LAPPEENRANTA-LAHTI UNIVERSITY OF TECHNOLOGY LUT

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APPLYING REVERSE MORTGAGE TO FOREST EQUITY

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ABSTRACT

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Applying reverse mortgage to forest equity

Master's thesis
2021
141 pages, 13 figures, 6 tables
Examiners: Professor Mikael Collan and Post-Doctorial Researcher Jyrki Savolainen

Key words: Forest equity, reverse finance, reverse forest finance, forest financing, forest collateral value, forest equity collateral

This thesis is an exploratory work on developing reverse finance instrument into forest equity. The objective of this thesis is to create a reverse forest finance instrument for consumers by applying reverse mortgage finance instrument into forest equity. The applied instrument fulfils restriction of financier's risk adverse preferences and satisfaction of borrower's needs.

This exploratory process was conducted through a meticulous literature review of reverse mortgage product and cross-breeding the findings with the particular properties of forest finance equity business. In addition to the literature review two separate specialist interviews were conducted

Appliance of reverse mortgage into forest equity was conducted in four steps. First step; a careful excluding process in which 10 applicable products were identified out of 960 possible products. Second step; determination of the loan-to-value ratio and covenants adjusting riskiness of the instrument. Third step; examination though restricted model which of the ten plausible products fulfil the requirements set to reverse forest finance instrument. Fourth step; verifying the sufficiency of the four surviving instruments, executed as Monte Carlo simulation, in examining business viability set to the products.

Based on the examination reverse mortgage framework is suitable to the reverse forest finance instrument in the Finnish markets. This thesis created three superior product combinations of variable interest non-capitalization bullet loan, fixed interest capitalization bullet loan and variable interest loan with flexible term withdrawals. Other key findings of this thesis are the deviating determination of loan-to-value ratio of reverse forest instrument compared to reverse mortgage and additional covenants which need to be placed to adjust the risk of the product.

TIIVISTELMÄ

Lappeenrannan-Lahden teknillinen yliopisto LUT
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Käänteisen asuntolainan soveltaminen metsäkiinteistöille

Pro gradu -tutkielma
2021
141 sivua, 13 kuvaa, 6 taulukkoa
Tarkastajat: Professori Mikael Collan ja tutkijatohtori Jyrki Savolainen

Metsä, käänteinen rahoitus, käänteinen metsärahoitus, metsärahoitus, metsän vakuusarvo, metsä vakuus

Tämän työn päämäärä on luoda käänteisen rahoituksen tuote metsäkiinteistöille. Tutkielman tavoite on muodostaa käänteisen metsärahoituksen tuote kuluttajille soveltamalla käänteisen asuntolainan mallia metsäkiinteistöille. Muodostettavan käänteisen metsärahoitustuotteen on täytettävä sekä rahoittajan riskiä kaihtava preferenssiehto että lainan nostajan tarpeet.

Työ on toteutettu yksityiskohtaisen käänteisen asuntolainan kirjallisuuskatsauksena sekä risteyttämällä löydökset metsäkiinteistön erityispiirteisiin. Empiria-osuuden tukena on kaksi erillistä asiantuntijahaastattelua.

Käänteisen asuntolainan implementointi metsäkiinteistöille toteutettiin neljässä vaiheessa. Ensimmäinen vaihe; järjestelmällisellä poissulkemisella mahdollisten tuotteiden määrää vähennettiin 960:stä kymmeneen tuotteeseen. Toinen vaihe; tuotteiden riskisyyttä vähennettiin laina-vakuus suhteen ja muiden laina kovenanttien hyödyntäen. Kolmas vaihe; kymmentä soveltuvaa tuotetta tutkittiin rajoitetulla mallilla paljastaen täyttävätkö tuotteet niille asetetut ehdot. Neljäs vaihe; todennettiin neljän käyvän ja ehdot täyttävän tuotteen markkina soveltuvuutta rajoittamattomalla mallilla, joka toteutettiin Monte Carlo simulaatiolla.

Tämän työn johtopäätöksenä on, että käänteisen asuntolainan malli sopii sovellettavaksi metsäkiinteistöille Suomen markkinoilla. Työssä löydettiin kolme soveltuvaa ja ehdot täyttävää käänteisen metsärahoituksen tuotetta; muuttuva korkoinen pääomittamaton kertalaina, kiinteäkorkoinen pääomitettava kertalaina ja muuttuvakorkoinen laina joustavalla lainan-nosto ohjelmalla. Muita työn keskeisiä löytöjä on käänteisen metsärahoituksen lainan-vakuus suhteen eriävä määrittelytapa verrattuna käänteiseen asuntolainaan sekä lainan kovenantteja, jotka tämä työ näkee tarpeelliseksi tuotteiden riskin vähentämiseksi.

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1. INTRODUCTION

This thesis explores the suitability of applying reverse mortgage instrument to forest equity. The focus is on the theoretical possibility of generating a new potential financial instrument for forest equity markets. It is notable that the existing scholarly or business literature or business models do not discuss the cross-fertilization of applying a reverse mortgage instrument into forest equity business.

Reverse mortgage instrument is part of reverse finance topic area. Reverse finance instruments are equity release instruments which aim is to release tied capital of the borrower. Reverse mortgage is the most used and only accessible reverse finance instrument to consumers. In a reverse mortgage agreement, the lender offers single or periodic withdrawals for the borrower in exchange for interest and future reimbursement. The reimbursement plan of reverse mortgage utilizes typically the underlying asset as a reimbursement means, which is also held as a collateral to the loan. Reverse mortgage was developed in the 70's and 80's to address the needs of senior citizens who suffered from "housing rich, cash poor" symptom, in which the loan is still mainly used today. This symptom implies that the seniors have large wealth, which is tied to real assets, but do not have sufficient cash assets to meet consumption or health costs.

Reverse mortgage is offered by nine out of ten banks operating in Finland and utilized only to real estate assets. The thesis will examine the reverse mortgage instrument framework utilization to forest equity. Forest equity is the second largest real asset holding by Finnish households, consisting of 632.000 consumers owning 90 percent of the forest land (LUKE a 2021). In terms of market size, the forest land covers 86 percent of Finnish land area and the market capitalization of forest equity is 27-28,4 billion Euros. On annual basis forest equity provides 1,6 billion of capital return. (LUKE a 2021)

Broadly, forest equity resembles real estate as both are real investment assets. And yet, on a one-to-one comparison forest equity has some pivotal differences in value generation and value realizing as well as in market dynamics. The similarities and differences of forest equity and real estate is previously studied by the author in bachelor's thesis *Comparison of real estate and forest equity as investment assets* (Nojonen 2021). The thesis will not execute a comparison between the assets but will examine real estate only through the framework of reverse mortgage through literature review. However, in order to gain the required knowledge to implement the reverse mortgage instrument to forest equity and model reverse forest finance instrument, fundamentals of the forest equity will be studied. In the thesis forest equity will be studied through the lenses of reverse finance. Hence in the theoretical examination of forest equity the properties of forest and their implications on applying reverse mortgage framework to forest equity will be immediately examined.

1.1. Motivation to create reverse forest finance product

There are several factors that motivate the development of the reverse forest finance instrument. Most important reason to develop a reverse forest finance instrument rises from borrower needs. This thesis identifies and hypnotises needs of three forest owner segments: investors, forest entrepreneurs and seniors. The thesis argues that there is a potential at developing a product of reverse forest finance instrument. This view rises from the particular property of forest equity that is shared by all forest owners. Forest equity is very capital-intensive investment which value develops according to turn over periods cyclically (Caulfied 1998). This characteristic of forest equity rises from the underlying value creation mechanism of biological growth (Caulfied 1998). Due to the cyclicality and restrictions on value generation forest owners must settle for large and very discrete disbursements of cash flow to realise the accumulated value in form of harvest or by selling the estate. Reverse forest finance's main advantage as a financial tool is to enable the forest owner to release part of the accumulated value pre-eminent before the large disbursement of accumulated wealth without divesting the asset.

The need of the equity withdrawal and the reluctance to disinvest varies between the borrower segments. For seniors, the main need is the same as in reverse mortgage, to finance consumption with wealth tied into real asset. The reluctance to divest from the forest can relate to will to hand over the estate as heritage to posterity as forest ownership in Finland is very family centric and bears high emotional load (Hänninen et al. 2020, 36). For some seniors, the divesting can be also impractical as nearly third of the forest estates are still owner occupied in Finland (Hänninen et al. 2020, 20-24). For these owner-occupiers, majority of who are also seniors, the reverse forest finance instrument would be the only feasible equity release instrument. As according to market study into Finnish reverse mortgage market conducted in this thesis, utilisation of the reverse mortgaging instrument for a detached house located outside of population centres is not feasible to the lender due to underlying value risk.

For forest entrepreneurs the need is to provide a continuous income stream. Due to the discrete value release of forest equity forest entrepreneurs face a problem of irregular income to cover consumption, at the same time as the forest entrepreneur executes forestry operations and covers the cost of forestry. For investors, the need can arise from leveraging, decentralization, willingness to divesting or to increase the real return of forest equity. These needs arise from forest’s illiquidity and large maturity mismatch between cost and income. The illiquidity of forest is caused by delay in realization decision and time of harvest. Forest is typically sold by vertical-trade custom in which a contract over the right to harvest the estate is signed. In vertical-trade custom the majority of income realise once the harvest is done, and the contract is settled. In vertical-trace custom the delay is typically nine months and in worst cases the settlement of the harvesting contract can be delayed by two years (Horne 2018). In addition, the divestment of forest equity is time consuming and costly. On annual bases there are approximately 4 000 representative estate transactions, which highlights the illiquidity of the market. Estate transactions also cumulate tax liability and other cost related to transaction (Ärölä et al. 2019).

