and declines afterwards, the optimal share of risky assets decreases exponentially over time.

The other view on human capital, which can be referred to as 'the risky human capital view' is developed by Benzoni, Collin-Dufresne and Goldstein (2007). This view is based on the idea that, from a long-term perspective, capital income and labour income as shares of national income are more or less constant. Therefore, in the long run, on average, the growth rate of productivity equals the growth rate of wages, which equals the growth rate of capital income (dividend), which equals the growth rate of national income. This indicates that wage growth and the growth rate of stocks (dividends) have the same kind of volatility in the long-run, and, thus, that the human capital of a young worker is more stock-like than bond-like. The young are, therefore, over-exposed to stock-like risk. Thus, in the beginning of the life cycle the financial capital should be invested in bond-like assets to offset the high stock risk exposure. However, as the participant ages the correlation between dividends and wage growth has less time to act and labour-income acquires bond-like properties. Thus, human capital becomes more bond-like, but the value declines at a fast rate. This leads to a hump-shaped optimal share of risky assets over the life cycle, as can be seen in figure 4 below.

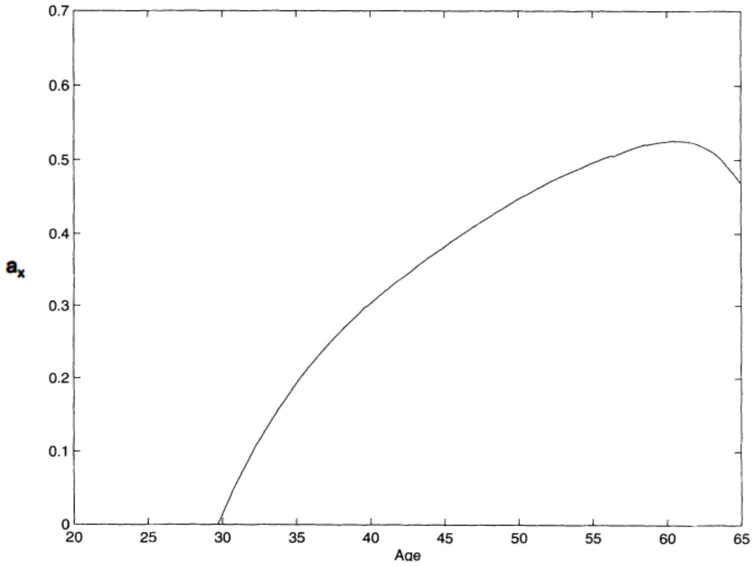

Figure 4. Graphical Representation of the Development of $\boldsymbol{a_x}$**.** The figure shows the development of the optimal share of risky assets as defined in Benzoni, Collin-Dufresne and Goldstein (2007).

Figure 4 shows that according to 'the risky human capital view', developed by Benzoni et al. (2007), the participant should go short in risky assets or not invest in risky assets at the beginning of the life cycle, then increase the share in risky assets until the age of +/- 60 and then decrease the share in risky assets again.

The two theories outlined above are the two main theories about life cycle investing and their basic implications for the optimal share of risky assets over the life cycle. However, other research has been done that expresses other views on the optimal portfolio choice over the life cycle. See for example Cocco et al. (2005) and Gomes et al. (2008) who predict a decreasing share in risky assets until retirement, and an increasing share afterwards, or, Chai et al. (2011) who predict a decreasing optimal fraction invested in risky assets with a short sudden temporary increase at the retirement age.

2.4.2.2. Career related factors

The career related factors are the wage level and career path and work interruptions divided in the probability of dismissal or disability and voluntary work interruptions.

- Wage level and career path: The wage level and the career path are the main determinants of the human capital, as described in the previous section. As explained in section 2.4.1., a participant's wage level together with the form of the career path (income growth) can influence the relative size of the first pillar (expressed as the replacement rate) differently between countries depending on the design of the first pillar. The relative size of the first pillar can have a significant influence on the optimal asset allocation of the second pillar pension income.

- Probability of disability or dismissal: For every participant there is a probability of disability or dismissal over the life cycle. If a participant gets dismissed or disabled it leads to interruptions in the contributions to the DC pension plan, because these contributions are part of the wage which is not earned at that moment. Since dismissal is usually temporary while disability is usually for the whole remaining working life of the participant the consequences are more severe for disability than for dismissal. Less contribution leads to less second pillar pension income, assuming that the participant still retires at the same age, and this might lead to a different optimal asset allocation. If the retirement age is variable, then, in the case of dismissal, a participant might decide to retire later to make up for the lost years and the consequences might be less severe. The predicted influence of work interruptions on the optimal DC default investment strategy are further outlined in section 5.4.

- Voluntary work interruptions: Participants might voluntary decide to work less or not during some of the years of the working life. For example, because of marriage, children or travelling. This has the same consequences as disability or dismissal, however it might be easier to predict. Therefore, it can be easier taken into account in the decision of the optimal DC default asset allocation, which has to be made ex-ante. It should be noted that a difference should be made between singles and couples and men and women to take this into account appropriately.

2.4.3. Personal wealth factors

Personal wealth is a component that can be added to total pension income because a participant is able to withdraw money from this source as additional pension income. Personal wealth factors might change the risk preferences regarding the asset allocation of the DC pension plan of the participant because it adds a component to total pension income which changes the relative importance of the DC pension plan as source of pension income. Different sources of personal wealth that might add a component to total pension income can be distinguished. Examples of wealth added to pension income are house ownership, a possible inheritance or partner income.

- House ownership: A possible source of extra income during retirement is house ownership. If the remaining mortgage on a house is much less than the value of the house and the house is sold during retirement, this might lead to extra retirement income. This extra income can be spent all at once, or it can be saved to leave as a bequest. However, it can also be spend gradually to provide the participant with an extra annuity like stream of income. It should be noted that house ownership as extra source of pension income faces liquidity issues, since the liquidity of investment in real estate is often limited.

- Possible inheritance: There is a probability that a participant receives an inheritance from relatives or close friends. As for the money out of house ownership, this can be spent all at once, saved for a bequest, or, it can be gradually spent to provide the participant with an extra annuity like stream of income.

- Partner income: Decision making for couples is very different from decision making for a single individual. Furthermore, in some countries, first pillar pension income differs between singles and couples. When one of the spouses has sufficient income, the other spouse might make different decisions about working and saving for retirement. It can also change the income during retirement for both spouses because it has to be shared between them.

The predicted influence of additional wealth on the optimal investment strategy of the DC pension plan is further outlined in section 5.4.

3. Model and methodology

3.1. Approach

The framework developed in section 2.4 outlines many possible factors that might influence the risk preferences of the participant regarding the asset allocation of the DC pension plan. For the empirical part of this research there is chosen to focus on the combination of differences in the size and design of the first pillar, with different possible wage levels and career paths of the participant. It is important to consider these factors together, because, when, for example, a first pillar is of the Beveridgean type, and, thus, the benefit is a flat-rate amount, this might lead to different risk preferences for participants with different wage levels and career paths.

These factors are chosen because they have a high practical relevance, and limited research has been done on empirical cases across Europe, investigating the influence of these factors on the risk preferences of the default asset allocation. Though, stylized, mathematically well developed models have researched the influence of several factors (like labour income risk and shocks, borrowing constraints, education and bequests) on the optimal asset allocation over the life cycle (see for example Cocco, Gomez and Maenhout, 2005), these examples are very stylized and they are not easily applicable to real world cases. In this thesis there is chosen to mimic the first pillar pension systems of several countries and the wage levels and career paths of different participants as close as possible, given reasonable assumptions about the development of these factors over the life cycle, and to infer conclusions about the optimal risk preferences of the default asset allocation of the DC pension plan based on these simulations. The countries that are chosen for this analysis are the Netherlands, the United Kingdom, Italy and Poland. These countries are selected because they all have very different PAYG pension systems and, therefore, are very suited to show the influence of different PAYG pension systems on the optimal investment strategy.

In order to predict the development of the income and the pension accumulation and decumulation for a person who starts saving for retirement now, 10.000 possible scenarios are simulated. These simulations are used to predict the mean and volatility of pension income when the participant retires, expressed as a percentage of the final wage of the participant (the replacement rate). The replacement rate is chosen as main measurement tool because it is one of the most useful bases for an international evaluation of old-age benefits (Aldrich, 1982). The replacement rate as a percentage of the final wage, instead of the average wage, is chosen because it is reasonable to assume that participants of pension plans value their pension income as the share of the wage they were earning just before retirement. Since the replacement rate as a percentage of the final wage is only used for evaluation in this thesis and, thus, does not influence the benefit like in DB plans, this decision is of minor relevance. Based on the simulated replacement rates of the PAYG and funded (DC) part of total pension income, the relative importance of the DC pension plan as a percentage of total pension income is determined. To evaluate the relative risk-return distribution of DC pension income, a mean-variance utility function is used, for which a higher mean relative share leads to higher utility, while a higher volatility leads to a lower utility.

In the next sections the methodology and model used for this research are outlined. Firstly, the methodology and formulas that are used to construct the replacement rate and the corresponding risk-return distribution are explained. To calculate the replacement rate the final salary and the first pension instalment at retirement should be calculated.

3.2. Final salary

To calculate the final salary of a participant with certain characteristics, the following inputs are necessary. First of all, the wage at the start of the career (I_0) should be inputted. After that, this wage should grow up and until the retirement age. In this analysis, there is assumed that the wage grows with inflation and, depending on the career path, a fixed real wage growth is added to inflation. Formula 2 below shows this development mathematically.

$$I_T = I_0 * (\prod_{t=1}^{T} 1 + i_t + w_t) \qquad (2)$$

Where:

I_t = salary at time t; T=retirement age

i_t = inflation at time t

w_t = real income growth at time t

In formula 2 inflation is simulated. The wage level at the start of the career varies between countries and between individuals within countries. Within countries, a distinction between a low, medium and high wage is made.

In the next section, the determination of total pension income at the retirement age is explained. Total pension income is determined by two different factors in this analysis. These two factors are pension income out of the first pillar (PAYG) and pension income out of the funded pillar. First the calculations of the first pillar pension incomes for the countries that are selected for this analysis are explained.

3.3. PAYG pension income

In this section an overview of the calculation of the first pillar pension income for the countries selected for this analysis, namely the Netherlands, the United Kingdom, Italy and Poland, is provided.

3.3.1. The Netherlands

The first pillar in the Netherlands is called the AOW (Algemene Ouderdomswet) and was introduced in 1957 as a basic part of the old age provision. The AOW is a basic income of which the amount is coupled to the legal minimum wage. Someone who is married or living together receives 50% of the minimum wage and someone who is living alone receives 70% of minimum wage. The AOW is mainly financed on a PAYG basis. The part of the full amount of AOW a person receives is coupled to the amount of years the person has lived or worked in the Netherlands. The AOW is mainly financed out of tax on wages or benefits and, partly, out of general funds of the government[2]. The amount that is used in this analysis is the amount a person who is living alone receives as of the moment this person has reached the legal retirement age, because couples are not analyzed in this research. Since the retirement age is gradually increasing to 67, this is the legal retirement age used to calculate the benefit. As of July 2013 the gross yearly AOW amount (including 8% holiday allowance) for a person who is living alone is 14.081 Euros. The current yearly gross amount of AOW should be converted to the amount it will be at the retirement age. In order to calculate this amount, the current amount is assumed to grow with inflation (since it is coupled to the minimum wage) according to formula 3 below.

$$FP_T = FP_0 * \prod_{t=1}^{T} (1 + i_t) \tag{3}$$

Where:

FP_T = first pillar pension income at retirement age

FP_0 = current first pillar pension income

3.3.2. The United Kingdom

The current first pillar system of pension provision of the United Kingdom consists of a flat-rate first-tier, which is provided by the state and is known as the basic state pension (BSP). Furthermore, employees with earnings in excess of the low earnings limit (LEL) automatically participate in the S2P (state second pension), unless they belong to an employer's occupational pension scheme or to a personal or stakeholder pension scheme that has been contracted out of S2P (Blake, 2003).

The annual flat rate amount of basic state pension is currently 5647 British Pounds annually, which is, with the exchange rate used in this analysis, equal to 6566 Euros. Similar to the flat-rate first pillar of the Netherlands this amount grows with the simulated inflation. For the calculation of the S2P the following system is used. Between an income of 5304 GBP and 12704 GBP the pension accrual is 40%. Between an income of 20318 GBP and 14400 GBP the pension accrual is 10%. The benefit calculation is based on a three step process outlined below:

1. Earnings for each tax year are split across the bands and revalued in line with the changes in average earnings (simulated inflation + real income growth) from the tax year in question up to the tax year before the employee reaches State Pension Age (SPA), which is set at 67 in this analysis (earnings in the tax year before SPA are not revalued).

2. The revalued earnings at SPA in each band are then multiplied by the accrual rate applicable to that band.

[2] Source: Pensioenfederatie

3. These revalued earnings are divided by the total number of years in the individual's working life, which is set at 42 years in this analysis, to give the S2P benefit [3].

