Reverse mortgages: a good diversifier for Dutch pension funds?

An explorative study

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Word of Gratefulness

After two-and-a-halve years of hard labor next to a regular job, this thesis is the endpoint of the EMAS trajectory. Finishing such a trajectory cannot be accomplished without help. Therefore, there are some people I would like to thank.

First of all, all fellow students. We worked intensively together, sometimes had harsh discussions, but always were respectful and supportive to each other. Even the very early Saturdays with beautiful weather seemed less hard because of the shared suffering.

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Source: Efficientboekhouden.nl

Executive Summary

In this thesis, I have examined whether reverse mortgages can play a role in enhancing liquidity at and after retirement. The main problems I have identified (that are relevant for this thesis) are that future retirees face decreased liquidity because of reduced pensions, while at the same time their wealth that is stored in their house is increased but cannot be liquidated easily. Pension funds seek new investment opportunities that offer reasonable returns and good hedging capabilities. Preferably, these investment opportunities should be based in The Netherlands. Such investment opportunities are very hard to find. I suggested that reverse mortgages have the potential to be such an investment opportunity for pension funds. Reverse mortgages could also offer means to consumers to liquidate the wealth stored in stones.

A reverse mortgage consists of a number of steps in time. At retirement, the contract is initiated and the loan amount is transferred to the consumer. The consumer can use the loan to supplement the pension income by buying an annuity (either by the provider of the reverse mortgage of by another provider) or in any other way, for example by receiving a lump sum. During the loan period, no interest payments have to be made. At death or when the house is sold (mostly because the consumer needs to move to a care facility such as a nursing home), the loan is repaid from the proceeds of the sale. If the proceeds of the sale exceed the outstanding debt, the excess goes to the consumer or his relatives. If the proceeds of the sale are lower than the outstanding debt, the remaining debt should be paid by the consumer or his relatives, or is at the risk of the provider (this is called a no negative equity guarantee). In this thesis, I assume all reverse mortgages contain such a guarantee.

The international reverse mortgage market is not very well developed. The US and UK have some market, in other countries the market is very small or even non-existent. Lessons from these markets are that reverse mortgages should be regulated, contain a no negative equity guarantee, and that local culture and attitudes toward borrowing are very important. The Dutch market currently is almost non-existent, with only one provider. However, there are some circumstances that could lead to more demand for reverse mortgages in the future. First, it is expected that pension benefits will decrease in the future, which leads to decreased liquidity of retirees. Second, there are more fiscal incentives to pay off the ordinary mortgage, which results in higher amounts of housing equity. Third, the bequest motive is weak in The Netherlands. Fourth, there is a well regulated and developed financial market. Some factors could hinder demand. An important one is that house values and equity are concentrated amongst higher incomes that might be less in need of extra liquidity anyways. Furthermore, in The Netherlands a prudent attitude towards borrowing exists. Nevertheless, the outlook for reverse mortgage demands seems positive.

An important question is what the advantages and disadvantages of reverse mortgages for consumers are. The main advantage is that reverse mortgages offer supplemental liquidity and enable consumption smoothing. Reverse mortgages also increase access to credit at old age and shift house price and longevity risk from individuals to financial institutions that generally are better suited to face and diversify these risks. However, reverse mortgages have some disadvantages as well. They are complex, come with additional and hidden costs (such as a maintenance obligation), deplete all or most current and future housing wealth, and come with ownership restrictions. Furthermore, the borrowing amount is uncertain beforehand. This make reverse mortgages hard to implement in one's financial planning. In spite of these disadvantages, reverse mortgages have the potential to be very valuable for consumers that are in search for extra liquidity.

But before consumers can benefits from reverse mortgages, providers are needed. In general, providers could benefit from reverse mortgages because they are expected to deliver high profits. Furthermore,

reverse mortgages can help providers to enter niche markets, increase market share in the pensions and mortgage market, cross sell to elderly, build a social reputation, and complement the existing product palette. The main disadvantage is the crossover risk. This risk occurs if the sale value of the house is lower than the value that should be repaid. The shortfall is at the expense of the provider (if a no negative equity guarantee is part of the contract). This crossover risk is a function of the house price appreciation, interest rates (if these are not fixed), the loan-to-value ratio, and the duration of the mortgage (because timing of repayment is uncertain). Other risks are the risk of adverse selection and moral hazard, the illiquidity and uncertainty about the time of repayment, and the little experience providers have with such products.

Pension funds are a potential provider of reverse mortgages. Pension funds more and more have contradicting tasks. One the one hand, they try to guarantee the nominal benefit as much as possible. On the other hand, they aim to make investment returns to finance indexation. Some of the disadvantages of reverse mortgages are less relevant for pension funds. Because pension funds are long term investors by nature, the illiquidity and uncertainty of timing of the repayment might not be much of a problem to them. Furthermore, selection and moral hazard can also be a problem for pension funds, but funds typically know their population quite well compared to other financial institutions. Moreover, the expected high return and interest rate sensitivity of reverse mortgages might make these products particularly interesting for pension funds.

Based on this theoretical discussion, I have posted my hypothesis and sub hypotheses. The main hypothesis is:

Reserve mortgages can offer substantial diversification and hedging potential for Dutch pension funds and can therefore offer a valuable investment opportunity

I divided this hypothesis in sub hypotheses:

1. **Adding reverse mortgages to an asset-only portfolio increases the efficiency of this portfolio**
2. **Reverse mortgages are both able to generate excess returns and increase the liability matching of a pension funds' investment portfolio**
3. **Adding reverse mortgages to the investment portfolio increases the interest rate risk hedge**
4. **Reverse mortgages are suitable in a pension fund portfolio to maintain purchasing power**

After the theoretical discussion, I have quantified the theory with the use of a stochastic scenario analysis. For this, an average pension fund was modelled. This average fund represents an average of all Dutch pension funds. This fund contained a risky and a less risky investment portfolio, to control the robustness of the results for risk appetite.

It was also necessary to model the returns on reverse mortgages. Two cases were modelled, reverse mortgage returns where the interest on the outstanding debt was fixed and where this interest was variable. The resulting returns are stochastic and consistent with the economic scenario set used. The resulting expected returns are almost equity like, with a high median and a large standard deviation. The high return is mainly caused by the high interest charged on the loan. The standard deviation is caused by the crossover risk and (for the fixed interest rate alternative) the discount rate volatility. Contrary to equities, the correlation with the liability returns was quite high, suggesting good hedging potential.

The results show support for reverse mortgages in a pension funds' portfolio. From an assets only perspective, adding reverse mortgages makes investment portfolios more efficient in case the interest is

variable. For the fixed interest alternative, this is not the case. Nevertheless, this provides some support for sub hypothesis 1 that adding (variable interest) reverse mortgages to an asset-only portfolio increases the efficiency of this portfolio.

Next, liabilities were added to the equation. The results show that the efficiency of the portfolio (in terms of excess returns) increased with adding reverse mortgages to the portfolio. Moreover, in terms of funding ratios, support for the liability matching potential of reverse mortgages was found. Both findings provided support for sub hypothesis 2. The positive effects of reverse mortgages were stronger for the fixed interest rate alternative.

Maintaining purchasing power is an important objective of pension funds. The results of the analysis show that adding reverse mortgages to the investment portfolio do not really change the expected outcomes (in the median), but clearly provide downside protection in bad economic circumstances. This accounts for both alternatives of the reverse mortgages. These results support sub hypothesis 4.

Finally, the interest rate hedging potential of reverse mortgages was investigated. For the fixed interest rate alternative, strong support that reverse mortgages offer interest rate hedging was found. For the variable interest rate alternative, this support was less strong, but there was still some support for sub hypothesis 3.

To check whether these (positive) results were not caused by the modelling assumptions, a sensitivity analyses on the house price increase, the risk premium, and the loan-to-value was performed. This analysis showed a slight impact on the magnitude, but the effects did not change.

To conclude, support was found for all of the sub hypotheses. This leads to the conclusion that there is support for the main hypothesis as well. Based on the results in this thesis, reverse mortgages can offer substantial diversification and hedging potential for Dutch pension funds and can therefore offer a valuable investment opportunity.

Contents

Chapter 1: Introduction

The economic crisis and an ageing society have put public welfare provisions and government budgets under pressure. In The Netherlands, this has led to large reforms in the fiscal arrangements for both pensions and mortgages.

In the pension domain, Dutch residents face lower expected nominal pensions because of the more stringent fiscal arrangements, while at the same time the inflation protection of these pensions (called "indexation") is decreased under the new financial rules for pension funds[1]. Therefore, it is more likely that (future) pensioners will face decreased liquidity after retirement.

At the same time, the fiscal incentive to pay off the mortgage has increased. Thus, while on the one hand a pensioner is expected to face decreased liquidity, it becomes more likely he or she owns a fully financed house. Therefore, a pensioner might still have a very high net equity, since the mortgage is completely repaid and the value of the house is directly translated into equity for the resident. The problem is, that it currently is hard to liquidate this housing equity without high transaction costs. The increased housing equity as such does currently not seem to offer attractive opportunities to compensate the expected liquidity decrease.

Of course, it is possible to sell the house and move to a smaller house or apartment, but most elderly are not willing to move (Toussaint and Elsinga, 2010). Another option is to enter into a second mortgage, but this does not solve the problem systematically, because this results in periodical repayments and the risk of being evicted in case of default. Second mortgages thus do not provide enduring liquidity, although they have the potential to solve an immediate and one-off liquidity gap.

In other countries, reverse mortgages offer possibilities to liquidate the equity in the house while at the same time not having to pay periodical installments and without eviction risk. Naturally, these reverse mortgages also have their disadvantages, but they certainly might have the potential to satisfy the expected liquidity needs of Dutch retirees.

Meanwhile, Dutch pension funds have to cope with increasingly strict financial rules (such as the already mentioned new financial assessment framework "nFTK"), that are expected to make pension benefits more flexible, but inflation protection harder. Pension funds operate in a world that expects them to deliver inflation protected benefits without almost any risk of benefit reductions. In this world, financial markets are becoming more volatile, inflation hedging assets are rare, longevity is ever increasing and there is pressure to decrease pension premiums. This increasingly difficult task for pension funds gives them the incentive to investigate alternative investment possibilities that better align with their targets and restrictions. Offering reverse mortgages might be such an investment possibility.

In this master thesis:

I investigate the potential of reverse mortgages as an investment asset for Dutch pension funds.

After I have identified the factors that make a reverse mortgage product attractive (or not) for consumers, I will try to verify if these factors also are attractive from a pension fund point of view. Since the Dutch market for reverse mortgages is almost non-existent (there currently only is one product, the Florius Verzilverhypotheek, available on the market and this product is seldom sold), and international data is very rare, this thesis has an explorative nature. In this thesis,

[1] The financial rules are stated in the financial assessment framework (in Dutch "financieel toetsingskader", or "FTK"). The updated FTK is called nFTK and will be in place as of January 1, 2015

I qualitatively posit my assumptions and show how they work out in a numerical example using stochastic scenario analysis.

In the next chapter, I will elaborate about the combination of ageing, living, nursing and retirement and present my problem definition and main hypothesis. Chapter three deals with the qualitative part of this thesis and discusses how life cycle theory and housing equity release are interrelated. Also, it contains a description of what reverse mortgages actually are and how the international and national market for these products looks like. I will discuss benefits, risks and attitudes surrounding these products from a consumer and a provider point of view, before discussing the pension fund characteristics and stating theories how reverse mortgages could enhance pension fund performance. At the end of chapter three, I present the more detailed sub hypotheses, that follow from this qualitative part. Chapter four deals with working out numerically the hypothesis. With the aid of economic and survival scenarios I will control whether the hypotheses set out in chapter three will hold given the assumptions used. Because of this modelling exercise, this chapter also provides very interesting insights in how reverse mortgages actually work. Chapter five contains the summary and conclusions of this thesis and chapter six discusses possibilities for further research, but more importantly discusses practical issues and ideas involving the implementation of reverse mortgages as an investment asset.

Not much is written about the benefits of reverse mortgages for providers in general and Dutch pension funds in particular. Also, historical return data of reverse mortgages is lacking. Therefore, this thesis is not based on extensive research of economic data. It is explorative in nature and has the aim to give insights in potential benefits of reversed mortgages to Dutch pension funds. Therefore, this thesis hopefully serves as a starting point for broader discussion an research about this subject, possibly leading to a new and interesting investment opportunity for pension funds from which society may benefit.

Chapter 2: Problem Definition and Main Hypothesis

In this chapter, I will present my problem definition and main hypothesis. First, I start with a brief description about the current problems in the Dutch society that are related to ageing and reduced welfare for residents. Second, I will shortly discuss Kemeny's theory, that links the amount of welfare provisions in society to home-ownership. After that, I will continue with describing the challenges pension funds struggle with. After that, I present my research question and main hypothesis.

2.1. Ageing, Nursing, Living, and Retirement – A Residents' Perspective

General developments in the Dutch Society

Just as most other Western Societies, the economic crisis and the increased ageing of the population have put pressure on welfare provisions. This is reflected in different areas. Asbeek, Brusse and Van Montfort (2012) identified the following developments. In the area of living and home-ownership, house prices have decreased significantly and the housing market has almost been locked. Financing opportunities for new housing have decreased and many home-owners are "under water", meaning that their mortgage debt exceeds the value of their home. In the field of care, costs have risen substantially, while budgets have decreased. The fact that people get older results also in people needing nursing and caring longer. The pension sector suffers from deficits because of the increased longevity and persistent low interest rates.

At the same time, home-ownership rates are still increasing (Turner and Yang, 2006) and so is the amount of housing equity (housing equity is the value of the house minus the outstanding mortgage debt of the house) for the ageing population (Haffner, 2008).

To summarize residents in the Dutch society get older and live longer, with increasing housing equity, in a society were old age provisions (caring, living and retirement) are under severe pressure.

Reducing Welfare and Fiscal Arrangements

All this has led the Dutch government to reduce state-sponsored welfare provisions (Toussaint et all., 2007). Meanwhile, Goudswaard (2013) and many others with him have established that the current pension system has reached its boundaries and cannot hold in the future. This is also acknowledged by the Verbond van Verzekeraars (The Dutch society of insurers), that states that the current pension system suffers from the economic crisis and reduced support of society, and expects reduced retirement benefits with higher risks. Toussaint (2011b) confirms this by stating that the present working generation is expected to receive less than the current generation of retirees. So, it is likely that pension provisions will decline for future generations. This can lead to liquidity problems for retirees.

So, the societal trend is that the government is reducing its involvement in all areas of welfare, relocating responsibility to individuals.

2.2. Kemeny's Theory to Connect Home-Ownership with Welfare

In the research field of sociology, there is an important theory that connects home-ownership with welfare provisions. Kemeny (2005) finds a strong inverse relation between the amount of welfare provision in a country and the rate of home-ownership. This means that, in general, countries with low welfare provisions tend to have higher home-ownership rates, and vice versa. The causality of this relation is

unclear. It could be that reduced welfare is a reaction to high ownership rates, or that high ownership rates are a reaction to low welfare provisions. Nevertheless, according to Kemeny's findings, there is a correlation between welfare and home-ownership.

The findings of Kemeny have received criticism, for example from Somerville (2005). Somerville thinks that this is not the way societies work. The rate of home-ownership cannot be directly related to the amount of welfare provisions in a country. Even more, the rate of home-ownership and the welfare provisions are the result of a complex history and societal and cultural circumstances. Boelhouwer and Van der Heijden (2005) found that home-ownership is more related to increased prosperity in a country than to the welfare provisions. They only find an indirect relationship between these two.

Be that as it may, whether or not there is a causal relationship between home-ownership and welfare, the trend in The Netherlands is that of reduced welfare and higher ownership rates and housing equity for the elderly, which may offer interesting opportunities to combine these two areas.

Connecting the Different Areas

The Taskforce Verzilveren (2013), a commission installed to investigate the possibilities of releasing the housing equity for old age, identified that many pensioners in The Netherlands are "cash-rich and money-poor", meaning they have a relatively high wealth (mostly in the form of a house), but a low retirement income. Even more, housing equity is clustered at the older generations. Furthermore, retirees are not willing to give up their home to release equity.

On the other hand, Toussaint and Elsinga (2009) recognize that home-ownership may be thought of as a possible way to cover for reducing welfare. Bovenberg, Koelewijn en Kortleve (2011) plea for a connection between living, caring and retiring.

2.3. The Challenges of Pension Funds

Next to the struggles of consumers, Dutch pension funds have their own challenges. During the financial crisis, the inflation protection of the benefits almost evaporated and a number of funds even had to decrease benefits. Pension funds are expected to make investment returns that enhance inflation protection, while at the same time guaranteeing nominal benefits as much as possible. This paradox is becoming more challenging under the "nFTK", since under these rules rewarding indexation is becoming harder in order to secure the nominal benefits. Next to this increasing challenge, the pressure for pension funds to invest more of their assets in The Netherlands[2] is increasing.

Pension funds thus try to seek Dutch investment products that generate reasonable returns with good hedging capabilities. These products are hard to find in the current

MAIN PROBLEMS IDENTIFIED:

- **FUTURE RETIREES FACE LESS LIQUIDITY BECAUSE OF REDUCED PENSIONS, AND INCREASED EQUITY IN THEIR HOUSE THAT THEY CANNOT LIQUIDATE**
- **PENSION FUNDS SEEK (NEW) INVESTMENT OPPORTUNITIES THAT OFFER REASONABLE RETURNS AND GOOD HEDGING CAPABILITIES AND ARE BASED IN THE NETHERLANDS**

[2] Even the government programme (in Dutch "regeerakkoord") of 2012 "Bruggen slaan" mentions more public-private investments in The Netherlands by, amongst others, pension funds.

investment spectrum of pension funds.

2.4. Problem Definition

This is where the reverse mortgage comes into play as the linking pin between the pension funds' quest and the individuals desires. In a society that reduces welfare provisions and relocates risks and responsibility for retirement to housing-equity rich individuals that are not willing to move, financial products that can release housing equity and make it possible to stay in the home might represent a valuable offer from the consumers point-of-view. The problem however, is that the supply of these products in The Netherlands is extremely limited. Currently, there is only one provider. Therefore, this thesis focuses on the products characteristics that might be beneficial for consumers and providers. To be more precise, this thesis focuses on which characteristics of a reverse mortgage product would make it attractive for Dutch pension funds to invest in it, while still being attractive for consumers too. This leads to the following problem definition:

Can reverse mortgages be designed in such a way that they are an attractive investment opportunity for Dutch pension funds?

2.5. Hypothesis

Since reverse mortgages can have different product characteristics, I think it is possible to design it in such a way that they offer both benefits for the Dutch pension funds as a provider and to consumers. If pension funds enter the reverse mortgage market this could enhance the liquidity of retirees in an efficient manner. In turn, society might profit twofold, because retirees will need to request welfare provisions less often and pension funds are able to invest the pension contributions in a more fitting asset allocation.

Pension funds have different targets and suffer from different risks (interest, inflation, longevity, for example). In chapter three, I will discuss the different opportunities in more detail, so in this part, I will only posit my main hypothesis, that will be detailed into sub hypotheses in the next chapter.

Reserve mortgages can offer substantial diversification and hedging potential for Dutch pension funds and can therefore offer a valuable investment opportunity.

Chapter 3: Reverse Mortgage Theory

This chapter contains the theoretical part of my thesis project. First, I will discuss why and how people receive income, save, and spend and how equity release can play a role in that. After that, I will discuss what reverse mortgages exactly are and discuss the market for them, both internationally and locally. Subsequently, I will discuss benefits, risks and attitudes that surround them, from a consumers and a providers point-of-view. Finally, I will introduce Dutch pension funds and their characteristics and relate them to the characteristics of reverse mortgages, identifying opportunities in which reverse mortgages can add value. This will lead to my sub hypotheses, that are quantified by using scenarios in the fourth chapter.

3.1. Equity Release, Life Cycle Theory and Saving for Retirement

Life Cycle Theory in General

Many studies focus on how people spend, save, and consume during their life. An important theory in this is the life cycle theory of Modigliani and Brumberg (1955). This theory tries to explain the behavior of economic rational consumers. According to the summary of Haffner (2008) households smooth their consumption during their lifetime based on their permanent expected income. Wealth, lending or saving are used as instruments to smooth the consumption. Toussaint et all. (2007) state that, according to the life cycle theory, young borrow, middle age save, and elderly consume. Younger households do not have the necessary means to finance their expenditures. Especially the house is an important investment that cannot be financed without borrowing. Therefore, the younger households generally consume more than their income would allow and have negative wealth. Middle-aged households typically earn more than they consume, thus they are able to repay existing debts and save money. Part of this saving occurs through repaying the mortgage for their house. So, the middle-aged are saving and building up wealth until retirement. After retirement, income generally decreases and older households should (according to theory) spend their wealth in order to keep their consumption stable. Fully rational households will have depleted all wealth upon death, according to this theory. A good graphical summary of the life cycle hypothesis is shown in figure 1.

Over the years, the life cycle theory as described above has been subject to much research, finetuning, criticism, and modifications. Levin (2008) for example, claims that people are not rational and proposes a behavioral life-cycle model. This model incorporates the findings from behavioral economics that self-control problems cause individuals to depart substantially from rational behavior. Furthermore, Levin states that not all assets are fungible (eg. easy to liquidate), so it might not be possible to spend all wealth. Rowlinson (2006) also incorporates the bequest motive into the life cycle theory. She gives some credibility to the life cycle model, since people do not wish to live poor to die rich. But she also acknowledges that people are not willing to spend all wealth, because they wish to leave something for their family (this is called a bequest). Mastrogiacomo and Alessie (2011) find that, even if people feel that saving for retirement is important, this not necessarily is reflected in additional retirement savings. Most savings are residual savings.

So, although the life cycle theory in its original and most pure form may not be realistic, some truth in the fact that people build up wealth for retirement is generally accepted. This being the case, an important follow-up question is how wealth in turn is translated in consumption.

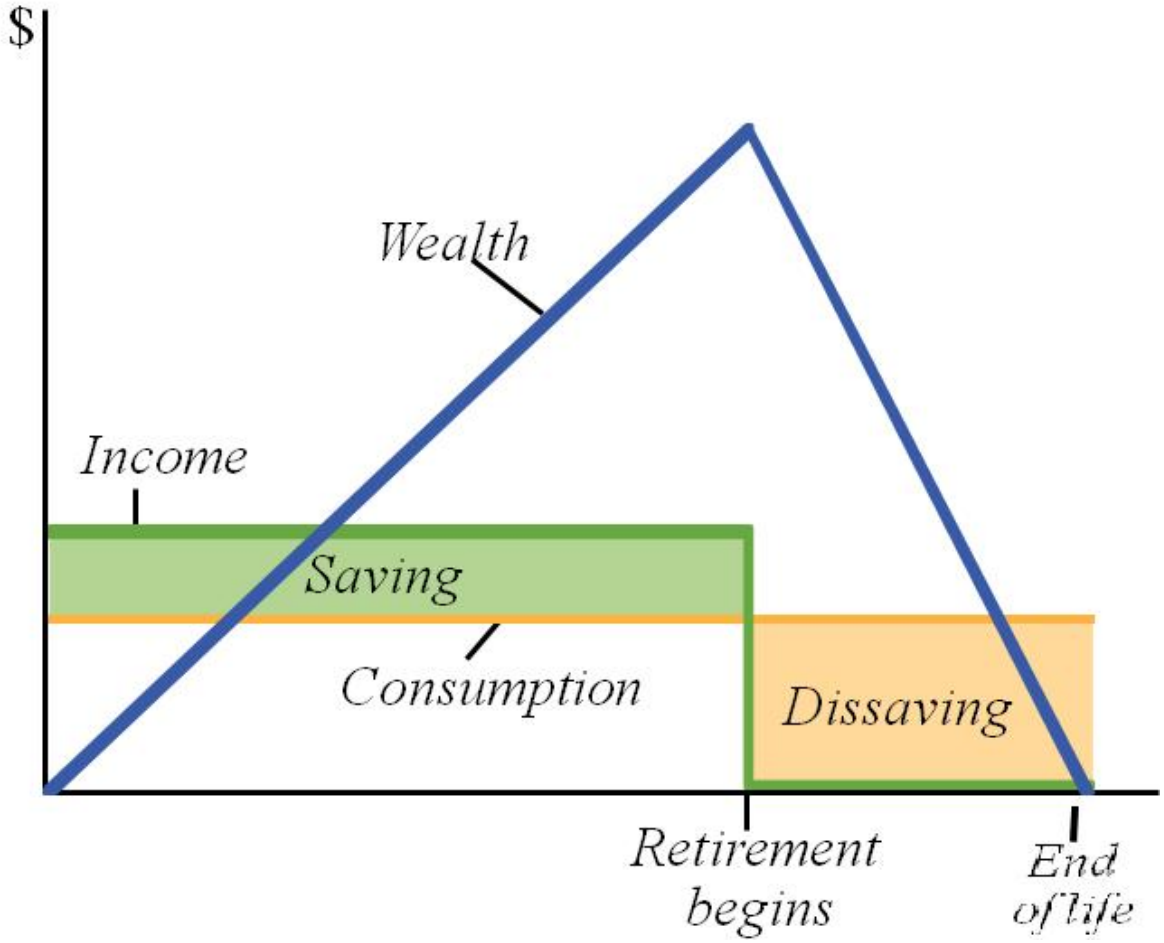


Figure 1: Life cycle hypothesis (source: www.wikipedia.org)

An often used instrument to do so is an annuity. If an annuity is bought, a consumer pays an upfront lump sum to a provider (typically a life insurer) in exchange for a lifelong periodical income. Because of this exchange, the longevity, mortality, and investment risk (in most cases) are transferred from the consumer to the provider. In other words, the consumer has a guaranteed lifelong income. Many research focuses on how much wealth should be annuitized upon retirement. Peijnenburg, Nijman, and Werker (2013) point out that a risk of full annuitization is that people completely deplete their buffers for sudden high costs. Nevertheless, their research shows that, if saving is possible after retirement (thus the periodical annuity income is higher than the consumption), full annuitization is optimal. It turns out that the benefits of insurance against longevity risk outperform the negative consequences of reduced liquidity and equity exposure in the short run. Only if there are serious liquidity shocks in the first period after retirement would full annuitization be suboptimal (Brown and Nijman, 2011). Blake, Cairns and Downd (2003) earlier came more or less to the same conclusions. Without the bequest motive, full annuitization is optimal for high risk averse consumers. For more risky consumers, a partial exposure to a mixture of bonds and equities next to annuitization is preferable.