In conclusion, inability to realize accumulated wealth, illiquidity, emotional ties and large maturity mismatch contributes to forest equity’s attractiveness as an investment asset to all forest owners. Therefore, an implementation of reverse forest finance can also enhance forest equity attractiveness as an investment asset and possibly change the behaviour of forest owners in their decision making. The large maturity mismatch of forest equity encourages some forest owners to harvest the estate earlier with the cost of lost future value growth. According to Huuskonen et al. (2018,148) two third of the value growth of forest investments is generated by the sturdying of timber as the timber grows from pulp wood to log timber. Reverse forest finance instrument could incentivise forest owners to postpone harvests by realising part of the accumulated value and allowing the forest to sturden and thus, enabling higher return on equity. The usage of reverse mortgage could also have fiscal sense as leveraging brings the possibility to reduce paid interest from capital gain tax.

Hence, there is potential for developing a reverse forest finance instrument that could circumvent the conditions set by the conventional properties and practices of forest equity as an investment asset. The reverse forest finance instrument targeting senior owners, forest entrepreneur and other forest owners would tackle the negative features of forest equity and make it more compelling investment asset.

1.2. Research objectives

The aim of the thesis is to implement reverse mortgage instrument to forest equity and to form a framework of reverse forest finance instrument. The applicability of reverse mortgage will be measured by level of the risk of the instrument to the lender and the borrower satisfaction. Therefore, the risk of forest equity and the risk related to reverse financing are studied. Also, to understand the needs of the borrowers an examination of forest owners is conducted.

The main research questions:
Is reverse mortgage instrument applicable to reverse forest finance instrument framework?

The supporting research questions are:

- *What instrument configurations, terms and covenants are used in reverse mortgage and which of them are applicable to reverse forest financing?*
- *Who are the forest owners and what are the key borrower segments and possible needs?*
- *If reverse forest finance instruments are found to be applicable what are potential risk of the instrument to lender and to the borrower?*

1.3. Research methods and framework

The study will be carried out as a literature review into reverse mortgage instruments, after which the properties of forest equity and the implications that they create into the applying of reverse mortgage framework will be studied. Lastly a reverse forest finance instrument models, which are found feasible will be introduced and examined. This work is exploratory by nature and aims at creating a reverse forest financing product. The creation of the reverse forest finance product is conducted through examining existing reverse mortgage products and by excluding process find the suitable financial products. The framework of this work constitutes of inter-breeding reverse finance and forest economy frameworks. The emerging framework is new to literature and there are no previous publications or business products of the topic. For this reason, the literature review focuses to establishing the framework of examining the reverse finance and forest equity frameworks hand-in-hand. The theoretical examination starts from reverse finance. After this the study turns to examining forest equity properties and what potential limitations they impose in the implementation of reverse mortgage model on reverse forest finance.

Existing reverse mortgage instruments will be examined to study potential implementation of reverse mortgage instruments to forest equity. Reverse mortgage is not a single instrument but rather an umbrella term for a large number of different instruments with different instrument options. In the thesis the different reverse mortgage instrument options will be examined in generating an understanding the mechanisms of the instrument. The examination of the different reverse mortgage instrument options will be structured into terms and configurations.

In this thesis certain loan agreement terms are referred as configurations whilst the rest of the loan agreement terms are referred as terms. Configurations are defined to be the main loan agreement terms which shape the functionality of both reverse mortgage and reverse forest finance instrument. The eight loan agreement terms defined as configurations are: fixed-flexible maturity, callability-non-callability, fixed-variable interest, capitalization-non-capitalization of interest, withdrawal method, reimbursement method, resourceness of the loan and appreciation-non-appreciation. Other loan agreement terms are referred just as terms. The distinction between terms and configurations is highlighted in the examination of reverse forest finance instrument as the loan agreement terms referred as terms are the equal for each option examined. Whereas the configurations of different reverse forest finance instrument options are changed and examined.

Reverse mortgage instrument will be examined in the thesis through literature review of reverse finance literature and through a market study of Finnish reverse mortgage markets. The market study will be conducted as a combination of online research of offering and by interviewing the providers of reverse mortgages. The offering of reverse mortgages in Finland consists of commercial banks and one mortgage specialised financial institution. In the market study all commercial banks were examined, and nine of the ten reverse mortgage providers were interviewed.

In order to be able to implement the reverse mortgage instrument to forest equity the particular configurations and properties of forest equity need to be examined. Namely, forest equity properties, such as, value creation, valuation and suitability of collateral value are of interest. Based on the findings of literature review the adaptability of reverse mortgage configurations, terms and covenants are studied with respect to forest equity to create a framework of reverse forest finance instrument.

To examine the risks and functionality of the reverse forest finance framework the suitable reverse finance instruments are examined with a hypothetical estate while simulating different outcomes of parameters affecting the instrument. The examination of reverse forest finance instrument is conducted in two models: restricted model and unrestricted model. The restricted model is a ceteris paribus model to examine the interest sensitivity of different parameters of the loan. The unrestricted model is Monte Carlo simulation to examine multiple different outcomes of the loan by generating random variables as input parameters.

1.4. Restrictions and limitations

The reverse forest finance model will be developed to the Finnish forest equity markets. Even though majority of literature regarding the reverse mortgage is from international sources the literature related to forest equity and forestry is Finnish and regarding Finnish forest equity. The construction of forest equity and timber markets varies greatly between countries and therefore the reverse forest financing instrument will be developed and be applicable only to the Finnish forest equity markets. In addition, the examination of forest equity is restricted to only direct ownership of private individuals. Forest equity is also restricted to imply only forest accruable land.

2. REVERSE MORTGAGE

This chapter will carry out an examination of reverse forest financing. This analysis advances from a more aggregate level description of reverse finance and advances to a more focused analysis of a reverse mortgage products that will then eventually be applied to experimental nature reverse forest financing product in chapter four. In the first section, the chapter will explore the general properties and utilization of the reverse mortgage instrument. This is followed by exploration of different terms that define the behaviour of the reverse mortgage loan agreements. In particular, the focus will be on the different ways the loan is raised, how instrument matures and what are the covenants defining the maturity, different ways how the interest is handled and paid, determination of the amount of withdrawable dept, usual loan terms, how the expenses are determined, and level of expenses compared to the loan amount, how the loan is reimbursed and other terms and configurations.

After these ground-laying steps the focus will shift to examine the typical risks and benefits involved in reverse mortgage instrument and its configurations. This risk analysis of different configurations and their interlinks is of great value when the reverse forest finance instrument is introduced. Lastly, the focus will turn to the Finnish reverse mortgage offerings. In analysing Finnish reverse mortgage market, the interest will be on how lenders operate at the market and what the offering consists of. After this chapter, a firm understanding of different types of reverse mortgage instruments is established including insight to terms, risks and benefits of instrument.

2.1. Reverse financing and instruments accessible to consumers

Reverse finance is considered to be part of the structured finance field. Structured finance instruments are financial instruments which contain properties of both bonds and derivatives (Leppiniemi 2005, 165-166). Derivatives are financial instruments whose value is driven by the value of an underlying variable (Hull, J. 2012, 1). Bonds are contracts between lender and borrower over an exchange of principal, payments of coupons also known as interest, and reimbursement of the principal. (Hull, J. 2012, 75-76). Therefore, reverse finance instruments are essentially bonds which principals value behaves like a financial derivate. For example, the principal paid at the end of the contract is dependable on the value development of the underlying assets. If the price of the underlying assets increases, the reimbursable principal increases, whereas if the price of the underlying assets decreases the payable amount of principal decreases. (Leppiniemi 2005, 165-166) Reverse mortgage instruments are also called equity release instruments as they are used largely to finance exits of equity holdings (Hyde 2008). In reverse finance instruments, it is also possible that there are built in or scheduled changes in the coupon payments and ownership of the underlying asset during the contract (Leppinimei 2005, 166).

For reverse finance instruments, it is common to have an initial plan to use the collateral in reimbursement of the principal at the termination of the agreement (Määttänen & Valkonen 2008). This plan can realise as change of ownership of underlying assets between the lender and borrower or the borrower and a third party. Majority of instruments under reverse finance field are primarily directed to the needs of institutional cliants. The only type of reverse finance instruments which are accessible to a large proportion of consumers are the reverse mortgage and reverse buy-out instruments (Lepiniemi 2005 165-166).

Hyde (2008) categorises the reverse finance instruments offered to consumers into two instrument families: reverse buy-out and reverses mortgage instruments. He categorises the instruments based on the initial plan on how the ownership of the collateral changes during the loan period. Reverse mortgages buy-out instruments include an intention to change the ownership of the collateral from the borrower to the lender. The change of ownership can happen at the start of the loan period, gradually during the period or at the end of the period and the ownership can change either fully or partially. This is contrary to the reverse mortgage instruments, where the intention is to finance with the proceeds of selling the collateral on the open market. In a reverse mortgage, the change of ownership between the borrower and lender is seen only as an extreme measure by the lender to minimise realised risk. (Hyde 2008) In the thesis, the same categorisation is used to define reverse buy-out and reverse mortgage.

In the definition, the initial intention is to emphasise the planned outcome of the instrument. Reverse mortgages can terminate in situation where the lender is forced to take control of the collateral due to insolvency, default or high cross-over value. In these cases, the change of ownership from the borrower to lender is not a favourable outcome, and it is done to minimise realised losses or risks of the lender. Most often the lenders of reverse mortgages are financial institutions which are not aiming to acquire a real estate portfolio, and hence will eventually opt-out from the property when the reverse mortgage agreement is settled. In reverse mortgage the real estate asset is thought more as a collateral and not as an underlying asset, thus reverse mortgage is essentially a mortgage-backed security with reversed cash flows compared to a conventional forward loan (Lepiniemi 2005 165-166). From these findings and Leppiniemi’s (2005, 165-166) definition on reverse finance instruments we can observe that reverse mortgage instruments have three key characteristics which define the instrument as bond, derivative and collateral or underlying asset.