3.3.3. Italy

In the course of the last century, Italy adopted a PAYG pension system which used a generous award formula. Because of developments like aging and economic slowdown, reforms were necessary to provide a sustainable first pillar (Gronchi, Nistico, 2006). Italy chose to establish a contributions-based scheme (Notional Defined Contribution), which makes it possible to retain the PAYG architecture, but with award and indexation formulas which are typical for funded defined contribution systems. Besides the sustainability of this system, this new system also led to more relative 'fairness' since early retirement and careers with fast-rising earnings are not rewarded anymore (Aben, 2011). This is the case because benefits are based on lifetime earnings, rather than a subset of the highest earnings or final years. Thus, an extra year of contribution gives rise to an additional benefit and benefits are reduced to reflect the longer expected duration of payment for people who retire early or for a higher life expectancy.

In order to calculate the replacement rate of the Italian first pillar the methodology as described in the paper of Gronchi and Nistico (2006) is used, adjusted to incorporate the assumptions used in this analysis. Formula 4 below is used to calculate the first pension instalment.

$$p = \frac{\alpha * \sum_{t=1}^{T}(w_t) * \prod_{j=t+1}^{T+1}(1+i_t)}{(1+\sum_{t=T+2}^{T+N}\prod_{j=T+2}^{t}\frac{1+i_t}{1+i_t+r})} \tag{4}$$

Where

p = first pension instalment

a = tax rate

w_t = wage in year t

i_t = inflation in year t (rate of return workers and pension indexation factor)

r = real rate of return pensioners

With the help of formula 4 the first pension instalment (p) can be calculated, which should be divided by the final income of the participant to calculate the replacement rate. There should be noted that inflation is simulated for the first 42 years when the participant is working, but is assumed fixed for the years in retirement, as explained

[3] www.lafargeukpensions.com

in section 4.1. The tax rate for the Italian first pillar is equal to 32.7% and the real rate of return of pensioners is set equal to 1.5% (Aben, 2011). The benefit calculation can be done in this way for wage levels between 177.42 Euro per week (35% of average earnings) and 88.669 Euros a year (337% of average earnings). All the wage levels used in this analysis (see section 4.3.1.) fall within these boundaries.

3.3.4. Poland

Because of an inefficient, extremely fragmented (250 working categories enjoyed varying early retirement rules during the 1990s) and fiscally unsustainable old age pension system Poland reformed its pension system in 1998. Like Italy, Poland introduced a multi-pillar structure consisting of a multi-tiered first pillar, combining a flat-rate means-tested tier with a state-run PAYG Notional Defined Contribution first tier and a privately-managed fully funded second tier (Guardiancich, 2010). In this analysis the 0 and 1st tier of the first pillar are considered as first pillar pension income, since first pillar pension income is defined as PAYG pension income in this analysis. The funded tier of the first pillar can be incorporated in the DC pension plan designed in this research. The 0 tier is means-tested, and thus only received when the participant earns below a certain threshold. Only for participants with individual earnings below 30% of average earnings there 1st and 2nd tier pension income is supplemented to reach the minimum guaranteed level of 20% of average gross earnings (Chlon-Dominczak, Strzelecki, 2010).In this analysis, no participants earn less than 30% of average earnings, because the minimum fulltime wage is higher than 30% of average earnings. Only participants who work part-time are eligible for this minimum pension guarantee. The contribution rate for the first pillar in Poland is equal to 19.52% of gross wage. Of these 19.52%, 12.22% goes to the PAYG (NDC) component of the first pillar, the other 7.30% is diverted to the funded part (2nd tier) (Guardiaricic, 2010). The annuity rate of return (r) is set to 0% in Poland (World Bank's Pension Reform Primer). For the rest of the calculations the same assumptions and formulas as for Italy are used. This means that the rate of return for workers and the pension indexation factor are equal to inflation (simulations).

3.4. Funded pension income

In this section the calculation of second pillar pension income is explained. The second pillar is perceived to be the only pillar with variability in this analysis, since first pillar pension income expressed as a percentage of final wage is perceived to be risk-free. The total pension income out of the second pillar is dependent on eight different variables, namely the income, the contribution rate, the length of the career, the number of years in retirement, the annuity factor, the inflation, the real income growth and the return on investments. In this section there is explained how to calculate the total pension income out of the second pillar using these eight variables as input variables in the model.

To be able to calculate the total pension income out of the second pillar at the retirement age, first the contributions to the second pillar should be calculated. As the contribution is a fixed percentage (defined contribution) of the wage each year, the yearly wage is the most important variable to determine the contribution to the DC pension fund. As explained in section 3.2., the inputs necessary to calculate the income in a certain year are the salary at the beginning of the career, inflation and real income growth. Therefore, formula 5 below is used to determine the salary in a certain year is:

$$I_t = I_0 * \prod_{t=1}^{t} (1 + i_t + w_t) \tag{5}$$

This salary should be calculated for each year and should be multiplied by the fixed contribution rate, like in formula 6 below:

$$C_{dc,t} = I_t * \overline{C}_{dc} \tag{6}$$

Where

$\overline{C}_{dc}$ = contribution rate DC scheme (in %)

$C_{dc,t}$ = contribution at time t (in Euros)

The next step is to determine the growth of the contributions over the life cycle. This is done by simulating the investment returns of the different investment strategies implemented in the model. The methodology and inputs of the simulations are outlined in section 4.2. and the different investment strategies are outlined in section 4.4.2.1.

Using these simulated portfolio returns, the total pension income out of the second pillar at the retirement age can be calculated for the 10.000 different scenarios. Formula 7 below is used to calculate these 10.000 possible scenarios of total second pillar pension income:

$$SP_N = \sum_{t=1}^{T} C_{acc,t} = C_{dc,t} \prod_{t=1}^{T} (1 + x_t) \tag{7}$$

Where

SP_N = value of total assets in DC scheme at retirement

x_t = portfolio return at time t

$C_{acc,t}$ = contribution with accumulated investment returns at time t

As explained in section 2.4.1., the regulation regarding the pay-out of pension income varies between countries. However, since pension income is expressed as the replacement rate in this analysis, it is assumed that all the accumulated second pillar pension income is converted into an annuity. The appropriate annuity payment that should be calculated, is the amount that is paid out in the first year after retirement and grows with inflation afterwards. This is because this annuity provides benefits for the participant that are adjusted for inflation each year, which means that the replacement rate will stay the same during retirement, assuming that both the annuity value of total pension income and the final salary grow with inflation during retirement. Because it is not common that pension providers offer real annuities, which hedge inflation risk, the inflation after retirement is assumed to be fixed at 2% in this analysis. To determine the annuity payment of the first year, the term structure of interest rates is used. As explained before, this term-structure is simulated, starting at the moment of retirement. Formula 8 below is used to determine the yearly annuity payment that follows out of the lump-sum amount out of the second pillar collected at the retirement age:

$$SP_{an} = \frac{SP_T}{\left(\sum_{n=1}^{N} \frac{1+i_n}{1+r_n}\right)} \tag{8}$$

Where

SP_{an} = the first annuity payment of second pillar pension income at the retirement age

i_n = inflation rate

r_n = interest rate with maturity n (term structure)

n = number of years in retirement

Formula 8 is applied to calculate the first yearly annuity payment of the DC pension plan for all scenarios. This first yearly annuity payment is divided by the final wage to calculate the replacement rate of funded pension income, as shown in formula 9 below:

$$SP_{rpr} = \frac{SP_{an}}{I_T} \tag{9}$$

The same formula is applied to calculate the replacement rate of first pillar pension income. From these 10.000 simulated replacement rates, the mean and variance are calculated. This mean and variance form the risk-return profile of PAYG and funded pension income.

3.5. The relative importance of second pillar pension income

After the replacement rates of the PAYG part of pension income and the funded (DC) part of pension income are determined, their relative weights as % of total pension income are calculated. Intuitively, this is done because it should not matter for the optimal risk preference of the default asset allocation whether the replacement rate out of the first pillar is 50% and the average replacement rate of the second pillar is 50%, or, whether the replacement rate out of the first pillar is 20% and the average replacement rate of the second pillar is 20%. But it is the ratio between the first and second pillar pension income that should matter (which is 50%-50% in both cases). The replacement rate is not the relevant determinant because it is also dependent on the overall generosity of the pension system of a certain country and on the contributions paid to the system, which cannot be influenced by the participant.

Furthermore, the overall generosity of the PAYG part of pension income for a certain country is not only dependent on the tax rate, but also on the demographics of the country (dependency ratio etc.), since the current benefits for the old are paid by the current young. Therefore, it is the relative importance of the DC pension plan for the total pension income that should matter for the risk preferences of the default asset allocation.

The relative importance of the DC pension plan as percentage of total pension income can be calculated easily based on the replacement rates, this is shown in formula 10 below.

$$SP_{rel} = \frac{SP_{rpr}}{SP_{rpr} + FP_{rpr}} * 100\% \tag{10}$$

Where

SP_{rel} = relative importance second pillar as percentage of total pension income

SP_{rpr} = replacement rate second pillar

FP_{rpr} = replacement rate first pillar

The standard deviation of the replacement rate is fully determined by the second pillar in this analysis. This is because the first pillar develops in the same way as the income and, thus, has no volatility. The standard deviation should be adjusted to match the mean of the relative importance of the second pillar as is shown in formula 11 below:

$$\sigma_{sp,rel} = \sigma_{sp} * \frac{SP_{rel}}{SP_{rpr}} \tag{11}$$

Where

$\sigma_{sp,rel}$ = adjusted relative standard deviation of the second pillar

σ_{sp} = standard deviation of the replacement rate of the second pillar

3.6. Expected utility

The risk-return distribution of the second pillar relative to total pension income can be determined for all investment strategies evaluated in this analysis. In order to determine the optimal risk-return distribution, a utility function is used. In that case the investment strategy with the highest utility can be appointed as the optimal strategy for a participant.

In this section the utility function used to evaluate the different default strategies is explained. The utility theory is based on the concept of risk-aversion. Risk-aversion is best explained by a graphical representation as shown in figure 5 below.

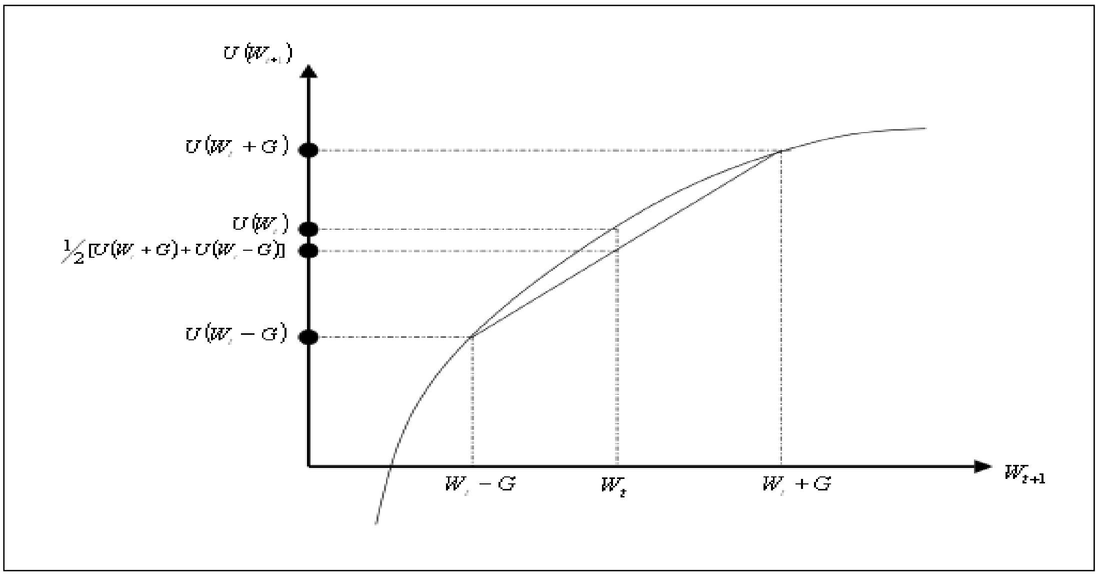

Figure 5. Concept of Risk-Aversion. The graph visualizes the concept of risk-aversion The graph shows that a risk-averse investor with initial wealth (W_t) who is offered a risky gamble which will add or subtract G to his initial wealth with equal probabilities will turn down the gamble since the utility (U) of the gamble is lower than the utility of initial wealth, because the risk that is taken is not rewarded with a higher expected value. (Source: Barr and Diamond, 2008)

Figure 5 shows that a risk-averse participant with initial wealth (w_t) who is offered a risky gamble which adds or subtracts G to his initial wealth with equal probabilities turns down the gamble since the utility (U) of the gamble is lower than the utility of initial wealth, because the risk that is taken is not rewarded with a higher expected value. The curvature of the utility function determines the intensity of the risk-aversion.