LIFE CYCLE THEORY:

- **YOUNG BORROW, MIDDLE-AGED SAVE, ELDERLY CONSUME**
- **MIGHT NOT BE ENTIRELY REALISTIC IN ORIGINAL FORM**
- **BUT PEOPLE DO BUILD UP WEALTH FOR RETIREMENT**

The Role of Housing and Housing-equity Release During the Life Cycle

From the above, it can be concluded that people tend to save for their retirement and that full or almost full annuitization of this wealth is optimal. An important question related to this, is how the wealth that is stored in the house, is used in this annuitization process.

In general, many home-owners view their home and the mortgage repayments as a pension saving (Mastrogiacomo and Alessie, 2011) or an investment good (Toussaint et all., 2007). Toussaint and Elsinga (2009) and Toussaint (2001b) recognize three ways in which the value of the house is used in the financial planning of retirement: lowering housing expenses, selling and moving, or equity release.

Owning a house, in general, results in lower housing expenses in old age (compared to renting), especially when the mortgage is repaid. Owning a mortgage free house is comparable to an annuity of rental payments for an equal house (Sun, Triest, and Webb, 2008). Thus, owning a mortgage free house results in the release of the obligation of paying mortgage installments at retirement. Although this can be a significant reduction in housing costs, it does not actually generate income, since the value of the house remains “in stone”.

A way to liquidate the value of the house is by simply selling it and move to a smaller (cheaper) home or to a rental home (Taskforce Verzilveren, 2013). Although this method indeed liquidates the value, the success of it depends on the willingness to move and the availability of good living alternatives. People are generally strongly attached to their home, especially the elderly (Turner and Yang, 2006), so the willingness to move might be very small, making this solution undesirable for many retirees. This especially is the case in Southern-European countries.

The last option is equity release. With an equity release product, consumers are able to liquidate (part of) the value of the house, while still being able to live in it (Taskforce Verzilveren, 2013). Two type of equity release products exists: loan models and sale models (Reifner et all., 2009). In the loan model, people receive a loan at initiation of the contract and repay this loan after a certain time (at death or movement) by selling the house. A typical loan model product is the reverse mortgage (a more detailed description of reverse mortgages can be found in section 3.2). In the sale model, people sell their house forward to the provider. This means that they receive the sale price, while they keep the right to live in their home (which legally isn’t theirs anymore).

But do people release housing equity? Academics do not agree about this subject. Davidoff (2008) finds that US elderly seldomly release housing equity, except when health costs make this necessary. Turner and Yang (2006) also find that home-ownership is mostly used to reduce housing costs. The low amount of release is also confirmed by Chiuri and Japelli (2008), who find that ownership rates hardly decrease at an older age. These findings are contradicted by Parkinson and all. (2008) and Smith and Searle (2008), who take a different viewpoint. Parkinson and all. find that borrowing is a common tactic among home-buying household, but it is not just used to fund older age, but much earlier in the life cycle (in the form of second mortgages). Smith and Searle also find evidence of equity leakage, meaning that the value of the house is used for other expenditures and thus consumed.

CONSUMPTION-SMOOHTING WITH A (FULLY FINANCED) HOUSE

- **REDUCES HOUSING EXPENSES – BUT DOES NOT ACTUALLY GENERATE INCOME**
- **SELLING AND MOVING – BUT MOST ELDERLY ARE NOT WILLING TO MOVE**
- **EQUITY RELEASE – NO WIDESPREAD USE AND PRODUCTS MIGHT NOT BE AVAILABLE**

To summarize section 3.1, people tend to (partially) smooth consumption by borrowing, spending, and saving according to the life cycle theory. At retirement, it is optimal to annuitize a large part of the accumulated wealth. A problem is how to liquidate (and annuitize) the wealth that is stored in stones. Equity release products might be a suitable way to do so, although no consensus is reached about whether the use of release products is widespread. I have very briefly mentioned different equity release products. Since this thesis concerns reverse mortgages, I will not discuss other equity release products in the remaining parts. In the next section, I will discuss reverse mortgages in more detail.

3.2. Reverse Mortgages

Now, what is a reverse mortgage exactly? Before I present my formal definition, I start with discussing which value is released by a reverse mortgage. Sun, Triest, and Webb (2008) call this value the revisionary interest, and it consists of the present value of the eventual sale proceeds of the house. So, the value that is suitable for liquidation is the amount that is expected to be received from the sale of the house in the future, discounted to present time.

In the definition I will use in this thesis, I will stay close to the definition that Reifner and all. (2009) use in their discussion of the EU equity release market. First of all, a reverse mortgage serves the purpose of transforming fixed assets in a house into liquid assets that can be used for consumption. Second, it is a financial contract, and at the start of the contract, the provider provides a loan to the consumer. During the contract period, there are no interest payments. Instead, the interest is added to the repayment amount. At the end of the contract (at death, or at the time of the sale of the house), the interest payments and the loan amounts are to be repaid by the sale of the house. It is possible that the total amount of debt exceeds the sale price. The risk of this can be borne by either the consumer or the provider. During the loan period, the consumer can continue living in its home and there is no transfer of ownership. Furthermore, although it is possible to use the loan amount freely, in this definition it is used to supplement the periodical pension income.

In other words and in the context of this thesis, a reverse mortgage consists of a number of steps in time. At retirement, the contract is initiated and the loan amount is transferred to the consumer. The consumer can use the loan to supplement the pension income by buying an annuity (either by the provider of the reverse mortgage of by another provider) or in any other way dependent on product characteristics. During the loan period, no interest payments have to be made. At death or when the house is sold (mostly because the consumer needs to move to a care facility such as a nursing home), the loan is repaid from the proceeds of the sale. If the proceeds of the sale exceed the outstanding debt, the excess goes to the consumer or his relatives. If the proceeds of the sale are lower than the outstanding debt, the remaining debt should be paid by the consumer and its relatives, or is at the risk of the provider (this is called a no negative equity guarantee). In this thesis, I assume all reverse mortgages contain such a guarantee. Figure 2 represents a timeline of a reverse mortgage contract that is initiated at retirement of the consumer.

NO NEGATIVE EQUITY GUARANTEE:

- **FINANCIAL INSTITUTION GUARANTEES THAT CONSUMERS HAVE NO REMAINING DEBT IF SALE PRICE OF THE HOUSE IS LOWER THAN THE OUTSTANDING DEBT**
- **CAN BE SEEN AS A PUT OPTION ON THE HOUSE PRICE, WRITTEN BY FINANCIAL INSTITUTION**

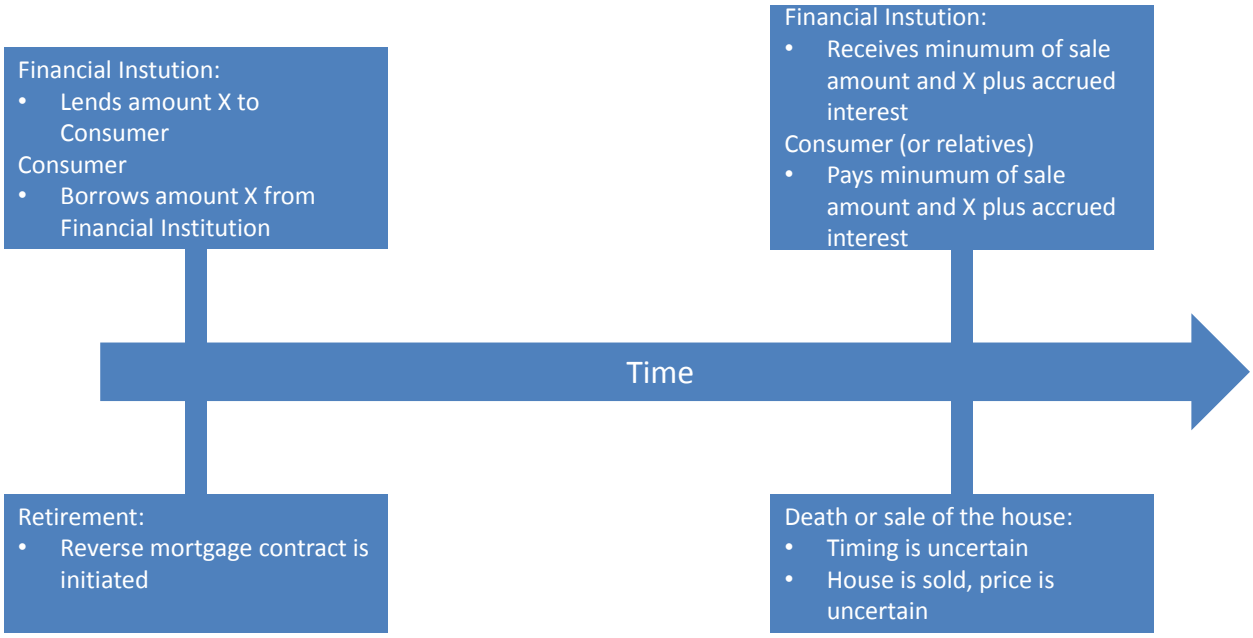


Figure 2: Example timeline of a reverse mortgage with no negative equity guarantee

3.2.1. Different Product Aspects

Reverse mortgages can have very different forms. Reifner and all. (2009) identify a number of variable product characteristics of reverse mortgages. Reverse mortgages differ with respect to eligibility criteria, form of the loan, credit limits, interest, fixed end date of the contract, and the no negative equity guarantee.

Eligibility criteria

Eligibility criteria are criteria set by the financial institution that decide whether a potential consumer can enter into a reverse mortgage contract or not. The criteria differ for each provider. For some providers, consumers only are eligible for a reverse mortgage if the house on which the mortgage is placed is occupied. Another important criterion is age. Almost all providers have a minimum age requirement, but this minimum age differs widely. Whether or not an existing (ordinary) mortgage is still in place can be a showstopper as well. Some providers require that the house should completely mortgage free before initiation of the reverse mortgage, other require that the existing mortgage is repaid from the loan amount of the reverse mortgage.

Although repayment discipline is not really relevant for reverse mortgages (because repayment depends on the value of the house and not on the discipline of the borrower), some providers limit eligibility to credible consumers.

A final criteria that is sometimes used is the property type and region. since repayment of the reverse mortgage partially depends on the appreciation of the value of the house, some providers exclude certain property types (such as apartments) or regions (such as rural areas).

Form of loan payment
When the reverse mortgage is initiated, the consumer receives a loan amount. This loan amount can have different forms. The most basic form is a one-off lump sum. At initiation, the full loan amount is transferred immediately to the consumer. The second form is a periodical payment. Either for a certain fixed time, during the life of the reverse mortgage, or during the entire life of the consumer, an amount is paid periodically. The final form is a line of credit. With a line of credit, the consumer is free to borrow amounts when he or she pleases until the credit limit is reached.

Credit limit
The amount that can be borrower differs for each provider. It mostly is related to the value of the house (in that cases, it is called a loan-to-value), but can also be limited by a maximum amount.

Interest
The interest charged for the loan has two dimensions. First, the interest charged can be fixed for the entire loan period, or variable, depending on actual market levels. The second dimension is whether or not interest payment occur during the loan. Most reverse mortgages add the interest to the outstanding debt, but in some cases interest payments occur during the lifetime.

End of contract
The end of a reverse mortgage contract can be pre-specified at a certain point in time, or uncertain, depending on a pre-specified event, such as death of the consumer or the sale of the house.

No negative equity guarantee or not
The no negative equity guarantee is an important product characteristic that protects consumers, but also the reputation of the financial providers. Nevertheless, reverse mortgages without this guarantee still exist.

3.3. Market for Reverse Mortgages
Now that I have defined what a reverse mortgage is and identified the different product aspects, it is time to discuss the existing market for reverse mortgages. I start with a discussion of the international markets and continue with the Dutch market. Where possible, I will try to explain differences by institutional settings and market circumstances.

3.3.1. International

USA
The USA has the largest (but still relatively small) market for reverse mortgage products. The most often sold product is the Home Equity Conversion Mortgage (HECM) that has the following characteristics (Hendriks, 2013):

- A no negative equity guarantee provided by the government. The government charges a fixed insurance premium for this guarantee.
- Minimum eligible age is 62 years
- Existing mortgage debts should be repaid first. This can be done with the loan amount of the reverse mortgage.
- The level of the maximum loan amount depends on the age of the youngest borrower. The level of the amount that can be borrowed is calculated in three steps (Shan, 2009). First, the maximum claim amount is established. This is the minimum of the appraised value of the home and a

certain limit that varies by state. Second, the principal limit is calculated by multiplying an age and interest rate dependent factor with the maximum claim amount. Third, the net principal limit is set by deducting closing costs from the initial principal limit.

- The loan payment can be periodical for a fixed period or lifelong, a lump sum payment, a credit line, or a combination of this.

The fact that the reverse mortgage market is relatively large in the US can possibly be explained by a number of factors. First of all, the US has a very large financial industry that has a track record of product innovation. Second, the US has a "credit culture", people are used to borrowing. Third, the US is a highly individualized society with low welfare provisions. People need to take care of themselves. In such a setting, it is more likely reverse mortgages will blossom.

Australia

In Australia, the reverse mortgage has gained some market as well. There, the product is highly regulated and should include a no negative equity guarantee (Taskforce Verzilveren, 2013), may not have any age requirements, costs should be clear in advance, and independent advice before entering into the contract is required (Hendriks, 2013).

European Union

In the European Union, three countries have a significant market for equity release products (UK, Ireland, and Spain). In total, the market is very small (0.1% of the overall mortgage market). A shift towards the loan model is seen within this market (Reifner and allies, 2009). Reasons that most markets are small in the EU differ. For example, in Southern-European countries, people are very attached to their homes and are not willing to place some debt burden on it (Turner and Yang, 2006). Furthermore, in these areas the bequest motive is very important. Therefore, reverse mortgages typically are seen as a last resort (Dillingh and all., 2013). In the Northern part of the EU, people might be more prudent with regards to borrowing.

UK

The UK has the biggest reverse mortgage market (because the UK has similar characteristics as the US with respect to the financial industry), but the products have a bad reputation. This is mainly because they have not been very well regulated in the past, which resulted in bad repayment conditions and a lack of the no negative equity guarantee in the past. This even has led to outplacements (Taskforce Verzilveren, 2013; and Hendriks, 2013). Another problem that reverse mortgages in the UK suffer from is the fact that income from reverse mortgages need to be taken into account when depending the eligibility for certain governmental welfare provisions. A consumer has the risk to lose the right to some of these provisions when entering into a reverse mortgage.

LESSONS LEARNED FROM THE INTERNATIONAL MARKET:

- **LOCAL CULTURE AND ATTITUDE TO HOUSING AND BORROWING ARE VERY IMPORTANT**
- **REGULATION IS A NECESSITY**
- **THE NO NEGATIVE EQUITY GUARANTEE IS A VERY IMPORTANT PRODUCT FEATURE**

3.3.2. Dutch Market

The Dutch market for reverse mortgages is currently almost non-existent. An important reason for this is that in general, pension provisions in The Netherlands are relatively generous, making reverse mortgages not really a necessity. In the past, some providers offered reverse mortgage products, but currently, only one provider is active in the market (Taskforce Verzilveren, 2013). Next to the financial crisis, an important reason for the small market is that in The Netherlands, housing equity is concentrated at the higher incomes (Dewilde and

Delfanie, 2012). This group typically has less need for reverse mortgages, especially because of the relative generous pension conditions in The Netherlands. The bequest motive is less important for Dutch residents (Dillingh and all., 2013).

The provider that is active in the Dutch market is Florius with the Florius Verzilverhypotheek (www.florius.nl). This product has the following conditions:

- No negative equity guarantee
- No maximum contract period, repayment only at sale of the house or decease
- Fixed interest rate
- No payments during contract period
- The option to protect 30% of the excess value of the home for bequests
- Minimum age is 60 years
- Current mortgage debt should be zero or repaid with the loan amount
- Loan in the form of a lump sum or fixed monthly payments for a pre-specified period (a lifelong payment is not possible)
- The requirement to maintain the house properly is part of the contract.

PROS AND CONS OF DUTCH MARKET POTENTIAL FOR REVERSE MORTGAGES:

+ **DECREASING PENSION BENEFITS IN THE FUTURE**
+ **MORE FISCAL INCENTIVES TO PAY OFF ORDINARY MORTGAGE**
+ **ONLY WEAK BEQUEST MOTIVE**
+ **WELL REGULATED AND DEVELOPED FINANCIAL MARKET**
– **HOUSE VALUE CONCENTRATED AMONGST HIGH INCOMES**
– **PRUDENT ATTITUDE TOWARDS BORROWING**

Although the demand in The Netherland currently is very small, it might be that in the future the demand increases because of the disappearance of fiscal support for non-repayment mortgages (leading to more mortgage repayment and higher housing equity), less generous pension and long-term care provisions, increasing rates of home-ownership, and an increase in entrepreneurs without a pension provision (Taskforce Verzilveren, 2013).

3.4. Benefits, Risks, and Attitudes for Consumers

In this section, I will elaborate on the reasons to enter into a reverse mortgage, the attitudes towards it, the perceived benefits and risks and disadvantages of it from a consumers point of view, as they are identified in the academic literature.

3.4.1. Reasons to enter in a reverse mortgage contract

For consumers, several reasons exist to enter into a reverse mortgage contract (Taskforce Verzilveren, 2013). First, a reverse mortgage can be used for a planned, large, one-time expense, such as a big renovation or a long trip. Second, it can be used for unexpected, large, one-time expenses. These expenses are often related to health-care related adaption of the house. In this way, it is possible to live longer in the own house during illness. Bovenberg, Koelewijn, and Kortleve (2011) add to this that releasing equity from the

USES OF A REVERSE MORTGAGE FOR CONSUMERS:

- **PLANNED, ONE-TIME EXPENSE**
- **UNEXPECTED, ONE-TIME EXPENSE**
- **SUPPLEMENT TO DAILY EXPENDITURES**
- **FOR ADDITIONAL COMFORT OR HOBBIES**

house for care reasons is an efficient form of saving for long-term care (in Dutch: “zorgsparen”). Third, it can be used to supplement the necessary daily expenditures. Dillingh and all. (2013) find that in The Netherlands, most potential interest is in the use of reverse mortgages for higher comfort or to spend on hobbies. This is supported by Shan (2009), who finds that recent reverse mortgage borrowers in the US generally are younger, better educated and have a higher income. Dillingh and all. (2013) also recognize that reverse mortgages can be used to better time bequests. This means that, because of a reverse mortgage, it is possible to grant part of the value of the house to the kids during an earlier stage in life than normally would be the case. Armand (2012) adds to this conversation that currently in The Netherlands, the equity in the house mostly gets inherited. Making this equity liquid would not so much harm the financial position of the elderly, but would reduce the level of the bequest.

3.4.2. Attitudes towards reverse mortgages

Attitudes towards reverse mortgages can differ greatly between individuals. They can be positive or negative.

Positive attitudes

A large survey in The Netherlands (Hendriks, 2013) has showed that 80% of the respondents is willing to use the equity in the house, but only as a mean of last resort or for financing care. People without children were more interested than people with children. The last resort motive is confirmed by Toussaint (2007, 2011a).

Negative attitudes

In spite of the relatively positive view of releasing equity as a last resort, different negatives attitudes exist as well. Most of them are emotional or cognitive:

- Most elderly do not regard housing wealth as fungible wealth. People do not yet accept that housing wealth can be liquidated (Turner and Yang, 2006).
- People are strongly attached to their home, so they are not willing to place debts on it (Turner and Yang, 2006).
- Reverse mortgages are associated with high transaction costs, it is expensive to close the deal (Turner and Yang, 2006)(Toussaint, 2011b).
- People are not willing to enter into a new debt after they have (just) repaid the original mortgage on the house (Hendriks, 2013). Related to this are generational traits. The generation that has recently retired or will retire very soon (“the babyboomers”) in general has large amounts of housing equity, but is raised in a situation of financial tightness and is not used to consume. This generation might regard a reverse mortgage as a new undesirable debt for luxury purposes.
- People want to be independent of financial institutions, the confidence in these institutions has decreased during the financial crisis and several other incidents (such as the usurious policies [in Dutch “Woekerpolis”] in The Netherlands)(Toussaint, 2011b).
- Incidents in the past in the UK, where reverse mortgage borrowers were outplaced, have led to a bad reputation of these products (Toussaint, 2011b).
- One can liquidate the equity in the house only once. So, after entering in the reverse mortgage, the safety net function of the housing equity has disappeared and will not come back (Hendriks, 2013).
- Financial literacy is low, thereby making a reverse mortgage unknown and unwanted (Hendriks, 2013). It also is a very complex product (Toussaint and Elsinga, 2010).
- A reverse mortgage can deplete the bequest (Hendriks, 2013). This attitude is stronger in more family-centered countries, such as in Southern Europe, but less in The Netherlands.

Benefits and advantages

Reverse mortgages are associated with many benefits and advantages. First of all, they can offer supplemental income or liquidity (Taskforve Verzilveren, 2013). This is also confirmed by Ong (2006), who shows that the net retirement income can increase substantially because of the use of reverse mortgages. Moreover, this is achieved without the requirement to leave the house (Reifner and all., 2009).

Another advantage, related to the life cycle theory, is that a reverse mortgage enables consumption smoothing. This can have significantly positive utility gains, as Hanewald, Post, and Sherris (2014) show. Bovenberg (2012) makes this more concrete by means of an example for The Netherlands, by proposing that people should be able to use their pension premium to repay their mortgage, thus increasing consumption possibilities during the pre-retirement stages in the life cycle, and release equity from the house during retirement, compensating for the lower accrued old age pension.

A third advantage is the increased access to credit at old age that is possible with reverse mortgages. Elderly generally have very poor access to credits of financial institutions. Using the house as a security for the debt can solve this problem (Reifner and all., 2009).

A fourth, very important advantage, is that reverse mortgages shift the risk of housing price and longevity from a single household (that is exposed to entity specific and systematic risk) to the financial institution, that is better able to diversify these risks. In fact, a reverse mortgage has option characteristics, since it protects the individual borrower against housing price decreases as long a no negative equity guarantee applies (De Roon, Eichholtz, and Koedijk, 2010).

Risks and disadvantages

Reverse mortgages also contain some risks and disadvantages for consumers. First of all, borrowers are exposed to some risks, such as house price risk, longevity risk, and interest rate risk (Taskforce Verzilveren, 2013). However, these risks can easily be overcome by product design. The house price risk can be overcome by adding the no negative equity guarantee to the product, the longevity risk can be overcome by giving the payout the form of a livelong annuity or using the lump sum to buy an annuity, and the interest rate risk can be overcome by agreeing on a fixed discount rate when entering the contract. Because these risks can be managed or even overcome by product characteristics, I will not regard them as real disadvantages.

Second, the complexity of the product is a disadvantage. Since people generally have low financial literacy, it is hard for them to understand even the basics of the product, let alone the more complex details (Taskforce Verzilveren, 2013). Prast, Teppa, and Smits (2012) mention that one of the factors that hinders rational behavior is the complexity of the choice. More complex choices tend to lead to less rationality in these choices.

Third, reverse mortgages come with high costs (Reifner and all., 2009). The closing costs for example include a loan origination fee and the appraisal costs. Also, a monthly servicing fee is applicable. If a no negative equity guarantee is included in the product design, insurance premiums also apply (Rose, 2009).

Fourth, the amount that can be borrowed is highly volatile. This is because it depends on the age and sometimes marital status of the borrower, but also on current house prices and interest levels. Because of the volatility of the maximum loan amount, it is hard to include reverse mortgages in one's financial planning (Sun, Triest, and Webb 2008). Scanlon, Lunde, and Whitehead (2008) add to this that especially borrowers with lower home equity are more exposed to house price shocks.

Fifth, reverse mortgages come with hidden costs. For example, the maintenance obligation (which can involve large expenses) remains with the borrower, since the borrower is the owner. (Reifner and all., 2009). Other, less important hidden costs are the time and anxiety a borrower needs to put into the process before being able to enter into a contract (Jarvis, 2008).

Sixth, Ong (2008) points to the fact that, especially for slow appreciation properties, taking a reverse mortgage can deplete all current and future housing wealth, so the safety buffer function of the housing equity vanishes.

Seventh, reverse mortgages likely come with ownership restrictions, such as the prohibition of sub-letting or major renovations without the consent of the mortgage provider (Reifner and all., 2009). Related to this is the inflexibility of the contract once entered.

Other minor disadvantages were mentioned as well. Amongst them were the risk of a changing tax regime, resulting in unfavorable fiscal treatment of the reverse mortgage and the risk of provider bankruptcy. This latter is especially a risk if annuities are part of the contract (Reifner and all., 2009).

Conclusion
In this section, many different aspects of reverse mortgages were discussed. Overall, reverse mortgage certainly have the potential to increase liquidity of the elderly while continuing to live in the house. Although there are risks associated with it, most of these risks can be solved through product design and good advice and financial information.