For further examination of reverse finance instruments available to consumers the reverse mortgage offering is categorised into generalised instrument families. Both instrument families embed a variety of different characteristics which can be implemented. The characteristics vary with respect to the loan terms and configurations . The configurations define how the instrument behaves during and after maturity. Thus, the configurations define for whom and to what situation the instrument is eligible, and what are the risk and benefits for the parties involved. Other loan terms define mostly the riskiness of the product. Hosty (et al. 2008) has examined variety of reverse finance instruments offered to consumers and they categorised the offered instruments under six generalised instrument categories:

- Reverse mortgage scheme, which is a loan with the house as collateral. The loan and cumulated interest are repaid in termination events which usually include at least that borrower deceases, borrower moves out from the collateral, there ownership of the collateral faces changes or the principal is reimbursed.
- Reverse mortgage interest only schemes, in which the borrower pays interest periodically and repays the principal only in termination events.
- Home income plan, in which the borrowers receive regular income against the property while paying interest to the lender. This is in essence, a hybrid of interest only and an annuity reverse mortgage.
- Shared appreciation mortgage, in which the lender is granted a proportion of the future value growth of the estate and the borrower gets an interest free loan with the house as collateral. In shared appreciation, the lender gives part of the interest return for a proportion of the value which the house accumulates during the loan period.

- The property option from pensioners and investors (POPI) scheme, which entitles the lender the right to purchase part or the whole estate with predetermined price upon certain event to terminate the agreement. POPI is virtually an option to the real estate in exchange of fixed payments to the borrower.
- Revisions: Where the lender buys a proportion or the hold property and leases the estate for life back to the borrower.

The first four generalised instruments, reverse mortgage without and with interest, the home income plan and shared appreciation, resemble Hyde's (2008) reverse mortgage instrument family. Whereas the last two, POPI and revision resemble Hyde's (2008) reverse buy-out instrument family. This is because the initial change of ownership plan is between the borrower and the lender. In revision, the lender has only a claim to the proportion of future value growth which is realised and claimed at termination event, without planned change of ownership between the borrower and the lender.

From the four reverse mortgage instruments categories key configurations can be observed, for example, interest capitalisation, appreciation-non-appreciation, and the withdrawal method. Whereas in the reverse buy-out option the configuration obviously is when the ownership of the underlying asset changes. In total, the thesis studies eight configurations of reverse mortgage instruments found in the literature: fixed-flexible maturity, callability, withdrawal method, interest capitalisation, fixed-variable interest, resource-non-resource nature, appreciation-non-appreciation, and amortisation-bullet reimbursement. These configurations make up 960 combinations, which ensures a variety of properties. From page 87 under heading 4.1 configurations and key parameters of applicable models a figure of the configuration under examination can be found.

In reverse buy-out five configurations can be found in the literature: fixed-floating maturity, callability, payment method, time of ownership change, and the trade-off between rent collection and discount. These configurations add up to 64 combinations. Due to the number of different configurations and their combinations as well as the objectives of the thesis, there is a need to limit the scope of interest. Therefore, the reverse buy-out is limited the outside of the scope of this work. Reasoning why the reverse mortgage is selected as the compelling framework to the reverse forest mortgage is its properties. In reverse mortgage, the ownership of forest is not designed to transfer from the borrower to the lender. This is ideal as the ownership of forest equity can be seen as a burden to lender. By using the reverse mortgage, the lender is released from the risk of owning forest because there is no planned change of ownership between borrower and lender. Reversed mortgage is also a more established instrument in Finland than reverse buy-out. Nearly all the commercial banks offer reverse mortgages in Finland, whereas reverse buy-out is offered only by Hypoteekkiyhdistys, which is a finance institute solely focused on real estate financing.

As mentioned above, reverse finance instruments hold properties of both bonds and derivates. This is the case in some, but not all, instruments offered to borrowers. The derivative nature rises from some configurations which affect the payoffs in a way which transforms the payoff diagram of the instrument to resemble the payoff of options, see chapter 2.3.5. and figures two to four. Thus, a short introduction to options is needed. An option contract is a right or obligation to sell or buy an underlying asset, which can be any commodity, at a predefined time, known as expiration date, with a predetermined price, known as the strike price. In call options, the writer of the option is obligated to sell the underlying asset to the option holder, and the party which purchases the option, if he or she decides to exercise his or hers right, to purchase the underlying asset at the expiration date with the declared strike price. In the put option, the option writer is obligated to purchase the underlying asset if the option holder decided to exercise his or her right to sell the underlying asset at the expiration date with the declared strike price. The profit for the option to the holder is the subtraction of the premium and the strike price with the value of the underlying asset. (Brealey et al. 2011, s. 513-516) The configurations that affect the payoff diagram to resemble options payoff are callability, resources and appreciation. As discussed later in the thesis these three make it possible to one party to opt-out or opt-in into matters which will get the payoff to resemble an option payoff.

2.2. The history and development of reverse mortgage

From the field of reverse finance, the first instrument accessible to the broad consumer public was the reverse mortgage. The equity release instrument was designed to give a possibility to consumers to free up capital from their real estate holdings to consumption. The real estate is held as collateral, against which the principal is withdrawn. Reverse mortgages usually have a clause which ensures the borrower with the right to occupy, ownership and mastery of the real estate. (Leppiniemi 2005, 108) The right to occupy and mastery of the underlying is also known as tenancy guarantee (Kumar et al. et l 2008). At the end of the loan period, the principal withdrawn will be paid either by realising the real estate or with other capital. (Leppiniemi 2005, 108)

Reverse mortgage instruments have been developed almost at the same time both in the United Kingdom and in the United States separately from each other. In both countries, the instrument was designed for the retirees to solve their financial problem (Redstone 2010, 41). The main issues that the instrument addresses are matching consumption with the decreasing income streams and the problem of owner occupancy, which can lead to a situation called "housing rich cash poor". (Redstone 2010, 41) Many elderly may face a problem with matching falling income with old consumption habits or even rising expenditure as health expenditure rise. The falling income in itself may not be a problem if one has cumulated wealth during the professional carrier, but for many retirees the majority of their wealth is concentrated into their home. This wealth is not accessible to consumption without selling the house. This problem is called "housing rich cash poor" as the retirees can have significant wealth tied into their house and have no cash at disposal. The reverse mortgage was developed to solve this problem. (Redstone 2010, 42-43)

The first known reverse mortgage grant was recorded in the 1950s by a private financial institution in United States. The instrument was not standardised and thus was not accessible to the vast public, which was the reason for low demand. (Jhonson & Simks 2014) The birth of reserve mortgage is considered to be in the 1980s when the reverse mortgage instrument got political interest in the United States, where it was seen as a solution to retirement income. Since then, the development of reverse mortgage has been greatly influenced by political will and guidance in the United States. Reverse mortgage became a commonly available instrument to the vast public when it was established by Housing and Urban Development (later HUD) in 1987 with a instrument name home equity conversion mortgage program (later HECM). (Bishop & Shan 2008) The aim was to get the instrument quickly to the market to boost the consumption of retirees, but the market penetration was slow. (Mayer & Simons 1994, 4) The first HECM loan was granted in 1989, and at the start, the instrument was not as popular as was expected (Peterson 2002, 40-41). Nevertheless, HECM loans dominate the US market over the less standardised reverse mortgage options that came latter accessible to the market. This is seen to be the result of the high standardisation of HECM. (Jhonson & Simks 2014)

In the United Kingdom, the first reverse instrument was launched as early as 1960 as a revision scheme and joined by a home income plan in 1972. (Shao 2014) The supply of instruments was bank-specific, and there was close to no regulation or standardisation in the instruments. As in the US, the instrument faced problems with demand at the beginning. By 1980 the instruments got much attention which leads to a boom in the industry. The boom was shortly cut off by the burst of the housing price boom, which significantly harmed the reverse mortgage market nearly collapsing the market. Many of the borrowers went bankrupt, and many of the providers quit the instrument as losses rise and demand collapsed. (Shao 2014)

Peterson (2002, 40) argues that standardisation by regulating the market in the US is the main reason why the instrument is so prevalent in the United States and why the instrument is considered to be developed in the US. Rose (2009, 69) argues that reverse mortgage needs regulation to ensure that the instruments are used correctly and that the lenders do not take excessive risk, and to ensure a functioning and stable market. Regulation is also essential to the public to trust the instrument, and it keeps check on the market on who can start to provide the instrument, as just one bad actor in the market can harm the trust of the public against the industry (National consumer council 2012)

2.3. The behaviour of reverse mortgage during maturity

This section of the chapter will examine different product configurations and practices used in the reverse mortgage. The emphasis will be on defining the configurations and examining different options of the configurations and their mechanics. The mechanics of configurations will be useful it the next section, which studies the risks related in the configurations. During the examination of this chapter references to Hosty's (et al 2008) generalised products; reverse mortgage with, and without-interest scheme, home income plan and the shared appreciation will be made to understand the differences in the generalised products and what are the configurations which separate the general product categories. Due to the share number of combinations of configurations each configuration will be studied more or less separately from the other configurations, excluding some points of combined effects.

As discussed earlier, the three main financial concepts which relate to reverse mortgage are collateral, bond and derivative. This chapter will start with a short introduction to the relationship of collateral and principal and how the main risk, cross-over risk, relates to the collateral value and withdrawable principal. The concept of cross-over risk defines the limitations for many of the configurations. After the short introduction into collateral the examination turns to studying configurations which define the bond structure of the reverse mortgage. The configurations associated with the bond structure are maturity, withdrawal method, interest terms and reimbursement. Lastly, the examination will turn to the derivative dimension of the instrument. The derivative features of the reverse mortgage are created by callability, resource-non-resource aspect and shared appreciation.