To evaluate the outcomes the utility function that results from basic mean-variance analysis is used. This utility function is shown in formula 12 below.

$$U(SP_{rel}) = \mu(SP_{rel}) - \frac{\gamma}{2}\sigma(SP_{rel})^2 \qquad (12)$$

Where

$U(SP_{rel})$ = utility of relative importance second pillar

$\mu(SP_{rel})$ = relative importance of mean second pillar

$\sigma(SP_{rel})$ = relative importance of standard deviation second pillar

γ = coefficient of risk-aversion

When the mean-variance model is used to perform an analysis, a couple of important assumptions are made considering the nature of the investor and the distribution. Namely, that all investors are single period risk-averse utility of terminal wealth maximizers, that a portfolio choice can be made solely on the basis of mean and variance, that there are no taxes or transaction costs and that all investors have homogeneous views regarding the parameters of the joint probability distribution of all security returns (Jensen et al., 1972). These assumptions should be carefully considered when this mean-variance utility function is used.

However, even though the mean-variance framework hinges on some strong assumptions, this utility function has two big advantages. The first advantage is the clear and intuitive structure of the function, which makes it easily applicable. The second advantage is that this function is often applied in the financial returns literature because of its clear an intuitive interpretation. The function is intuitive in its use because it clearly shows that a higher mean is rewarded with a higher utility, and a higher volatility leads to a lower utility. Furthermore, it captures the fact that a higher risk-aversion leads to an increasing decrease in utility when the volatility increases. This mean-variance utility function can be used with different forms of the utility function together with different assumptions (Barr and Diamond, 2008), as outlined below.

1. Investors have quadratic utility over wealth: In this case $U(W_{t+1}) = aW_{t+1} - bW_{t+1}^2$. Thus, maximizing utility is equivalent to maximizing a linear combination of mean and variance. No distributional assumptions are needed on asset returns. Absolute and relative risk aversion are increasing in wealth.
2. Investors have exponential utility and asset returns are normally distributed. In this case $U(W_{t+1}) = -\exp(-\theta W_{t+1})$. Absolute risk aversion (θ) is constant, while relative risk aversion increases in wealth.
3. Investors have power utility and asset returns are log normally distributed. In this case $U(W_{t+1}) = (W_{t+1}^{1-\gamma} - 1)/(1-\gamma)$. Absolute risk aversion is decreasing in wealth and relative risk aversion is a constant (γ).

Power utility has the most attractive properties. This is because for power utility absolute risk aversion is decreasing in wealth, which makes sense because it indicates that the more wealth an investor has, the less the investor cares about absolute losses. Relative risk aversion is constant, which makes sense because it indicates that risk aversion as a share of wealth is constant over different wealth levels. In order to be realistic, relative risk aversion should either be constant or be decreasing in wealth. Relative risk aversion which is increasing in wealth is not realistic. However, the power utility function only leads to the intuitive mean-variance result when asset returns are log normally distributed. Since the simulations used for this analysis also capture mean-reversion and persistence this is not entirely plausible for this analysis. Though this is an disadvantage of the use of this utility function, the function is still used because of its clear advantages.

The utility function, with the mean and variance of the relative size of the second pillar as the input variables, as used in this analysis, can only be used to compare the five different possible investment strategies, in order to determine the optimal strategy given the size of the first pillar. The utility level that follows out of this analysis is not realistic, since the first pillar, which should also give utility, is not incorporated in the utility function. However, since the first pillar is the same for every investment strategy for a participant with certain characteristics, the incorporation of the utility of the first pillar does not change the optimal investment strategy, but only shifts the utility levels upward for every strategy. Because the goal of the research is to determine the optimal investment strategy for a participant, given the characteristics of this participant (country, wage level, career path and risk-aversion level), the utility level is less relevant. Therefore, in this thesis only the relative size of the second pillar and corresponding variance is evaluated in order to determine the optimal default for the participant.

4. Research design: parameters, assumptions, inputs and simulations

In this chapter the research design is outlined. The chapter describes all the necessary inputs to be able to determine the replacement rate, of a participant with certain characteristics, of the PAYG part of pension income and of the funded (DC) part of pension income. First, the fixed parameters and assumptions are outlined. Next, the generation of the simulations is summarized. Lastly, the necessary inputs to determine the final wage, PAYG pension income and funded pension income and a justification of their use are provided.

4.1. Fixed parameters and assumptions

In order to make the empirical model work, some inputs have to be fixed and some assumptions have to be made in this analysis. These assumptions and fixed parameters are outlined in table 3 below.

Parameter	**Assumption**
Length of Career	42 years (from age 25-67)
Length of Retirement	20 years (from age 67-87)
Basic Income Growth (Without Promotions etc.)	Simulations of European Price Inflation
Growth of First Pillar/Franchise	Simulations of European Price Inflation
Inflation After Retirement	Fixed at 2%
Stocks	Simulations of MSCI World (50% Europe)
Bonds	Simulations of European Government Bonds (+/- 6 years duration)
First pension instalment (annuity)	To calculate the first pension instalment out of the lump-sum amount accumulated at retirement the term structure of interest rates starting 42 years from now is simulated and a fixed inflation of 2% is used

Table 3. Fixed Parameters and Assumptions. In the table the parameters which are assumed to be fixed throughout the analysis and the assumptions regarding certain variables or variable growth are outlined. Income and the first pillar/franchise are assumed to grow with price inflation which is simulated for this analysis. Also stock and government bond returns are simulated in order to predict their development. The length of the career and the length of retirement are assumed fixed throughout the analysis. Also inflation after retirement is set at a fix rate of 2%. This fixed inflation together with simulations of the term structure of interest rates after 42 years is used to calculate the first pension installment at retirement.

Table 3 shows that for the simulations of the development of income, career patterns and the length of the retirement period (which is determined by the retirement age and the life expectancy) simplifying assumptions, applicable to an average person, are used. Therefore, longevity risk and dismissal or disability risk are not considered in this analysis. Furthermore, there is assumed that the first pillar grows with the same rate as wages, which implies that the first pillar is risk-free, if expressed as the replacement rate. The inflation is simulated for the accumulation phase of the retirement income and is assumed fixed thereafter. This is chosen because for the accumulation phase of retirement income, the development of stocks and bonds together with the development of inflation are of crucial importance for the resulting replacement rate. After retirement the relationship between the development of stocks and bonds and the inflation is not relevant anymore and inflation is only used to convert the lump-sum into an annuity which has a growth rate, correcting for price increases during retirement.

4.2. Simulations

The simulations of stocks returns, bond returns, European inflation and the term structure of interest rates after 42 years are generated by the Asset and Liability Management department of APG. The model used to generate the simulations is based on the model described in the paper of van den Goorbergh, Molenaar, Steenbeek and Vlaar (2011). An elaborate description of this model can be found in this paper. In this section a short summary of the model is provided and the some summary statistics of the simulations are outlined. Furthermore, it is explained how there is dealt with the different risks incorporated in the analysis.

4.2.1. Model summary

The model used to generate the simulations is used for the asset management of a pension fund. Therefore, both the development of assets and liabilities is of crucial importance. In the model, it is taken into account that risks in the short run can deviate from risks in the long run. The model also carefully estimates the term structure of interest rates since it is used to calculate pension liabilities. Because of the very long maturity of investments (>50 years) also the long end of the term structure is modelled adequately. Because of the ambition of indexation also inflation and real interest rates are modelled. The ALM model also takes into account that the volatility of investments can both increase or decrease with the length of the investment horizon because of mean-reversion of stocks returns (a negative shocks leads to higher dividends and therefore to higher returns on stock investments in the next periods) and persistence of interest rates (lower short-term interest rates lead to lower returns now and because of persistence also in the next periods). Furthermore, because the model should also be able to predict events like the credit crisis, a low-probability jump process is inserted in the model and the model allows for time-varying volatilities and correlations. Time variation in correlations is due to the changing importance of two sources, namely monetary shocks leading to a positive stock-bond correlation and risk-aversion (‘flight to safety’) shocks leading to a negative stock-bond correlation. Furthermore, an inflation target of 2% is used.

The model used to describe the dynamics of the financial time series is called a vector auto regression model (VAR) model. The VAR model is one of the most successful, flexible and easy to use models used for the analysis of multivariate time series. A VAR model is especially useful for describing the dynamic behaviour of economic and financial time series and forecasting (Zivot, Wang, 2006). In a VAR model each variable has an equation explaining its evolution based on its own lags and the lags of the other model variables. In this model inflation, the excess return on the stock market, the interest rate, the credit spread and dividend yield are linearly interdependent. A detailed description of the variables and their linear interdependence can be found in the paper of van den Goorbergh, Molenaar, Steenbeek and Vlaar (2011). The small change of sudden panic in the market is modelled by means of stochastic jumps. The jump represents a sudden change in sentiment in the market and the probability of a jump is assumed to be constant.

4.2.2. Simulation results

With use of the model, briefly summarized in the previous section, 10.000 simulations of stocks, European Government Bonds and European price inflation are generated. All these variables have a European focus. The stock index is chosen because European pension providers often invest in international equity, but the own country and other European countries are usually slightly overrepresented in the portfolio measured relative to their market capitalization (equity home bias). The bond index is chosen, because pension providers usually use European government bonds as the most risk-free bonds in the portfolio, because of the high credit rating[4]. Other bonds, like corporate bonds or emerging market debt, are perceived as more risky assets. European price inflation is chosen because inflation is relatively stable across Europe. The term structure after 42 years is estimated for 10.000 different scenarios in order to convert the lump-sum pension amount at retirement into an annuity. These interest rates are based on European government bonds.

In table 4 below the summary statistics of the simulations of stocks, bonds and inflation are provided. In the first column the short-term summary statistics, based on the final period, are provided. In the second column, the summary statistics of the cumulative annualized returns over the entire life cycle are provided.

	Short-term			**Long-term**		
	Inflation	**Stocks**	**Bonds**	**Inflation**	**Stocks**	**Bonds**
Mean	2,00%	4,97%	2,60%	2,00%	4,93%	2,50%
Standard Deviation	0,99%	18,90%	4,68%	1,96%	14,11%	3,41%
Minimum	-0,90%	-27,42%	-28,62%	0,93%	0,51%	0,47%
Maximum	6,35%	113,37%	25,56%	4,02%	16,53%	4,36%

Table 4. Summary Statistics Simulations. In the table the summary statistics of the simulations of stocks, bonds and inflation are provided for the short-term (over the final period) and the long-term (cumulative annualized returns). The mean, standard deviation, minimum and maximum are provided.

Table 4 shows that for the cumulative annualized returns, the volatility on stocks and bonds decreased compared to the short-term results, because of mean-reversion and persistence. For the inflation the volatility increased when measured over the cumulative period. The minimums and maximums are less extreme over the cumulative annualized returns than over one period. Besides the summary statistics, the correlation between the simulated stock and bond returns and inflation over the life cycle should also be considered. The correlations for both the short-term (one quarter) and the long-term (the entire life-cycle) are provided in table 5 below.

[4] Source: APG Asset Management Department

Short-term	Stocks	Bonds	Inflation	Long-term	Stocks	Bonds	Inflation
Stocks	1			Stocks	1		
Bonds	0,09	1		Bonds	-0,16	1	
Inflation	-0,24	0,07	1	Inflation	0,41	0,04	1

Table 5. Correlation Matrix Simulation. The table shows the short-term and long-term correlation between the simulated stocks and bond returns and inflation. The short-term correlation is over 1 quarter and the long-term correlation over the entire life cycle.

Table 5 shows that while the correlation between stocks and inflation is negative in the short run, it turns positive in the long run. This is in line with the 'risky HC view' explained in section 4.4.2.1. This indicates that, using these simulations, the optimal age based asset allocation should be hump-shaped.

For the term structure of interest rates, starting in 42 years, the mean and standard deviation are provided in table 6 below for the 20 years which are relevant for this analysis. Figure 6 below shows the graphical representation of the average term structure.

	Mean	Standard Deviation
1	0,87%	1,47%
2	1,02%	2,18%
3	1,18%	3,08%
4	1,30%	0,67%
5	1,44%	0,64%
6	1,60%	0,63%
7	1,75%	0,63%
8	1,87%	0,63%
9	1,99%	0,64%
10	2,09%	0,65%
11	2,18%	0,66%
12	2,23%	0,67%
13	2,29%	0,67%
14	2,33%	0,68%
15	2,37%	0,68%
16	2,39%	0,69%
17	2,41%	0,69%
18	2,42%	0,70%
19	2,43%	0,70%
20	2,44%	0,70%

Table 6. Summary Statistics Term Structure after 42 Years. The table shows the mean and standard deviation of the term structure after 42 years for the 20 years in retirement.

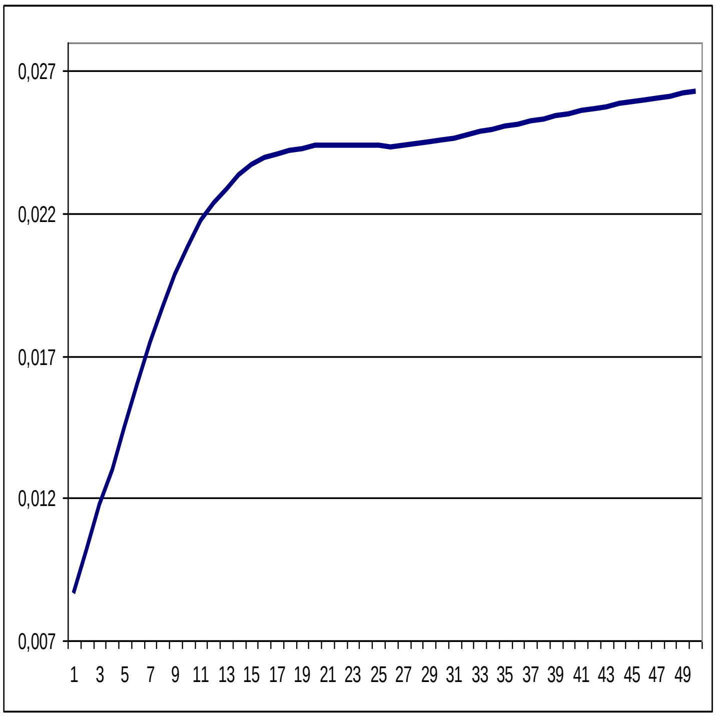

Figure 6. Average Term Structure in 42 Years. The figure shows average term structure of interest rates after 42 years graphically. It is a regular concave upward sloping term structure.