ADVANTAGES FOR CONSUMERS:	DISADVANTAGES FOR CONSUMERS:
• OFFERS SUPPLEMENTAL LIQUIDITY • ENABLES CONSUMPTION SMOOTHING • INCREASES ACCES TO CREDIT AT OLD AGE • SHIFTS HOUSE PRICE AND LONGEVITY RISK FROM INDIVIDUALS TO FINANCIAL INSTITUTION	• COMPLEX PRODUCT • HIGH ADDITIONAL COSTS • BORROWING AMOUNT UNCERTAIN • HIDDEN COSTS • DEPLETES ALL CURRENT AND FUTURE HOUSING WEALTH • COMES WITH OWNERSHIP RESTRICTIONS

3.5. Benefits, Risks, and Attitudes for Providers

In this section, I will elaborate on the reasons to enter the reverse mortgage market, the perceived benefits and risks and disadvantages of it from a providers point of view, as they are identified in the academic literature.

Reasons to enter the market
Several reasons to enter the market are identified. The most important reason is that reverse mortgages have the potential to deliver high profits (Reifner and all., 2009)(Bergman and Setterqvist, 2013) in a market that has significant growth potential. Sadly, both reports do not mention the level of the perceived high profits. In chapter 4, I will show that, under the assumption used, return levels are somewhere between government bond and equity levels.

Reifner and all. (2009) mention other reasons to enter the market. One of them is entering a niche market. The reverse mortgage market is quite immature and small, and specific knowledge is needed to be successful in it. If parties succeed in doing so, profits might be very rewarding.

Another commercial reason might be to increase market share in the pensions and mortgage market. Reverse mortgages are mortgage products, but when used for retirement, they also are retirement products. Given a society with increasing amounts of retirees and homeownership, it is likely that both markets will show future growth.

Furthermore, elderly in general do hardly buy financial products. While they are the most wealthy group in society, financial institutions find it hard to reach them. Reverse mortgages can be products that are specifically appealing to this age group, enabling institutions to do business with this group and possibly generate cross selling opportunities.

Also, building a social reputation can be a reason to enter the market. If marketed convincingly, financial institutions that sell reverse mortgages can claim that they sell products that provide necessary liquidity to elderly, that prevent poverty for the elderly, and that benefits society.

Finally, reverse mortgages can be a good complement to the existing product palette. Especially current ordinary mortgage providers might already have administration systems in place that could easily be adapted to administrate and maintain reverse mortgages.

Benefits and advantages
The benefits and advantages that reverse mortgages can offer for providers, are equal to the reasons to enter the market. Therefore, I will not repeat them.

Risks and disadvantages
There are several risks related to a reverse mortgage for a provider. Most of them are related to the no negative equity guarantee. If such a guarantee is rewarded, the biggest risk providers face is when the amount of outstanding debt (the loan sum plus accrued interest) exceeds the sale price, because the excess is at the expense of the provider. This risk is called the crossover risk (Wang, Valdez, and Piggot, 2008). The crossover risk highly depends on the loan-to-value ratio (the level of the loan compared to the appraised value of the house). Reverse mortgages with low loan-to-value ratios are relatively riskless (Hanewald, Post, and Sherris, 2014).

The crossover risk depends primarily on how long a borrower keeps inhabiting the house, the increase of the outstanding debt, and the value of the house (Wang, Valdez and Piggot, 2008). Therefore, the main drivers of the crossover risk are:

- House price appreciation: whether or not the debt can be repaid depends entirely on the value of the house at the time of sale. Slow appreciation or even depreciation result in a higher crossover risk.
- Longevity and mortality: in normal economic circumstances, the appreciation of the house value is less than the interest accrual. Therefore, it is expected that eventually the debt will exceed the value of the house. The longer a borrower keeps inhabiting the house, the more likely it is that this will occur. The main reasons to sell the house for elderly are decease or moving to a nursing home. The mortality risk is identified as the most important factor of the crossover risk.
- Interest rates: this risk is related to the volatility of the interest rate. Reverse mortgages can have fixed or variable interest rates. If the rate is fixed, the risk the provider bears is that of an increase in the interest rate. In that case, the interest earned on the contract is lower than would be

possible to make in the market. On the other hand, a fixed interest rate protects from downward moves in the rate. If the interest rate is variable, a problem can occur if the interest rate increases and all else remains equal. Due to higher interest accrual, the crossover point comes closer in time.

Figure three provides a stylized illustration of the crossover risk.

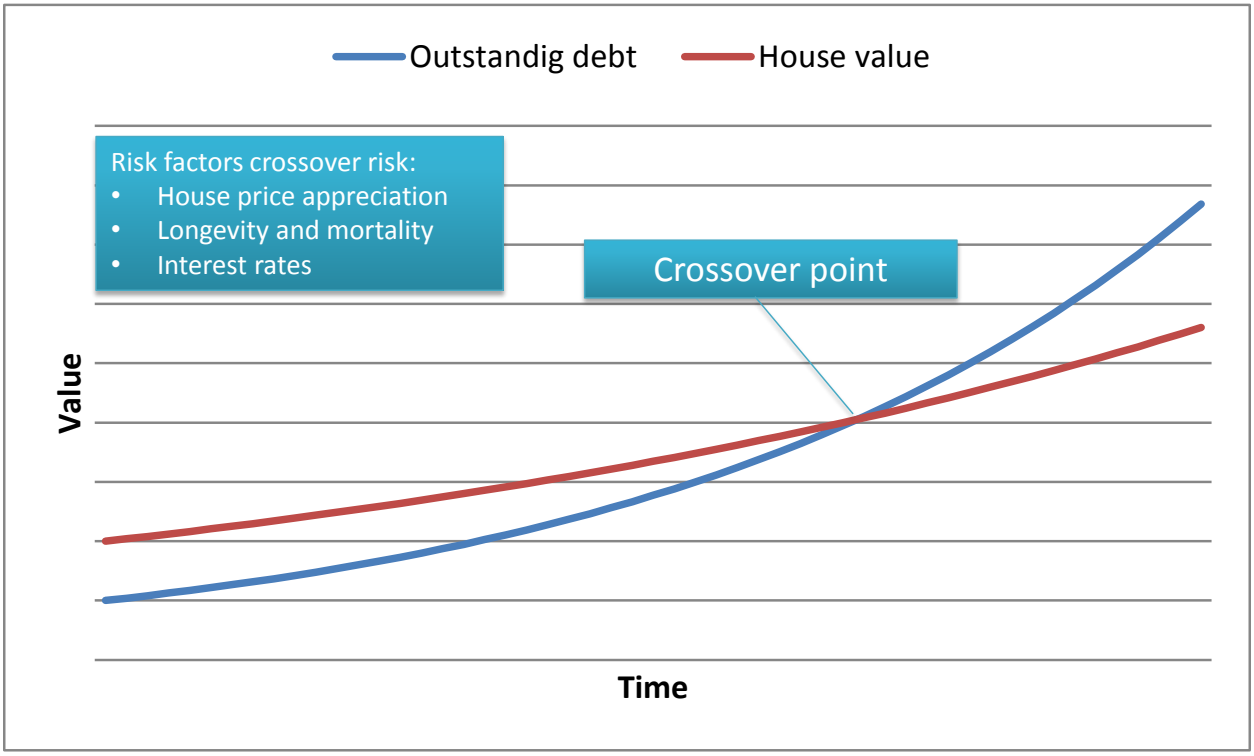


Figure 3: Crossover risk

Associated with the crossover risk is the risk of adverse selection. Adverse selection means that people who are expecting to live longer in their home and thus receive more benefits from the reverse mortgage, are more likely to enter into such a contract. If that is the case, providers should carefully price their products (Taskforce Verzilveren, 2013). However, evidence of Davidoff and Welke (2004) showed the opposite. Selection in the US market has been advantageous to providers. This seemingly strange effect has two reasons. First, borrowers who buy a reverse mortgage are more likely to also take out the remaining equity (if any) by selling their homes. Secondly, reverse mortgages are often used to cover sudden health care expenses of people who are ill. Therefore, the average health of reverse mortgage borrowers is worse than that of the average population, again leading to adverse selection (Shan, 2009).

Another possible threat is the moral hazard risk (Taskforce Verzilveren, 2013). This risk occurs because of the option-like nature of a reverse mortgage with a no negative equity guarantee (Wang, Valdez, and Piggot, 2008). For a reverse mortgage borrower, at the moment that the value of the house becomes lower than the accrued value of the debt, there is no gain anymore in selling the house. This could increase the length of the stay in the house at the expense of the provider. Furthermore, at this point further depreciation of the value does not harm the borrower. This might result in a neglect of the maintenance (Davidoff and Welke, 2004). Moral hazard appears to be more of a problem than adverse selection.

Another risk and disadvantage for the provider is the illiquidity and uncertainty about the time of the repayment. If a reverse mortgage contract is entered, the investment cannot be touched or reclaimed until the borrower sells the house or deceases. While this illiquidity is common for most standard mortgage loans, the timing uncertainty of reverse mortgages adds an additional risk (Hendriks, 2013).

Other possible risks related to these products are the little experience providers have with these products, the fact that these products are only profitable when they are sold in a sufficient volume, and the fact that they are difficult to finance and securitize (Shan, 2009).

Conclusion
In this section, I discussed the pros and cons of reverse mortgages from a providers point of view. The main reasons for most provider to enter this market are the expected high profits and portfolio diversification potential. The main risk is the crossover risk. In the next section, I will discuss the specificities of Dutch Pension funds and how the reverse mortgage characteristics do or do not apply for them.

ADVANTAGES FOR PROVIDERS:	DISADVANTAGES FOR PROVIDERS:
• HIGH EXPECTED PROFITS • ENTERING NICHE MARKET • INCREASE MARKET SHARE IN PENSIONS AND MORTGAGE MARKET • CROSS SELL TO ELDERLY • BUILDING SOCIAL REPUTATION • COMPLEMENT EXISTING PRODUCT PALETTE	• CROSSOVER RISK • ADVERSE SELECTION • MORAL HAZARD • ILLIQUIDITY AND UNCERTAINTY ABOUT TIME OF REPAYMENT • LITTLE EXPERIENCE WITH PRODUCTS

3.6. Potential for Dutch Pension Funds

A possible role for pension funds in selling reverse mortgages is often proposed by policy makers, practitioners, and academics. Bovenberg, Koelewijn, and Kortleve (2011) suggest that the pension sector could help its retirees with releasing equity. According to Hendriks' (2013) survey among participants of a large Dutch pension fund, pension funds are the most trustworthy party to offer reverse mortgages.

In this section, I will discuss what characteristics make a pension fund suitable to be a reverse mortgage provider. I start with describing some typical characteristics of pension funds that are important in the light of this thesis. Next, I will discuss the possible benefits of adding reverse mortgages to the portfolio from an asset-only perspective. After that, liabilities are added to the discussion, and I will discuss how reverse mortgages possibly could offer protection against interest rate risk and inflation risk.

3.6.1. Characteristics of Pension Funds

In The Netherlands, a pension fund is a non-profit organization with a board that consists of representatives of its primary stakeholders; the (former) participants, retirees, and the sponsoring companies.

Tasks of a pension fund

The main tasks of a pension fund are to manage the pensions of its stakeholders by collecting employer and employee contributions, investing the contributions in the interest of the stakeholders, administrating the accrued benefits, and taking care of the actual payment of the benefits. Almost all pension plans that Dutch pension funds administrate are of a defined benefit nature or have strong defined benefit characteristics (such as collective DC plans).

A pension fund has the following main priorities, which are partially contradicting. Therefore, it has to balance all the risks and benefits in its decisions:

- Assuring as much as possible the accrued nominal benefits; benefit reductions are possible under certain circumstances. A pension fund tries to minimize the risks of these benefits reductions by trying to match the investment portfolio with the pension liabilities.
- Financing inflation indexed benefits: in most pension plans, the contributions are paid to finance the nominal accrual of the benefits, but benefits increases to keep benefits in line with inflation (also called indexation) are often conditional and depend on the financial position of the pension fund. Therefore, this indexation needs to be financed with investment returns, resulting in a more risky asset allocation.
- Asking fair, but stable contributions: During the crisis years, pension contributions have increased because of recovery contributions and the increasing maturity of the population. Employers value low and stable contributions, therefore it is essential that the financial policy of a pension fund minimizes the contribution risk. Furthermore, some investment return is often necessary to justify a lower contribution level.

CONTRADICTING TASKS OF A PENSION FUND:

- **GUARANTEE NOMINAL BENEFITS AS MUCH AS POSSIBLE**
- **MAKE INVESTMENT RETURNS TO FINANCE INDEXATION**
- **KEEP CONTRIBUTIONS STABLE**
- **FOR ADDITIONAL COMFORT OR HOBBIES**

Liabilities

The value of the liabilities is based on the fair market value of the accrued nominal benefits. By pension law and government decrees, fair market value means:

- Expected cashflows are calculated on best estimate mortality assumptions
- The cashflows are discounted based on a risk-free interest rate curve. The actual curve published by the Dutch Central Bank (DNB), is based on the swap rates, and is modified in two ways:
    - The curve is based on rolling three-month daily averages of the swap rates
    - After a maturity of twenty years, the liquidity of the swaps used is questioned. Therefore, the curve is modified with an Ultimate Forward Rate (UFR) extension. This UFR incorporates expectations for longer term interest rates in the curve, thus decreasing volatility for the longer terms.
    - As of January 1, 2015, the three-month averaging will stop. The curve will be based on daily swap rates. Furthermore, the UFR methodology will change. Since this is not subject of my thesis, I will not elaborate on this.

Investment

The investment policy of pension funds is heavily influenced by the risk appetite and indexation ambition of the pension fund and the valuation method of the liabilities. Pension funds try to match at least part of the investment portfolio to the value of the liabilities. Therefore, a significant portion (often around 50% or

higher) of the portfolio is invested in fixed income assets with a high maturity, such as government bonds and credits. If required for the matching purpose, and to protect against (mostly downward) interest rate movements, interest rate swaps and swaptions can be added to the portfolio. The part of the portfolio that aims to match the liabilities is often called the matching portfolio.

Next to the matching portfolio, to finance the conditional indexation and to keep contributions low, some investment return in excess of the risk-free return is necessary. This part of the return is generally called the return portfolio and is invested in risky assets, such as equities (in developed and emerging markets), high yield bonds, real estate, and commodities.

Funding ratio, solvency buffer and minimum required solvency buffer
The financial position of pension funds in The Netherlands is measured by the funding ratio. The funding ratio is the market value of all investment assets divided by the (market) value of the liabilities. A funding ratio of 100% means that the liabilities are equaled by the assets. A funding ratio lower than 100% means that the assets are not enough to equal to liabilities.

In The Netherlands, pension funds should possess a funding level of at least 105%[3]. This level is called the minimum required solvency level. If the funding level is below this threshold, the pension fund officially is in funding deficit. A pension fund has five years to recover from this deficit, otherwise harsh measures such as benefit reductions are necessary.

Next to the minimum required solvency level, a required funding ratio exists. This level depends mainly on the (investment) risk that a pension fund is exposed to. Higher risks result in higher required funding ratios. A common level of the required funding ratio is 120%, but these levels vary greatly by pension funds. If the funding level is below the required level, but above the minimum required level, the pension fund has a reserve deficit. A pension fund has fifteen years[4] to recovery from this deficit.

Main risks
Pension funds suffer from many kinds of risks. The most important risk factors that are often identified (and relevant in the light of this thesis) are the interest rate risk and the inflation risk. Other risk factors that are important are, amongst many others, longevity risk, investment risk, operation and legal risk, and counterparty risk. However, since they appear to be less relevant for this thesis, I will not discuss these risk factors here.

Interest rate risk
Interest rate movements have an effect on both sides of the balance sheets. Since the liabilities are valued based on the DNB curves (which is a result of the market swap rates), the value of the liabilities is very sensitive to movements in the interest rate. A downward movement results in an increase in the value of the liabilities, whereas an upward move has the opposite effect. The amount of these movements depends on the interest rate sensitivity of the liabilities and is commonly measured by the duration.

On the asset side of the balance sheet, all fixed income assets are sensitive to movements in the market rates. Again, a downward shift in interest rates results in an appreciation of the value of the fixed income assets, whereas an upward shift results in a depreciation of these assets. The magnitude of these movements depends on the maturity of the assets, the longer the maturity, the larger the magnitude.

[3] The level of 105% is a commonly rounded value. A more detailed calculation of the minimum required funding level would most often result in a value of 104.2% or 104.3%.
[4] In the new financial assessment framework “nFTK” this period is reduced to a rolling 10-years window.

In theory, it is possible to eliminate all interest rate sensitivity of the balance sheet by matching the sensitivity of the assets exactly to the sensitivity of the liabilities. In practice, this seldom occurs. Practical or strategic reasons cause this to be the case. In general, the assets do not fully match the interest sensitivity of the liabilities. Therefore, some risk remains. The result of this is that a downward movement of the interest rates results in a downward move of the funding ratio.

Inflation risk
In a previous section, I mentioned that funds have the ambition to keep pension benefits in line with inflation in order to maintain purchasing power. Especially if inflation is very high, it might be very hard to make investment returns that enable this ambition[5]. Indexation often is conditional, so a high inflation might not lead the pension fund to a deficit situation (since pension funds have the opportunity to not reward this indexation if the financial position does not allow this), but a lasting high inflation can erode the purchasing power of the pensions and thus is a serious risk factor.

According to Brounen and Mahieu (2014), pension fund are more and more interested in investment opportunities that offer inflation protection. According to their analysis, equities do not offer sufficient protection and neither do bonds. Inflation-linked bonds could offer this, but there are no such bonds that specifically hedge Dutch inflation. The authors acknowledge that the housing market contains some interesting inflation linkages.

3.6.3. Adding Reverse Mortgages – Asset-Only Perspective

Investors that focus on an asset-only perspective, focus mainly on investment returns and risks and ignore the liability side of the balance sheet. Although it is not advisable for pension funds to work from such a perspective, it often is a starting point for further analyses.

In an asset-only perspective, the aim is to maximize expected returns while minimizing the volatility of these returns. The portfolio that succeeds in doing this best, is called an efficient portfolio. Adding additional asset classes that are uncorrelated to the existing asset classes can increase the efficiency of the portfolio. This is called diversification.

Reverse mortgages have some interesting characteristics from this point of view. They not only are expected to offer high returns, but since these returns (as will be discussed in chapter 4) depend on interest rates and house price appreciation, they also might offer diversification potential. This idea is also supported by the article of Brounen, Porras Prado, and Verbeek (2008). They conclude that real estate acts as an important diversifier in asset-only portfolios. This could lead to more efficient portfolios. Therefore, my first sub hypothesis is:

Adding reverse mortgages to an asset-only portfolio increases the efficiency of this portfolio

3.6.3. Adding Reverse Mortgages – Balance Sheet Perspective

Contrary to asset-only investors, pension funds have to manage both sides of the balance sheet. As stated before, the value of the liabilities is sensitive to movements in the interest rate (the swap rate in particular). A balanced investment strategy would try to partially match this sensitivity. This implies that asset categories that possess this interest sensitivity, will contain some share of the investment portfolio. Typical products used to match the liabilities are long duration bonds and interest rate swaps.

[5] For example, if the risk-free interest rate is 2% and inflation is 5%, a pension fund should make an investment return of 7.1% (1.02 * 1.05 - 1) to be able to realize full indexation.

Because reserve mortgages have characteristics that are partially similar to long duration bonds (especially the fixed interest rate alternative), it is probable that adding reverse mortgages increases the liability hedging rate.

Besides matching the liabilities, pension funds try to make returns in excess of the interest on the liabilities in order to finance the conditional indexation. Typically, hedging products are not suitable for generating excess returns. Reverse mortgages on the other hand offer (according to Reifner and all. (2009), and Bergman and Setterqvist (2013)) high expected profits. That implies that reverse mortgages might have the potential to generate excess returns, while at the same time maintain the match with the liabilities.

Therefore, my second sub hypothesis is:

Reverse mortgages are both able to generate excess returns and increase the liability matching of a pension funds' investment portfolio

3.6.4. Adding Reverse Mortgages - Interest Rate Hedging

As discussed in section 3.6.1., the most important financial risk pension funds face is the interest rate risk. Funds try to hedge this risk by adding interest sensitive assets to the portfolio, such as long duration bonds, swaps, and swaptions. Reverse mortgages, by nature, could also possess characteristics that support interest risk hedging. A reverse mortgage in essence is an ordinary zero coupon loan with a long maturity. Some additional risks related to crossover and timing insecurity also apply, but that does not change much for the interest rate sensitivity. Moreover, Brounen, Porras, and Verbeek (2008) mention that real estate offers hedging benefits against interest rate risk. Especially the alternative with a fixed interest rate charge could therefore prove to be very suitable for interest rate hedging.

That leads me to my third sub hypothesis:

Adding reverse mortgages to the investment portfolio increases the interest rate risk hedge

3.6.6. Adding Reverse Mortgages - Inflation Hedging Perspective

The second important risk factor discussed in section 3.6.1 was inflation risk. Inflation risk occurs if inflation is high and investment struggle to deliver equally high returns. Investment products that have returns that are strongly correlated with inflation would therefore be desirable. The problem is that there are not many of such products, especially not for Dutch inflation, since there are no Dutch inflation-linked bonds.

According to Brounen and Mahieu (2014), the relation between the Dutch inflation and the interest on ordinary mortgages is strong. Brounen, Porras Prado and Verbeek (2008) find that real estate offers hedging benefits against inflation risk.

Return drivers of reverse mortgages are, amongst others, real estate appreciation and nominal interest rates. Given that both these elements are correlated with inflation, I assume that reverse mortgages can add inflation hedging capabilities to the portfolio.

Therefore, my fourth sub hypothesis is:

Reverse mortgages are suitable in a pension fund portfolio to maintain purchasing power

3.7. Conclusions and Hypotheses

I have started this chapter with the life-cycle theory and the role of housing equity in it. Next, I explained how reverse mortgages could play a role in releasing this housing equity. I explained what reverse mortgages are and how they work. I continued with a description of the international and local Dutch market for reverse mortgages. In The Netherlands, the market is almost non-existent with only one provider and very low sales volumes.

After that, I looked with a consumers view to reverse mortgages. A consumer can use reverse mortgages for four purposes; a planned, one-time expense; an unexpected, one-time expense; as a supplement to daily expenditures; and for additional comfort or hobbies. The main reasons to enter into a reverse mortgage contract for a consumer are that they offer supplemental liquidity and thus enable consumption smoothing, increase access to credit at old age, and shift the house price and (possibly) the longevity risk from individuals to financial institutions. There also are some disadvantages to reverse mortgages. It is a highly complex product that comes with high additional costs. The amount that can be borrowed in the future is uncertain. This makes it hard to include reverse mortgages in financial planning. Reverse mortgages also come with hidden costs, such as a maintenance obligation. Furthermore, reverse mortgages deplete all housing wealth and they come with ownership restrictions. Nevertheless, in a society (as the Dutch) in which pension benefits are likely to decrease in the future, while at the same time fiscal incentives to repay the ordinary mortgage are increased, demand for these product can be expected to increase.

Next, I have looked at reverse mortgages from a providers point of view. The most important reason to offer reverse mortgages mentioned by providers are the expected high profits. Other important reasons are entering a niche market, increasing market share in the pensions or mortgage market, the opportunity to cross sell to elderly, building a social reputation, and complementing the existing product palette. Reverse mortgages also bring some risks with them. The most important risk is the crossover risk. This risk occurs if there is a no negative equity guarantee in place. Furthermore, risks of adverse selection and

MAIN HYPOTHESIS:

REVERSE MORTGAGES CAN OFFER SUBSTANTIAL DIVERSIFICATION AND HEDGING POTENTIAL FOR DUTCH PENSION FUNDS AND CAN THEREFORE OFFER A VALUABLE INVESTMENT OPPORTUNITY

SUB HYPOTHESES:

1. **ADDING REVERSE MORTGAGES TO AN ASSET-ONLY PORTFOLIO INCREASES THE EFFICIENCY OF THIS PORTFOLIO**
2. **REVERSE MORTGAGES ARE BOTH ABLE TO GENERATE EXCESS RETURNS AND INCREASE THE LIABILITY MATCHING OF A PENSION FUNDS' INVESTMENT PORTFOLIO**
3. **ADDING REVERSE MORTGAGES TO THE INVESTMENT PORTFOLIO INCREASES THE INTEREST RATE RISK HEDGE**
4. **REVERSE MORTGAGES ARE SUITABLE IN A PENSION FUND PORTFOLIO TO MAINTAIN PURCHASING POWER**

moral hazard are associated with reverse mortgages. Another risk for financial institutions is that timing of repayment of the outstanding debt is uncertain. This can cause liquidity problems.

After this discussion, I have described how the financial management of pension funds in The Netherlands occurs. The main contradiction pension funds face is that they try to match the liabilities as much as possible on the one hand, while on the other hand they aim to make excess returns. I identified as main risks for pension funds relevant for this thesis the interest rate risk and the inflation risk.

In the search for assets that match the liabilities and generate excess returns, I have proposed to investigate reverse mortgages. I have come up with four sub hypotheses (see blue box). Furthermore, pension funds might be very well positioned to deal with some risks of reverse mortgages other possible providers might face. The crossover risk is a risk that is present for all providers, but the risk of adverse selection and moral hazard might be less severe for pension funds if reverse mortgages are sold to their own population. That is because pension funds know their population very well, so should be able to estimate and price these risks. Furthermore, given the long term nature of pension funds, the timing and illiquidity issues of reverse mortgages might not be much of a problem for pension funds.