2.3.1. Role of collateral and cross-over risk

Before the close examination of configurations, a note must be made of the nature of the reverse mortgage. Reverse mortgages differ from a conventional forward loan or from collateralised-dept instruments on a fundamental level (Vishaal 2010,3). A conventional forward loan is usually raised to acquire assets, and reimbursement is done by using income. In reverse mortgage, the loan is raised usually to cover consumption, and it is usually reimbursed by realising assets. Due to the difference in loan usage and the plan on how the loan is funded, the four configurations of the bond structure have a much more significant role in determining the instrument than in a conventional loan. (Vishaal 2010,3) A typical loan is granted after careful examination of solvency and the income of the borrower. But in reverse mortgages, the focus lays primarily in the value of the collateral against which the principal is withdrawn, and secondarily in borrower’s solvency. (Määttänen & Valonen 2008)

The concept of principal in the reverse mortgage is not similar to the principal of a conventional forward loan. This is due to the various configurations which subjugate the principal to carry uncertainty. This is because reverse mortgage can have an exact maturity or unknown maturity, interest can be variable or fixed and interest can fall due periodically or be capitalised, withdrawals can vary from single disbursements to lifelong annuity payables, and reimbursement can be bullet type or be amortized during several years (Shan 2009). If these instrument features are compared to a traditional loan, with set maturity, set reimbursement and predictable interest payables, the nature of reverse mortgage is very different. For this reason risk management in reverse mortgages is a key priority. The critical risk in the reverse mortgage is cross-over risk, which is an aggregate risk of several risk factors. Cross-over risk is the risk that the outstanding loan is greater than the collateral or underlying asset value exposing the lender to losses. (Shao 2014) Therefore the principal of the loan is tied to the collateral value of the underlying asset to ensure that the cross over risk does not realise.

Nevertheless, the principal of the loan is not be determined solely by the house value as the principal of the loan carries uncertainty, which is due to configurations and market variables. This is why the principal of the loan is also determined by the configuration of the instrument. Thus the examination of configurations starts by studying the relationship between collateral and loan principal. The principal of a reverse mortgage is determined as a proportion of the value of the collateral, this proportion is called loan-to-value ratio, and it is one of the key indicators of risk in reverse mortgages (Shan, 2009). Shan (2009) has outlined a model on how to manage the loan-to-value ratio during the loan grading process to minimise exposure. He divides the determination of loan-to-value ratio into three steps and defines three different loan-to-value levels, maximum claim amount, initial principal limit and the net principal limit. Each of these limits is determined by considering different risk factors and configurations. In the below diagram the determination of the three principals is adverted with the main risk factors and configurations affecting them. (Shan 2009)

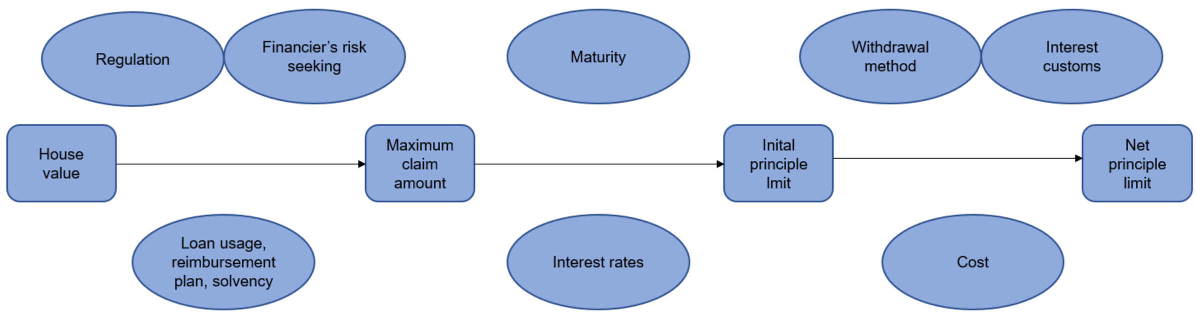

Figure 1 Determination of loan-to-value ratio in the loan granting process (after Shan 2009)

The process of granting a loan starts from valuing the collateral, i.e. the house. From the value of collateral, a maximum claim amount is decided by considering the regulatory environment, the lender's risk appetite, the features of the borrower, the loan type and how well the collateral is estimated to stain its value. Critical factor in the examination of the borrower is the age of the borrower, usage of the loan, how the loan is planned to be reimbursed and what is the solvency of the borrower. The usage of the loan affects greatly the overall risk of the instrument as the main usages of reverse mortgage are consumption, renovation and investing. The question of reimbursement is considered at the start as the reimbursement plan, whether to cover the loan by selling the house or by other wealth, determinates the requirements on the house value and solvency. The critical factor in the loan type is in appreciation-non-appreciation, resources, shared appreciation and callability as they affect the lender's payoff greatly. (Shan 2009)

After the maximum claim amount is decided, the lender considers the initial principal limit, which is the maximum amount of principal the borrower is allowed to withdraw. The initial principal limit is smaller than the maximum claim amount as it is used as a buffer against configurations which bring uncertainty to the outstanding amount of debt. The initial principal limit is set to ensure that the loan does not exceed the maximum claim amount, which is considered to be a buffer to house value declining and to limit the risk according to lender's risk appetite. The main variables which create uncertainty are the maturity and interest rate levels. Finally, the withdrawal method combined with the cost of the instrument to borrower and interest terms determine the net principal limit. The net principal limit is the amount of principal that the borrower is able to withdraw. It is computed as initial principal limit minus costs of the loan minus the estimated cumulated interest in the case of capitalisation instruments which is a function of interest terms and withdrawal method.

2.3.2. Maturity of reverse mortgages

Reverse mortgage maturity can be fixed or flexible and callable or not callable. In flexible maturity, the maturity of the loan is tied to specific events, whereas in the fixed maturity the maturity date is defined in the loan agreement. Callability of the instrument refers to the borrowers right to call-off the loan by refinancing or paying off the loan. The choice between fixed and flexible maturity and callability reflects significantly to the risk of the instrument as flexible maturity and the option to call the loan inherit uncertainty to the borrower. (Bohem & Ehrhard 1994) The choice between fixed and flexible maturity is heavily dependent on government regulation and lender's risk appetite. Because the maturity impacts the risk of the instrument, it affects the maximum claim amount greatly as well as possible choices to be utilised in interest and withdrawal. Reverse mortgages can also mature pre-emptily based on loan covenants (Warshawsky 2017). In these cases, the borrower has violated the covenants or does no longer fulfil the terms of loan agreement (Warshawsky 2017).

Flexible maturity is typically tied to the life circumstances of the borrower or is tied to the collateral value and is forced by loan covenants. Typical covenants concern borrower occupancy of the collateral and change of ownership of the collateral. For example, the loan matures when the borrower passes away, there are changes in collateral ownership, the borrower moves definitively away from the collateral. These types of covenants are considered to be natural maturities as the agreement is planned from the start to mature in these termination events. (Warshawsky 2017)

One can easily see that a flexible maturity bears a lot of risk to the lender as the borrower can affect the maturity greatly and even plan the maturity to one's benefit, of course in the limits of natural lifetime. Thus, the flexible maturity is also known as repayment guarantee. This is because the lender basically gives a guarantee to the borrower that he or she does not have loan repayment obligations as long as the maturity covenants are fulfilled. (Kumar et al. et al 2008). The risk associated with prolonged and uncertain maturity is called long lively risk, which is part of the occupant risk. Long lively risk exposes the lender to greater house value risk and cross-over risk through interest compounding. (Shao 2014) This is why the diction of flexible and fixed maturity affects the decision on interest terms and withdrawal methods as they determine the amount of cumulated interest, and vice versa. Thereby, maturity, interest rate level and interest terms affect the maximum claim amount.

Fixed maturity in a reverse mortgage is the most usual arrangement. This is because of the greater risk embedded in flexible maturity reverse mortgage. To tackle the risk of flexible maturity, lenders often require a third-party guarantee to the instrument. Therefore, government role is essential to the flexible maturity instruments, as most guarantee programmes are initiated by governments. (Bridwell & Natus 1997) Third-party guarantees cover the amount of reimbursement which cannot be covered by the sale of collateral. This means that the guarantee covers the lenders cross-over risk and covers the interest rate and house value risk of the borrower. Guarantees also expand the potential demand as the lender can share part of the risks. (Mayer & Simons 1994,4).

In callable reverse mortgage the borrower has the right call-off the loan by refinancing the loan during maturity. Whereas a non-callable reverse mortgage will mature only at the set maturity or if the maturity covenants are fulfilled. The risk of refinancing the loan during maturity is called the risk of unanticipated termination. The risk of pre-eminent maturity in callable reverse mortgages is associated with the interest rate risk. In callable reverse mortgages the lender essentially gives a call option to the borrower, with a call price equal to the outstanding loan amount. As the outstanding loan amount usually increases towards maturity the option to call off the loan is important in the case of reverse mortgage compared to a forward loan. (Bohem & Ehrhard 1994) The lender can decrease this risk of unanticipated termination by not allowing the borrower the right to call-off the loan. However, in many countries the borrowers are granted with the right to call loans by the regulation. For example, in Finland borrowers have the right to pay pre-eminent dept (FCCA 2014). In these cases, the lender can reduce the unanticipated termination by a covenant which decrease the borrower's incentive to use this right by introducing a pre-emptive maturity cost into the instrument, if that is not prohibited by regulation. According to Finnish Competition and Consumer Authority, the lender has a right to charge extra closing cost of one percent of the reimbursed amount if the loan is issued with fixed interest and reimbursement occurred prior the last year of the loan agreement. (FCCA 2014)

Reverse mortgages can also face a non-natural pre-emptive maturity. In these cases, the instrument matures due to violation of restrictive covenants, which are not considered to be desired maturities for either party. The restrictive covenants are used by the lender to manage risk and make it possible to force the instrument to mature to cut possible losses. In these cases, the borrower's behaviour or financial situation endangers the lender's benefits. These covenants of pre-emptive maturity result from violating terms of the loan agreement. The usual terms which lead to early maturity concern mandatory side expenses such as neglecting tax payables of collateral, insurance payments of collateral, neglecting reverse mortgage insurance payments or decreasing value of collateral due to damage or neglect of owner. (HUD 1994;) Some of these covenants protect the lender from undesired behaviour of the borrower or enforce the solvency requirements of the borrower.