Table 6 and figure 6 show the development of the interest rate over time during the years in retirement. The interest rate increases with maturity at a decreasing rate and so has a concave shape. The standard deviation is decreasing, the longer the maturity.

4.2.3. Risks

The model used in this analysis incorporates several risks which should be considered for this analysis. In this section these risks are shortly discussed and the way there is dealt with these risks in this analysis is outlined.

The first risk is inflation risk. Inflation risk can be defined as the volatility of inflation. Inflation risk is taken into account in the calculations of this analysis, since inflation is simulated and not assumed fixed. However, inflation risk is not hedged, since the simulated bond returns are not inflation linked. This is done because inflation is assumed to be one of the most important determinants of income growth and, thus, final wage and the replacement rate in this analysis. Therefore, it might be important to take into account different inflation scenarios in the determination of the optimal investment strategy.

Another risk relevant for this analysis is exchange rate risk. However, since all the data is expressed in the same currency (Euros) throughout this analysis and because a fixed exchange rate is used to convert currencies, exchange rate risk is not taken into account. Exchange rate risk exists for both the United Kingdom and Poland because they have a different currency than the Euro. Because there are several options in the market available to hedge against currency risk, this risk factor is not taken into account in this analysis.

The last risk that should be considered is interest rate risk. Interest rate risk has two components relevant for pension providers. The first component consists of the risk that an investment's value will change due to a change in the absolute level of interest rates, in the spread between two rates, in the shape of the yield curve or in any other interest rate relationship. This is the interest rate risk carried by everyone who is holding a bond portfolio. Because these changes usually affect securities inversely it can be reduced by diversifying the portfolio with fixed-income securities with different durations or by hedging through, for example, an interest rate swap.

Another component of interest rate risk relevant for pension providers is the conversion risk associated with it. This risk can be defined as the risk that at the moment the accumulated pension income of a participant has to be converted into an annuity, the interest rate is very low and the annuity is thus very expensive risk. This risk could be hedged by a corresponding portfolio consisting of bonds that provide the exact same return as the interest rates used to calculate the annuity stream. This means that not only the type of bonds should be exactly the same but also the duration of the bonds should match the duration of the term structure used to convert the accumulated pension income into an annuity. When a participant starts with building a bond portfolio that fulfils these requirements several years before retirement than interest rate risk can be (partly) hedged. The underlying idea behind this hedge is that when the interest rate goes up from the moment the bond portfolio is constructed until retirement than the bond portfolio decreases in value, but the annuity is cheaper and the other way around. Thus, theoretically, it is possible to hedge this risk for the most part. However, since the portfolios constructed in this thesis only consists of one stock index and one bond index, this risk is not taken into account in this analysis.

As the previous paragraphs show the second pillar pension income is exposed to many risks. It is important to consider these risks when participating in a DC pension plan, because, if not hedged, these risks are all carried by the participant. However, for the research goals this thesis pursues it is not necessary to take these risks into account. Therefore, there is chosen to mention them only qualitatively in this analysis.

4.3. Income

4.3.1. Wage levels

In this section, the wage levels for the different countries selected for this analysis are outlined. A distinction between three different wage levels is made, namely a low, medium and high wage level. Low income is defined as the minimum wage of the country, medium income as the average salary and high income as two times the average salary. These levels are chosen, because they can be measured uniformly across countries, and, because it is reasonable to categorize the income of a participant in one of these categories. For the average salary the gross, full-time annual salary of the age group under 30 is used. These statistics are retrieved from the Eurostat Database and date from 2010. Only for Italy these statistics were not available, but only general average annual salary was available. The age group under 30 earns, on average, across the analyzed countries, 75% of the general average annual salary. Therefore 75% of the general average salary is used as medium wage for Italy. The same methodology is used to specify the low income category for Italy, since Italy does not have a national minimum wage, unless specified in collective bargaining agreements. For Italy, the wage level is not very relevant, since the first pillar is of the NDC type. The irrelevance of the wage level for Italy is explained in section 5.2. A fixed exchange rate is used to convert all the amounts to Euros. The resulting wage levels and exchange rates (if applicable) are shown in table 7 below.

country/income	low	medium	high	exchange rate
Netherlands	€ 18.814	€ 28.652	€ 57.304	n/a
Poland	€ 4.206	€ 8.088	€ 16.176	1 EU/4.28 PLN
Italy	€ 12.868	€ 21.424	€ 42.848	n/a
The United Kingdom	€ 14.772	€ 23.626	€ 47.252	1 EU/0.86 GBP

Table 7. Income Levels. The table shows the income levels for the different countries used in this analysis. Low is defined as the minimum yearly income, medium as the gross average annual earnings under the age of 30 and high as two times the gross average annual earnings under the age of 30. Because of unavailability of data, reasonable estimates are used in the case of Italy. The exchange rate dates from 5/7/2013. (Source: OECD, Eurostat Databases).

4.3.2. . Career Paths

In order to show the influence of different career paths, three different scenarios are used, which can be categorized as low, medium and high income growth. Since inflation is simulated in the analysis and this is a crucial part of income growth, the growth should be expressed as real income growth. For the low income growth scenario, the income is assumed to only grow with inflation, which implies a real income growth of 0% over the entire life cycle. The medium income growth is assumed not to be constant over the life cycle, but steeper in the beginning and less steep at the end of the life cycle. One of these growth paths ,which is used for actuarial calculations of the consequences of different propositions of the government (Weekers, 2013), is the so-called 3%-2%-1%-0% real income growth path, which is shown in table 8 below. This growth path is used to calculate consequences of government proposals for an average Dutch person. Therefore, it is also chosen to use as the average growth path in this analysis. For the high income growth scenario an additional 1% is added to these levels, which can also be seen in table 8 below. Furthermore, figure 7 shows the evolvement of income over the life cycle using these scenarios and a fixed inflation of 2%. In figure 7 a yearly income of 30.000 Euros is assumed.

Age	Low Income Growth	Medium Income Growth	High Income Growth
25-35	0%	3%	4%
35-45	0%	2%	3%
45-55	0%	1%	2%
55-67	0%	0%	1%

Table 8. Real Income Growth Profiles. The table shows the low, medium and high real income growth profiles by age. For the nominal income growth the simulated values of inflation should be added. The growth in income is assumed to change approximately every 10 years.

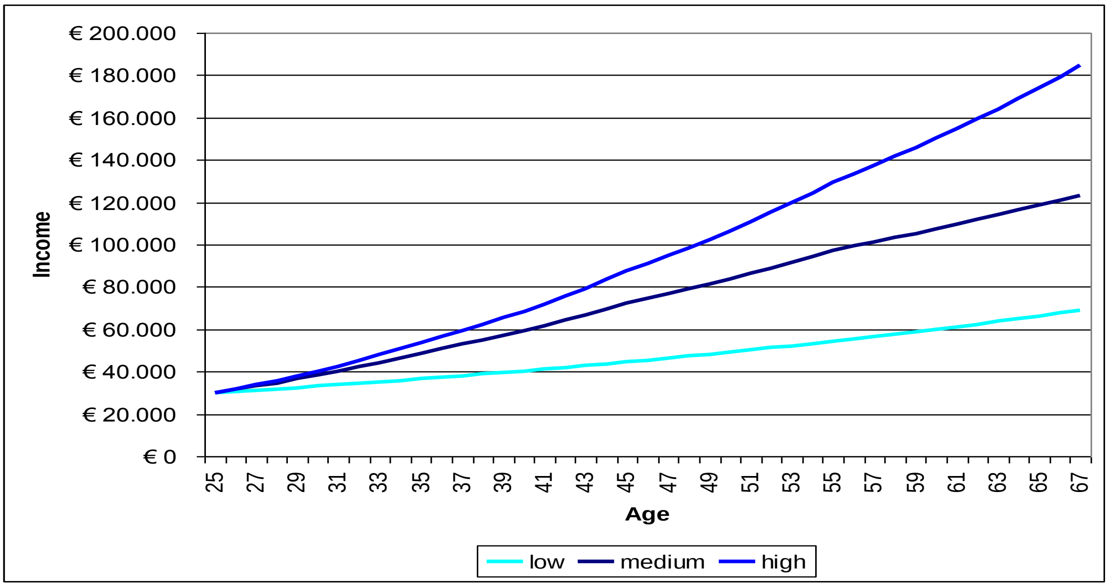

Figure 7. Development Of Nominal Income With Different Growth Profiles. The graph shows the development of income with the different growth profiles used in the analysis. The income at age 25, when entering the pension plan, is assumed to be 30.000 Euros and the inflation is fixed at 2%. The real income growth profiles used can be found in table 8.

Figure 7 shows that the different career paths lead to large differences in the wage level at retirement. Therefore, the assumptions regarding these career paths are a crucial determinant of the replacement rate of total pension income and should be considered carefully in the analysis.

4.4. Total pension income

4.4.1. First pillar pension systems

In this section the replacement rates of the first pillar pension systems of the countries used in this analysis are provided. The countries are selected based on their differences in the first pillar pension system and on their relevance. Table 9 below shows the main characteristics of the countries selected for this research.

		Country	Type
Flat-rate	**High**	Netherlands	Flat-rate
	Low	The United Kingdom	Flat-rate/small earnings related
Earnings-related	**High**	Italy	NDC
	Low	Poland	NDC/flat-rate means-tested

Table 9. Countries and Main Characteristics. The table shows the countries used in this research and their main characteristics. In the analysis countries with very different first pillars are used to clearly show the effect of differences in the first pillar on the optimal default strategy. Poland and Italy both have a first pillar which is mainly based on Notional Defined Contribution, but the replacement rate for Poland is much lower than for Italy. The United Kingdom and the Netherlands both have a first pillar which is mainly flat rate, but the replacement rate for the United Kingdom is slightly lower than for the Netherlands. The United Kingdom has besides the flat-rate benefit also an earnings-related PAYG benefit.

For the flat-rate PAYG benefits of the Netherlands and the United Kingdom both the level of income and the career path have a significant impact on the replacement rate the first pillar provides. For the NDC PAYG first pillar of Poland and Italy only the career path has an influence on the replacement rate, since the benefit is earnings-related and, thus, the wage level does not change the replacement rate. In table 10 below the replacement rates per income growth profile, and, for the countries for which it is relevant per wage level, are provided. The methodology applied to calculate these benefits is explained in section 3.3.

Income Growth	Low	Medium	High
The Netherlands			
Low Income	75%	42%	28%
Medium income	49%	27%	19%
High Income	25%	14%	9%
The United Kingdom			
Low Income	62%	37%	27%
Medium Income	43%	26%	20%
High Income	25%	15%	12%
Italy	80%	68%	57%
Poland	26%	22%	19%

Table 10. Replacement Rates First Pillar. The table shows the replacement rates of the first pillar pension system for the different wage levels and career paths. For the NDC first pillar of Italy and Poland the replacement rate is the same for all wage levels and only differs between the different career paths, whereas for the mainly flat-rate first pillars of the Netherlands and the United Kingdom, the replacement rate also differs for the different wage levels.

Table 10 shows that the replacement rate of the first pillar largely differs between countries and also within countries for different wage levels and career paths. The first pillar of the Netherlands and Italy are relatively generous with high replacement rates. However, in the Netherlands the benefit largely varies between both different

wage levels and different career paths. This is because the benefit is flat-rate and, thus, the same for every wage level and career path. Poland has the least generous first pillar with replacement rates varying from 18.6% to 26.2%. The United Kingdom has a slightly lower replacement rate than the Netherlands, and, because part of the benefit is earnings-related it is also slightly less redistributive.

4.4.2. Second pillar pension systems

4.4.2.1. Life cycles

In this section the different investment strategies that are evaluated are outlined. Because of the reasons mentioned in section 4.4.2.1. of this thesis, the possible investment mixes are all based on a life-cycle based asset allocation. Currently, existing DC pension schemes base their asset allocation on 'the riskless human capital view'. Because the aim of this thesis is to stay close to reality, life-cycle asset allocations with a decreasing share in risky assets as the participant ages are used in this analysis. Even though, as explained in section 4.4.2.1., because of the positive long-term correlation between stocks and inflation 'the risky human capital view', and, thus, a hump-shaped age based asset allocation, would be more realistic. Besides the fact that existing life cycle strategies base their asset allocation on 'the riskless human capital view' they vary largely in their form and complexity. There are funds that decrease the share of risky assets very gradually, starting already in the beginning of the life cycle. There are also funds that decrease the share of risky assets quicker, starting closer to retirement. Funds also vary in the degree of diversification in the asset mix. There are funds that invest in many different asset categories and also incorporate, for example, cash and real estate, and there are funds that only invest in two different asset categories, usually stocks and bonds. Since the goal of this research is to investigate whether heterogeneity in personal and institutional factors plays a role in the optimal degree of riskiness of the default mix, the complexity and form of the investment mix is less relevant. Therefore, there is chosen to use a simple default mix with only two asset categories. Hereby is chosen to use life cycle investment mixes applied by an existing DC pension provider in the Netherlands, namely Brand New Day.