As assumed in my hypothesis and based on this theoretical chapter, it is very well possible that reverse mortgages might be an attractive investment opportunity for pension funds. If my hypotheses are correct, pension funds become more efficient investors by offering reverse mortgages. That alone is a benefit to society. Even better, more reverse mortgage providers likely results in a more competitive market. Consumers should be able to benefit from this, resulting in better liquidity for pensioners and more efficient use of the wealth that is stored in stones. This could be a “double win” for society. In my next chapter, I will try to quantify the benefits to pension funds using scenario analysis.

Chapter 4: Quantitative Analysis of Reverse Mortgages in a Pension Funds' Investment Portfolio

4.1. Introduction and ALM-context

In the previous chapter, I have set out the theory and my hypotheses. Now, it's time to try to test them quantitatively in this chapter. This quantification is done by means of a stochastic scenario analysis, or an ALM (asset and liability management) study as it is called in the financial world. In an ALM study, the financial situation of a financial institution (in this case, a pension fund) is projected to the future with the help of multiple stochastic scenarios. Since this is done for multiple policy variants, such a study gives insights in how policy alternatives are expected to work out and the risks associated with these policies. In this way, ALM studies are well suited to support strategic decisions.

Of course, such a study involves lots of modelling effort and assumption setting. Therefore, in section 2, I describe the characteristics of my example pension fund. Section 3 is a very important section, since it describes the stochastic modelling of the reverse mortgage portfolio returns. In section 4, I present the main characteristics of the economic scenarios used in the study. In section 5 I discuss the different investment portfolios that are analyzed in this study. The results are discussed in section 6, whereas in section 7 some sensitivity analyses on these results are performed. This chapter ends in section 8 with my conclusions.

4.2. Modelling of the Pension Fund

Average Pension Fund

Consulting company Aon Hewitt publishes the funding level of the average Dutch pension funds on a daily basis[6] on a website. For this publication, the example pension fund is modelled such that its characteristics correspond to the average of all Dutch pension funds. The financial position is regularly checked with other publications (for example, DNB regularly publishes the average funding ratio of all pension funds as well) to keep modelling up-to-date. Working at Aon Hewitt provided me the opportunity to use this modelling for my analysis. Therefore, this study is based on the modelling of the average of the Dutch pension funds. Of course, since pension fund characteristics differ widely, outcomes might as well differ. Nevertheless, this study should give a good picture for the sector as a whole.

Assessment framework

As of January 1, 2015, a new financial assessment framework (nieuw Financieel Toetsingskader, from now: nFTK) will be in place[7]. This nFTK replaces the current framework. I have chosen to assume that the nFTK already is in place. This should make my conclusions more appropriate for the future. Although not all details of nFTK are known yet, it was possible to implement a policy that is likely to be quite nFTK compliant.

[6] In its widely used www.pensioenthermometer.nl

[7] See www.rijksoverheid.nl/documenten-en-publicaties/kamerstukken/2014/06/25/wetsvoorstel-wet-aanpassing-financieel-toetsingskader.html for official documents with respect to the nFTK. The website http://www.aon.com/netherlands/campagnes/nftk/verbetering-financieel-toetsingskader.jsp provides more details of the new framework.

Pension plan

The pension plan is a fairly common plan for Dutch pension funds. It is in line with the new fiscal arrangement that will be in place as of January 1, 2015[8]. In table 1 the pension plan is summarized.

Table 1: Description of pension plan

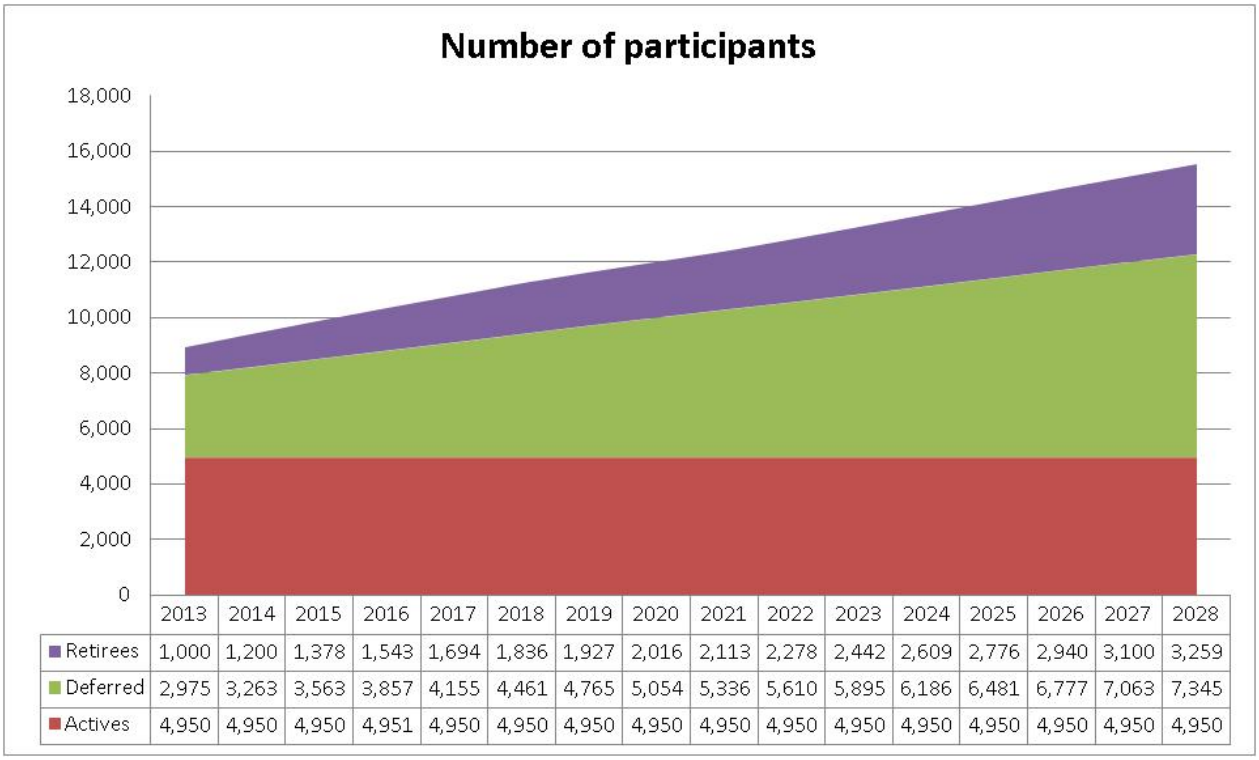
Pension plan description	
Type of pension plan	Career average plan
Indexation	Conditional
Retirement age	67
Maximum pensionable salary (2015)	EUR 100.000
Offset (2015)	EUR 12.552
Accrual percentage old age pension	1,875% of pension base
Spouse pension	70% of attainable old age pension

Participant data and demographic and actuarial assumptions

The distribution of the type of participant (active, deferred, retired) is in line with the average distribution of Dutch pension funds. The development of the distribution of the participants is shown in figure 4. It is assumed that the number of actual participants remains equal during the analysis. Due to dismissals (voluntary or unvoluntary) the number of deferred participants (not active but no retiree yet) increases. Also, due to retirements, the number of retirees (which includes the spouse pensions in payment) also increases. Broadly speaking, the total number of participants increases and so does the inactive proportion of the population.

Of the active participants, 52% is male and 48% is female. This division is also used for new entrants.

[8] See http://www.aon.com/netherlands/publicaties/connected/2014/pensioenopbouw-vanaf-1-januari-2015-afgetopt.jsp for details about the tighter fiscal allowance for second pillar pension plans in The Netherlands.



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Retirees	1,000	1,200	1,378	1,543	1,694	1,836	1,927	2,016	2,113	2,278	2,442	2,609	2,776	2,940	3,100	3,259
Deferred	2,975	3,263	3,563	3,857	4,155	4,461	4,765	5,054	5,336	5,610	5,895	6,186	6,481	6,777	7,063	7,345
Actives	4,950	4,950	4,950	4,951	4,950	4,950	4,950	4,950	4,950	4,950	4,950	4,950	4,950	4,950	4,950	4,950

Figure 4: Development of participants

Both for calculating the liabilities as for developing the participant file, mortality assumptions are required. Most pension funds use the “Prognosetafel 2012-2062”, a mortality table published by the Dutch Actuarial Association[9]. Since these mortality figures are based on the total population, and in general the working population (which typically is the pension fund population) tends to live longer than the total population, many pension funds downscale the mortality probabilities with correction factors. An often used mortality correction table is ES-P2A, which I used as well.

When modelling spouse pensions, it is important to assume which proportion of the population is married. Since my research focusses on diversification benefits in the investment portfolio, the exact modelling of this part of the liabilities is a minor issue. Therefore, I have chosen the most simple assumption that every participant has a partner. Female partners are assumed to be three years younger, while male partners are assumed to be three years older.

Finally, it is important to model dismissal and new entrants properly, since these assumptions can have important consequences on the development of the participants. This also accounts for salary increases due to career moves. These increases are in excess of the general wage increases which are the result of collective labour agreements. Therefore, I have used common assumptions for dismissal, entry, career increases, and the salaries of new entrants. These assumptions can be found in appendix 1.

[9] The mortality table can be found of the website of the Ducth Actuarial Association: http://www.ag-ai.nl/view.php?action=view&Pagina_Id=333. Recently, a new mortality table has been introduced by the association. Because of time constraints, I have chosen not to use this table. In its press release as at September 9, 2014, the association mentioned the new tables only would have a minor impact on the value of the liabilities. Therefore, I concluded that the impact for my analysis, which is mainly investment driven, would be negligible.

Financing and Indexation Policy

In this section, I discuss the financing of the pension liabilities. Furthermore, I discuss the rules for conditional indexation and benefit reduction.

First of all, the value of the liabilities is calculated by discounting the expected cash flows of the accrued pension benefits with a certain discount curve. DNB requires that Dutch pension funds use a risk-free discount curve. DNB publishes this curve on a monthly basis. The curve is based on the Euro Swap Curve, but has undergone two modifications in recent years. First, the curve is subject to three month averaging of the daily curves. This is done to reduce daily volatility. Second, for maturities longer than 20 years, the interest rates are increased using an Ultimate Forward Rate (UFR) methodology. As of 2015, this methodology will change. The averaging will not be part of the curve anymore, and the UFR methodology is changed. However, since the most recent economic data set available is of June 30, 2014, I will use the current UFR methodology. The resulting interest rate curve is shown in figure 5.

Second, an allowance for future costs should be added to the present value of the liabilities. This allowance typically is 2% of the net liability. I have used this percentage in my analysis as well.

Third, rewarding indexation is essential in the inflation protection of pensions. However, in general employers are not willing to directly finance nor guarantee this inflation protection. Therefore, indexation needs to be financed by returns made in excess of the liability return (that is based on the risk-free discount rate). The amount that is rewarded, depends on the funding level. For this, I made a funding level dependent table that approaches the indexation policy under nFTK. In table two, I have summarized this table. The indexation ambition for active participants is equal to the general wage inflation. The indexation ambition for the inactive participants is equal to the price inflation.

Fourth, it is possible to reduce accrued benefits as an ultimate measure in case to recover from insolvency. I have modelled that the accrued benefits are reduced if the funding level is below the minimum required funding level (approximately 105%) for five consecutive years. This is in line with the nFTK conditions.

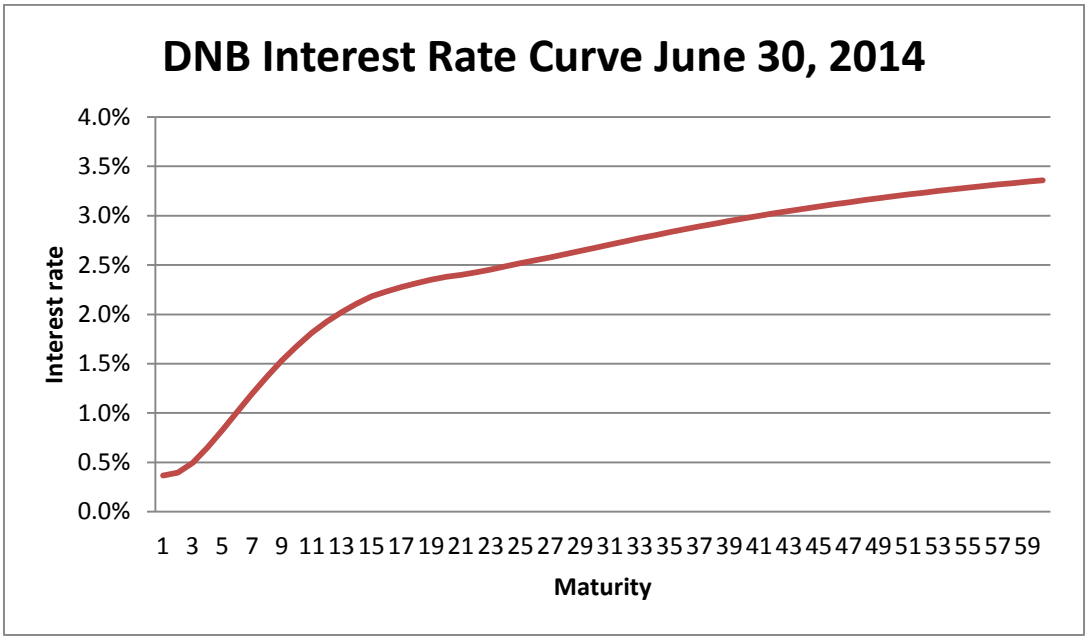


Figure 5: Interest Rate Curve published by DNB as at June 30, 2014

Table 2: Indexation scheme

Funding level	% of indexation ambition rewarded
< 110%	No indexation
110% < Funding level < 130%	Linear partial indexation
> 130%	Full indexation

Fifth, the way the contributions for new accrual are calculated is an important decision to be made. Several methods exist for calculating the contributions. Since the focus is on reverse mortgage returns, and not on contribution methods, I will use the cost covering contribution method. In this method, the contributions paid are calculated based on the same assumptions (with respect to mortality and discount rate) as the valuation of the liabilities. These actuarial costs are increased with a solvency allowance that is equal to the required funding level (this level depends on the asset mix, amongst others and is discussed in section 4.2.7.).

Investment Policy
In this section I will describe the investment policy of the fund without the reverse mortgage in the portfolio. I have constructed two investment portfolios, in order to capture the differences in risk attitudes that exist between pension funds. Moreover, by modelling these two portfolios (a risky and a risk-averse portfolio) I have the opportunity to control whether the results hold for different kinds of risk exposure.

The first portfolio is a relatively risky portfolio that consists of 50% fixed income and 50% equities. The (nominal) interest rate is hedged by 50%. The second portfolio is a relatively risk averse portfolio that consists of 75% fixed income and 25% equities. The interest rate is hedged by 75%. I have chosen to use simple portfolios by limiting the assets to Euro government bonds and global equities. This is done to prevent that the focus is subtracted from reverse mortgages.

Initial Financial Position
The pension fund I have used in my analyses has the following characteristics. The value of the liabilities at the start of the analysis is EUR 1,442 million. The market value of the assets equals EUR 1,558 million. This results in an initial funding level of 108%. This is in line with the funding level of the average pension fund as at September 18, 2014[10].

The duration of the liabilities is equal to 18.

Pension funds in The Netherlands are required to calculate a solvency buffer, the required funding ratio. This buffer is based on the investment and actuarial risks of the pension fund. A riskier asset allocation results in a higher required funding ratio. The required funding ratio for the risky asset allocation (the mix with 50% equities) is 126%. The required funding ratio for the less risky portfolio (with 25% equities) is 113%.

4.3. Modelling Reverse Mortgage returns

Setting assumptions for reverse mortgage returns is not straightforward, since historic return data is not available. Therefore, the returns heavily rely on assumptions and modelling choices. In this section, I explain how I have modelled reverse mortgage returns and which assumptions are underlying.

[10] www.pensioenthermometer.nl

Basics

Ignoring specific reverse mortgage dynamics, a reverse mortgage is nothing more than a zero coupon bond. Therefore, the annual return can be modelled as being the difference between the value of such a bond at the end of the year and at the beginning of the year. In formula:

$$r_t = LV_{t+1}/LV_t \quad (1)$$

Where LV is the loan value. The loan value is nothing more than the discounted expected payoff at the expected end date.

$$LV_t = E(payoff)_t/(1+r_t)^{E(m_t)} \quad (2)$$

Payoff is the amount that ultimately is repaid. R is the appropriate discount rate (discussed in section 4.4.5), and m is the period until the expected date of payment (discussed further in section 4.4.3).

This is the point where reverse mortgages start deviating from ordinary zero coupon bonds, since both payoff and expected date of payment are uncertain.

The expected payoff depends on the value of the debt and the value of the house at the time of repayment. If the value of the debt (initial loan value increased with interest) is lower than the sale proceeds, the debt is fully repaid. If the house price is lower, the debt is not fully repaid but all sale proceeds go to the provider. In essence, this is the no negative equity guarantee. In formula:

COMPONENTS OF REVERSE MORTGAGE RETURNS:

- **LOAN AMOUNT**
- **EXPECTED AND ACTUAL INTEREST RATE**
- **EXPECTED AND ACTUAL HOUSE PRICE INCREASE**
- **DISCOUNT RATE**
- **PERIOD UNTIL REPAYMENT**

$$E(payoff)_t = \min(L_t * \prod_t^{E(m_t)}(1+E(i_t)), H_t * \prod_t^{E(m_t)}(1+E(hpi_t)) \quad (3)$$

In this formula, L is the current loan value, which in turn is the initial loan value increased with past interest. i_t is the interest rate that is charged upon the consumer. I have modelled two variants. In the first variant, the interest rate is fixed. In the second variant, the interest rate charged is variable and depends on the actual interest rate. That is the reason I have added the expected interest rate. H is the current house price. Hpi is the house price increase. Of course, the future house price is uncertain. Therefore, I have added an expectation to it.

Now, I have identified all components that are necessary for the return of a reverse mortgage. I will describe the modelling of the separate components in the following sections. Formula (4) is the formula I have used for modelling the returns.

$$r_t = \frac{\min(L_{t+1}*\prod_{t+1}^{E(m_{t+1})}(1+E(i_t)), H_{t+1}*\prod_{t+1}^{E(m_{t+1})}(1+E(hpi_t))/(1+r_{t+1})^{E(m_{t+1})}}{\min(L_t*\prod_t^{E(m_t)}(1+E(i_t)), H_t*\prod_t^{E(m_t)}(1+E(hpi_t))/(1+r_t)^{E(m_t)}} \quad (4)$$

In chapter three I have mentioned that the return is equal to a zero coupon bond and an option on the house price. I have captured this optionality by taking the minimum of the expected loan value and expected house price. This does not capture the time value of the option[11]. I have chosen not to take this

[11] The time value of the option is the value of the option that lies in the fact that circumstances can change over time, leading to a better payout of the option

value into account, since the modelling of this time value would be a thesis itself. It would involve, amongst other, modelling random distributions of future house price development within each scenario as well as modelling moving behavior and moral hazard. As can be noticed though, the moment the crossover risk is expected to occur, it is immediately recognized as a negative return.

Illustration of reverse mortgage returns

Now that I have posited my formulas for calculating the reverse mortgage returns, I will illustrate how these returns are calculated in practice. This is a simple deterministic illustration to get the basic idea. In the following sections, I will explain how I have modelled all components of the return in detail. In this section, I will present three examples of the return on a reverse mortgage for one 65-year old person, with a house value of EUR 400.000 and a reverse mortgage loan of EUR 200.000. The expected and actual maturity of the loan is 20 years.

Case 1: Everything occurs as expected

In this example, the actual and expected increases of the house price are equal to 2% a year. The interest rate charged on the outstanding debt is 6.25% annually and so is the discount rate used for calculating the present value of the expected payment. So, everything occurs as expected, crossover does not occur and there are no changes in the discount rate.

In this scenario, the annual return is equal to the return on a zero-coupon bond with an interest of 6.25%. There are no fluctuations in the returns. This is illustrated in figure 6.

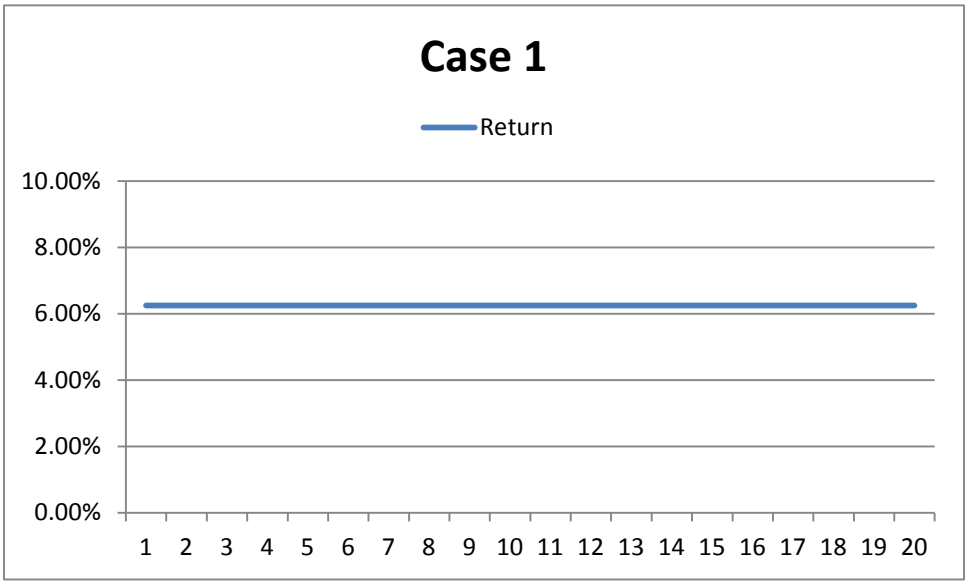


Figure 6: Reverse mortgage return in case 1

Case 2: Crossover occurs due to a large house price decrease in year 10

In this example, the actual and expected increases of the house price are equal 2% a year, except for year 10, in which house prices drop with 20%. The interest rate charged on the outstanding debt is 6.25% annually and so is the discount rate used for calculating the present value of the expected payment.

In this scenario, the annual return is equal to the return on a zero-coupon bond with an interest of 6.25%, except for year 10. In year 10, the house price drops with 20%. This reduces the expected repayment of the loan, since from that moment, the expected house price is lower than the expected outstanding loan

(this is the “crossover”). This effect is reflected in full at the moment it occurs, leading to a large negative return in year 10. After that, everything is stable again. This is shown in figure 7.

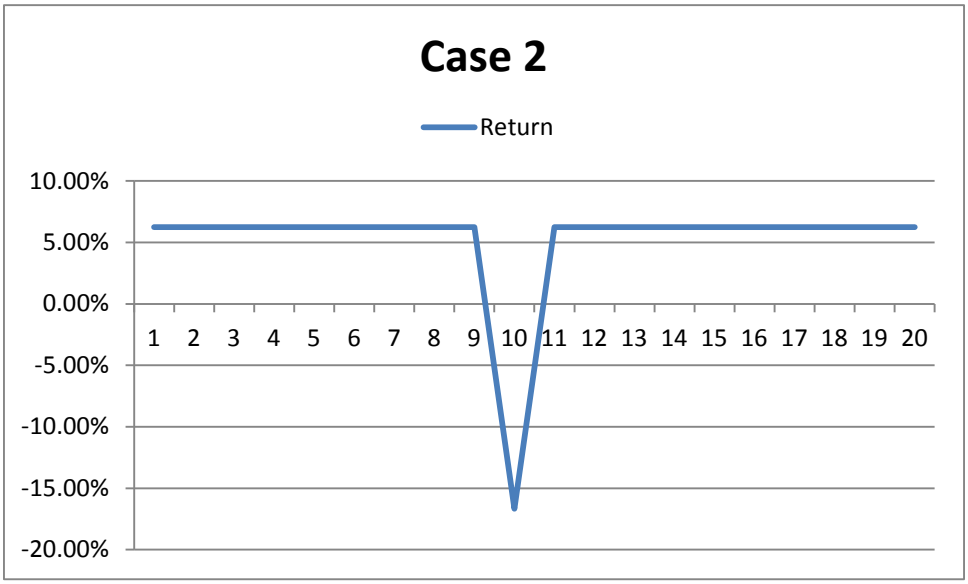


Figure 7: Reverse mortgage return in case 2

If the house price would increase in a later year, the effect would be opposite (a positive return), until the point that the expected outstanding debt is lower than the expected sale value of the house.

There can be more causes for a crossover to occur, such as an increase in the expected duration of the loan or an increase in the interest rate charged on the outstanding debt (if this interest is variable). However, the effect to the returns is similar on the effect shown in case two, therefore, I will not elaborate on this.

Case 3: Effect of change in discount rate

Another important factor in the returns of reverse mortgages is a shift in the discount rates used (especially if the interest on the debt is fixed), since this can cause the present value of the loan to become volatile. In this case, I have shown what occurs if from year 10 and forward the discount rate increases with 1%, all else being equal.

Such an increase causes the present value of the loan to drop. This leads to negative returns at the moment the change occurs. After that, due to the higher discount factor, the return is higher, compensating for the loss of value, since the actual interest rate charged was fixed. Therefore, if the interest rate charged was fixed, changes in the discount rate cause deviation, but do not have an impact on total returns, as long as all else remains equal (of course, in real life, house price developments, expected duration of the loan, etc. do not remain equal). This is illustrated in figure 8.