2.3.3. Withdraw and reimbursement plan of the principal

The withdrawal method defines the phase and amount in which the net initial principal is withdrawn by the borrower. Whereas reimbursement plan defines the phase and amount of payback of the principal and the cumulated interest, in the capitalization instruments. A central part of reimbursement plan is the plan how the funding for reimbursement is exercised. Withdrawal method and interest terms define the net principal limit from the initial principal limit and the lender's financial exposure (Shan 2009). Together with reimbursement method withdraw method and interest terms determine the lender's liabilities and assets concerning the instrument. (Bohem & Ehrhard 1994)

Compared to regular forward loans reverse mortgage offers a range of different withdrawal possibilities. Below the different withdrawal of reverse mortgage: (Määttänen & Valkonen 2008; Evans 2001; Federal Housing commission 1994; Warshawsky 2017)

- Single disbursement: borrower gets a single lump sum at the beginning of the loan agreement.
- Line of credit: unscheduled payments or instalments. The borrower can decide time and amount of withdrawal until the line is exhausted.
- Term also known as fixed period annuity: Equal periodic payments during a predetermined duration.
- Modified tenure: a combination of line of credit and term where the borrower gets equal periodic payments and has the right to withdraw from the line of credit.
- Tenure also known as life annuity: Equal periodic payments of principal during a flexible period which is restricted with covenants, for example as long as the borrower occupies the house. The life annuity is also known as income guarantee (Kumar et al. et al 2008).

The withdrawal method can also be combined with different banking services. One frequently used banking service is credit account which is used usually together with line of credit withdrawal method. A credit account is an account to which the lender deposits the net principal limit, also known as credit, which can be withdrawn by the borrower. Interest is charged only on the amount of withdrawn credit from the account. Credit accounts are typically dynamic so that the borrower can also deposit money into the account. The deposit is added back to the credit and can be withdrawn again by the borrower. The deposit also decreases the interest payables of the borrower as the withdrawn credit decreases. (Nordea 2021) The withdrawable amount of principal, in line of credit, can also be dynamic by rising higher when maturity closes. This changing net principal limit limits the lender's exposure and maximizes the borrower's withdrawable limit.

Withdrawal method determines the lender’s financial exposure of the instrument as well as the interest payables of the instrument. This is because the withdrawn principal and the cumulated capitalized interest is the monetary exposure of the lender which will be lost in the worst-case scenario. And as interest is charged based on the amount of outstanding dept the withdrawal method also determines the amount of interest paid, together with interest terms. According to Behem and Ehrhard (1994) more forward balanced the withdrawal method is riskier the method and bigger the interest payables of the instrument are. From the withdrawal methods listed on page 19 the first four are typically used with fixed maturity and whereas the last two are typically used with flexible maturity.

The withdrawal method has a great impact to the balance sheet of the bank and affects greatly the value of the transaction. For lender the outstanding loan amount is an asset, and the future withdrawals are liabilities. However, the future liabilities of reverse mortgages are not stated in the balance sheet. This can lead to large off-balance-sheet liabilities, which can expose the lender to hedging risk. The chosen withdrawal method has significant impact to value of the transaction as the value is determined by the timing and amount of cashflows between the lender and borrower. (Bohem & Ehrhard 1994)

The reimbursement plan determines the way the borrower is expected to repay the loan as well as the method by which the loan payment is done. The reimbursement type is affected by the usage of the loan, loan-to-value ratio and borrowers’ solvency. Typical reimbursement of reverse mortgage is a bullet repayment, which is a single lump payment. Bullet payment is required by the lender in cases where there is change of ownership or occupancy in the collateral. In the occurrence of these changes the lender sees that the house does not fulfil the collaterals purpose increasing the lender’s risk. The reimbursement can also involve an amortisation plan, in which the borrower pays the loan back similarly to regular forward loans. (Warshawsky 2017)

Amortisation of reverse mortgage is used mainly in low loan-to-value ratio loans such as renovation and investment where the borrower’s solvency is sufficient for the method. The decision to use amortisation in reverse mortgage shifts the interest from the collateral to the solvency of the borrower, as in amortisation the financial resources to pay back the loan do not come from the sale of the house. Solvency of the borrower can change drastically during the maturity at the same time as the financial exposure stays constant or increase, which is not the case is forward loans. The usage of amortisation is done by rolling the instrument. In rolling, the reverse mortgage instrument is renegotiated to a new loan instrument before it matures. This enables the lender to consider the borrowers financial situation and the risk of amortisation option before committing to the plan. Instrument rolling is also frequently used in fixed maturity loan agreements to renegotiate a new fixed maturity agreement to follow the maturing agreement. This enables the borrower to delay the sales of the collateral or possibly update the house value to negotiate a new net principal limit. Rolling loan instruments always include a rolling risk which is the risk that the counterparty is reluctant to renegotiate the maturing contact. (Warshawsky 2017)

2.3.4. Interest and other costs

One of the factors that affect the withdrawable amount is the cost of the dept to the borrower. The total cost of reverse mortgage to the borrower is a combination of interest, transaction costs and costs which are obligated by the loan agreement. The charged and obligated costs can be divided into direct and hidden costs of the instrument. From these costs only interests and the direct cost of the instrument affect the determination of net principal limit, as both are either charged from the withdrawals of principal or added as dept to be paid at the maturity.

Reverse mortgage is expensive loan instrument compared to other collateralised loan instruments. This is because reverse mortgage has lot of expenses in different times of its maturity on top of high interest compared to other collateralised loans. (Godfrey & Malmgren, 2006, 40) The interest charged on reverse mortgage is closer to consumption loan interest than regular mortgage loans, regardless of the lower loan-to-value ratio compared to regular mortgage loans (Reed and Gilbert 2003). Rose (2009) estimates that the total cost of reverse mortgages is up to six to eight percent of the loan amount or the house value, whichever is greater. The largest and most frequently used costs are opening cost, loan management cost, closing cost and insurance costs (Lynch & Prior 2012, 44). The higher cost charged in reverse mortgage is considered to be the compensation to the lender due to demanding service and time regarding the operations of reverse mortgage (Kulkosky 2002, 24). Some lenders also use opening and closing costs to cover some of the risk of the instrument (Bohem & Ehrhard 1994).

Interest is the price of money and the price is paid by the borrower to the lender as a compensation for providing capital. Interest is measured in percent and the amount of interest to be paid is determined by determined by the outstanding loan amount and the interest rate. (Tuhkanen 2006, 9) The interest rate of a loan instrument is affected by three parts. The time value of money, the risk premium, and the required rate of return. The time value of money is also known as inflation, which decreases the value of money as time passes. The time value of money is equal to both the lender and the borrower, which is the reason why the lender requires interest at least as big as inflation to cover the decreasing value of the principal during the loan period. Risk premium of interest is compensation for the lender of the risk imbedded in the loan as future payments from borrower to lender bear uncertainty. (Knupfer & Puttonen et al. 2009, 70) The uncertainty arises from the borrower's ability to meet the payments at maturity and the longer the time is the more uncertain is the payment. Therefore, the lender also requires a compensation of time risk (Knupfer & Puttonen et al. 2009, 70). The final part of interest, the required rate of return is the amount of interest which the lender considers as profit for conducting business (Määttä & Valkonen 2008).

The interest in reverse mortgage instruments can be either fixed or variable (Bridewell & Natus 1997, 27). Variable interest rate is an interest rate which changes at pre-determined time intervals accordingly to some underlying reference rate. Whereas the fixed interest rate is a constant rate of interest, quoted typically for a longer duration also known as interest period. The interest period of fixed interest can be either the whole duration of the loan period, in which case the instrument has a truly fixed rate, or the fixed rate can be adjusted at the beginning of the interest period. Usually in these type of adjustable fixed rate instruments the borrower is given an option to either accept the new fixed rate or change the interest to a pre-determined variable interest policy for the upcoming interest period. (Tuhkanen 2006, 37-38)

In both fixed and variable interests, the interest is composed by two parts, market rate and interest premium. The market rate in variable interest rate instruments is tied to an underlying interest rate. The underlying rate can be either a publicly quoted interest rate, LIBOR, EURIBOR or EONIA, or it can be a prime rate, which is quoted by the lender. (Tuhkanen 2006, 45-46) The interest premium is the sum of risk premium and required rate of return to lender. The risk premium is typically borrower and instrument specific as the risk imbedded into borrowing is proportional to the instrument and the borrower itself. (Knupfer & Puttonen et al. 2009, 70) In reverse mortgage the risk premium of the instrument is widely considered to be 1percent on average. And it is considered to cover the cross-over losses of the lender that holds a large portfolio of reverse mortgages. (Alai et al. 2014) This instrument risk premium is presented by Alai et. al. (2014) is in line with the

1.25percent paid to FDA for reverse mortgage insurance. Rest of the interest is the sum of borrower specific risk premium and required rate of return to lender.