There are small differences in the indices used by Brand New Day and the ones used for this analysis, because Brand New Day has a Dutch focus. However, of the existing Dutch DC pension plans, the indices of Brand New Day come closest to the indices simulated for this analysis. The government bonds used by Brand New Day are inflation-linked, German government bonds, while the government bonds used for this analysis are non-inflation-linked European government bonds. Furthermore, the stock index used by Brand New Day is the Vanguard Global Stock Index Fund which is Euro-hedged and follows the returns of the MSCI World Free Index[5], while the stock index used for this analysis is the MSCI World (50% Europe) Index.

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[5] Source: www.brandnewday.nl

Brand New Day offers seven different standard investment lines. In this thesis, five of them are used, varying from very defensive to very offensive. The format of these life cycles is shown in table 11 below, with the first number corresponding to the percentage of assets in the stock index and the second number corresponding to the percentage of assets in the government bond index. Table 11 is clarified by figure 8 below, with on the horizontal axis the age of the participant and on the vertical axis the percentage of assets invested in the stock index.

Age/life cycle	Very defensive	Defensive	Neutral	Offensive	Very offensive
25-57	0%/100%	30%/70%	50%/50%	70%/30%	100%/30%
58	0%/100%	30%/70%	45%/55%	45%/55%	45%/55%
59	0%/100%	30%/70%	40%/60%	40%/60%	40%/60%
60	0%/100%	30%/70%	35%/65%	35%/65%	35%/65%
61	0%/100%	30%/70%	30%/70%	30%/70%	30%/70%
62	0%/100%	25%/75%	25%/75%	25%/75%	25%/75%
63	0%/100%	20%/80%	20%/80%	20%/80%	20%/80%
64	0%/100%	15%/85%	15%/85%	15%/85%	15%/85%
65	0%/100%	10%/90%	10%/90%	10%/90%	10%/90%
66	0%/100%	5%/95%	5%/95%	5%/95%	5%/95%
67	0%/100%	0%/100%	0%/100%	0%/100%	0%/100%

Table 11. Life Cycle Asset Allocations. In the table the division of the different life cycle strategies between a global stock index (MSCI World (50% Europe)) and a European bond index is shown. These are the life cycles that are used for this analysis. The first number in each cell indicates the percentage divided to the stock index and the second number in each cell indicates the percentage divided to the bond index. The life cycles changes by age, but are constant for the first 32 years (25-57 years of age).

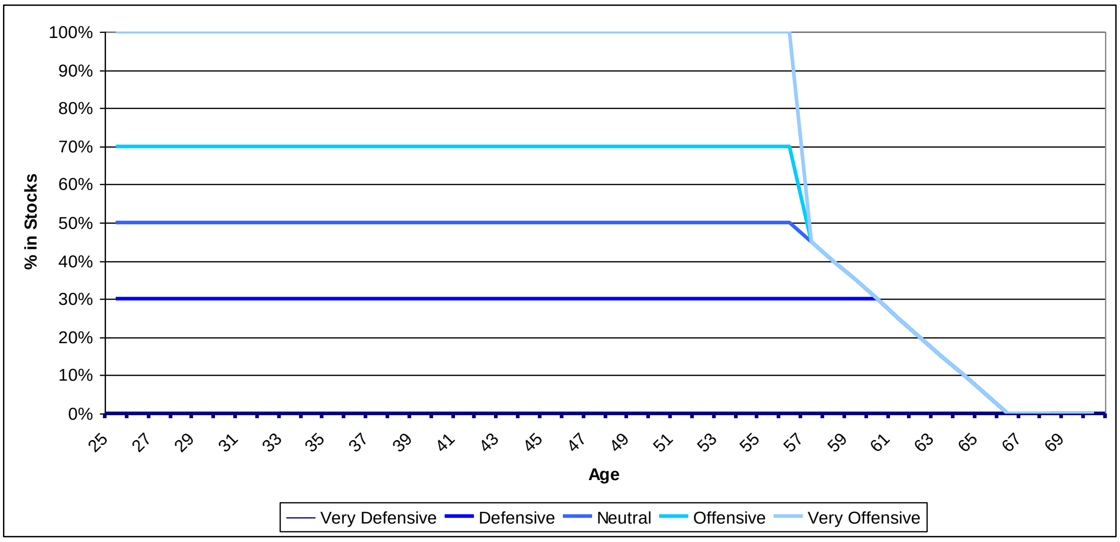

Figure 8. Graphical Representation of the Life Cycle Asset Allocations. In the table the division of the different life cycle strategies between a global stock index (MSCI World (50% Europe)) and a European bond index with an average duration of 6 years is shown graphically. These are the life cycles that are used for this analysis. The life cycles changes by age, but are all constant for the first 32 years (25-57 years of age).

4.4.2.2. Contribution rates to the second pillar

In this section the contribution rates that are used to determine the contribution to the second pillar pension system of the specific country are outlined. A uniform contribution rate for all countries cannot be used, this would not be realistic: pension systems differ in their overall generosity and the magnitude of the contribution to the second pillar is partly dependent on the magnitude of the first pillar. The contribution rates to the second pillar of each country are shown in table 12 below:

Country	Contribution rate second pillar
The Netherlands	16.4%
Poland	7.3%
The United Kingdom	19.1%
Italy	6.9%

Table 12. Contribution Rate Second Pillar. The table shows the actual contribution levels to the second pillar of each country used in the analysis. It is defined as the contribution rate of the employer plus the contribution rate of the employee. When a distinction is made between the defined benefit and the defined contribution second pillar pension system of the country, the defined benefit contribution rate is chosen, because this usually is the most realistic contribution to obtain a reasonable replacement rate (source: OECD).

In the Netherlands and the United Kingdom, no contribution to the second pillar has to be paid over part of the income, the so-called ‘franchise’. The franchise is installed in these countries because part of the pension income consists of a flat-rate benefit. The idea is that for a person who earns an income equal to or only slightly higher than the flat-rate benefit provided by the state, it is not necessary to accumulate supplementary pension. So the franchise is deducted from the income and the contribution is paid over this part of the income. The franchise differs per pension fund, therefore, an average is used in this analysis. Because the contribution rates in table 12 above, are average contribution rates over the whole income, also the contribution has to be adjusted. The contribution is recalculated for a person earning average gross full-time wage (modal). The results are shown in table 13 below.

	Average full time earnings	Franchise	Contribution
The Netherlands	€33.000	€12.600	25.4%
United Kingdom	€30.813	€6.566	24.3%

Table 13. Franchise and Adjusted Contribution Rates UK and NL. The table shows the franchise and the adjusted contribution for the United Kingdom and the Netherlands. The franchise is higher for the Netherlands than for the United Kingdom, because the flat-rate benefit is higher for the Netherlands. The Franchise is deducted from the income and the adjusted contribution is calculated over this amount.

4.5. Risk-aversion levels

In this section the chosen risk-aversion levels are explained. In this research four different risk-aversion levels are considered. As explained in section 3.6. the utility function used in this research is as shown in formula 13 below:

$$U(SP_{rel}) = \mu(SP_{rel}) - \frac{\gamma}{2}\sigma(SP_{rel})^2 \qquad (13)$$

To determine the risk-aversion, the coefficient of risk-aversion of this utility function (γ) should be defined. To be able to determine this coefficient a mental experiment is used.

In order to determine this coefficient, first the concept of risk-aversion is explained. Risk-aversion means that any risk-averse individual would be willing to give up more than 1% in the good state for 1% more in the bad state (Feldstein and Ranguelova, 2001). To translate this sentence to this research, take for example a relative weight of the second pillar of 50% with a standard deviation of 12.5%. A person would always prefer a relative second pillar of 50% with no volatility, instead of taking the risk that the replacement rate will be lower than 50%, even though this risk also carries upside potential. Therefore, the 50% with no volatility should provide higher utility than the 50% with volatility. This explains the concept of risk-aversion. Based on the consumption smoothing theory people are always risk-averse to some degree, since they prefer a smooth consumption path over the life cycle. Therefore, in this research there is assumed that there is always a certain degree of risk-aversion.

However, people might vary in the degree of risk-aversion. In this thesis a distinction is made between four different risk-aversion levels. In order to determine these risk-aversion levels, there cannot be looked to the values taken in the finance literature from the difference between the yields on stocks and on 'risk-free' treasury bills, since these values are implausibly high because of the 'equity premium puzzle' (Feldstein and Ranguelova, 2001). Furthermore, since this utility function is expressed in relative replacement rates the value of the risk-aversion coefficient doesn't match the value of the risk-aversion coefficient using returns and risks of asset portfolios. Feldstein and Ranguelova (2001) face a similar problem in their research and they use a mental experiment together with common sense to solve this issue. In this thesis a similar method is used.

In order to calculate the corresponding risk-aversion levels, take again the example of a replacement rate of 50% with a standard deviation of 12.5%. This result was an average result of the empirical part of this research and is used because it can be used easy and intuitively. This means that there is an equal probability that the second pillar determines 62.5% of the total pension income as that it determines 37.5% of total pension income (since the amount of the first pillar remains the same this indicates a higher or lower second pillar pension income). Assume that an average participants gets the same utility out of a relative share of total pension income of the second pillar of 47% as out of a share of 50% with a standard deviation of 12.5%. Out of the utility function can be obtained that the corresponding risk-aversion coefficient should be equal to 4 in this case. The same can be done for other risk-aversion levels in order to determine the coefficient. This is shown in table 14 below.

Risk-Aversion	Certainty Equivalent Return	Risk-Aversion Coefficient (γ)
Low	48.5%	2
Medium	47%	4
High	44%	8
Very High	40%	20

Table 14. Certainty Equivalent Returns and Risk-Aversion coefficients. The table shows the assumptions regarding the certainty equivalent return of a certain participant. The certainty equivalent return can be read as follows: the person obtains equal utility out of the certainty equivalent return with no volatility as out of the relative share of the second pillar of 50% with a volatility of 12.5%. The certainty equivalent returns are determined using common sense and the corresponding risk-aversion coefficient is calculated.

Table 14 shows the risk-aversion coefficients for the participants with low, medium, high and very high risk-aversion level and the intuitive steps taken to determine these coefficients. In the empirical part of this research these coefficients are used in order to determine the effect of different risk-aversion levels on the optimal default for a certain participant.

5. Results

In this chapter the results of the research are discussed. In the analysis in this chapter, the five possible default asset allocations (section 4.4.2.1), varying from very defensive to very offensive, are compared for participants with different characteristics. The optimal investment strategy is the one which results in the highest utility for the participant. In this chapter participants in different countries, with different wage levels (section 4.3.1.) and with different career paths (section 4.3.2.) are considered. The resulting utility level is provided for different risk-aversion levels.

5.1. Differences in the first pillar

In this section the different optimal investment strategies for different first pillar pension systems are discussed. In order to make the difference between different first pillar systems clear, average participants of each country are compared. An average participant has a medium wage (as defined in section 4.3.1.) and an average career path (as defined in section 4.3.2.). In table 15 below, the replacement rates and the corresponding relative allocation between the PAYG and funded part of pension income are shown for the four countries selected for this analysis.

		as % of final wage			as % of total pension income		
		mean 1st pillar	**mean 2d pillar**	**stdev 2d pillar**	**mean 1st pillar**	**mean 2d pillar**	**stdev 2d pillar**
Italy	**very defensive**	67,7%	14,9%	2,4%	81,9%	18,1%	3,0%
	defensive	67,7%	18,2%	3,3%	78,8%	21,2%	3,8%
	neutral	67,7%	20,1%	5,1%	77,1%	22,9%	5,9%
	offensive	67,7%	22,1%	7,9%	75,4%	24,6%	8,8%
	very offensive	67,7%	25,5%	14,7%	72,7%	27,3%	15,8%
Poland	**very defensive**	22,1%	15,8%	2,6%	58,3%	41,7%	6,8%
	defensive	22,1%	19,2%	3,5%	53,5%	46,5%	8,4%
	neutral	22,1%	21,3%	5,4%	51,0%	49,0%	12,6%
	offensive	22,1%	23,3%	8,3%	48,6%	51,4%	18,4%
	very offensive	22,1%	26,9%	15,6%	45,1%	54,9%	31,8%
Netherlands	**very defensive**	27,5%	38,9%	6,2%	41,4%	58,6%	5,6%
	defensive	27,5%	47,0%	8,3%	36,9%	63,1%	11,2%
	neutral	27,5%	51,7%	12,8%	34,7%	65,3%	16,2%
	offensive	27,5%	56,5%	19,5%	32,7%	67,3%	23,2%
	very offensive	27,5%	64,7%	36,0%	29,8%	70,2%	39,0%
United Kingdom	**very defensive**	26,1%	42,9%	6,9%	37,8%	62,2%	10,0%
	defensive	26,1%	55,9%	10,7%	31,8%	68,2%	13,0%
	neutral	26,1%	57,3%	14,4%	31,3%	68,7%	17,3%
	offensive	26,1%	62,7%	22,0%	29,4%	70,6%	24,8%
	very offensive	26,1%	72,1%	40,8%	26,6%	73,4%	41,6%

Table 15. Replacement Rates and Relative Allocation between Pillars per Country for an Average Participant. The first three columns of the table shows the replacement rates that follow from the model explained in chapter 3 and 4 for an average participant, for each investment strategy. An average participant is a participant with medium wage (section 4.3.1.) and a medium income growth profile (section 4.3.2.). The last three columns convert these replacement rates into a relative allocation between the first and the second

The first three columns of table 15 show that for an average participant the first pillar of Italy provides a much higher replacement rate than the first pillar of the other countries. The first pillars of Poland, the Netherlands and the United Kingdom provide comparable replacement rates. Table 15 also shows that the second pillars of Poland and Italy as well as the second pillars of the Netherlands and the United Kingdom provide comparable replacement rates and that the replacement rates of the second pillar are higher for the Netherlands and the United Kingdom than for Poland and Italy.