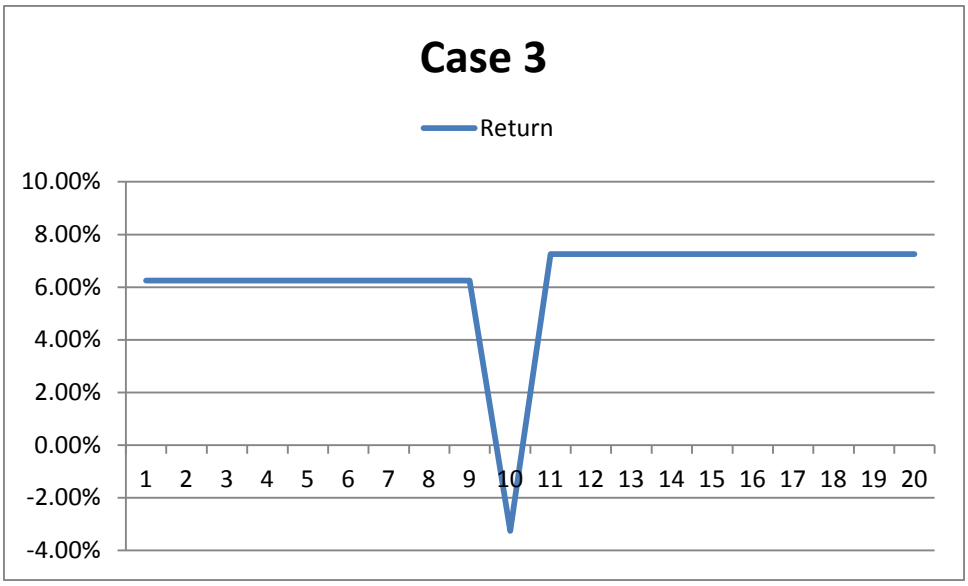


Figure 8: Reverse mortgage returns in case 3

In this section, I have illustrated how reverse mortgage returns work for a simple, one person deterministic case. In the following sections, I will apply multiple persons and multiple scenarios.

Consumers

I have modelled the expected returns of reverse mortgages for a portfolio of customers. I have used 2,000 customers, since this number eliminates the effects of randomness in deceases and still is workable in terms of calculation time. Gender is randomly chosen, resulting in 1,011 male customers and 989 female customers. The age at initiation of the loan is random between 65 and 70, capturing normal pension ages. The division of the ages is shown in figure 9.

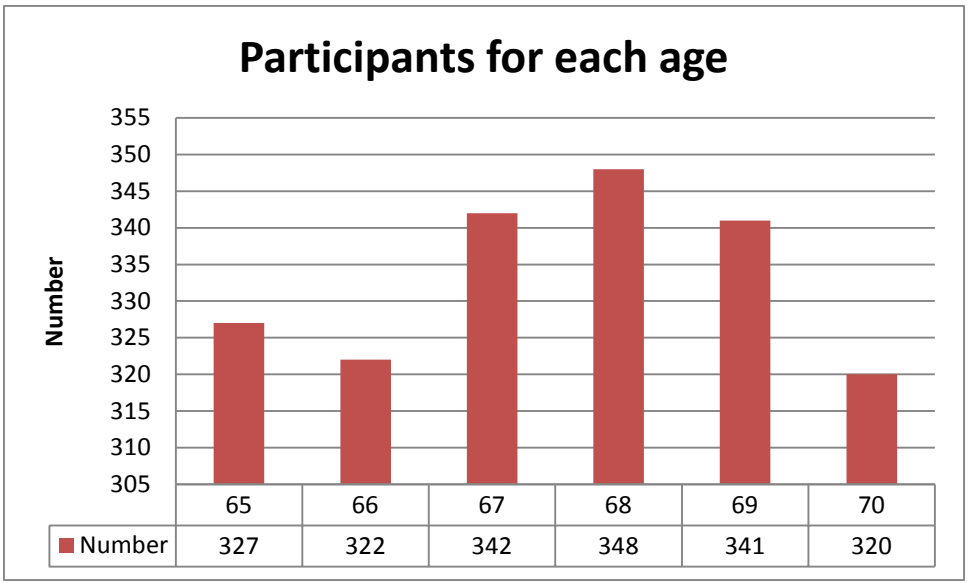


Figure 9: Number of participants for each age

The house value at origination is randomly generated for each participant as well and is between EUR 200,000 and EUR 1,000,000. The average house price is approximately EUR 600,000. This value is

higher than the average house price in The Netherlands. However, since returns are measured relative to house value, this is not a problem.

For the loan-to-value (the amount that can be borrowed as a percentage of the value of the house) I have used the actual loan-to-values of Florius[12]. These values depend on age and are shown in table 3. As can be seen, the values appear to be low, thus reducing the crossover risk. I have assumed that every customer borrows the maximum loan-to-value.

Table 3: Loan-to-value ratios for each age

Age	Loan-to-Value
65	18.50%
66	19.50%
67	20.60%
68	21.60%
69	22.70%

Expected maturity and actual decease

As stated in chapter 3.5, longevity is an important risk driver for the crossover risk. So, the longer a customer keeps inhabiting his house, the more interest is added to the outstanding debt, and the more likely it is that the eventual sale value of the house will not exceed the house price. Therefore, I had to model expected and actual maturity of the loan.

The first building block of this modelling are the mortality tables. I have used the same mortality tables as the ones are used for the valuation of the liabilities (Prognosetafel 2012-20162 with correction factors ESP-2A). I have chosen to do so because these probabilities can be assumed as best estimate mortality probabilities. Implicitly, I thus have assumed that no selection biases occur in the portfolio. However, I have increased the mortality rates with 30%, capturing the fact that the house of reverse mortgage owners not only is sold if the owner has passed away, but also can be sold for different reasons, such as moving to a nursing home or liquidity reasons.

The next step is calculating expected maturity for each participant in each year if still alive. For this, I have used the following formula (5):

$$E(m_{x,i}) = \frac{\sum_{t=1}^{T} t * {}_{t-1}p_{x+t-1,i+t-1} * q_{x+t-1,i+t-1}}{\sum_{t=1}^{T} {}_{t-1}p_{x+t-1,i+t-1} * q_{x+t-1,i+t-1}} \quad (5)$$

Where,

t is the time, measured in years

${}_{t-1}p_{x+t-1,i+t-1}$ is the probability an x+t-1 year old will survive t-1 years. These probabilities differ between men and women. The suffix i stands for the analysis year in which the calculation of the expected maturity starts, capturing the trend that is included in the Prognosetafel.

$q_{x+t-1,i+t-1}$ is the probability that an x+t-1 year old will die in that year, in which the probability again depends on gender and on calculation year.

[12] https://www.florius.nl/consument/hypotheken/floriusverzilverhypotheek

Finally, for the sake of simplicity, I have rounded the expected maturity to whole years. The resulting expected maturities are shown in table 4 (male) and table 5 (female). These tables should be interpreted carefully. The ages shown in the left column, refer to the age at initiation in year 0. So, a 65-year old male has an expected maturity of 20.4 years. However, one year later, if he's still alive, the customer is 66 years old, but his expected maturity of 19.6 years is still shown in the upper row. So, basically, the rows in the table correspond to cohorts.

Two things need to be remarked. First of all, it might be noticed that the expected maturity year after year (moving from left to right) does decrease with less than one year. This is caused by the fact that the expected maturities are maturities if one is alive. Second, the increasing trend in expected longevity can be seen that for a person that becomes 66 in one year from now, the expected maturity (19.6) is higher than the expected maturity of a person that is 66 right now (19.5).

Table 4: Expected maturities for male participants

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
65	20.4	19.6	18.8	18.0	17.3	16.5	15.7	14.9	14.2	13.4	12.7	12.0	11.3	10.6	9.9	9.3
66	19.5	18.7	17.9	17.1	16.4	15.6	14.8	14.1	13.3	12.6	11.9	11.2	10.5	9.9	9.2	8.6
67	18.5	17.8	17.0	16.2	15.5	14.7	14.0	13.2	12.5	11.8	11.1	10.5	9.8	9.2	8.6	8.0
68	17.6	16.9	16.1	15.4	14.6	13.9	13.1	12.4	11.7	11.1	10.4	9.8	9.1	8.5	7.9	7.4
69	16.7	16.0	15.2	14.5	13.8	13.0	12.3	11.6	11.0	10.3	9.7	9.1	8.5	7.9	7.3	6.8
70	15.9	15.1	14.4	13.7	12.9	12.2	11.6	10.9	10.3	9.6	9.0	8.4	7.9	7.3	6.8	6.2

Table 5: Expected maturities for female participants

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
65	22.0	21.2	20.4	19.6	18.8	18.0	17.2	16.4	15.7	14.9	14.1	13.4	12.7	11.9	11.2	10.5
66	21.1	20.3	19.5	18.7	17.9	17.1	16.4	15.6	14.8	14.1	13.3	12.6	11.9	11.2	10.5	9.8
67	20.2	19.4	18.6	17.9	17.1	16.3	15.5	14.8	14.0	13.3	12.5	11.8	11.1	10.4	9.8	9.1
68	19.3	18.5	17.8	17.0	16.2	15.4	14.7	13.9	13.2	12.5	11.8	11.1	10.4	9.7	9.1	8.5
69	18.5	17.7	16.9	16.1	15.4	14.6	13.9	13.1	12.4	11.7	11.0	10.3	9.7	9.0	8.4	7.8
70	17.6	16.8	16.0	15.3	14.5	13.8	13.1	12.4	11.7	11.0	10.3	9.6	9.0	8.4	7.8	7.2

Next, I had to model actual decease (or more correctly, sale or no sale of the house) with the desire to also capture the randomness of life. Therefore, probabilities that the loan is terminated equal the expected probabilities, but for each customer in each scenario, termination of the loan occurs randomly according to this probabilities. This is done by randomly choosing a value between 0 and 1 (by using the uniform distribution). If the value is lower than the termination probability, the loan is terminated, otherwise it is not.

Expected and Actual House Value

Modelling the crossover risk requires modelling expected and actual house price appreciation. It is important to capture Dutch house price dynamics. The economic scenarios of Aon Hewitt only provide return series for a broad Eurozone real estate index that includes all kinds of real estate (such as commercial, retail, and industrial). Therefore, I had to made other assumptions on the house price development. In order to get coherent results, it was important that the house price appreciation scenarios are consistent with the other scenarios. Therefore, in developing my house price series, I relied heavily on the paper of Brounen, Eichholtz, and Theebe (2007). This paper examines the relation between private Dutch homes and both expected and actual inflation. The advantage of including both expected and actual inflation in my model is that this gave me the possibility that actual house price

developments could substantially deviate from the expected values, just as in real life. I am aware that other factors (economic and non-economic) also can and will have an impact on house price developments, but I have chosen to use the relatively simple model for the three reasons mentioned above; possibility to make a difference between expected and actual house price dynamics, consistency with scenario set, and ease of implementation.

For the actual house price increase, I have assumed an arithmetic average of 4.5% and a standard deviation of 20.6%. This is in line with the very long run values Brounen, Eichholtz, and Theebe found. The authors also found a constant of 0.042 and a correlation with actual inflation of 0.181. I have used these results to model the actual house price increase in formula (6).

$$HPI_{t,s} = 0.042 + 0.181 I_{t,s} + \varepsilon_{t,s} \quad (6)$$

Where,

$HPI_{t,s}$ is the actual house price increase in year t for scenario s

$I_{t,s}$ is the actual inflation in year t for scenario s

$\varepsilon_{t,s}$ is an error term, randomly added with a normal distribution with mean 0 and a standard deviation of 20.5%.

The results of this model are actual house price appreciation scenarios with an arithmetic average house price increase of 4.2% and a standard deviation of 20.4%.

The expected house price appreciation is a function of expected inflation and some constants. I have modelled it by a formula (7) that also finds its roots in the paper of Brounen, Eichholtz, and Theebe (2007).

$$E\left(HPI_{E(m_{x,i}),t,s}\right) = C_{E(m_{x,i})} + \beta_{E(m_{x,i})} * \left((1 + BEI_{E(m_{x,i}),t,s})^{\wedge E(m_{x,i})} - 1\right) \quad (7)$$

In this formula,

$C_{E(mx,i)}$ is a constant that depends on the expected maturity of the loan

$B_{E(mx,i)}$ is a regression factor that depends on the expected maturity of the loan as well

The corresponding values of C and β can be found in appendix 2.

For the expected inflation, I have used the break-even inflation $BEI_{E(mx,i),t,s}$, which is a function of the expected maturity, the year of the analysis t, and the specific scenario. The break-even inflation is a measure for the expected inflation and is the difference between the nominal and the real interest rate for a given period. Since the break-even inflation curves are provided in the scenario set, this formula is implementable.

Interest Rate

Interest rates are used in my modelling of reverse mortgages in two ways. First of all, it is used for the interest accrual on the outstanding debt. This interest accrual can be either fixed over the entire maturity, or variable depending on the actual level of the interest rate. Second, in order to estimate the value of the reverse mortgage at any time, the expected payment should be discounted with the use of a discount factor.

Interest accrual on outstanding debt
Any financial institution that offers loans, will charge an interest on that loan. This interest is called the interest on outstanding debt. I decided to mark my interest charges on the outstanding debt to what is available in the market. The only provider in The Netherlands, Florius, currently charges 6.25% fixed interest for the entire maturity. Compared to regular mortgage rates in The Netherlands, this interest level appears high at first sight, but the no negative equity guarantee probably is partially to blame for that. Since this guarantee presents a risk to the financial institution, a risk premium should be charged for this risk. In section 4.7, I will perform some sensitivity analysis on the interest level. So, in the alternative that a reverse mortgage charges a fixed interest rate, the level of the interest is 6.25%.

For the alternative in which the interest charged is variable, I had to model two components of the interest rate. The first part is the variable part. This part is based on the nominal Euro yield curve, which is (in the scenario set) a stochastic yield curve based on the average yield curve of Eurozone bonds. What the model does in each scenario, in each year, for each participant, is calculating the expected maturity (rounded until whole numbers) and take the interest rate that corresponds with that expected maturity, year, and scenario. The second part is the risk premium and is not variable over time. This risk premium is set at such a level that the expected total interest rate at initiation is equal to 6.25%. For example, at t=0, for a male participant of age 65, the expected maturity is 20 years. The corresponding variable interest is 2.714%. As a result, the fixed risk premium is 3.536%. The sum of these two components is 6.25%.

Discount factor
The interest also plays a role in discounting the expected payment to derive the value of the reverse mortgage. It is a common valuation principle that the discount factor should include a risk premium in excess of the risk-free rate if there are risks. Basically, the discount factor should include the following three components:

- The current level of the risk-free interest rates
- A maturity-dependent factor
- A risk-premium that reflects the risk

These three factors come together in the variable interest I have modelled in section 4.3.5.1.. Therefore, I will use as a discount factor the variable interest rate charged. This is also done for the alternative of the fixed interest rate and thus results in valuation returns due to interest rate changes (just as is the case with common bonds).

In essence, the total annual return of a reverse mortgage with fixed interest depends on three factors:

- **The (fixed or variable) interest rate charged on the outstanding debt**
- **Changes in the discount factor that have an impact on the present value of the expected payment**
- **Changes in the expected payment due to the crossover risk**

In turn, the total annual return of a reverse mortgage with variable interest is less sensitive to the second factor, since expected interest charges are equal to the discount factor. However, a change in the discount factor can have an effect if simultaneously the crossover risk occurs.

Costs

Costs can play an important role, but it is hard to accurately model them and undesirable if choices with respect to costs have an impact on the conclusions. A major part of the costs are upfront costs. I have conveniently assumed that the upfront costs are paid from the initial loan. The result of this choice is that these costs are cost neutral, eg. have no effect on the results.

Ongoing costs are, again conveniently, assumed to be part of the risk premium. As an assumption, I deducted 0.25% of the annual returns as a cost charge for the provider. This 0.25% is in line what pension funds should use for common stock assets.

Summary of underlying assumptions

In table 6, I have shown the assumptions underlying the reverse mortgage returns.

Table 6: Summary of underlying assumptions for reverse mortgage returns

Category	Fixed interest alternative	Variable interest alternative
Number of customers	2,000	2,000
Age of customers	Random between 65 and 70	Random between 65 and 70
Loan-to-value	Equal to Florius	Equal to Florius
Expected and actual maturity of loan	According to AG Prognosetafel 2012-2062, with correction factor ES-P2A and increased with 30%	According to AG Prognosetafel 2012-2062, with correction factor ES-P2A and increased with 30%
House price increase (expected)	Stochastic, depends on expected inflation	Stochastic, depends on expected inflation
House price increase (actual)	Stochastic, depends on actual inflation	Stochastic, depends on actual inflation
Interest rate charged on debt	Fixed, 6.25%	Variable, depend on nominal yield curve and risk premium
Discount rate	Variable, depend on nominal yield curve and risk premium	Variable, depend on nominal yield curve and risk premium

Results

Given the model described above, I have applied the 2,000 economic scenarios to this model to derive to the reverse mortgage returns. The average geometric return and corresponding standard deviation can be found in table 7. Note that the values shown are gross returns.

As can be noticed, the expected returns are quite similar. However, the standard deviation is significantly higher for the fixed interest alternative. This is caused by the "discount factor effect", that is more present in the fixed interest alternative. From an asset-only perspective, this higher risk for the same return seems like a bad thing. However, from an ALM point-of-view, it is the question whether it really is a disadvantage. If this volatility is strongly correlated with the volatility of the liabilities, the fixed interest reverse mortgage might present valuable hedging opportunities. I will come back on this in a later section.

REVERSE MORTGAGE RETURNS:

- **EXPECTED RETURN LEVELS ARE ALMOST EQUITY-LIKE**
- **STANDARD DEVIATION IS HIGH, IN LINE WITH EQUITIES**

The higher volatility of the fixed interest reverse mortgage can also be seen when figures 10 and 11 are compared. For both alternatives, very negative returns are apparent. These can be caused by price

fluctuation due to a change in the discount factor, or by a depreciation of the value of the reverse mortgage due to the crossover risk.

In effect, the returns of the reverse mortgage are almost equity like. This is mainly caused by the high interest rates charged (which are partially driven by the risk premium for the crossover risk). However, due to the low loan-to-values, this crossover does not occur very often. The volatility of the returns also is high, especially for the fixed interest rate alternative. For this alternative, this is caused by discount rate fluctuations (just like it is for long duration bonds). For both alternatives, part of the high volatility is caused by crossovers. Although crossovers do not occur often, their impact on returns is large if they occur.

Table 7: Expected reverse mortgage returns

Category	Geometric return	Standard deviation
Fixed interest reverse mortgage	6.2%	19.5%
Variable interest reverse mortgage	6.1%	10.9%

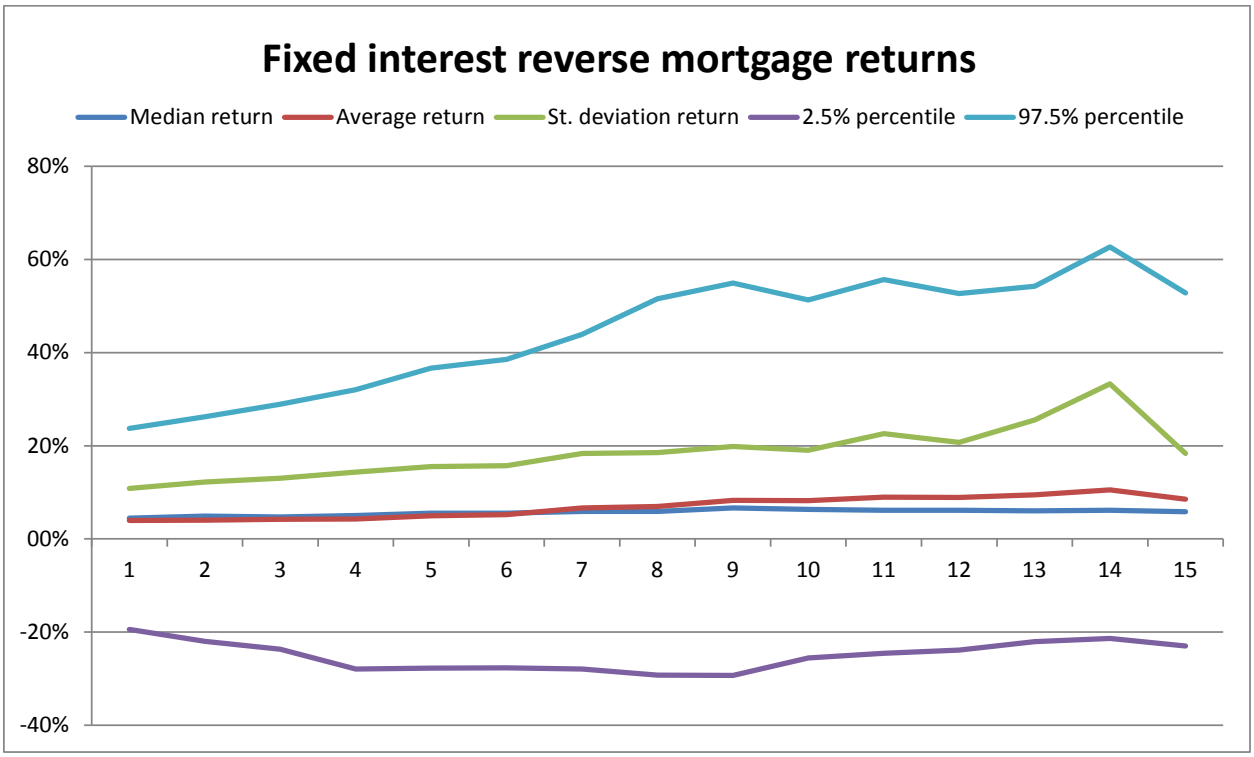


Figure 10: Fixed interest reverse mortgage returns

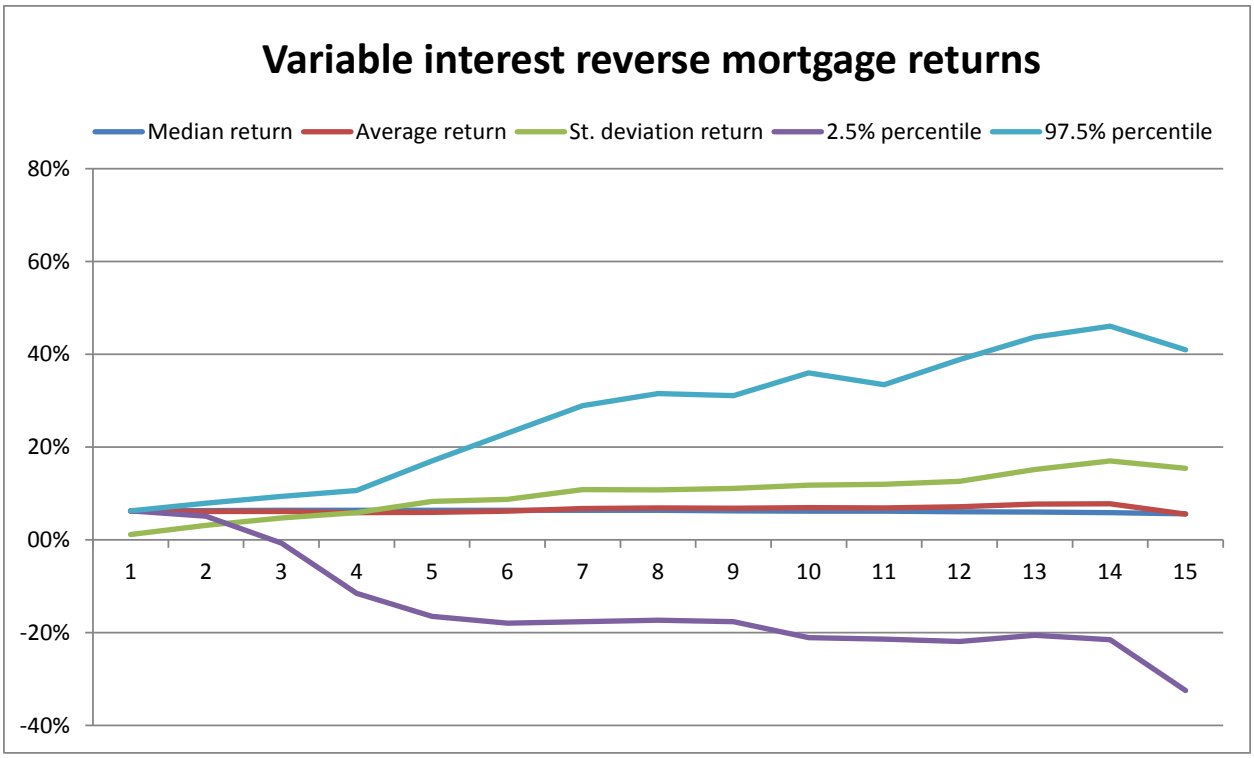


Figure 11: Variable interest reverse mortgage returns

4.4. Economic assumptions

For my economic assumptions, I have used the assumptions that are used by Aon Hewitt as at June 30, 2014 and added the reverse mortgage returns. Aon Hewitt used these assumptions globally. The assumptions are set by a specialized team and are based on historic data, technical analysis, and consensus economics (a survey of economic forecasts). I have used 2,000 stochastic economic scenarios.

The economic assumptions can be found in table 8. The values shown are annual measures over a period of fifteen years. The correlations between the categories are shown in table 9. I have highlighted the correlations of both reverse mortgage alternatives. The alternative with fixed interest rate has high correlations with bonds, almost zero with equity, and some correlation with the one-year swap rate. The variable interest alternative has some, both lower, correlations with bonds, no correlation with equity, and lower correlation with one-year swap rates.

I have also added the liability return. As can be seen,

the correlation between the fixed interest rate revere mortgage and the liability return is high. This is a first clue about the hedging potential of this category. The correlation between the variable interest rate reverse mortgage is lower, but still substantial.