Compared to the variable interest, the fixed interest is less transparent to the borrower as the interest is quoted as a single percent, which is not portioned into market rate and interest premium. (Tuhkanen 2006, 37) In fixed interest instruments the market rate is determined by the lender as the combination of current market interest rates and the expectations of future changes in the interest rate environment. Fixed interest rate instruments embed more interest rate risk, as they do not adjust to interest rate changes. Therefore, fixed rate instruments have usually a higher market rate than the market interest rates, to compensate the interest rate risk. (Bohem & Ehrhard 1994). To the computed market rate, the interest premium is added, which is determined similarly as in the variable interest. Bohem & Ehrhard (1994) have come to the conclusion that due to the riskier nature of fixed rate reverse mortgages the interest should be 45 to 75 basic points higher than other fixed interest collateralised dept instruments offered to consumers.

In reverse mortgage instruments a variable interest rate is the most popular option . The reason for this is that variable interest has lower interest rate risk. Interest rate risk is the risk that interest rate levels change during the maturity of the instrument in an unfavourable direction, which can lead to lower value of future cash flows or increase the value of future liabilities. Variable interest is also more popular for the lenders as it can be hedged relatively easily compared to fixed interest and there is larger aftermarket for variable rate collateralised instruments than for fixed interest instruments. (Bridge et al. 2010)

On top of the variable-fixed interest configuration there is a second configuration related to interest. Reverse mortgages interest can be charged from the borrower periodically during the maturity or the interest can be capitalised into the loan. In the capitalisation instrument, the interest is periodically added to the outstanding loan amount to be paid at the end of the maturity. In a case of interest capitalisation, the time to maturity and the loan-to-value ratio must be considered carefully as the loan amount can cumulate quickly due to the compounding interest effect. (Bridewell & Natus 1997, 27) According to Rose (2009, 68) the cost structure of capitalisation instruments is typically higher, especially in the opening and closing costs, and the loan-to-value ratio of the loan lower, to compensate the risk of compound interest. It is also typical for capitalisation instruments to have an insurance, to lower the lender risk (Bridewell & Natus 1997, 27). The decision on capitalisation and fixed-variable interest is tied to the decision on maturity and callability. Variable interest is typically used in callable and floating maturity instruments, whereas both fixed and variable interest is used for non-callable and fixed maturity instruments. Capitalization of interest is typically used only with fixed maturity instruments to avoid the instrument from compounding into cross-over. (Bridewell & Natus 1997, 27)

The cost structure of reverse mortgages consists of both direct and hidden cost. The cost of reverse mortgage instruments is measured usually with total annual loan cost (TALC) which includes all the costs of acquiring the needed documentation to apply the loan, direct costs of loan as well as all the hidden costs of the loan. TALC does not include interest cost (Bridewell & Natus 1997, 27). Direct costs are for example the costs that Lynch and Prior (2012, 44) listed earlier. These costs are directly caused by the instrument and are charged by the lender. These costs can be fixed, or they can be tied to the granted principal. It is typical in reverse mortgage to have costs tied to the initial principal limit, especially in opening and closing costs. (Godfrey & Malmgren, 2006, 40). The opening and closing costs are one-time fees which are paid at the signing of the loan agreement and at the end of the loan agreement as administrative fees (Bridewell & Natus 1997, 27). Sometimes these costs are also used to cover some of the finances risk (Rose 209, 68). In addition to closing and opening costs, there is loan management cost and reverse mortgage insurance cost which are usually paid periodically during the maturity. (Godfrey & Malmgren, 2006, 40) Reverse mortgage insurance cost is usually considered to be a direct cost even though the cost does not go to the lender, but to an insurer. The practice to include the reverse mortgage insurance to direct cost is based on the nature of the cost as the insurance premium is tied to the initial principal limit. (HUD 1994)

The hidden costs of reverse mortgage are costs which are required to be covered by the borrower in loan agreement but are not paid to the lender. On the border of direct and hidden cost, there are cost of acquiring the needed documentation to apply the loan. These costs are known in advance and they are mandatory in the process of applying the loan. These costs include all fees of documentation, such as appraiser, condition and maintenance inspections, maintenance plans, title search, credit reports and surveys. Hidden costs are insurance cost and property tax of the collateral and possible maintenance costs of the house according to the maintenance plan. (HUD 1994)

Persson (2012, 850) includes inflation also as a hidden cost. A rising inflation can increase the interest expenses, depending on the interest policy of the instrument, and decrease the value of the future cash flows from withdrawals. On the contrary inflation decreases also the future value of reimbursements, which works in favour of the borrower. (Perrson 2012, 850) Wang et al. (2008) points out also expense risk of the lender. Expense risk is the risk that future cost of management and closing of the instrument rise due to rising inflation, these costs are for example wage expenses related to loan management operations. (Wang et al. 2008). Montezuma (2006, 884) points out that moderate inflation does not have a reasonable impact on the cost of reverse mortgage.

2.3.5. Derivative feature configurations

Derivative feature adding configurations are configurations which affect the reverse mortgages payoff diagram seen in pages 26, 27 and 28. The change in the payoff diagram affect greatly the benefits and risks of both the lender and the borrower. (Noordewier and Harrison 2001) The configurations are callability, resourceness and appreciation. This section will study the mechanics and typical terms regarding these configurations and how they affect the instruments configuration.

The resource-non-resource configuration of a reverse mortgage defines which party in the loan agreement bears the house price risk (Noordewier and Harrison 2001). House price risk is one of the major risks concerning the lenders cross-over risk and the borrower's risk in the loan agreement. (Wang et al. 2010) In resource loan instrument the borrower is expected to cover the whole reimbursement, the principal, and the cumulated interest in capitalization instruments, at the termination. This means that the lender has a claim on the entire borrower's wealth and future income in the case that the proceeds from the sale of the collateral does not cover the full extent of the reimbursement at the time of termination. Thus, the house value risk is primarily carried by the borrower and secondly carried by the lender in the case the borrower is insolvent. (Noordewier and Harrison 2001) A resource loan does not affect the payoff diagram of either party.

In non-resource loan instrument, the lender or a third-party gives a non-negative equity guarantee (NNEG) to the borrower. A third party NNEG is also known as reverse mortgage insurance. The third-party can be either a private insurance institute or government entity (Congressional budget office 2019). The insurance caps the reimbursement of the borrower to the extent of proceeds from the sale of the collateral and compensates the lacking reimbursement to the lender. A compensation is paid to the third party for the house value risk covering. This is paid by the borrower and it is tied to the initial principal limit of the loan, for example, FDA charges an insurance premium of 1.25 percent. (Congressional budget office 2019) In third-party guaranteed instruments the payoff diagram of the lender is not affected, as the lender gets full reimbursement in any case. However, the third-party guarantee affects the borrower’s payoff diagram as the borrower’s exposure of the house value is capped to the interest premium payment. Thus, the borrower essentially holds an American call option where the value of collateral is the underlying asset, the cumulated interest payments is the options premium and the outstanding reimbursement is the strike price of the option. In the below figure the call option position is presented.

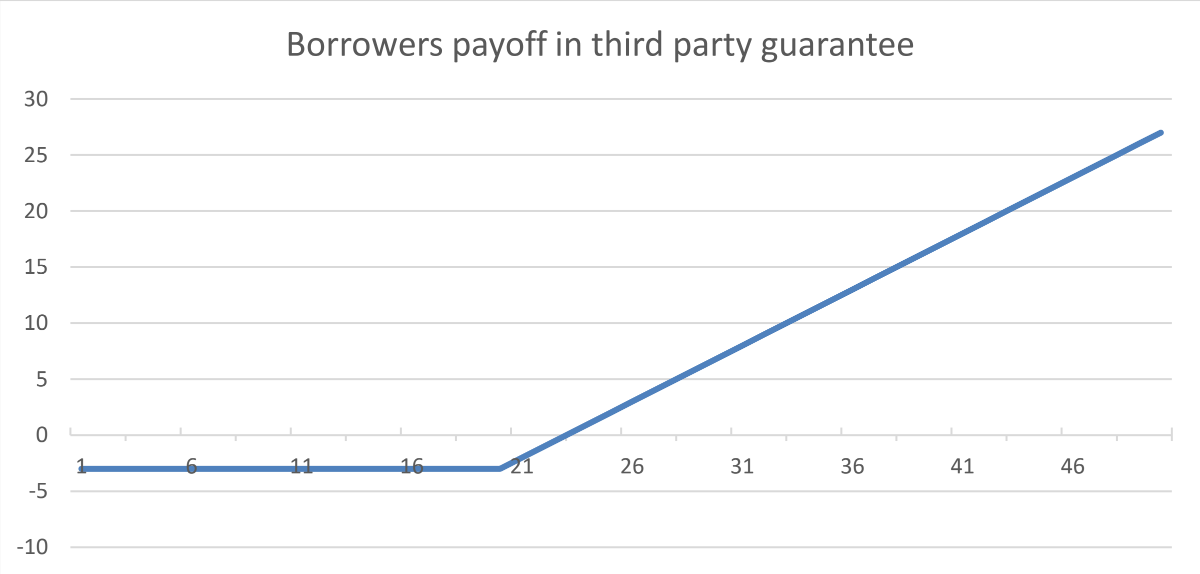

Figure 2 The payoff of borrower’s American call option in the case of third-party guarantee on reverse mortgage.

In the case of NNEG given by the lender, the reimbursement of the loan is capped with the proceeds from the sale of the collateral, i.e. the lender does not have a claim to borrower’s other wealth or future income. Thus, the house price risk is fully covered by the lender, and the borrower is protected against negative home value. (Chen et al. 2010) In NNEG the lender basically writes an American put option to the borrower with the value of collateral as underlying asset, the sum of interest revenue as premium and the outstanding principal as strike price. Whereas the borrower holds the put option with the same strike price and premium respectfully. (Li et al. 2010) Below the put options payoff diagram regarding lender granted NNEG.