The last three columns of table 15, which show the relative magnitude of the first and second pillar as a percentage of total pension income (which is equal to 100% for every country), show what the consequences are for the relative division between the first and second pillar. This relative division illustrates that even though the second pillar of both Poland and Italy provide similar replacement rates, the relative magnitude of the second pillar is much smaller for Italy than for Poland, because the first pillar of Italy provides a higher replacement rate. Furthermore, the relative division shows that even though the first pillars of Poland, the Netherlands and the United Kingdom provide similar replacement rates, this replacement rate is a larger percentage of total pension income for Poland than for the Netherlands and the United Kingdom. To conclude, the replacement rates shown in table 15 clearly illustrate the diversity in the design of pension systems across different European countries.

The relative importance of the second pillar leads to different risk preferences regarding the default asset allocation of the DC pension plan. This is because total pension income can be seen as a portfolio of risk-free (PAYG) and risky (funded, DC) pension income, where the relative share should matter, not the generosity level of the pension system of the country, which cannot be influenced.

Table 15 also shows that the more offensive the asset allocation of the DC pension plan, the higher the mean replacement rate of the second pillar. This is simply because a more offensive strategy leads to a higher expected return on investment and, therefore, to higher mean outcomes. However, this higher mean replacement also implies a higher volatility around this mean. This is clearly illustrated by the 95% confidence interval of the replacement rate of the DC pension plan for the different investment strategies. These confidence intervals, together with the relative allocation between the two pillars, are shown in table 16 below. These confidence intervals are constructed for a participant with an average wage level (section 4.3.1.) and average income growth (section 4.3.2.).

		as % of final wage		as % of total pension income	
		2.5% Percentile	**97.5% Percentile**	**2.5% percentile**	**97.5% percentile**
Italy	**very defensive**	10,9%	20,5%	13,9%	23,3%
	defensive	12,4%	25,5%	15,5%	27,4%
	neutral	12,1%	31,8%	15,2%	32,0%
	offensive	11,4%	40,6%	14,4%	37,5%
	very offensive	10,0%	60,1%	12,9%	47,0%
Poland	**very defensive**	11,5%	21,7%	34,2%	49,6%
	defensive	13,2%	26,9%	37,4%	54,9%
	neutral	12,8%	33,7%	36,7%	60,4%
	offensive	12,1%	43,0%	35,4%	66,1%
	very offensive	10,5%	63,6%	32,2%	74,2%
Netherlands	**very defensive**	28,6%	53,1%	51,0%	65,9%
	defensive	32,5%	65,3%	54,2%	70,4%
	neutral	31,7%	81,0%	53,6%	74,7%
	offensive	29,9%	102,2%	52,1%	78,8%
	very offensive	26,4%	149,4%	49,0%	84,5%
United Kingdom	**very defensive**	30,1%	56,8%	53,6%	68,5%
	defensive	34,4%	70,5%	56,9%	73,0%
	neutral	33,6%	88,1%	56,3%	77,2%
	offensive	31,5%	112,5%	54,7%	81,2%
	very offensive	27,6%	166,4%	51,4%	86,5%

Table 16. 95% Confidence Interval of the Replacement Rate and Relative Allocation between Pillars. The first two columns of the table show the 95% confidence interval (between 2.5% and 97.5% percentile) of the replacement rate for the different strategies of the different countries for an average participant (with an average wage level and medium income growth). The last two columns show the relative allocation between the first and second pillar as percentage of total pension income, adding up to 100%.

Table 16 shows that the more offensive the strategy, the wider the range in which the replacement rate of second pillar pension income falls with 95% confidence. Based on the 95% confidence interval the very defensive investment strategy (100% in bonds) should never be the optimal investment strategy, because for all other investment strategies both the lower and the upper boundary of the interval are higher. For the other investment strategies it depends on the risk-aversion which lower boundary a participant is willing to accept in order to benefit from the upside potential. Table 15 and table 16 combined indicate that the distribution of the replacement rates is positively skewed, because when the replacement rates would be normally distributed, the 95% confidence interval (mean +/- 2 x standard deviation) would be lower for both the lower and the upper boundaries. This effect is increasing the more offensive the strategy, which indicates that stocks are more positively skewed than bonds. This trend can be seen throughout the whole analysis and the conclusions are similar for the analyses in the next sections.

To conclude this section, the resulting utility levels for the four different risk-aversion levels described in section 4.5. are shown in table 17 below. The utility levels are provided for an average participant (medium wage level, medium income growth) for the five different investment strategies (as defined in section 4.4.2.1.) considered in this analysis.

		γ=2	γ =4	γ =8	γ =20
Italy	**very defensive**	0,180	0,179	0,177	0,172
	defensive	0,210	0,209	0,206	**0,197**
	neutral	0,226	0,222	**0,215**	0,195
	offensive	0,238	**0,230**	0,215	0,169
	very offensive	**0,248**	0,223	0,173	0,023
Poland	**very defensive**	0,412	0,407	0,398	0,370
	defensive	0,458	0,451	**0,437**	**0,394**
	neutral	0,475	**0,459**	0,427	0,333
	offensive	**0,480**	0,446	0,379	0,177
	very offensive	0,448	0,348	0,146	-0,460
Netherlands	**very defensive**	0,583	0,580	0,574	**0,555**
	defensive	0,619	**0,606**	**0,581**	0,506
	neutral	**0,627**	0,601	0,548	0,391
	offensive	0,619	0,565	0,458	0,135
	very offensive	0,549	0,397	0,092	-0,823
United Kingdom	**very defensive**	0,612	0,602	0,582	**0,521**
	defensive	**0,665**	**0,648**	**0,614**	0,512
	neutral	0,657	0,628	0,568	0,388
	offensive	0,645	0,584	0,461	0,094
	very offensive	0,561	0,388	0,042	-0,997

Table 17. Utility Levels for the Different Countries and Different Risk-Aversion Levels. The table shows the utility for the different investment strategies of the different countries of which the replacement rates and relative allocation to the first and second pillar are outlined in table 15. The utility is calculated for the four risk-aversion levels outlined in section 4.5.

Table 17 clearly shows that the higher the risk-aversion the more defensive the optimal strategy. This property is captured by the utility function used in this analysis, which is explained in section 3.6. This is because a more risk-averse person prefers more certainty, and, thus, utility decreases more with a larger variance than for a less risk-averse person. All countries show a clear pattern towards more defensive strategies if the risk-aversion increases.

Furthermore, table 17 shows that the higher the relative importance of the second pillar, the more defensive the optimal asset allocation for the DC pension plan. For the United Kingdom, where the second pillar provides the highest share of total pension income (+/- 70%) for an average participant, the optimal strategy is defensive. Whereas for Italy, where the second pillar provides the lowest share of total pension income (+/- 20%), the optimal strategy is very offensive. This trend is visible for all risk-aversion levels. However, for the higher risk-aversion levels the difference between the strategies gets smaller, from a very defensive strategy for the United Kingdom to a defensive strategy for Italy.

This differences in the optimal risk level of the default asset allocation between a country with a relatively large first pillar and a country with a relatively small first pillar can be explained by the idea that the first pillar can be seen as a risk-free asset in the portfolio forming total pension income. The larger the relative importance of the first pillar, the higher the share of the risk-free asset in the portfolio, and the more risky the remaining part of the portfolio can be invested. The analysis shows that the differences are considerable and lead to very different optimal default asset allocations, varying from 100% in stocks to 100% in bonds.

5.2. Differences in wage levels

In this section the different optimal investment strategies for different wage levels (as defined in section 4.3.1.) are discussed. Different wage levels can lead to a different replacement rate of the first pillar, if the first pillar is not earnings-related, because a flat-rate benefit is larger relative to income for a participant with low income than for a participant with high income. A different replacement rate of the first pillar leads to a different relative division between the first and second pillar, and, thus, to a different optimal investment strategy. Therefore, different wage levels are only interesting to consider for the Netherlands and the United Kingdom, because their first pillar is (partly) flat-rate (section 3.3.). The outcomes for the medium wage levels of the Netherlands and the United Kingdom are already provided in section 5.1.. Thus, in this section only the results for the low and high wage levels of the Netherlands and the United Kingdom are presented. Participants with average career paths are considered in this part of the analysis (as defined in section 4.3.2.). The influence of different career paths is discussed in the next section. In table 18 below, the replacement rates of the first and second pillar for the low and high wage levels of the Netherlands and the United Kingdom are presented and the consequences for the relative division between the two pillars are provided.

	Wage Level	as % of final wage mean 1st pillar	mean 2d pillar	stdev 2d pillar	as % of total pension income mean 1st pillar	mean 2d pillar	stdev 2d pillar
Netherlands	**low**						
	very defensive	41,8%	30,6%	4,8%	57,8%	42,2%	6,6%
	defensive	41,8%	36,6%	6,3%	53,3%	46,7%	8,1%
	neutral	41,8%	40,0%	9,6%	51,1%	48,9%	11,8%
	offensive	41,8%	43,5%	14,5%	49,0%	51,0%	16,9%
	very offensive	41,8%	49,5%	26,5%	45,8%	54,2%	29,0%
	high						
	very defensive	13,7%	46,9%	7,6%	22,7%	77,3%	12,5%
	defensive	13,7%	56,9%	10,2%	19,4%	80,6%	14,4%
	neutral	13,7%	62,8%	15,9%	17,9%	82,1%	20,7%
	offensive	13,7%	68,8%	24,2%	16,6%	83,4%	29,4%
	very offensive	13,7%	79,2%	45,1%	14,8%	85,2%	48,5%
United Kingdom	**low**						
	very defensive	36,8%	37,1%	5,9%	49,8%	50,2%	8,0%
	defensive	36,8%	44,7%	7,9%	45,1%	54,9%	9,7%
	neutral	36,8%	49,2%	12,2%	42,8%	57,2%	14,2%
	offensive	36,8%	53,8%	18,5%	40,6%	59,4%	20,5%
	very offensive	36,8%	61,6%	34,2%	37,4%	62,6%	34,8%
	high						
	very defensive	15,4%	47,7%	7,8%	24,4%	75,6%	12,3%
	defensive	15,4%	58,0%	10,4%	21,0%	79,0%	14,2%
	neutral	15,4%	64,0%	16,3%	19,4%	80,6%	20,5%
	offensive	15,4%	70,2%	24,9%	18,0%	82,0%	29,1%
	very offensive	15,4%	80,9%	46,4%	16,0%	84,0%	48,1%

Table 18. Replacement Rates and Relative Allocation between Pillars for NL and UK for Different Income Levels. The first three columns of the table shows the replacement rates that follow from the model explained in chapter 3 and 4 for participants with low and high income (as defined in section 4.3.1.), for each investment strategy. The participants have a medium income growth profile (section 4.3.2.). The last three columns convert these replacement rates into a relative allocation between the first and the second pillar.

between different wage levels in the Netherlands and the United Kingdom. The first pillar of the Netherlands provides a participant with low income with 41.8% of the final wage out of the first pillar, where a participant with high income only receives 13.7% of the final wage out of the first pillar. A similar relation holds for the United Kingdom, but with 36.8% and 15.4% respectively. This difference is caused by the fact that the first pillar of the United Kingdom is partly earnings-related, and, therefore, slightly less redistributive than the first pillar of the Netherlands.

Also the percentage of final wage received out of the second pillar differs between wage levels. This can be explained by the franchise described in section 4.3.1. Over part of the income no contribution is paid and this part is smaller for participants with high wage levels than for participants with low wage levels. Thus, a participant with an income only slightly higher than the franchise, pays only small amounts of contribution and, thus, receives less income out of the second pillar.