Table 8: Economic assumptions

Category	Geometric return	Standard deviation
Government bonds (5 year)	2.1%	7.0%
Government bonds (20 year)	2.7%	14.5%
Euro Equity	6.5%	20.9%
US Equity	6.5%	22.8%
UK Equity	7.2%	24.0%
Emerging Market Equity	8.8%	29.5%
Fixed Interest Reverse Mortgage	6.2%	19.5%
Variable Interest Reverse Mortgage	6.1%	10.9%
Swap rate (1 year)	2.4%	1.2%
Swap rate (10 year)	3.0%	1.2%
Liability return	2.7%	13.7%
Wage inflation	3.0%	1.7%
Price inflation	2.0%	1.7%

Table 9: Correlation table

	Gov. bonds (5 years)	Gov. bonds (20 years)	Eur. Equity	US Equity	UK Equity	Emm.t Equity	Fixed Int. Rev. Mort.	Var. Int. Rev. Mort.	Swap rate (1 year)	Swap rate (10 year)	Wage infl.	Price infl.
Government bonds (5 years)	1.00											
Government bonds (20 years)	0.86	1.00										
Euro Equity	0.01	(0.07)	1.00									
US Equity	0.03	(0.03)	0.76	1.00								
UK Equity	0.03	(0.03)	0.77	0.81	1.00							
Emerging Market Equity	(0.01)	(0.07)	0.78	0.79	0.77	1.00						
Fixed Interest Reverse Mortgage	0.82	0.87	(0.02)	0.00	0.00	(0.03)	1.00					
Variable Interest Reverse Mortgage	0.42	0.38	0.01	0.01	0.01	0.00	0.59	1.00				
Swap rate (1 year)	0.47	0.21	0.15	0.13	0.13	0.11	0.30	0.18	1.00			
Swap rate (10 year)	0.25	(0.05)	0.15	0.12	0.12	0.11	0.06	0.12	0.85	1.00		
Wage inflation	0.28	0.00	0.11	0.12	0.12	0.09	0.09	0.06	0.63	0.64	1.00	
Price inflation	0.28	0.00	0.11	0.12	0.12	0.09	0.09	0.06	0.63	0.64	1.00	1.00
Liability return	0.88	0.98	(0.06)	(0.03)	(0.03)	(0.06)	0.87	0.39	0.23	(0.04)	0.02	0.02

The swap rate is used for the valuation of the liabilities. The development of the swap curve is based on the forward methodology. This forward methodology is applied to the swap curve without UFR. The UFR is applied to the resulting swap curves.

4.5. Investment Portfolios

In an ALM-study, multiple investment portfolios are investigated. For the purpose of investigating the diversification potential of reverse mortgages, I designed in total 22 investment portfolios. These investment portfolios differ in riskiness, amount of fixed income assets, amount of equities, hedging of interest rate risk, amount of reverse mortgages, and type of reverse mortgages. The different variants can be found in figure 12 and table 10. The names of the variants can be explained as follows:

- The first number indicates the amount of fixed income assets
- The second number indicates the amount of equities
- The third number indicates the amount of reverse mortgages
- The fourth number indicates the amount of interest rate risk that is hedged (without the possible hedging effect of reverse mortgages taken into account)
- The letters "var" indicate that the reverse mortgages have a variable interest rate

As a benchmark, I have constructed two portfolios without reverse mortgages, one that is relatively risky ("50-50-0-50") and one that contains less risk ("75-25-0-75"). In both portfolios, I have increased the amount of risky assets gradually with 5% each time. I have limited the amount of reverse mortgages to 25% of the total portfolio. Given the current (non-existent) market, this might be an unrealistically high allocation. However, if the proportion of reverse mortgages is kept small, it is hard to identify the effects in the portfolio. I have kept the interest rate risk hedge constant for these portfolios. Notice that this is the hedge level without the possible hedging effect of reverse mortgages.

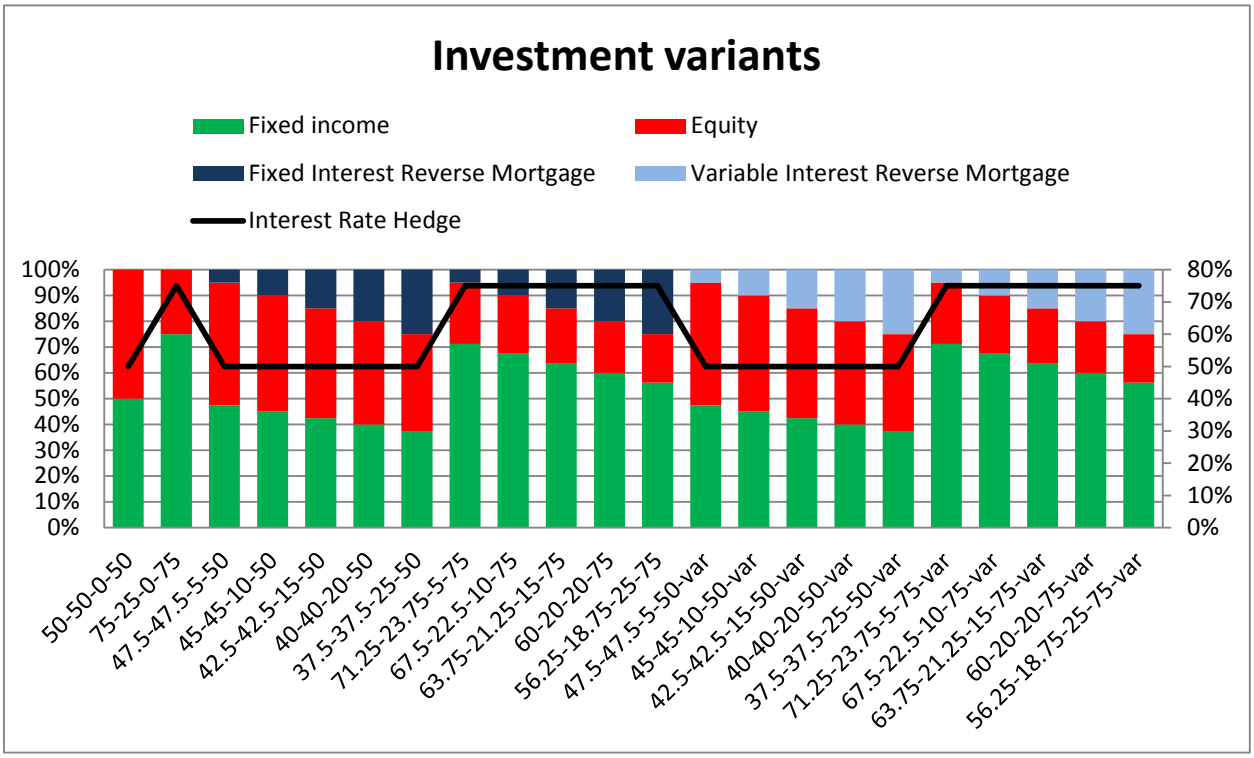


Figure 12: Investment variants analyzed

Table 10: Investment variants

Variant	Fixed income	Equity	Fixed Interest Reverse Mortgage	Variable Interest Reverse Mortgage	Interest Rate hedge[13]
50-50-0-50	50%	50%	0%	0%	50%
75-25-0-75	75%	25%	0%	0%	75%
47.5-47.5-5-50	48%	48%	5%	0%	50%
45-45-10-50	45%	45%	10%	0%	50%
42.5-42.5-15-50	43%	43%	15%	0%	50%
40-40-20-50	40%	40%	20%	0%	50%
37.5-37.5-25-50	38%	38%	25%	0%	50%
71.25-23.75-5-75	71%	24%	5%	0%	75%
67.5-22.5-10-75	68%	23%	10%	0%	75%
63.75-21.25-15-75	64%	21%	15%	0%	75%
60-20-20-75	60%	20%	20%	0%	75%
56.25-18.75-25-75	56%	19%	25%	0%	75%
47.5-47.5-5-50-var	48%	48%	0%	5%	50%
45-45-10-50-var	45%	45%	0%	10%	50%
42.5-42.5-15-50-var	43%	43%	0%	15%	50%
40-40-20-50-var	40%	40%	0%	20%	50%
37.5-37.5-25-50-var	38%	38%	0%	25%	50%
71.25-23.75-5-75-var	71%	24%	0%	5%	75%
67.5-22.5-10-75-var	68%	23%	0%	10%	75%
63.75-21.25-15-75-var	64%	21%	0%	15%	75%
60-20-20-75-var	60%	20%	0%	20%	75%
56.25-18.75-25-75-var	56%	19%	0%	25%	75%

4.6. Results

In this section, I will discuss the results of the different investment portfolios and thus gain insights in the diversification potential of reverse mortgages. The section starts with asset-only results, ignoring the liability side of the balance sheet of pension funds. After that, I will include the liabilities and discuss solvency measures, indexation measures, interest rate hedging potential, and longevity potential.

4.6.1. Asset Only

Risk-return

In this subsection, I focus on the investment return and its standard deviation. This is an asset-only perspective, which might not be perfectly suitable from a balance sheet perspective, but it gives first insights in the results. The 15 year results are shown in table 11 (for the risky portfolio) and table 12 (for the less risky portfolio. For a more easy interpretation of the tables, I have added some color scales. The color red means a bad outcome, compared to the other outcomes. The color green means a good outcome, compared to the other outcomes. In this section, I have identified a higher return as a good outcome. Opposite, I have identified a lower standard deviation as a better outcome.

[13] The interest rate hedge shown above is without the possible hedging effect of the reverse mortgage

The first finding is that adding reverse mortgages to the portfolios increases expected returns. This effect is only small for the risky portfolio (since the portfolio return without reverse mortgages was close to the added return of the mortgages), but sizeable for the less risky portfolio.

The second finding is the return increase appears to be slightly stronger for the variable interest reverse mortgages. This can be explained because geometric return decreases with a higher standard deviation, and the fixed interest variant has a higher standard deviation.

The third finding is that adding fixed interest reverse mortgages increase the volatility of the portfolio, while variable interest reverse mortgages decrease the volatility of the portfolio. This is in line with the standard deviations shown in section 4.4.

To conclude this section, adding variable interest reverse mortgages increases expected return, while it decreases the volatility, making the investment portfolio more efficient from an asset-only perspective. This is not the case for the fixed interest reverse mortgage.

Table 11: 15 year risk-return results for the risky portfolios

Variant	Geometric return	Standard deviation
50-50-0-50	5.5%	11.5%
47.5-47.5-5-50	5.5%	11.3%
47.5-47.5-5-50-var	5.5%	11.0%
45-45-10-50	5.6%	11.2%
45-45-10-50-var	5.6%	10.6%
42.5-42.5-15-50	5.6%	11.3%
42.5-42.5-15-50-var	5.6%	10.2%
40-40-20-50	5.6%	11.5%
40-40-20-50-var	5.7%	9.9%
37.5-37.5-25-50	5.6%	11.7%
37.5-37.5-25-50-var	5.7%	9.6%

Table 12: 15 year risk-return results for the less risky portfolios

Variant	Geometric return	Standard deviation
75-25-0-75	4.2%	9.0%
71.25-23.75-5-75	4.3%	9.5%
71.25-23.75-5-75-var	4.3%	8.9%
67.5-22.5-10-75	4.3%	10.1%
67.5-22.5-10-75-var	4.4%	8.8%
63.75-21.25-15-75	4.4%	10.8%
63.75-21.25-15-75-var	4.5%	8.8%
60-20-20-75	4.5%	11.6%
60-20-20-75-var	4.6%	8.9%
56.25-18.75-25-75	4.6%	12.4%
56.25-18.75-25-75-var	4.7%	9.0%

Excess return

In the previous subsection, I have focused only on assets and completely ignored the liabilities. Now, I will add the liability return. The liability return is the interest increase of the liabilities and consists of two components:

1. The annual interest accrual of the liabilities (eg. the increase of the liabilities with the one-year swap rate)
2. Changes in the (market) value of the liabilities due to a change in the discount rates

In the analysis, the median expected annual liability return over the 15-year period is approximately 2.7% (with a standard deviation of 13.7%). I have added the term “approximately” in the previous sentence, because the sensitivity of the liabilities to the discount rates depends on the duration, and indexation changes can have an impact on the duration. Since returns differ for the different investment portfolios, this indexation also differs. However, this causes only small very small effects in the liability returns.

I have identified three result measures:

1. Excess return: this is the difference between the investment portfolio return and the liability return (for the interpretation of the colors in the result tables, the higher the excess return, the better)
2. Standard deviation: this is the volatility of the excess return. It is also called (in the investment world) the tracking error and is a measure of the liability hedging capacity of the investment portfolio
3. Adjusted Sharpe ratio: this is a measure of the excess return premium. It is the amount of additional excess return that is received for each unit of additional tracking error. In formula (8):

$$Adj.Sharpe_t = \frac{R(port)_t - R(liab)_t}{Tracking\ error_t} \qquad (8)$$

The results for the 15 years period are shown in table 13 (risky portfolios) and table 14 (less risky portfolios). The results for a 1 and a 5 year period are shown in appendix 4.

The tables show that adding reverse mortgages increases excess returns. This effect is stronger for the less risky portfolio. More remarkably, this effect is stronger for the fixed interest alternative. Even more, although both alternatives shown tracking error reductions, this effect is stronger for the fixed interest alternative. This is also reflected in the adjusted Sharpe ratio, whereas variable interest reverse

mortgages show incremental improvements in adjusted Sharpe ratios, the fixed interest alternative shows large increases.

So, whereas from an asset-only perspective, adding variable interest reverse mortgages resulted in more efficient portfolios, when the liabilities are added to the equation, the most efficient portfolios are the result of adding fixed interest rate reverse mortgages. It thus turns out that the higher return volatility of fixed interest reverse mortgages appears to be strongly correlated to the liability value. This was also shown in the correlation matrix of section 4.4. These results are a first support for my second sub hypothesis[14].

Table 13: 15 year excess return results for the risky portfolios

Variant	Excess return	Standard deviation (tracking error)	Adjusted Sharpe Ratio
50-50-0-50	1.9%	14.7%	12.8%
47.5-47.5-5-50	2.0%	13.8%	14.8%
47.5-47.5-5-50-var	2.0%	14.2%	13.9%
45-45-10-50	2.2%	12.8%	17.0%
45-45-10-50-var	2.0%	13.7%	14.7%
42.5-42.5-15-50	2.3%	11.9%	19.4%
42.5-42.5-15-50-var	2.1%	13.3%	15.7%
40-40-20-50	2.4%	11.0%	22.1%
40-40-20-50-var	2.1%	12.8%	16.6%
37.5-37.5-25-50	2.5%	10.1%	25.1%
37.5-37.5-25-50-var	2.2%	12.4%	17.5%

Table 14: 15 year excess return results for the less risky portfolios

Variant	Excess return	Standard deviation (tracking error)	Adjusted Sharpe Ratio
75-25-0-75	0.9%	9.0%	10.2%
71.25-23.75-5-75	1.1%	8.1%	13.5%
71.25-23.75-5-75-var	1.0%	8.7%	11.7%
67.5-22.5-10-75	1.3%	7.3%	17.5%
67.5-22.5-10-75-var	1.1%	8.5%	13.4%
63.75-21.25-15-75	1.4%	6.6%	22.1%
63.75-21.25-15-75-var	1.3%	8.3%	15.2%
60-20-20-75	1.6%	5.9%	27.3%
60-20-20-75-var	1.4%	8.1%	16.8%
56.25-18.75-25-75	1.8%	5.4%	32.7%
56.25-18.75-25-75-var	1.5%	8.0%	18.5%

[14] The second sub hypothesis was: “Reverse mortgages are both able generate excess returns and increase the liability matching of a pension funds’ investment portfolio.”

SUB HYPOTHESIS 1:
ADDING REVERSE MORTGAGES TO AN ASSET-ONLY PORTFOLIO INCREASES THE EFFICIENCY OF THIS PORTFOLIO

CONCLUSION:
NO SUPPORT FOR THE FIXED INTEREST ALTERNATIVE

SUPPORT FOR THE VARIABLE INTEREST RATE ALTERNATIVE

4.6.2. Solvency

The next result measure I will discuss is the solvency of the pension fund. The financial position of a pension fund in The Netherlands is measured by the funding ratio (in Dutch: "dekkingsgraad"). The funding ratio is calculated by dividing the market value of the assets by the market value of the liabilities. Dutch pension funds should have a minimum funding level of approximately 105%, otherwise they are in funding deficit. In this section, I discuss three measures:

1. The median funding level at the end of year 15 (the higher, the better)
2. The 2.5% percentile of the funding level at the end of year 15. I have included this measure to highlight downside funding level risks (the higher, the better)
3. The probability of being in a funding deficit at the end of year 15 (the lower, the better)

Notice that I again use the results after 15 years. This captures the long-term nature of pension funds. In appendix 5, I have shown the results for a 1 and a 5 year period. Figure 13 shows the median funding ratios of the different investment portfolios after 15 years. Figure 14 shows the 2.5% percentile of these funding ratios. Figure 15 shows the corresponding probabilities of deficit. Table 15 (risky portfolios) and 16 (less risky portfolios) show the outcomes that underlie these graphs.

For the risky portfolio, the median funding ratio does not change much whether reverse mortgages are added or not. However, reverse mortgages offer downside protection, as can be seen in the 2.5% percentile and the probabilities of deficits. Higher allocations of reverse mortgages result in higher funding levels in the 2.5% percentile and lower probabilities of deficits. This effect is slightly stronger for the fixed interest alternative.

For the less risky portfolio, the median funding ratio does increase with higher allocations to reverse mortgages. This effect is slightly stronger for the variable interest alternative. The effect is stronger in the bad economic scenarios; higher allocations to reverse mortgages result in higher funding ratios and lower probabilities of deficit. This effect is stronger for the fixed interest alternative.

So, based on these results, it can be concluded that reverse mortgages offer protection against downside risk, irrespective of the riskiness of the asset portfolio. The risk reducing potential is stronger for the fixed interest alternative, because it is correlated with the interest sensitivity of the liabilities. In less risky portfolios, reverse mortgages may offer some additional return potential as well. Again, this supports sub hypothesis 4.

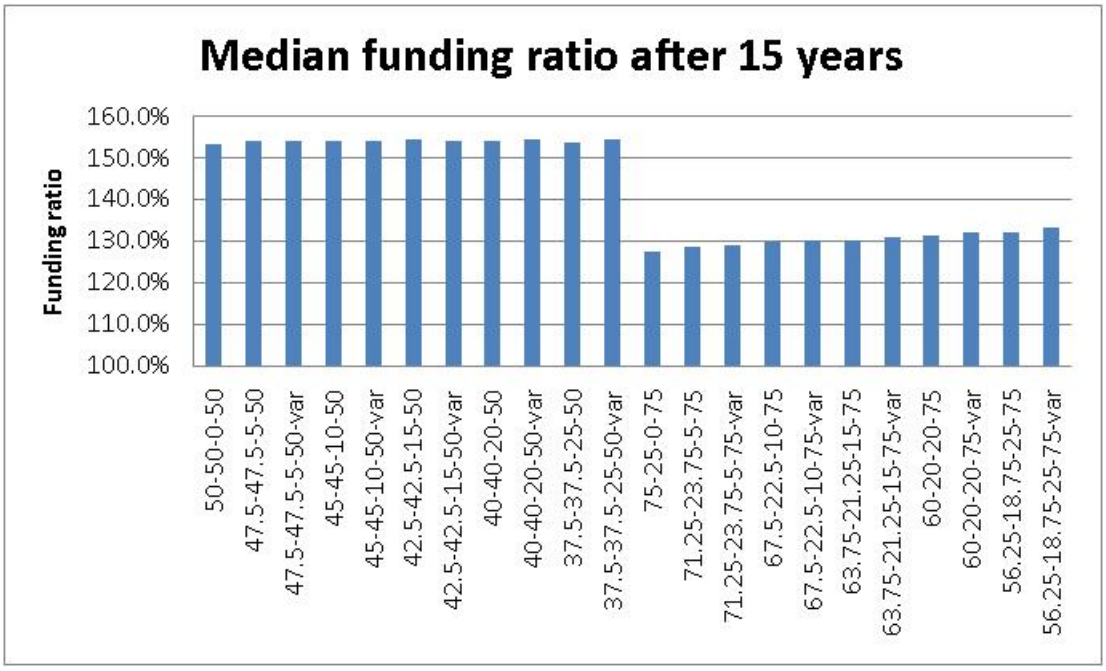


Figure 13: Median funding ratio after 15 years

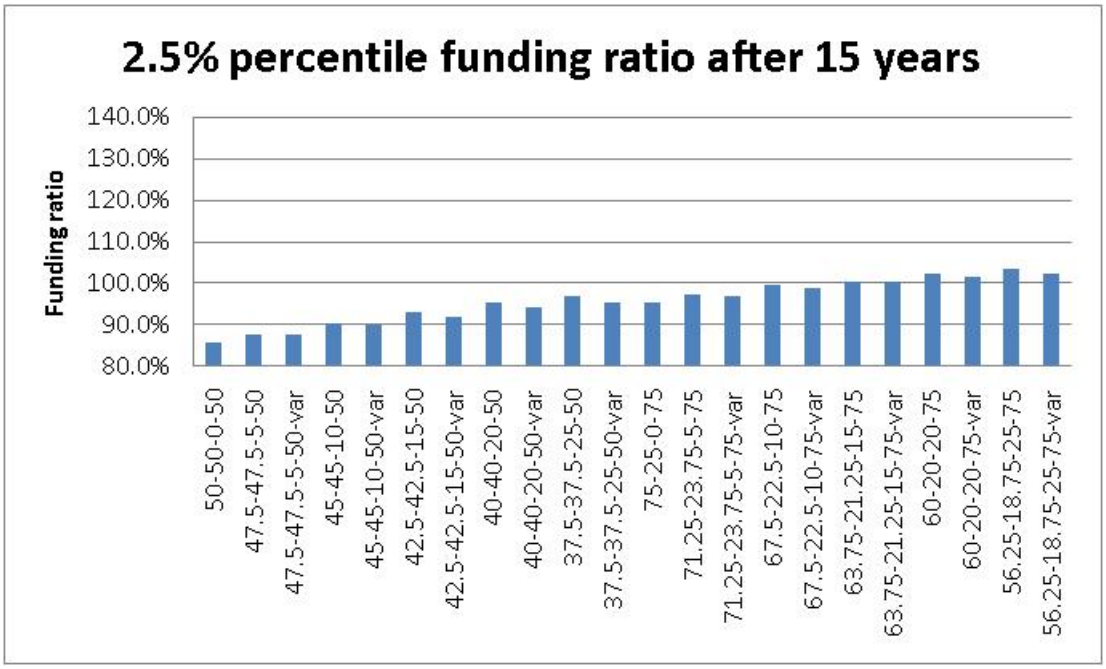


Figure 14: 2.5% percentile of the funding ratio after 15 years

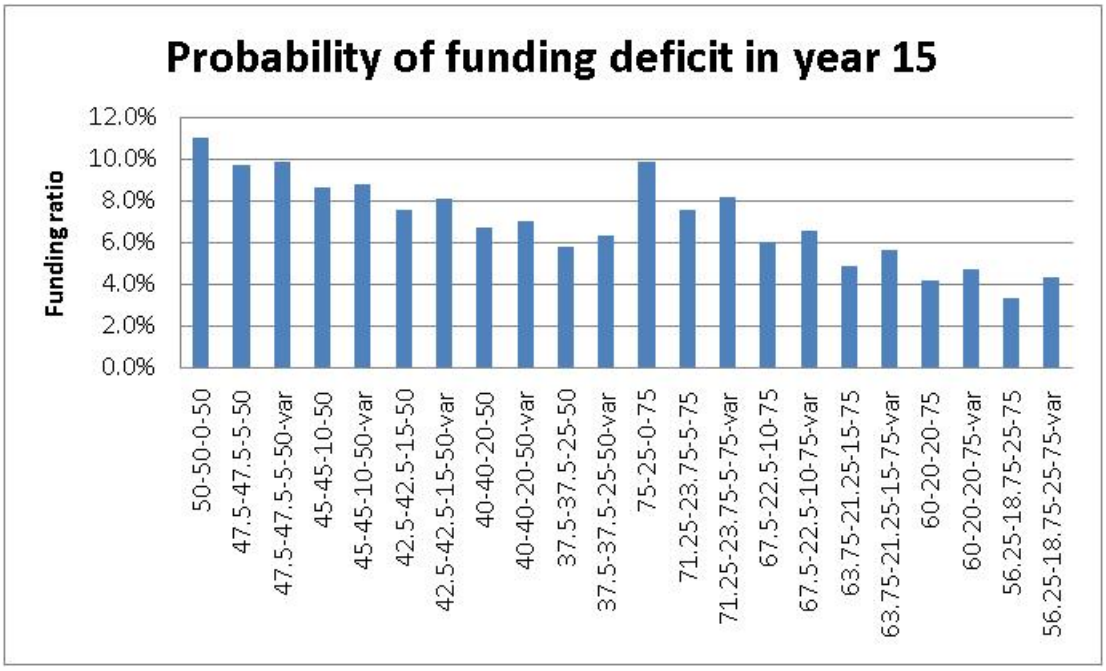


Figure 15: Probability of funding deficit in year 15

Table 15: 15 year solvency results for risky portfolios

Variant	Median funding ratio	2.5% funding ratio	Probability of funding deficit
50-50-0-50	153.4%	85.6%	11.1%
47.5-47.5-5-50	154.1%	87.6%	9.8%
47.5-47.5-5-50-var	154.2%	87.5%	9.9%
45-45-10-50	154.1%	90.3%	8.7%
45-45-10-50-var	154.1%	89.9%	8.8%
42.5-42.5-15-50	154.4%	92.9%	7.6%
42.5-42.5-15-50-var	154.1%	91.9%	8.1%
40-40-20-50	154.1%	95.4%	6.7%
40-40-20-50-var	154.3%	94.3%	7.0%
37.5-37.5-25-50	153.8%	96.8%	5.8%
37.5-37.5-25-50-var	154.4%	95.4%	6.3%

Table 16: 15 year solvency result for less risky portfolios

Variant	Median funding ratio	2.5% funding ratio	Probability of funding deficit
75-25-0-75	127.7%	95.3%	9.9%
71.25-23.75-5-75	128.8%	97.5%	7.6%
71.25-23.75-5-75-var	128.9%	97.0%	8.2%
67.5-22.5-10-75	129.7%	99.7%	6.1%
67.5-22.5-10-75-var	130.2%	98.8%	6.6%
63.75-21.25-15-75	130.3%	100.5%	4.9%
63.75-21.25-15-75-var	131.1%	100.5%	5.7%
60-20-20-75	131.3%	102.3%	4.2%
60-20-20-75-var	132.1%	101.4%	4.8%
56.25-18.75-25-75	132.3%	103.6%	3.3%
56.25-18.75-25-75-var	133.1%	102.5%	4.4%

SUB HYPOTHESIS 2:
REVERSE MORTGAGES ARE BOTH ABLE TO GENERATE EXCESS RETURNS AND INCREASE THE LIABILITY MATCHING OF A PENSION FUNDS' INVESTMENT PORTFOLIO

CONCLUSION:
STRONG SUPPORT FOR THE FIXED INTEREST ALTERNATIVE

SOME SUPPORT FOR THE VARIABLE INTEREST RATE ALTERNATIVE

4.6.3. Indexation

The main target of pension funds is to provide pensioners a reasonable level of purchasing power after retirement or decease of the insured partner. Inflation can significantly decrease purchasing power, especially in the long run. Therefore, pension funds aim to increase the pensions with inflation. This is called indexation. One of the most important measures of the success of a pension fund is the level at which the accrued pension benefits are kept in line with fully inflated benefits. A common indicator for this is the pension result. The pension result is calculated by dividing the level of the benefits that are increased with actual indexation by the level of the benefits if they had been increased with full inflation. It is a cumulative measure over time and as such, it measures the purchasing power of the pension benefits. For instance, a pension result of 100% means that the purchasing power is fully retained. A pension result of 80% means a loss in purchasing power of 20%. In formula:

$$Pension\ result_t = \frac{\prod_{t=1}^{t}(1+indexation_t)}{\prod_{t=1}^{t}(1+inflation_t)} \quad (9)$$

It is important to keep the participants in mind when discussing the pension result. For example, for a very old pensioner, a horizon of 15 years would not make any sense, since it is likely that he or she has passed away during this period. On the other hand, a horizon of 5 year wouldn't hardly mean anything for a very young participant, since the accrued benefits in the first years are very small and payment of the

benefits will be far away. Therefore, I have shown the results of three periods in table 17 (for risky portfolios) and 18 (for the less risky portfolios).