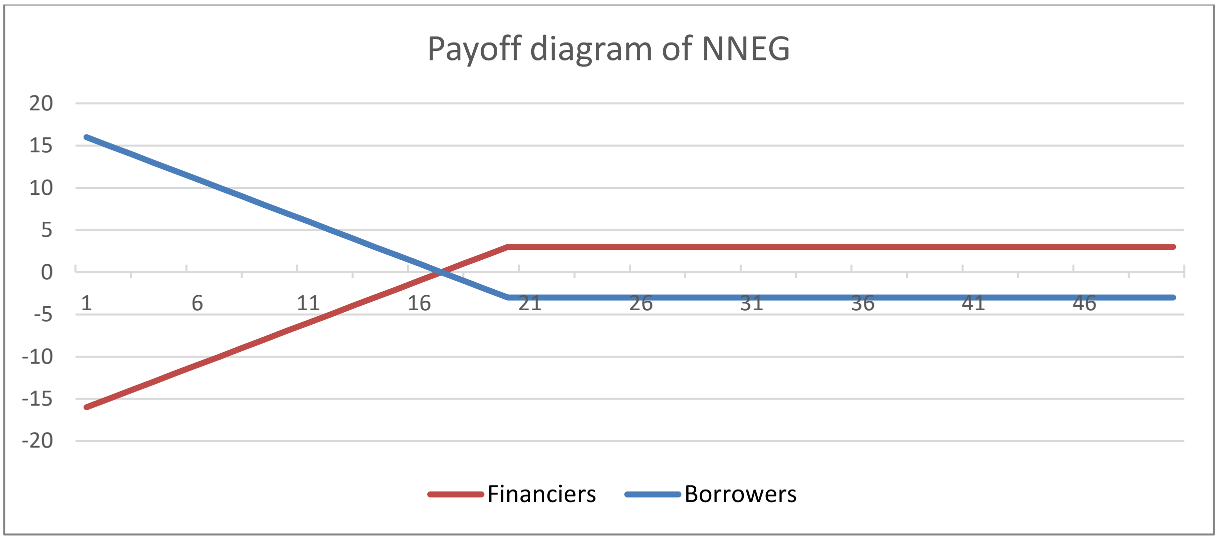

Figure 3 Put options payoff of lender granted non-negative-equity-guarantee for the lender and borrower.

Few important notions on the interlinks of option characteristics to other configurations must be made. The uncertain maturity and outstanding principal in reverse mortgage expose the maturity and the strike price of the option to uncertainty. In fact, the strike price of the option is increasing and uncertain (Chinloy & Megbolugbe 1994). This is especially true in capitalization instruments as the interest payables are cumulated into the principal. In capitalization instruments the premium of the option is naturally zero for both parties as the interest is not paid prior to the termination. For variable and adjusting fixed interest the options premium is under interest rate risk and thus bears uncertainty. The premium is known in the fixed interest instruments which are non-callable. But in the case of callable fixed interest instruments, the premium of the loan itself is an option (Bohem & Ehrhard 1994). In callable instruments, the lender writes an American call option to the borrower where the underlying asset is the market interest rate, the withdrawn principal is the strike price and cost of refinancing the loan is the premium. (Bohem & Ehrhard 1994)

In shared appreciation instrument the lender gives up the whole or part of the interest revenue in the exchange of future value growth of the collateral, i.e. the lender gets a proportion of the value growth of the collateral. In essence the borrower writes a call option with an uncertain expiration date to the lender with the collateral as underlying asset, principal as strike price, and lowered interest rate as premium. In the case of shared appreciation and lender granted NNEG, the lender has a forward loan agreement with the collateral as underlying, outstanding principal as forwards set price and the sum of interest payments as the price of the forward loan agreement. The borrower holds a put option and a short call option which the borrower sold to the lender. In the below figure the payoff diagrams of both lender and borrower are displayed in shared appreciation with and without NNEG.

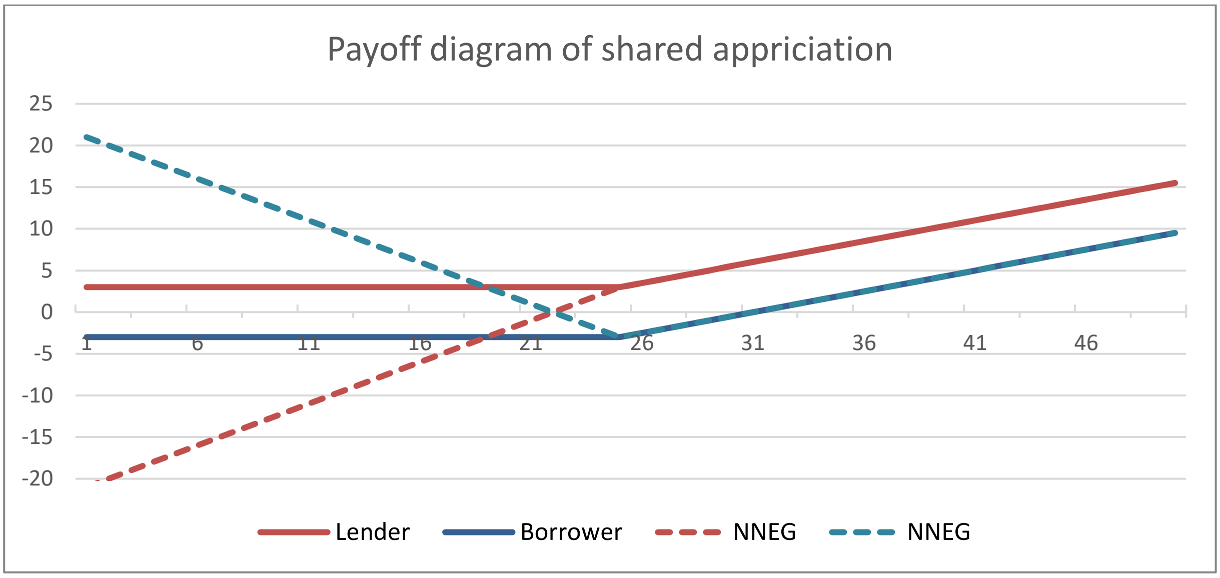

Figure 4 Pay-off diagram of lender and borrower in the case of shared appreciation. In shared application the lenders share of house value increase is 50 percent.

2.4. Risks of reverse mortgage

The main risk in reverse mortgage for lender is cross-over risk. The cross-over is caused by a combination of root risks involved in reverse mortgage and it is realised in the occasion when some of the root risks realize. Cross-over risk is the risk that the lender does not receive the full reimbursement of principal, interest payables and direct costs of the instrument. The root risks can be divided into three main subcategories: house price risk, interest rate risk and the occupant risk. (Wang et al 2008) The exposure to the root risks is determined by the configurations and covenants of the instrument. Thus, the lender needs to weigh each decision taking into consideration the configurations and their interconnections in the instrument to balance the exposure. This section of the chapter will cover the above-mentioned cross-over risks of reverse mortgage. Each risk will be introduced and then the relationship of the risk to the configurations will be studied. Lastly other risk concerning reverse mortgage instrument will be studied.

2.4.1. House price risk

House price risk is the most severe root risk concerning the cross-over risk in the reverse mortgage. This is because the loan principal is tied to the house price and the reimbursement plan is centred in using the proceeds of the collateral to cover the loan at the maturity. (Chen et al. 2010) The house price risk is the risk that the value of the underlying decreases during the maturity. In this case the instrument is more likely to fall into cross-over and thus the cross-over risk is tied the house price risk. The house price risk is the combination of valuation risk and price risk (LI et al. 2010). When talking about the house price risk there must be made a distinction between the occupant risk and the house price risk. House price risk is the risk that the price of the house falls or does not develop as assumed due to market conditions, which are powered by supply and demand. (Kumar et al. et al. 2008) Whereas the occupant risk is the risk that the house price decreases due to action by the occupant. (Shao 2014) This part concentrates into house price risk whilst the occupant risk is covered under chapter 2.4.3.

Valuation risk, also known as anti-selection risk, is the risk involved in the granting phase of the reverse mortgage when the underlying is valued. The valuation risk is the risk that the valuing process does not generate an accurate estimate of the collaterals real value. Real value is the price which would be paid on a perfect market if the collateral would be sold. (Kumar et al. et al. 2008) Therefore, if value estimate is high the cross-over risks of the instrument increases, as loan-to-“real value” of collateral is smaller, and vice versa. In real estate valuation there are two main risks involved risk concerning the valuation process and base risk. (Kumar et al. et al. 2008; Li et al. 2010) Risk in the valuing process concerns the process of valuing such as poor execution of valuation, poor valuation procedure or human error which can cause the estimate to variate from the real value. (Kumar et al. et. al. 2008) Base risk is the risk arising from the difference between the individual house price and the aggregate house price on markets (Li et al. 2010). Base risk is created by the homogeneity embedded in real estate commodities. Due to homogeneity the number of comparative trades is limited. This leads to a risk in valuation where the valuator cannot have a complete picture of the true value of the commodity. The real estate base risk realises when the value of a single asset, a house, variates from the aggregate price, from the average price of the neighbourhood, leaving the valuator responsible to estimate the price of the underlying. (Li et al. 2010)

The price risk is the combination of systemic price risk and idiosyncratic price risk (Patrick et al 2014). Systematic house price risk refers to the aggregate market price risk and it is the risk that the price levels of all commodities on the market depreciate in value (Schulte et al 2011). Idiosyncratic house price risk is the variability of individual house price compared to the price on the markets. The difference between base risk and idiosyncratic price risk is that base risk is the price difference to aggregate market, but the idiosyncratic price risk is the variability and price development of individual house price compared to that of markets. (Li et al. 2010) Idiosyncratic house price risk realises when the value of a house depreciates on markets while the aggregate market prices stays stale or increases. (Shao et al. 2015)

The valuation risk and house price risk can be managed in several ways. The easiest methods to manage each risk is to restrict the set of properties accepted as collateral, lowering the maximum claim amount and by third party insurance (Broussa et al. 2003; Shan 2009). By restricting the set of qualifiable properties to areas where there is good price transparency and to properties which can be seen to be liquid and stable can reduce the valuation risk, base risk, and idiosyncratic price risk, as there is more information of the property type being valued (Bourassa et al. 2003; Kumar et al. et al. 2008). However, by restricting the set of qualifying properties as collateral, one also restricts the potential demand for the instrument. The risks can also be managed by lowering the maximum claim amount. This option gives more leeway to valuation estimate and price changes. (Shan 2009) Shan et al. (2009) also suggests the possibility to increase the risk premiums charged from the instrument to compensate the risk. Another way to mitigate the risk is to use third party insurance and professional real estate personnel to value the collaterals. (Consumer financial protection bureau, 2012; Kumar et al. 2008).