Both the effect of the flat-rate first pillar and the effect of the franchise lead to a relatively higher dependence on the second pillar for total pension income for participants with high wage levels relative to participants with low wage levels. This is clearly shown in the last three columns of table 18, which show that for participants in the Netherlands the relative dependence on the second pillar for the provision of total pension income differs from 48.9% for low wage levels (which is still considerable) to 82.1% for high wage levels. For the United Kingdom this difference is slightly smaller, with 57.2% for participants with low wage levels to 80.6% for participants with high wage levels. Again, this is explained by the less redistributive first pillar of the United Kingdom relative to the Netherlands.

In table 19 below, the utility levels for the different wage levels in the Netherlands and the United Kingdom for the different investment strategies are shown for the four risk-aversion explained in section 4.5.

		γ=2	γ=4	γ=8	γ=20
Netherlands	**low**				
	very defensive	0,418	0,414	0,405	0,379
	defensive	0,460	0,453	**0,440**	**0,401**
	neutral	0,475	**0,461**	0,434	0,351
	offensive	**0,481**	0,452	0,395	0,223
	very offensive	0,458	0,374	0,206	-0,298
	high				
	very defensive	0,758	0,742	0,711	**0,617**
	defensive	**0,785**	**0,764**	**0,722**	0,597
	neutral	0,778	0,735	0,649	0,391
	offensive	0,747	0,661	0,489	-0,028
	very offensive	0,617	0,381	-0,090	-1,502
United Kingdom	**low**				
	very defensive	0,496	0,489	0,476	0,438
	defensive	0,540	0,530	**0,511**	**0,455**
	neutral	0,552	**0,532**	0,492	0,371
	offensive	**0,552**	0,510	0,426	0,175
	very offensive	0,505	0,384	0,141	-0,586
	high				
	very defensive	0,741	0,725	0,695	**0,605**
	defensive	**0,770**	**0,749**	**0,709**	0,587
	neutral	0,764	0,722	0,639	0,387
	offensive	0,736	0,651	0,482	-0,024
	very offensive	0,608	0,376	-0,087	-1,478

Table 19. Utility Levels for the Different Income Levels for the UK and NL for Different Risk-Aversion Levels. The table shows the utility for the different investment strategies (as defined in section 4.4.2.1.) of the different wage levels (as defined in section 4.3.1.) of the United Kingdom and the Netherlands of which the replacement rates and relative allocation to the first and second pillar are outlined in table 18 for participants with an average career path (as defined in section 4.3.2.). The utility is calculated for the four risk-aversion levels outlined in section 4.5.

Table 19 shows that for the different wage levels for the United Kingdom and the Netherlands, where (part of) the first pillar is flat-rate, the optimal investment strategy differs largely. If the wage level of a participant in the United Kingdom or the Netherlands is low, and, thus, the flat-rate benefit of the first pillar is a relatively large share of total pension income, the optimal default strategy is more offensive than when the wage level of the participant is high. In both cases the optimal strategy moves from offensive (mostly stocks) to defensive (mostly bonds), which is a considerable difference. Like in the previous section, the difference between the optimal strategies gets smaller for higher risk-aversion levels. The intuition behind the difference in the optimal investment strategy for the different wage levels is similar to the intuition in the first section, which compares different sizes of the first pillar. A lower wage level increases the relative share of the risk-free first pillar in the portfolio that forms total pension income, and, thus, leads to a more offensive optimal strategy for the pension accumulated in the second pillar. This is because more risk can be taken when a participant is less dependent on the second pillar.

5.3. Differences in career paths

In this section the influence of different career paths on the optimal investment strategy is discussed. Also for this analysis the Netherlands and the United Kingdom are the only countries for which the career path has an influence on the utility of the different investment strategies. This is because differences in income growth do not affect the optimal investment strategy for Poland and Italy, since the different career paths have the same decreasing influence on the replacement rate for the first pillar and the second pillar. Therefore, the relative allocation between the first and second pillar does change only slightly (see table 20).

	as % of final wage		as % of total pension income	
	first pillar	mean second pillar	first pillar	mean second pillar
Italy				
low	80,2%	24,6%	23,5%	76,5%
medium	67,7%	20,1%	22,9%	77,1%
high	56,8%	16,4%	22,3%	77,7%
Poland				
low	26,2%	26,0%	49,9%	50,1%
medium	22,1%	21,3%	49,0%	51,0%
high	18,6%	17,3%	48,3%	51,7%

Table 20. Replacement Rates and Relative Allocation between Pillars for Italy and Poland for Different Income Growth Profiles. The table shows the replacement rates and the relative allocation to the first and second pillar as percentage of total pension income for Italy and Poland for different income growth profiles (as defined in section 4.3.2.). The investment strategy is set to neutral (as defined in section 4.4.2.1.) and the income level is set to medium (as defined in section 4.3.1.) for this analysis.

Different career paths do have an influence on the relative allocation between the first and second pillar for the Netherlands and the United Kingdom, where part of the first pillar pension benefit is flat-rate (as explained in section 3.3). This is because the flat-rate benefit is assumed to grow with inflation in this analysis, while for different career paths a different percentage of real income growth (on top of inflation) is added to the income. Thus, steeper career paths can lead to much lower replacement rates for the first pillar. The replacement rates of the low and high income growth profiles (as defined in section 4.3.2.) and the corresponding relative allocation between the first and second pillar are shown in table 21 below. Again participants with medium wage levels are compared.

		as % of final wage			as % of total pension income		
	Income Growth	mean	mean	stdev	mean	mean	stdev
		1st pillar	2d pillar	2d pillar	1st pillar	2d pillar	2d pillar
Netherlands	**low**						
	very defensive	49,1%	36,4%	6,3%	57,4%	42,6%	7,4%
	defensive	49,1%	45,3%	8,7%	52,0%	48,0%	9,2%
	neutral	49,1%	50,8%	13,9%	49,2%	50,8%	13,9%
	offensive	49,1%	56,4%	21,8%	46,6%	53,4%	20,7%
	very offensive	49,1%	66,2%	41,5%	42,6%	57,4%	36,0%
	high						
	very defensive	18,5%	34,9%	5,3%	34,6%	65,4%	9,9%
	defensive	18,5%	41,5%	7,0%	30,9%	69,1%	11,6%
	neutral	18,5%	45,2%	10,5%	29,1%	70,9%	16,5%
	offensive	18,5%	48,9%	15,7%	27,5%	72,5%	23,2%
	very offensive	18,5%	55,3%	28,5%	25,1%	74,9%	38,6%
United Kingdom	**low**						
	very defensive	42,9%	44,9%	7,8%	48,8%	51,2%	8,9%
	defensive	42,9%	55,9%	10,7%	43,4%	56,6%	10,8%
	neutral	42,9%	62,6%	17,2%	40,6%	59,4%	16,3%
	offensive	42,9%	69,6%	26,9%	38,1%	61,9%	23,9%
	very offensive	42,9%	81,7%	51,2%	34,4%	65,6%	41,1%
	high						
	very defensive	19,6%	37,2%	5,7%	34,6%	65,4%	10,0%
	defensive	19,6%	44,4%	7,6%	30,7%	69,3%	11,8%
	neutral	19,6%	48,5%	11,5%	28,8%	71,2%	16,8%
	offensive	19,6%	52,7%	17,2%	27,2%	72,8%	23,8%
	very offensive	19,6%	59,8%	31,6%	24,7%	75,3%	39,8%

Table 21. Replacement Rates and Relative Allocation between Pillars for NL and UK for Different Income Growth Profiles. The table shows the replacement rates and the relative allocation to the first and second pillar as percentage of total pension income for the United Kingdom and the Netherlands for different income growth profiles (as defined in section 4.3.2.). The income level (section 4.3.1.) is set to medium for this analysis.

Table 21 shows that the replacement rate the first pillar provides differs substantially between the two income growth profiles in the Netherlands and the United Kingdom. This is because the replacement rate is expressed as a percentage of final wage, and, thus, a higher income growth leads to a lower replacement rate in the case of a flat-rate first pillar. The difference is smaller for the United Kingdom than for the Netherlands, because the flat-rate part of the first pillar of the United Kingdom is smaller than the flat-rate part of the first pillar of the Netherlands. As explained in the previous sections, different replacement rates of the first pillar lead to differences in the relative allocation between the two pillars, where a lower replacement rate of the first pillar leads to a higher dependence on the second pillar for the provision of pension income.

The main difference between the analysis of different wage levels and the analysis of different career paths is that the average replacement rate the second pillar provides is lower instead of higher, the higher the income growth. This can be explained by the fact that the franchise only has an effect on the second pillar pension income that is accumulated for different wage levels, not for different career paths. Higher income growth leads to lower replacement rates for both the first and the second pillar, while higher wage levels lead to higher replacement rates for the second pillar because of the franchise. Therefore, the relative dependence on the second pillar is lower for high income growth than for high wage levels.

In table 22 below, the utility levels for the different career paths (as defined in section 4.3.2.) in the Netherlands and the United Kingdom are shown for the different investment strategies, for a participant with medium wage (as defined in section 4.3.1.).

		γ=2	γ=4	γ=8	γ=20
Netherlands	**low**				
	very defensive	0,420	0,415	0,404	0,371
	defensive	0,471	0,463	**0,446**	**0,396**
	neutral	0,489	**0,469**	0,430	0,314
	offensive	**0,492**	0,449	0,364	0,107
	very offensive	0,444	0,315	0,056	-0,721
	high				
	very defensive	0,644	0,634	0,614	0,556
	defensive	0,678	**0,664**	**0,637**	**0,556**
	neutral	**0,682**	0,655	0,601	0,438
	offensive	0,671	0,618	0,510	0,187
	very offensive	0,600	0,451	0,153	-0,741
United Kingdom	**low**				
	very defensive	0,504	0,496	0,480	0,433
	defensive	0,554	**0,542**	**0,519**	**0,449**
	neutral	**0,567**	0,541	0,488	0,329
	offensive	0,562	0,504	0,390	0,047
	very offensive	0,487	0,318	-0,020	-1,035
	high				
	very defensive	0,644	0,634	0,614	**0,554**
	defensive	0,679	**0,665**	**0,637**	0,554
	neutral	**0,683**	0,655	0,598	0,428
	offensive	0,672	0,615	0,501	0,160
	very offensive	0,595	0,437	0,121	-0,828

Table 22. Utility Levels for the Different Income Growth Profiles for the UK and NL for Different Risk-Aversion Levels. The table shows the utility for the different investment strategies of the different income growth profiles (section 4.3.2.) of the United Kingdom and the Netherlands of which the replacement rates and relative allocation to the first and second pillar are outlined in table 21. The utility is calculated for the 4 risk-aversion levels outlined in section 4.5)

Table 22 shows that the lower the income growth, the more offensive the optimal strategy. This is in line with the conclusion in section 5.2 for the lower wage levels. This is because the first pillar is a relatively larger part of total pension income and is assumed to be risk-free, so the remaining pension income can be invested more offensive. Furthermore, the optimal strategies are slightly more offensive for the Netherlands than for the United Kingdom, because the flat-rate part of the first pillar of the United Kingdom is smaller than the flat-rate part of the Netherlands. Generally, the optimal investment strategies are more offensive for the steep career paths than for the high wage levels. This is because the relative allocation to the second pillar is higher for the high wage levels than for the steep career paths, because of the franchise. Again, the higher the risk-aversion the more defensive the strategy as is captured by the utility function.

Section 5.1. – 5.3. show that the differences in size and design of the first pillar and differences in wage levels and career paths all lead to different relative allocations to the first and second pillar as percentage of total pension income. Generally, it can be concluded that the higher the relative allocation to the first pillar, the higher the share of pension income that is invested risk-free, and, the more offensive the optimal investment strategy. Furthermore, higher risk-aversion always leads to more defensive optimal investment strategies. In the next section some examples of other factors for which this relationship may hold are discussed, which are not analyzed in this study.

5.4. Other factors

Based on the findings and underlying explanations applied in section 5.1. – 5.3. to explain the effects of different sizes and designs of the first pillar and differences in wage levels and career paths, predictions about the influence of other factors in the framework developed in section 2.4. can be made.

Firstly the influence of work interruptions is discussed. Work interruptions include disability, dismissal and voluntary work interruptions as described in the framework in section 2.4.2.2. As explained in the previous sections, in this analysis, only a difference in the relative allocation to the first and second pillar can lead to differences in the optimal investment strategy. For the NDC based first pillars of Italy and Poland, work interruptions have the same effect on the first and the second pillar. During working interruptions nothing is contributed to the first and the second pillar, and, since in both NDC and DC, the benefits are directly related to the contributions, less is accumulated in both the first and the second pillar. This does not lead to a different relative allocation between the two pillars. Therefore, according to the methodology chosen for this research, risk preferences regarding the asset allocation of the DC pension plan do not change because of work interruptions if the first pillar is of the NDC type. For the pension systems of the United Kingdom and the Netherlands, where the amount received out of the first pillar is not directly related to the amount of working years, this is different. In that case, work interruptions lead to less contributions to the second pillar, without influencing the benefit accumulation of the first pillar. Therefore, the first pillar becomes a relatively larger part of total pension income. As explained before, when the first pillar becomes relatively more important for the provision of total pension income, it leads to a more offensive optimal investment strategy, based on the methodology used for this research. Thus, work interruptions will only lead to different risk preferences when (part of) the first pillar is not directly related to the amount of working years, which is the case for the Netherlands and the United Kingdom, but not for Italy and Poland. It should be noted that work interruptions, especially when they are caused by dismissal or disability, are very unpredictable. Since the default asset allocation is an ex-ante decision that has to be made before these events (might) occur, it is hard to adjust default asset allocations accordingly. The best way to incorporate these factors into a model is to introduce a probability of different kind of work interruptions and see how this changes the risk preferences of the default investment strategy.