When analyzing median pension results, differences are very small. Especially for the risky portfolios, medians are almost equal, irrespective of the horizon of interest. This is in line with the analyses of the funding ratio. For the less risky portfolios, a small increase in median pension results is shown over longer horizons. This can be attributed to the additional excess return that is made on the reverse mortgages. It is interesting to see that the alternative with the variable interest rate appears to perform slightly better than its fixed interest counterpart. This can be attributed to the fact that the returns of variable interest reverse mortgages are more directly related to the prevailing interest level, and therefore to the inflation as well (e.g. high inflation leads to high interest rates, leading to high reverse mortgage returns).

In the 2.5% percentile, large losses of purchasing power are shown. However, the benefits of reverse mortgages are more clear now. For the risky and less risky portfolios, the 2.5% percentiles greatly increase with an increase in reverse mortgage allocations. For the risky portfolios, the fixed interest alternatives seem to perform better. This is probably caused by the higher correlation with the liability return. Since the risky portfolios only have an interest risk hedge of 50%, the reverse mortgages with fixed interest improve this hedge. This effect outperforms the benefit of higher correlation with inflation, as is the case with the variable interest alternative. On the other hand, for the less risky portfolios, the interest risk hedge already is high. Therefore, the correlation with inflation is more important, resulting in variable interest mortgages slightly outperforming the fixed interest counterpart.

Either way, also in terms of purchasing power, the reverse mortgage portfolios I modelled offer good downside protection without loss in the expected values. From this, it follows that there is support for sub hypothesis 4.

Table 17: Pension result for risky portfolios

	Median			2.5% percentile		
	5 year	10 year	15 year	5 year	10 year	15 year
50-50-0-50	97%	97%	97%	70%	59%	54%
47.5-47.5-5-50	97%	97%	97%	71%	61%	57%
47.5-47.5-5-50-var	97%	97%	97%	71%	61%	56%
45-45-10-50	97%	97%	98%	74%	64%	58%
45-45-10-50-var	97%	97%	98%	74%	63%	59%
42.5-42.5-15-50	97%	97%	98%	77%	66%	61%
42.5-42.5-15-50-var	97%	97%	98%	76%	66%	60%
40-40-20-50	97%	97%	98%	80%	69%	64%
40-40-20-50-var	97%	97%	98%	78%	68%	63%
37.5-37.5-25-50	97%	97%	98%	82%	72%	66%
37.5-37.5-25-50-var	97%	98%	98%	80%	70%	66%

Table 18: Pension result for less risky portfolios

	Median			2.5% percentile		
	5 year	10 year	15 year	5 year	10 year	15 year
75-25-0-75	95%	93%	92%	81%	71%	65%
71.25-23.75-5-75	95%	93%	92%	82%	73%	67%
71.25-23.75-5-75-var	95%	93%	93%	82%	72%	66%
67.5-22.5-10-75	95%	93%	93%	83%	74%	68%
67.5-22.5-10-75-var	95%	94%	93%	83%	74%	69%
63.75-21.25-15-75	95%	94%	93%	84%	75%	70%
63.75-21.25-15-75-var	95%	94%	94%	84%	75%	70%
60-20-20-75	95%	94%	94%	84%	76%	71%
60-20-20-75-var	95%	95%	95%	84%	76%	71%
56.25-18.75-25-75	95%	94%	94%	85%	77%	72%
56.25-18.75-25-75-var	96%	95%	95%	85%	77%	73%

SUB HYPOTHESIS 4:
REVERSE MORTGAGES ARE SUITABLE IN A PENSION FUND PORTFOLIO TO MAINTAIN PURCHASING POWER

CONCLUSION:
SUPPORT FOR BOTH THE FIXED INTEREST AND THE VARIABLE INTEREST ALTERNATIVE, ESPECIALLY IN BAD ECONOMIC CIRCUMSTANCES

4.6.4. Interest rate hedging

In this section, I focus a little more on the interest rate risk hedging potential. For this, I only look at the one year results. Of these results, I have made subsets of the scenarios with the 50 highest and 50 lowest liability returns. Since liability returns are caused by interest, a high liability return should correspond to low interest rates and vice versa. I have shown that this is indeed the case in table 19.

Table 19: Median outcomes of different scenario (sub)sets. Interest rates are end of year 1, liability returns is the return over year 1

Scenario set	Liabilitiy return	Interest rate (maturity = 1)	Interest rate (maturity = 5)	Interest rate (maturity = 10)	Interest rate (maturity = 20)
All scenarios	0.7%	0.4%	1.1%	2.0%	2.5%
Highest 50	-19.2%	0.5%	2.1%	3.8%	2.9%
Lowest 50	17.6%	0.4%	0.6%	0.9%	1.8%

So, if reverse mortgages (and especially the fixed interest alternatives) indeed have interest rate hedging potential, I would expect the differences between the subsets to be lower for higher allocations to these assets. More importantly, I would expect the downside to be higher for these portfolios.

Figure 16 (risky portfolios) and 17 (less risky portfolios) show that this is the case, especially for the fixed interest alternative. The lower part of the bar shows the median funding level after one year in case of low interest rates. The higher part of the bar shows the median funding level after one year in case of high interest rates. These pictures clearly show that the length of the bars is smaller for higher allocations to fixed interest rate reverse mortgages and that the downside is higher al well. This again supports sub hypothesis 3, fixed interest rate reverse mortgages can be suitable for interest rate risk hedging.

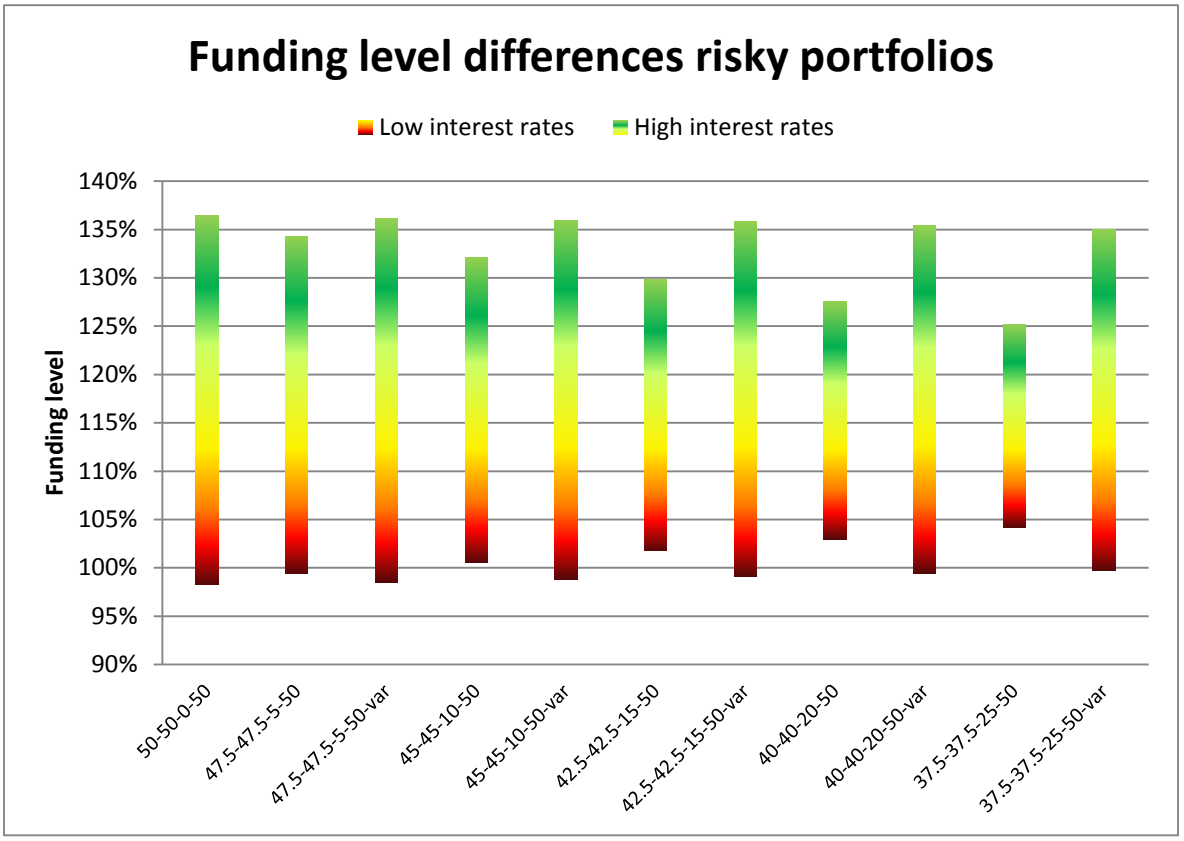


Figure 16: Differences between funding levels in case of high and low interest rates for risky portfolios

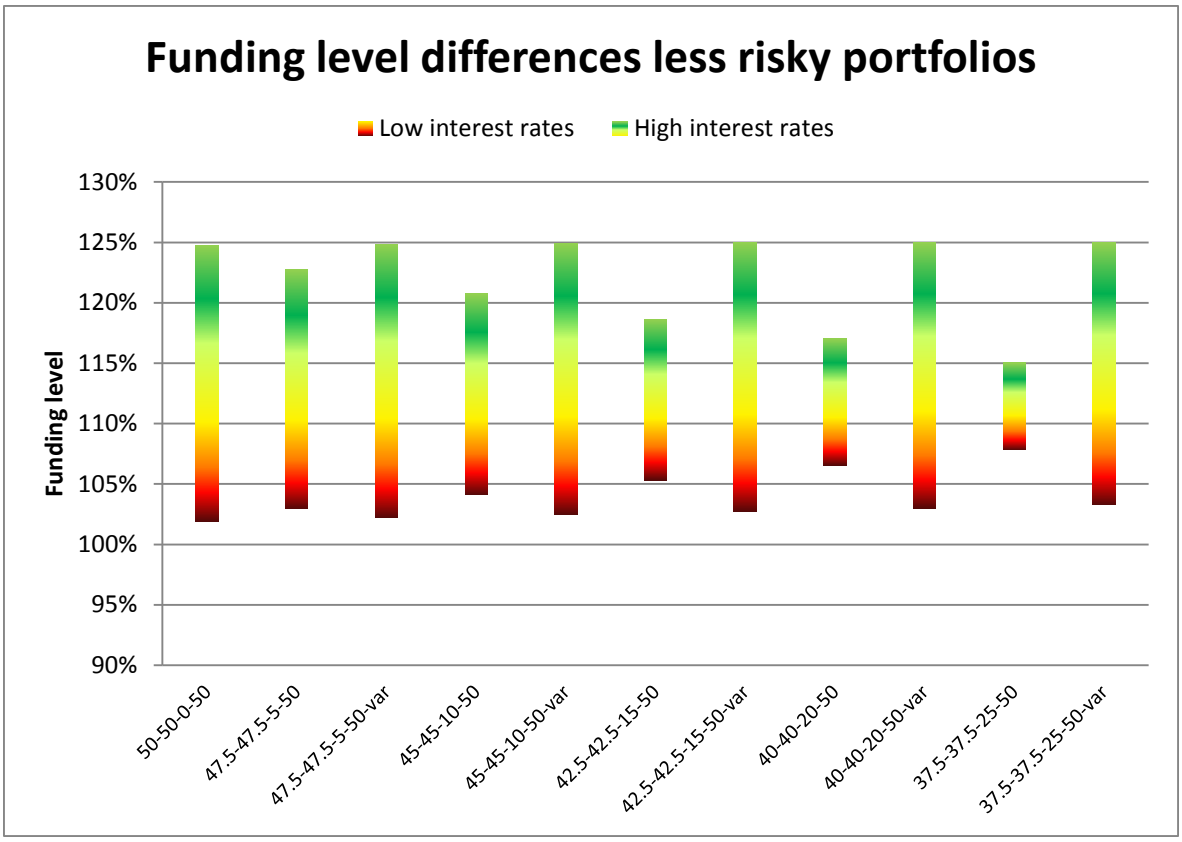


Figure 17: Differences between funding levels in case of high and low interest rates for less risky portfolios

SUB HYPOTHESIS 3:
ADDING REVERSE MORTGAGES TO THE INVESTMENT PORTFOLIO INCREASES THE INTEREST RATE RISK HEDGE

CONCLUSION:
STRONG SUPPORT FOR THE FIXED INTEREST REVERSE MORTGAGE

SOME SUPPORT FOR THE VARIABLE INTEREST REVERSE MORTGAGE

4.7. Sensitivity

The results above clearly support the case for reverse mortgages. However, it is interesting to control whether my modelling choices have an influence on the outcomes. Therefore, I have performed three sensitivity analyses on my modelling of the reverse mortgage returns. This concerns house price increases, the risk premium, and the loan-to-value ratios.

House price

An important factor that is present in the crossover risk is the development of the house prices. For example, a too slow appreciation or even a depreciation of house values could ultimately lead to an

incomplete repayment of the loan (only the house value is repaid). I have assumed an expected annual house price increase of approximately 4.2%.

In this section, I have run an analysis in which the expected and actual annual house price increase is 2.0% lower than in the original set-up. This should increase the crossover risk, leading to lower expected reverse mortgage returns. As can be seen in table 20, increasing the crossover risk by decreasing the house price increase indeed results in lower expected returns and higher standard deviation. Thus, house price appreciation is an important factor in the investment potential of reverse mortgages.

Table 20: Sensitivity of reverse mortgage returns to 2% lower house price increases

	Original modelling		Sensitivity analysis	
Category	**Geometric return**	**Standard deviation**	**Geometric return**	**Standard deviation**
Fixed interest reverse mortgage	6.2%	19.5%	5.8%	20.3%
Variable interest reverse mortgage	6.1%	10.9%	5.7%	13.5%

The results are shown in tables 21 (risky portfolios) and 22 (less risky portfolios). I have focused on 15 year pension results for active participants, since pension results are one of the most important metrics of pension funds, and conclusions are more or less similar for actives and inactives.

As can be seen, the conclusions of the sensitivity analysis are very much the same as for the original modelling. Although the decreased mortgage returns due to the lower house price increase are reflected in slightly lower pension results, portfolios with reverse mortgages still have equal or higher pension results in the median and higher pension results in the 2.5% percentile. It can be concluded that, even with a 2% lower (long-term) housing appreciation, reverse mortgages still can add value for pension funds.

Table 21:Sensitivity of 15 year pension results to 2% lower house price increases for risky portfolios

	Original modelling		Sensitivity analysis	
	Median	**2.5% percentile**	**Median**	**2.5% percentile**
50-50-0-50	97%	54%	97%	54%
47.5-47.5-5-50	97%	57%	97%	57%
47.5-47.5-5-50-var	97%	56%	97%	57%
45-45-10-50	98%	58%	97%	59%
45-45-10-50-var	98%	59%	97%	58%
42.5-42.5-15-50	98%	61%	98%	61%
42.5-42.5-15-50-var	98%	60%	98%	59%
40-40-20-50	98%	64%	98%	63%
40-40-20-50-var	98%	63%	98%	62%
37.5-37.5-25-50	98%	66%	98%	65%
37.5-37.5-25-50-var	98%	66%	98%	64%

Table 22: Sensitivity of 15 year pension results to 2% lower house price increases for less risky portfolios

	Original modelling		Sensitivity analysis	
	Median	2.5% percentile	Median	2.5% percentile
75-25-0-75	92%	65%	92%	65%
71.25-23.75-5-75	92%	67%	92%	67%
71.25-23.75-5-75-var	93%	66%	92%	67%
67.5-22.5-10-75	93%	68%	93%	68%
67.5-22.5-10-75-var	93%	69%	93%	68%
63.75-21.25-15-75	93%	70%	93%	69%
63.75-21.25-15-75-var	94%	70%	93%	70%
60-20-20-75	94%	71%	93%	70%
60-20-20-75-var	95%	71%	94%	70%
56.25-18.75-25-75	94%	72%	93%	69%
56.25-18.75-25-75-var	95%	73%	94%	71%

Risk Premium

Currently, the only provider of reverse mortgages in The Netherlands (Florius) charges an interest of 6.25%. In section 4.6. I have shown that this level of interest, in combination with the interest risk hedging potential of reverse mortgages, can lead to very positive outcomes. However, it is interesting to see whether a reverse mortgage still is attractive if the interest risk is decreased with 1%. If pension funds are able to charge these lower interest rates and still are profitable, they might increase competition in the market and likely offer a more attractive product to consumers.

Of course, decreasing the interest rate level will result in lower returns. However, the crossover risk is likely to be decreased as well, so it might be that the volatility of the returns decreases as well, without losing the interest rate hedging potential. As can be seen in table 23, the returns decrease by approximately 0.9%. This decrease is lower than the 1% drop in the interest rate, indeed suggesting that the crossover risk is slightly lower. This is also, mildly, supported by the lower standard deviation. These latter effects are rather small.

Table 23: Sensitivity of reverse mortgage returns to a 1% lower interest charge

	Original modelling		Sensitivity analysis	
Category	Geometric return	Standard deviation	Geometric return	Standard deviation
Fixed interest reverse mortgage	6.2%	19.5%	5.3%	19.2%
Variable interest reverse mortgage	6.1%	10.9%	5.2%	9.3%

I have shown the results of the sensitivity analysis in tables 24 (risky portfolios) and 25 (less risky portfolios).

The results in the median show that, for the risky and less risky portfolios, adding reverse mortgages hardly impacts the pension result compared to the alternatives with less or no reverse mortgages. More importantly, the downside protection in the portfolios is maintained. Although the improvements of adding reverse mortgages are slightly less than in the original setup, reverse mortgages still show very beneficial downside protection.

Table 24:Sensitivity of 15 year pension results to 1% lower interest charge for risky portfolios

	Original modelling		Sensitivity analysis	
	Median	2.5% percentile	Median	2.5% percentile
50-50-0-50	97%	54%	97%	54%
47.5-47.5-5-50	97%	57%	97%	56%
47.5-47.5-5-50-var	97%	56%	97%	56%
45-45-10-50	98%	58%	97%	59%
45-45-10-50-var	98%	59%	97%	58%
42.5-42.5-15-50	98%	61%	97%	60%
42.5-42.5-15-50-var	98%	60%	98%	60%
40-40-20-50	98%	64%	97%	62%
40-40-20-50-var	98%	63%	98%	62%
37.5-37.5-25-50	98%	66%	98%	64%
37.5-37.5-25-50-var	98%	66%	98%	64%

Table 25: Sensitivity of 15 year pension results to 1% lower interest charge for less risky portfolios

	Original modelling		Sensitivity analysis	
	Median	2.5% percentile	Median	2.5% percentile
75-25-0-75	92%	65%	92%	65%
71.25-23.75-5-75	92%	67%	92%	67%
71.25-23.75-5-75-var	93%	66%	92%	66%
67.5-22.5-10-75	93%	68%	92%	68%
67.5-22.5-10-75-var	93%	69%	93%	68%
63.75-21.25-15-75	93%	70%	92%	69%
63.75-21.25-15-75-var	94%	70%	93%	69%
60-20-20-75	94%	71%	93%	70%
60-20-20-75-var	95%	71%	94%	70%
56.25-18.75-25-75	94%	72%	93%	70%
56.25-18.75-25-75-var	95%	73%	94%	72%

To conclude, even decreasing the interest charge with 1% (and thus offering a 1% lower interest rate than currently is offered in the market) still makes reverse mortgages attractive for pension funds, since

expected (results) do not suffer and downside protection is still offered. This shows that there are opportunities to offer a competitive product.

Loan-to-Value

My final sensitivity analysis concerns the loan-to-value ratio. I my base-case modelling, I have used the loan-to-value ratios that Florius currently offers according to their website. These ratios do not exceed 25%. This causes the crossover risk to be relatively low and can be an important factor for the positive results. However, low LTVs can make the product less relevant for consumers, because what would be the use of entering into a reverse mortgage contract if the amount that can be borrowed is small anyways. Therefore, I have run an analysis with twice as high LTVs as in the original set-up. In the absence of crossover risk, this would not increase returns when measured as a percentage (it would of course in Euro amounts). However, in the presence of crossover risk, this risk is likely to become more apparent, ultimately leading to lower and more volatile results.

The resulting returns are shown in table 26. As can be seen, this indeed is the case. Due to the fact that more crossovers (the house value becomes less than the outstanding debt) occur, the expected returns decrease. At the same time, the volatility increases, because crossovers make the returns more volatile.

Table 26: Sensitivity of reverse mortgage returns to a twice as high LTV

	Original modelling		Sensitivity analysis	
Category	**Geometric return**	**Standard deviation**	**Geometric return**	**Standard deviation**
Fixed interest reverse mortgage	6.2%	19.5%	5.3%	21.9%
Variable interest reverse mortgage	6.1%	10.9%	5.4%	17.6%

When these results are measured in the pension fund context, the pension results are shown in tables 27 (risky portfolios) and 28 (less risky portfolios). In the sensitivity analysis, the median results are largely indifferent for the amount of reverse mortgages. This accounts for both the fixed interest as the variable interest alternative. However, in the 2.5% percentile, reverse mortgages still offer risk reduction benefits, albeit smaller than in the original modelling.

So, even when LTVs are doubled, reverse mortgages appear to make investment portfolios more efficient (at least in terms of pension results), since it does not harm expected outcomes but does increase outcomes in bad cases.

Table 27:Sensitivity of 15 year pension results to a twice as high LTV for risky portfolios

	Original modelling		Sensitivity analysis	
	Median	2.5% percentile	Median	2.5% percentile
50-50-0-50	97%	54%	97%	54%
47.5-47.5-5-50	97%	57%	97%	57%
47.5-47.5-5-50-var	97%	56%	97%	57%
45-45-10-50	98%	58%	97%	58%
45-45-10-50-var	98%	59%	97%	58%
42.5-42.5-15-50	98%	61%	97%	60%
42.5-42.5-15-50-var	98%	60%	97%	59%
40-40-20-50	98%	64%	97%	61%
40-40-20-50-var	98%	63%	97%	62%
37.5-37.5-25-50	98%	66%	97%	63%
37.5-37.5-25-50-var	98%	66%	97%	63%

Table 28: Sensitivity of 15 year pension results to a twice as high LTV for less risky portfolios

	Original modelling		Sensitivity analysis	
	Median	2.5% percentile	Median	2.5% percentile
75-25-0-75	92%	65%	92%	65%
71.25-23.75-5-75	92%	67%	92%	66%
71.25-23.75-5-75-var	93%	66%	92%	66%
67.5-22.5-10-75	93%	68%	92%	67%
67.5-22.5-10-75-var	93%	69%	92%	67%
63.75-21.25-15-75	93%	70%	92%	68%
63.75-21.25-15-75-var	94%	70%	93%	68%
60-20-20-75	94%	71%	92%	69%
60-20-20-75-var	95%	71%	93%	68%
56.25-18.75-25-75	94%	72%	92%	68%
56.25-18.75-25-75-var	95%	73%	93%	68%

4.8. Conclusions

In this chapter, I have quantified the theory set out in chapter three with the use of a stochastic scenario analysis. I started this chapter with a description of the model pension fund that I use for this exercise. This fund represents an average of all Dutch pension funds. I have chosen to model a risky and a less risky investment portfolio, to control the robustness of my results.