Secondly, the influence of additional pension income in the form of personal wealth is shortly discussed. Sources of additional pension income might be house ownership, an inheritance or income provided by the partner. Assume that this additional income is more or less risk-free (such as an inheritance deposited on a bank account earning a low interest rate, with low volatility). In this case, the risk-free part of total pension income increases. This has the same influence on risk preferences as an increasing share of total pension income dependent on the first pillar, which is also assumed to be risk-free in this analysis. Thus, this leads to a more offensive optimal investment strategy for the participant.

However, it should be noted that personal wealth does not have to be risk-free. For example, an inheritance can also be invested more risky, which changes the conclusion. Furthermore, personal wealth can be relatively illiquid. When it is for example invested in a house, no additional annuity like income can be withdrawn from the personal wealth each year. When personal wealth is illiquid, it cannot be used as additional pension income, and, thus, does not lead to a different optimal investment strategy in the model used for this analysis. It can also be the case that participants wish to leave part of their personal wealth as a bequest to their offspring or that it is left unintentionally because of unexpected early death. In this case it also does not change the optimal investment strategy. It can be argued that illiquid wealth and possible bequests should lead to different risk preferences, since participants always have a back-up in case pension income turns out to be less than expected. However, because the model used in this analysis only considers annuities to calculate the replacement rate, it does not capture this reasoning.

To conclude, the reasoning used to explain the differences in size and design of first pillar pension systems and differences in wage levels and career paths can be extended to explain many more factors that might influence risk preferences of the default investment strategy. However, there are always factors, such as unpredictability of work interruptions, liquidity issues and bequest motives, that can change this risk preferences again. Therefore, it is hard to predict the exact influence of these factors on the risk preferences of the optimal default investment strategy.

In section 5.1. – 5.3. the utility levels are analyzed for four different risk-aversion levels. The next section shortly discusses how the risk-aversion level of a participant can be determined in order to match the optimal default as good as possible to the risk-aversion level of the participant.

5.5. Risk-aversion levels

For the determination of the risk-aversion level that should be used to evaluate the different investment strategies based on the utility function, there are several possibilities.

The firs possibility is that the different investment strategies are evaluated using the same risk-aversion level for every participant. The medium risk-aversion would be the most obvious choice, since this risk-aversion level is based on a certainty equivalent return that provides an average person with the same utility level as the risky option (as explained in section 4.5.). The disadvantage of this method is that personal risk attitudes of participants are not taken into account when determining the appropriate default investment option for this participant.

Therefore, it is better to take personal risk attitudes into account when determining the optimal default for a certain participant. However, investors themselves find it difficult to assess and measure their preferences, and the large majority doesn't even succeed (Clark and Strauss, 2008). Therefore, risk preferences should be tested by a reliable method that gives an indication of the appropriate risk-aversion level of the participant. According to Hallahan et al. (2004) there are three main methods to measure risk preferences of individuals. The first method includes the investigation of existing investment behaviour of individuals. However, this method cannot be applied to all participants of occupational pension plans since for most of them no investment history exists (Schooley and Worden, 1996). The second method constitutes of investigating responses of investors to different hypothetical scenarios. This method is often used in choice-based questionnaires. In the last method, risk preferences are measured by using subjective questions, often including attitudinal questions[6] and several choice-based questions[7]. Using one of these methods, pension funds can scale their participants from highly risk-averse towards more risk-tolerant and evaluate the investment options accordingly, also taking into account the other characteristics of the participant, to determine the optimal default investment option of the particular participant.

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[6] **attitudinal questions:** ordinary scaling questions such as the simple question whether individuals prefer more secure savings (risk-averse) over savings with higher return potential but also higher risk (risk tolerant) (Clark and Strauss, 2008) or asking people to scale how they consider themselves as a risk taker on a scale of 1-11 (Dohmen et al., 2005).

[7] **choice-based questions:** questions where participants are asked to choose between several options, describing hypothetical situations, where one option is riskier than the other. see e.g. Dohmen et al, 2005 or Donkers et al., 2012.

6. Conclusion

6.1. Summary

Because of the gradual shift from DB to DC and hybrid pension plans over the past few decades, which shifts the investment risk from the corporate sector to households, the design of DC pension plans has gained significant importance. The increased individualization, which creates heterogeneous preferences across participants, has induced this shift from DB to DC pension plans even further. However, experience with these kinds of plans shows that many people 'choose not to choose'. These participants end up in the default investment mix. Most pension funds hold on to a 'one size fits all' default investment option, which does not differ between participants. In most cases, this default is based on an age based asset allocation, in which contributions are invested riskier in the beginning of the life cycle, and the share in risky assets decreases as the participant ages.

However, many more heterogeneous factors might influence the risk preferences of the participant regarding the default asset allocation of the DC pension plan. Examples are differences in the size and design of the first pillar, differences in wage levels and career paths, work interruptions (dismissal, disability or voluntary work interruptions), additional personal wealth (house ownership, inheritance or partner income) or different levels of risk-aversion. This thesis focuses on different sizes and designs of the first pillar, on different wage levels and career paths and on different levels of risk-aversion.

In order to investigate the influence of these factors on the risk preferences of the default, the distribution of future retirement incomes (first and second pillar) are simulated. These simulations are generated for four different countries, namely Italy, Poland, the Netherlands and the United Kingdom, in order to show the influence of different sizes and designs of the first pillar on the optimal investment strategy. Furthermore, the distinction has been made between three different wage levels in every country, namely minimum wage, average wage and double the average wage (see section 4.3.1.). In order to consider different career paths, three income growth profiles are considered, which differ in their real income growth, varying from no real income growth to a relatively high real income growth (see section 4.3.2.). To determine the optimal investment strategy, five different life cycle investment options are used, varying from very defensive to very offensive. The outcomes are expressed as replacement rates (as % of final wage). The predicted replacement rates are then converted to a relative allocation between the first and the second pillar expressed as a percentage of total pension income to determine the relative importance of the second pillar for the provision of total pension income. Lastly, a mean-variance utility function is used to evaluate this risk return distribution and determine the optimal investment strategy.

The analysis shows that for an average participant (medium wage, average career path) of the four analyzed countries, the size of the first pillar has a large influence on the optimal default for this participant. The optimal investment strategy varies from a very offensive asset mix when the first pillar is relatively large (Italy) to a much more defensive asset mix when the first pillar is relatively small (United Kingdom). The optimal default investment strategy is also highly dependent on the risk-aversion level of the participant. Furthermore, in countries where the first pillar is not of the NDC type, the wage level and career path also change the optimal default investment strategy significantly. A relatively low wage level or a flat career path lead to a relatively higher share of the first pillar in total pension income, and, therefore, to a more offensive optimal investment strategy. For a relatively high wage level or career path this is the other way around. Thus, different sizes and designs of the first pillar and differences in wage levels and career paths have a significant impact on the relative share of the first pillar in the provision of total pension income, which leads to very different optimal default investment strategies.

To conclude, the analysis has clearly shown that there is no 'one size fits all' default investment strategy for participants who refrain from exercising their option to choose their own investment mix. Heterogeneous characteristics of participants should be taken into account in the determination of the default investment strategy. Both country-specific characteristics, such as the design of the first pillar and the relative size of the first and second pillar, and individual characteristics, such as different wage levels and career paths, significantly influence the optimal default investment strategy.

6.2. Discussion and recommendations for further research

In this section a discussion of the assumptions and methodology used for this research is provided and some recommendations for further research are outlined.

In this thesis the different investment options are evaluated using a mean-variance utility function. However, there are many other options to evaluate the different investment options and determine the optimal default investment strategy. For example, the different investment strategies could be evaluated by their probability to reach a predefined target replacement rate or by their probability to not achieve a predefined minimum level of the replacement rate. However, the disadvantage of this method is that the results are completely dependent on the predefined target or minimum, which should differ between countries in order to take the different characteristics of the countries' pension systems into account. The determination of the target or minimum is very subjective, and will lead to different optimal investment strategies for different targets or minimums.

Another possibility is to evaluate the different investment strategies using a different utility function than the mean-variance utility function. For example, instead of using a utility function that decreases with a higher variance, a utility function that decreases with a higher Value-at-Risk could be used. As explained in section 3.6., the mean-variance utility hinges on some strong assumptions. One of them is that asset returns are normally distributed, and, thus, exhibit no skewness and/or kurtosis. However, since the simulated asset returns used in this thesis also capture mean-reversion and persistence, this assumption is not entirely plausible. When Value-at-Risk instead of variance is used to evaluate the different investment strategies, no assumptions about the distribution have to be made. For further research it would be interesting to compare different methods of evaluating the different investment strategies (by means of a target or a different utility function) and show the influence on the optimal investment strategy of different evaluation methods.

The life cycles used in this analysis are very simple life cycles, with only two possible asset categories to invest in, and a constant fraction invested in stocks and bonds over the largest part of the life cycle. This method is chosen, because the focus in this thesis was only on the riskiness of the investment strategy. However, it would be interesting to include more asset categories (cash, real estate) or to decrease the investment in risky assets over the life cycle more gradually, in order to investigate whether this leads to higher expected replacement rates because of better diversification or a more optimal life cycle investment strategy. Another interesting life cycle strategy to consider would be the hump-shaped life cycle based on the 'risky human capital view' , discussed in section 4.4.2.1., since in the long term stocks and wage growth tend to be positively correlated. It should be noted that this strategy would decrease the natural hedge against conversion risk that the 'risk-free human capital' life cycle does capture.

The model used for this analysis compares five different life cycles varying from very defensive to very offensive. It should be noted that the more options a pension fund offers the more costs are involved for the pension fund. In further research it would be interesting to consider these costs to evaluate the optimal amount of options a pension fund should offer to its participants.

In this thesis is assumed that both the income and the first pillar of the different countries develop in exactly the same way, namely with European price inflation. This leads to a completely risk-free first pillar with no volatility if expressed as a percentage of final wage (replacement rate). It would be interesting to consider the possibility that the first pillar and income develop differently over the next decades. For example, by using a function for the development of the first pillar capturing demographic properties, such as ageing and decreasing fertility. According to a report of the European Commission (2009) pension benefits as a percentage of wage will, on average, be 20% lower in 2060 because of the increasing dependency ratio. This would lead to a different relative importance of the first pillar in the provision of total pension income and can change the optimal default investment strategy for a participant.

The risk-aversion level in this thesis is assumed to be constant across individuals in different countries with different characteristics. However, evidence suggests that a lower income leads to higher risk-aversion. For example, Yesuf and Bluffstone (2008) report that there is a significant difference in risk-averting behaviour between relatively poor and wealthy farm households in Ethiopia, suggesting that as wealth accumulates, households are willing to take on more risk in exchange for higher returns. A higher risk-aversion level for participants with low income would lead to a more defensive optimal default investment strategy in this analysis. This would mitigate the difference in the optimal default investment mix between low and high wage levels and career paths for the United Kingdom and the Netherlands, and it would create different optimal default strategies between different wage levels and career paths for Italy and Poland. Therefore, varying risk-aversion levels between participants with different characteristics would be interesting to consider in further research.

In this research only the relative importance of the first and second pillar for the provision of total pension income is considered. However, besides the relative allocation to the first and second pillar, also the level of pension income the first and second pillar provide might play a role in the determination of optimal default investment strategies. For example, Tversky and Kahneman (1979) report that people are loss-averse relative to a certain reference point. It would be an interesting topic for further research to also consider the level of pension income (the replacement rate a certain pension plan provides) relative to a certain reference point, where replacement rates under this reference point give more negative utility than gains above this reference point give positive utility.

6.3. Policy implications

Despite the recommendations for further research described in the previous section, the main conclusions of the research are still valid. Out of these conclusions some important policy implications for pension providers can be inferred.

For pension providers who offer, or are considering to offer their DC products in multiple countries, it is important to make the default investment option dependent on the characteristics of the first pillar in this country. If, in the country, the size of the DC plan is relatively small compared to the first pillar pension plan, the pension provider should offer a more offensive default investment mix than when the size of the DC plan is relatively large.

Furthermore, within a country where (part of) the first pillar is flat-rate, the default investment mix should depend on the wage level of the participant. Pension providers have access to income information of their participants, and, thus, can easily adjust the default investment mix based on the wage level of the participant.

Lastly, the steepness of the career path has considerable influence on the risk preferences of the asset mix. Though the career path of a participant is hard to predict, pension providers can make a distinction between participants in different industries. In low skilled industries a flatter career path can be expected than in high skilled industries, and, this leads to a more offensive optimal investment strategy for participants in low skilled industries in countries where (part of) the first pillar is independent of income.

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