I also have spent some pages on describing how I modelled the returns on reverse mortgages. I have modelled reverse mortgage returns in case the interest on the outstanding debt was fixed and in case this

interest was variable. The resulting returns are stochastic and consistent with the economic scenario set used. The resulting expected returns are almost equity like, with a high median and a large standard deviation. The high return is mainly caused by the high interest charged on the loan. The standard deviation is caused by the crossover risk and (for the fixed interest rate alternative) the discount rate volatility. Contrary to equities, the correlation with the liability returns was quite high, suggesting good hedging potential.

The results show support for reverse mortgages in a pension funds' portfolio. From an assets only perspective, adding reverse mortgages makes investment portfolios more efficient in case the interest is variable. For the fixed interest alternative, this is not the case. Nevertheless, this is some support for sub hypothesis 1 that adding reverse mortgages to an asset-only portfolio increases the efficiency of this portfolio.

Next, I added liabilities to the equation. The result showed that the efficiency of the portfolio (in terms of excess returns) increased with adding reverse mortgages to the portfolio. Moreover, when I looked at funding ratios, I found support for the liability matching potential of reverse mortgages. Both findings provided support for sub hypothesis 2. In this case, the positive effects of reverse mortgages were stronger for the fixed interest rate alternative.

Maintaining purchasing power is an important objective of pension funds. The results of my analysis show that adding reverse mortgages to the investment portfolio do not really change the expected outcomes (in the median), but clearly provide downside protection in bad economic circumstances. This accounts for both cases of the reverse mortgages. These results support sub hypothesis 4.

Finally, I investigated the interest rate hedging potential of reverse mortgages. For the fixed interest rate alternative, I have found strong support that reverse mortgages offer interest rate hedging capabilities. For the variable interest rate alternative, this support was less strong, but there was still some support for sub hypothesis 3.

To check whether these (positive) results were not caused by my assumptions, I have performed sensitivity analyses on the house price increase, the risk premium, and the loan-to-value. Although I found that there was a slight impact on the magnitude, the effects did not change.

To conclude this chapter, I have found support for all of my sub hypotheses. This leads me to the conclusion that there is support for the main hypothesis as well. Based on the results in this chapter, I would conclude that reverse mortgages can offer substantial diversification and hedging potential for Dutch pension funds and can therefore offer a valuable investment opportunity.

Chapter 5: Summary and Conclusions

In this thesis, I have examined whether reverse mortgages can play a role in enhancing liquidity at and after retirement. The main problems I have identified (that are relevant for this thesis) are that future retirees face decreased liquidity because of reduced pensions, while at the same time their wealth that is stored in their house is increased but cannot be liquidated easily. Pension funds seek new investment opportunities that offer reasonable returns and good hedging capabilities. Preferably, these investment opportunities should be based in The Netherlands. Such investment opportunities are very hard to find. I suggested that reverse mortgages have the potential to be such an investment opportunity for pension funds. Reverse mortgages could also offer means to consumers to liquidate the wealth stored in stones.

A reverse mortgage consists of a number of steps in time. At retirement, the contract is initiated and the loan amount is transferred to the consumer. The consumer can use the loan to supplement the pension income by buying an annuity (either by the provider of the reverse mortgage of by another provider) or in any other way, for example by receiving a lump sum. During the loan period, no interest payments have to be made. At death or when the house is sold (mostly because the consumer needs to move to a care facility such as a nursing home), the loan is repaid from the proceeds of the sale. If the proceeds of the sale exceed the outstanding debt, the excess goes to the consumer or his relatives. If the proceeds of the sale are lower than the outstanding debt, the remaining debt should be paid by the consumer or his relatives, or is at the risk of the provider (this is called a no negative equity guarantee). In this thesis, I assume all reverse mortgages contain such a guarantee.

The international reverse mortgage market is not very well developed. The US and UK have some market, in other countries the market is very small or even non-existent. Lessons from these markets are that reverse mortgages should be regulated, contain a no negative equity guarantee, and that local culture and attitudes toward borrowing are very important. The Dutch market currently is almost non-existent, with only one provider. However, there are some circumstances that could lead to more demand for reverse mortgages in the future. First, it is expected that pension benefits will decrease in the future, which leads to decreased liquidity of retirees. Second, there are more fiscal incentives to pay off the ordinary mortgage, which results in higher amounts of housing equity. Third, the bequest motive is weak in The Netherlands. Fourth, there is a well regulated and developed financial market. Some factors could hinder demand. An important one is that house values and equity are concentrated amongst higher incomes that might be less in need of extra liquidity anyways. Furthermore, in The Netherlands a prudent attitude towards borrowing exists. Nevertheless, the outlook for reverse mortgage demands seems positive.

An important question is what the advantages and disadvantages of reverse mortgages for consumers are. The main advantage is that reverse mortgages offer supplemental liquidity and enable consumption smoothing. Reverse mortgages also increase access to credit at old age and shift house price and longevity risk from individuals to financial institutions that generally are better suited to face and diversify these risks. However, reverse mortgages have some disadvantages as well. They are complex, come with additional and hidden costs (such as a maintenance obligation), deplete all or most current and future housing wealth, and come with ownership restrictions. Furthermore, the borrowing amount is uncertain beforehand. This make reverse mortgages hard to implement in one's financial planning. In spite of these disadvantages, reverse mortgages have the potential to be very valuable for consumers that are in search for extra liquidity.

But before consumers can benefits from reverse mortgages, providers are needed. In general, providers could benefit from reverse mortgages because they are expected to deliver high profits. Furthermore,

reverse mortgages can help providers to enter niche markets, increase market share in the pensions and mortgage market, cross sell to elderly, build a social reputation, and complement the existing product palette. The main disadvantage is the crossover risk. This risk occurs if the sale value of the house is lower than the value that should be repaid. The shortfall is at the expense of the provider (if a no negative equity guarantee is part of the contract). This crossover risk is a function of the house price appreciation, interest rates (if these are not fixed), the loan-to-value ratio, and the duration of the mortgage (because timing of repayment is uncertain). Other risks are the risk of adverse selection and moral hazard, the illiquidity and uncertainty about the time of repayment, and the little experience providers have with such products.

Pension funds are a potential provider of reverse mortgages. Pension funds more and more have contradicting tasks. One the one hand, they try to guarantee the nominal benefit as much as possible. On the other hand, they aim to make investment returns to finance indexation. Some of the disadvantages of reverse mortgages are less relevant for pension funds. Because pension funds are long term investors by nature, the illiquidity and uncertainty of timing of the repayment might not be much of a problem to them. Furthermore, selection and moral hazard can also be a problem for pension funds, but funds typically know their population quite well compared to other financial institutions. Moreover, the expected high return and interest rate sensitivity of reverse mortgages might make these products particularly interesting for pension funds.

Based on this theoretical discussion, I have posted my hypothesis and sub hypotheses. The main hypothesis is:

Reserve mortgages can offer substantial diversification and hedging potential for Dutch pension funds and can therefore offer a valuable investment opportunity

I divided this hypothesis in sub hypotheses:

1. **Adding reverse mortgages to an asset-only portfolio increases the efficiency of this portfolio**
2. **Reverse mortgages are both able to generate excess returns and increase the liability matching of a pension funds' investment portfolio**
3. **Adding reverse mortgages to the investment portfolio increases the interest rate risk hedge**
4. **Reverse mortgages are suitable in a pension fund portfolio to maintain purchasing power**

After the theoretical discussion, I have quantified the theory with the use of a stochastic scenario analysis. For this, an average pension fund was modelled. This average fund represents an average of all Dutch pension funds. This fund contained a risky and a less risky investment portfolio, to control the robustness of the results for risk appetite.

It was also necessary to model the returns on reverse mortgages. Two cases were modelled, reverse mortgage returns where the interest on the outstanding debt was fixed and where this interest was variable. The resulting returns are stochastic and consistent with the economic scenario set used. The resulting expected returns are almost equity like, with a high median and a large standard deviation. The high return is mainly caused by the high interest charged on the loan. The standard deviation is caused by the crossover risk and (for the fixed interest rate alternative) the discount rate volatility. Contrary to equities, the correlation with the liability returns was quite high, suggesting good hedging potential.

The results show support for reverse mortgages in a pension funds' portfolio. From an assets only perspective, adding reverse mortgages makes investment portfolios more efficient in case the interest is

variable. For the fixed interest alternative, this is not the case. Nevertheless, this provides some support for sub hypothesis 1 that adding (variable interest) reverse mortgages to an asset-only portfolio increases the efficiency of this portfolio.

Next, liabilities were added to the equation. The results show that the efficiency of the portfolio (in terms of excess returns) increased with adding reverse mortgages to the portfolio. Moreover, in terms of funding ratios, support for the liability matching potential of reverse mortgages was found. Both findings provided support for sub hypothesis 2. The positive effects of reverse mortgages were stronger for the fixed interest rate alternative.

Maintaining purchasing power is an important objective of pension funds. The results of the analysis show that adding reverse mortgages to the investment portfolio do not really change the expected outcomes (in the median), but clearly provide downside protection in bad economic circumstances. This accounts for both alternatives of the reverse mortgages. These results support sub hypothesis 4.

Finally, the interest rate hedging potential of reverse mortgages was investigated. For the fixed interest rate alternative, strong support that reverse mortgages offer interest rate hedging was found. For the variable interest rate alternative, this support was less strong, but there was still some support for sub hypothesis 3.

To check whether these (positive) results were not caused by the modelling assumptions, a sensitivity analyses on the house price increase, the risk premium, and the loan-to-value was performed. This analysis showed a slight impact on the magnitude, but the effects did not change.

To conclude, support was found for all of the sub hypotheses. This leads to the conclusion that there is support for the main hypothesis as well. Based on the results in this thesis, reverse mortgages can offer substantial diversification and hedging potential for Dutch pension funds and can therefore offer a valuable investment opportunity.

Chapter 6: Ready for take-off? Practical implications and subjects for further research

Should pension funds, after reading this thesis, directly start offering reverse mortgages? I would say no. As the subtitle says, this thesis is exploratory by nature and does not present reverse mortgages as a product in its final version. What this thesis does however, is that it provides interesting insights in the potential this product has for both consumers and pension funds. This thesis could be a starting point for further research and feasibility studies and I would greatly encourage pension funds, other practitioners, and academics to do so. In this chapter, I will present some ideas for further research.

6.1. Demand Side

In order to understand the demand better, market research should be performed. Reverse mortgages never gained a reasonable market share, in spite of their potential. It would be interesting to know why this is the case. This can be done by case studies on the current product offering of Florius, but also on product offers that are not available anymore. The focus in the market research can be either on how interest levels and other product characteristics (such as no negative equity guarantee) impact demand, but can also be on consumer characteristics. For example, what are common characteristics that explain high or low demand? Would that be income, gender, marital status, age, or maybe culture or attitudes? If more is known about these subjects, providers would be more able to design products that fit demand and align marketing with this. Only if this research shows that it is possible to increase sufficient demand for the product, development of it would be feasible.

6.2. Pension Fund Side

On the other hand, the financial aspects of reverse mortgages can be examined in much further details. I have proposed a valuation model that is based on my best knowledge, but this model can be improved. For example, the time value of the no negative equity guarantee is not captured in my model. It would be interesting to research whether option-like valuation techniques can value this guarantee. Furthermore, I have made some assumptions on costs that are rather blunt. The actual costs of providing reverse mortgages can be subject to further research. Also, more advanced models for actual and expected house price appreciation can be added to my valuation model. Another interesting research direction is in hedging the crossover risk. Can the crossover risk be hedged away, for example by short selling real estate?

Of course, other practical issues have to be worked out if pension funds want to invest in reverse mortgages. Such issues are, amongst other, the level of involvement (from just providing the money to completely administrate the product in house), possible permits required (for example by AFM), the incorporation of reverse mortgages in the risk buffer, the target consumer group (only pension fund participants or all possible consumers), other possible restrictions and how to value the product and deal with the risk.

6.3. Final Remarks

In this chapter, I mentioned some possibilities for further research. Of course, numerous other research possibilities exist. The main point I want to make is that product development of reverse mortgages still is on the drawing table and not at an end point. Further research is necessary, but to my opinion it would be a missed opportunity if this research does not occur, since reverse mortgages have potential to increase liquidity of elderly in an efficient way, and improve the investment portfolio of pension funds.

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Appendix 1: Demographic assumptions

Age	Probability of dismissal	Probability of entry	Career increases	Salary of new entrant
21	26.2%	0.0%	4.9%	€ 24,206
22	26.2%	5.0%	4.9%	€ 25,386
23	26.2%	5.0%	4.9%	€ 26,625
24	26.2%	5.0%	4.9%	€ 27,924
25	26.2%	5.0%	4.9%	€ 29,286
26	24.9%	4.0%	4.7%	€ 30,714
27	23.7%	4.0%	4.4%	€ 32,143
28	22.4%	4.0%	4.3%	€ 33,571
29	21.2%	4.0%	4.1%	€ 35,000
30	19.9%	4.0%	3.9%	€ 36,429
31	18.7%	4.0%	3.8%	€ 37,857
32	17.4%	4.0%	3.6%	€ 39,286
33	16.2%	4.0%	3.5%	€ 40,714
34	15.0%	4.0%	1.7%	€ 42,143
35	12.5%	4.0%	1.7%	€ 42,857
36	12.5%	4.0%	1.6%	€ 43,571
37	11.8%	4.0%	1.6%	€ 44,286
38	11.2%	4.0%	1.6%	€ 45,000
39	10.6%	4.0%	1.6%	€ 45,714
40	10.0%	4.0%	1.5%	€ 46,429
41	9.3%	4.0%	1.5%	€ 47,143
42	8.7%	4.0%	1.5%	€ 47,857
43	8.1%	4.0%	1.5%	€ 48,571
44	7.5%	4.0%	1.4%	€ 49,286
45	6.9%	4.0%	1.4%	€ 50,000
46	6.2%	0.0%	1.4%	€ 50,714
47	6.2%	0.0%	1.4%	€ 51,429
48	5.6%	0.0%	1.4%	€ 52,143
49	5.6%	0.0%	1.4%	€ 52,857
50	5.0%	0.0%	0.0%	€ 53,571
51	4.4%	0.0%	0.0%	€ 53,571
52	3.7%	0.0%	0.0%	€ 53,571
53	3.1%	0.0%	0.0%	€ 53,571
54	2.5%	0.0%	0.0%	€ 53,571
55	1.9%	0.0%	0.0%	€ 53,571
56	1.9%	0.0%	0.0%	€ 53,571
57	1.3%	0.0%	0.0%	€ 53,571
58	1.3%	0.0%	0.0%	€ 53,571
59	0.6%	0.0%	0.0%	€ 53,571
60	0.6%	0.0%	0.0%	€ 53,571
61	0.0%	0.0%	0.0%	€ 53,571
62	0.0%	0.0%	0.0%	€ 53,571
63	0.0%	0.0%	0.0%	€ 53,571
64	0.0%	0.0%	0.0%	€ 53,571
65	0.0%	0.0%	0.0%	€ 53,571
66	0.0%	0.0%	0.0%	€ 53,571
67	0.0%	0.0%	0.0%	€ 53,571

Appendix 2: Values for C and β in formula (7)

Horizon	C	Beta
1	0.039	0.344
2	0.043	0.23
3	0.055	0.37
4	0.078	0.377
5	0.095	0.367
6	0.1044	0.4026
7	0.1138	0.4382
8	0.1232	0.4738
9	0.1326	0.5094
10	0.142	0.545
11	0.161	0.5287
12	0.18	0.5124
13	0.199	0.4961
14	0.218	0.4798
15	0.237	0.4635
16	0.256	0.4472
17	0.275	0.4309
18	0.294	0.4146
19	0.313	0.3983
20	0.332	0.382
21	0.3574	0.3768
22	0.3828	0.3716
23	0.4082	0.3664
24	0.4336	0.3612
25	0.459	0.356
26	0.4844	0.3508
27	0.5098	0.3456
28	0.5352	0.3404
29	0.5606	0.3352
30	0.586	0.33

Appendix 3: Risk-return results

Table 29: 1 year risk-return results for the risky portfolios

Variant	Geometric return	Standard deviation
50-50-0-50	4.3%	10.7%
47.5-47.5-5-50	4.2%	10.4%
47.5-47.5-5-50-var	4.4%	10.2%
45-45-10-50	4.2%	10.1%
45-45-10-50-var	4.4%	9.7%
42.5-42.5-15-50	4.1%	9.8%
42.5-42.5-15-50-var	4.5%	9.2%
40-40-20-50	4.1%	9.6%
40-40-20-50-var	4.6%	8.8%
37.5-37.5-25-50	4.1%	9.5%
37.5-37.5-25-50-var	4.7%	8.3%

Table 30: 5 year risk-return results for the risky portfolios

Variant	Geometric return	Standard deviation
50-50-0-50	4.5%	10.9%
47.5-47.5-5-50	4.5%	10.6%
47.5-47.5-5-50-var	4.6%	10.4%
45-45-10-50	4.5%	10.4%
45-45-10-50-var	4.7%	9.9%
42.5-42.5-15-50	4.5%	10.2%
42.5-42.5-15-50-var	4.7%	9.5%
40-40-20-50	4.5%	10.1%
40-40-20-50-var	4.8%	9.0%
37.5-37.5-25-50	4.5%	10.1%
37.5-37.5-25-50-var	4.9%	8.6%

Table 31: 1 year risk-return results for the less risky portfolios

Variant	Geometric return	Standard deviation
75-25-0-75	2.3%	7.0%
71.25-23.75-5-75	2.3%	7.2%
71.25-23.75-5-75-var	2.4%	6.9%
67.5-22.5-10-75	2.4%	7.5%
67.5-22.5-10-75-var	2.6%	6.7%
63.75-21.25-15-75	2.5%	7.8%
63.75-21.25-15-75-var	2.8%	6.5%
60-20-20-75	2.6%	8.1%
60-20-20-75-var	3.0%	6.4%
56.25-18.75-25-75	2.6%	8.5%
56.25-18.75-25-75-var	3.2%	6.3%

Table 32: 5 year risk-return results for the less risky portfolios

Variant	Geometric return	Standard deviation
75-25-0-75	2.9%	7.6%
71.25-23.75-5-75	3.0%	7.9%
71.25-23.75-5-75-var	3.1%	7.5%
67.5-22.5-10-75	3.2%	8.3%
67.5-22.5-10-75-var	3.2%	7.3%
63.75-21.25-15-75	3.3%	8.8%
63.75-21.25-15-75-var	3.4%	7.2%
60-20-20-75	3.4%	9.3%
60-20-20-75-var	3.6%	7.1%
56.25-18.75-25-75	3.4%	9.8%
56.25-18.75-25-75-var	3.8%	7.1%

Appendix 4: Excess return results

Table 33: 1 year excess return results for the risky portfolios

Variant	Excess return	Standard deviation (tracking error)	Adjusted Sharpe Ratio
50-50-0-50	4.0%	12.1%	33.2%
47.5-47.5-5-50	4.0%	11.3%	35.0%
47.5-47.5-5-50-var	4.1%	11.6%	35.1%
45-45-10-50	4.0%	10.6%	37.5%
45-45-10-50-var	4.1%	11.1%	36.9%
42.5-42.5-15-50	3.9%	9.9%	39.9%
42.5-42.5-15-50-var	4.2%	10.6%	39.1%
40-40-20-50	3.9%	9.2%	42.0%
40-40-20-50-var	4.3%	10.2%	41.8%
37.5-37.5-25-50	3.9%	8.5%	45.5%
37.5-37.5-25-50-var	4.3%	9.7%	44.6%

Table 34: 5 year excess return results for the risky portfolios

Variant	Excess return	Standard deviation (tracking error)	Adjusted Sharpe Ratio
50-50-0-50	3.2%	13.0%	24.9%
47.5-47.5-5-50	3.3%	12.2%	27.1%
47.5-47.5-5-50-var	3.4%	12.5%	26.9%
45-45-10-50	3.4%	11.4%	29.6%
45-45-10-50-var	3.4%	12.1%	28.4%
42.5-42.5-15-50	3.4%	10.6%	32.6%
42.5-42.5-15-50-var	3.5%	11.6%	30.4%
40-40-20-50	3.5%	9.8%	35.6%
40-40-20-50-var	3.6%	11.1%	32.1%
37.5-37.5-25-50	3.5%	9.0%	39.2%
37.5-37.5-25-50-var	3.6%	10.7%	33.4%

Table 35: 1 year excess return results for the less risky portfolios

Variant	Excess return	Standard deviation (tracking error)	Adjusted Sharpe Ratio
75-25-0-75	1.9%	6.5%	29.3%
71.25-23.75-5-75	2.0%	6.0%	33.2%
71.25-23.75-5-75-var	2.1%	6.3%	32.8%
67.5-22.5-10-75	2.1%	5.5%	37.8%
67.5-22.5-10-75-var	2.3%	6.0%	38.1%
63.75-21.25-15-75	2.2%	5.1%	42.9%
63.75-21.25-15-75-var	2.5%	5.8%	42.6%
60-20-20-75	2.3%	4.6%	48.8%
60-20-20-75-var	2.6%	5.6%	47.4%
56.25-18.75-25-75	2.4%	4.3%	55.6%
56.25-18.75-25-75-var	2.9%	5.4%	53.6%

Table 36: 5 year excess return results for the less risky portfolios

Variant	Excess return	Standard deviation (tracking error)	Adjusted Sharpe Ratio
75-25-0-75	1.7%	7.3%	23.3%
71.25-23.75-5-75	1.9%	6.6%	28.1%
71.25-23.75-5-75-var	1.9%	7.0%	26.8%
67.5-22.5-10-75	2.0%	6.0%	33.0%
67.5-22.5-10-75-var	2.0%	6.8%	30.0%
63.75-21.25-15-75	2.1%	5.5%	38.3%
63.75-21.25-15-75-var	2.2%	6.6%	32.9%
60-20-20-75	2.2%	5.0%	44.4%
60-20-20-75-var	2.3%	6.4%	35.9%
56.25-18.75-25-75	2.3%	4.5%	51.1%
56.25-18.75-25-75-var	2.5%	6.2%	39.6%

Appendix 5: Solvency results

Table 37: 1 year solvency results risky portfolios

Variant	Median funding ratio	2.5% funding ratio	Probability of funding deficit
50-50-0-50	112.5%	87.6%	30.0%
47.5-47.5-5-50	112.5%	88.8%	28.9%
47.5-47.5-5-50-var	112.5%	88.8%	29.1%
45-45-10-50	112.5%	89.9%	27.5%
45-45-10-50-var	112.6%	89.7%	27.8%
42.5-42.5-15-50	112.4%	91.3%	26.3%
42.5-42.5-15-50-var	112.7%	90.9%	26.6%
40-40-20-50	112.3%	92.7%	24.5%
40-40-20-50-var	112.8%	92.2%	24.9%
37.5-37.5-25-50	112.3%	93.8%	22.9%
37.5-37.5-25-50-var	112.8%	93.2%	23.6%

Table 38: 5 year solvency results risky portfolios

Variant	Median funding ratio	2.5% funding ratio	Probability of funding deficit
50-50-0-50	127.4%	75.9%	22.9%
47.5-47.5-5-50	127.8%	78.5%	21.4%
47.5-47.5-5-50-var	127.7%	77.8%	21.7%
45-45-10-50	127.6%	81.1%	19.5%
45-45-10-50-var	128.0%	80.2%	20.0%
42.5-42.5-15-50	127.7%	83.4%	17.7%
42.5-42.5-15-50-var	128.5%	82.1%	18.3%
40-40-20-50	127.5%	86.0%	15.8%
40-40-20-50-var	128.7%	84.7%	17.0%
37.5-37.5-25-50	127.3%	88.5%	13.6%
37.5-37.5-25-50-var	129.1%	86.9%	15.2%

Table 39: 1 year solvency results less risky portfolios

Variant	Median funding ratio	2.5% funding ratio	Probability of funding deficit
75-25-0-75	110.2%	97.2%	22.9%
71.25-23.75-5-75	110.4%	98.3%	21.3%
71.25-23.75-5-75-var	110.5%	98.0%	21.4%
67.5-22.5-10-75	110.4%	98.9%	18.8%
67.5-22.5-10-75-var	110.6%	98.7%	20.2%
63.75-21.25-15-75	110.5%	99.6%	16.4%
63.75-21.25-15-75-var	110.8%	99.4%	18.1%
60-20-20-75	110.6%	100.6%	13.8%
60-20-20-75-var	111.1%	100.0%	16.0%
56.25-18.75-25-75	110.7%	101.3%	11.3%
56.25-18.75-25-75-var	111.2%	100.7%	14.3%

Table 40: 5 year solvency results for less risky portfolios

Variant	Median funding ratio	2.5% funding ratio	Probability of funding deficit
75-25-0-75	118.7%	90.8%	19.3%
71.25-23.75-5-75	119.0%	93.1%	15.7%
71.25-23.75-5-75-var	119.3%	92.5%	16.3%
67.5-22.5-10-75	119.6%	95.4%	13.1%
67.5-22.5-10-75-var	120.1%	94.4%	14.1%
63.75-21.25-15-75	119.8%	97.3%	9.8%
63.75-21.25-15-75-var	120.8%	95.8%	11.4%
60-20-20-75	120.2%	99.1%	7.8%
60-20-20-75-var	121.4%	97.6%	9.6%
56.25-18.75-25-75	120.4%	100.9%	6.5%
56.25-18.75-25-75-var	122.0%	99.3%	7.9%