From the house price risks, systematic risk is most unpredictable and impossible to avoid totally when operating in the market. (Schulte et al. 2011) Systematic risk can be managed through financial derivates such as housing price indexes or futures concerning house prices. Unfortunately, for reverse mortgage lenders the benefits of hedging are limited as the portfolio of collaterals held by reverse mortgage lender can hardly be thought to represent the aggregate market. (Shoa et al. 2015) Li et al. (2010) even argue that even if the lender holds a market portfolio, hedging covers only the systematic risk proportion of the risk and leaves out the idiosyncratic proportion of house price risk, which he argues is far larger in housing markets than the systematic risk component. Counter intuitively the idiosyncratic risk in reverse mortgage has not been studied widely, even though it is the main risk in the reverse mortgage (Shao et al. 2015). The idiosyncratic risk is also difficult to mitigate solely by the lender as the idiosyncratic risk is property specific. One way to hedge against idiosyncratic risk is to acquire a large enough portfolio which resembles the aggregate market but as noted earlier this is not usually possible (Shao et al. 2010).

The house price risk can be also amplified by using lender granted NNEG or shared appreciation. In NNEG reverse mortgages the pricing risk is larger, as the total amount of dept exceeding the house price falls to cross-over, whereas without the NNEG some can be charged from borrower's wealth and future income. (Shao et al. 2014) In these cases the entire house price risk is carried by the lender. NNEG and third-party insurance are the only tools disposable to the borrower to mitigate house price risk. As the borrower cannot choose the property, nor build a market portfolio by diversifying the idiosyncratic risk, and as the borrower does not have access to same hedging tools as lender; borrower can't hedge systematic house price risk. The borrower can negotiate the net principal limit lower or choose not to withdraw all the net principal value, which will decrease the cross-over risks of borrower in the case of resource loan. In the case of shared appreciation, the lenders price risk and valuation risk increase. This is because in both schemes the reverse mortgage provider holds a portfolio of options on individual properties instead of option to portfolio or a pure portfolio of properties. This amplifies the idiosyncratic price risk and makes it also harder to hedge against the systematic price risk. (Shao et al. 2014) Other configuration which affect the house price risk is maturity. The house price variation gets more uncertain with longer maturity. The maturity affects the house price risk also through interest rates, as will be discussed in the next part of this section. Interest rates and real estate value are negatively correlated and thus a longer maturity exposes the lender to higher and more uncertain interest rates.

2.4.2. Interest rate risk

Interest rate risk is the risk that the lender's required rate of return changes during the loan period. According to financial economic theory the required rate of return is the sum of risk-free interest rate and the risk premium. (Nikkinen et al. 2002, 94-95) In addition the house price risk, the interest risk is a major risk concerning reverse mortgages. Compared to other risks involved in reverse mortgage, the interest rate risk has some special properties as it is non-symmetrical between the borrower and lender and the bearer of interest rate risk can be influenced greatly by the loan agreement. (Määrää & Valkonen 2008) Bohem & Ehrhard (1994) argues that compared to regular coupon bond or mortgage the interest rate risk is significantly higher in reverse mortgage, by several magnitudes. Although the interest rate risk is higher compared to other dept instruments, the magnitude of interest rate risk can be greatly influenced by the configuration of the reverse mortgage instrument.

The interest rate risk is tied to the cross-over risk in three ways. Interest rate changes impact the value of the instrument for both lender's and borrower's assets and liabilities of the reverse mortgage, and thus affect the future value of the value loan agreement to both parties. (Bohem & Ehrhard 1994) Interest rate changes can affect the outstanding loan amount in the capitalisation instruments, which can lead the instrument into cross-over (Huang et al. 2011). Interest rate changes can also implicitly affect the cross-over risks as interest rates and real estate values are negatively correlated (Määttää & Valkonen 2008). In this chapter, the interest rate risk is first examined on a general level, after which the interlinks between configurations and interest rate risk is studied. The interest rate risk will be studied for both fixed and variable interest, as well as for capitalisation and non-capitalisation instruments. As following analysis show, the risk profile of different interest configuration differs greatly.

The interest rate risk materialises when the required rate of return change. The required rate of return is also used as the lender's discount rate. The change in the discount rate is caused either by a change in the level of risk-free interest or a change in the riskiness of the instrument, which causes a change in the risk premium. Riskiness of the instrument refers to the risk embedded in the instrument and risks associated with the borrower. (Nikkinen et al. 2002, 94-95) Previously the interest rate of reverse mortgage was defined to compose of three components the market rate, risk premium and the required rate of return to the lender. If the same composition is brought together with Nikkinen's division of discount rate, the risk premium of discount rate refers to the risk premium and required rate of return. And the risk-free interest of discount rate is the market rate. Risk-free interest is a hypothetical rate and in practical applications it is considered to be a government bond which has a negligible risk thus presenting risk-free interest (Nikkinen et al. 2002, 94-95). Thus, as this chapter discusses of interest rate or interest rate level the risk-free interest rate is indicated.

According to the financial economics theory, the risk-free interest rate is tied to interest bearing securities through the concept of net present value. The present value is the result of discounted cash flows. (Tuhkanen 2006, 18-19) The cash flows of reverse mortgage are withdrawals, payments of interest and reimbursement of principal. Present value allows the standardisation cash flows and valuation of instruments (Tuhkanen 2006, 18-19). When the interest level changes, the present value of cash flows changes and so does the net present value of the loan agreement. This change does not affect same way the borrower and the lender as the change of interest causes a non-symmetrical change in the benefit for the parties. When interest rates increase, the discount rate increases which decreases the present value of future cash flows. Therefore, the value of future cash flows is subjacent to interest rate changes and the correlation between present value and interest rate is negative. As one's payment is one's receivable, the increase in the interest rate decreases the future value of a payments, which benefits the payer, and decreases the value of receivable, which is a disadvantage for the receiver. (Kupiner & Puttonen et al. 2009, 84-85) In this chapter the viewpoint of benefits and disadvantages will be examined from the lender's perspective. But by taking into account the non-symmetrical property of interest rate effects the borrower's position can be inducted by mirroring the lender effects.

Interest rate risk is defined as change in the interest rate, but as illustrated earlier the change can realise with either positive or negative outcome. A positive change would always be welcomed, whereas a negative change would not be desired. Therefore, both parties of the agreement consider the interest rate risk to be related only to the negative changes for given parties respect. Nevertheless, this is not the case as interest rate risk is created from the uncertainty of interest rates (Tuhkanen 2006, 68, 315). Therefore, unlike other risks related to reverse mortgage interest rate risk is business risk. Business risks are risk which are taken knowingly, and they can bear positive or negative outcomes. (Suominen 2001, 10-11) This uncertainty carries both positive and negative effects of interest rate changes, but the uncertainty of the change creates the interest rate risk. This is key in understanding how the maturity affects interest rate risk. The uncertainty of interest rates risk increases when maturity is longer. This is because the lender cannot, nor can the borrower, fully predict interest rates into the future. (Tuhkanen 2006, 68, 315) This is why the maturity of the instrument is the most important determinant of interest rate risk.

Maturity affects the interest rate risk in two ways. The longer the maturity the longer is the exposition to interest rate changes. As the maturity gets longer it becomes more likely that the interest rates will change into unfavourable direction and the uncertainty on the magnitude of change becomes larger. (Tuhkanen 2006, 315) Besides exposing the instrument to interest rate changes for a longer duration, longer maturities also expose the cash flows and the outstanding principal to unfavourable interest conditions for longer duration. The longer the duration of unfavourable interest condition is, the greater is the imposed effect of interest rates to the value. (Kupiner & Puttonen et al. 2009, 85-85) This is why longer maturity instruments have a higher sensitivity and greater value change for change in interest rate. (Tuhkanen 2006, 314)

The effect of maturity in interest rate risk in reverse mortgage is essential as the maturity of reverse mortgages are typically long and in flexible instruments the maturity itself bears uncertainty. The risk of uncertain maturity is known also as longevity risk and it is closely tied to the interest rate risk (Kumar et al. et al. 2008). In reverse mortgages the importance of maturity is also emphasised by the rising exposure of reverse mortgage. As the uncertainty of interest rates increases so does the outstanding amount of dept which is under the risk. Compared to forward loans which are amortised, the exposure to interest rate risk decreases as uncertainty increases. (Boehm & Ehrhard 1994) Contradictory, the possibility of pre-emanant maturity also increases interest rate risk, especially in callable reverse mortgages, as the borrower has the option to refinance the loan. The borrower will naturally refinance the loan when the interest rate conditions are not favourable. This leads to situation where lender is not able to benefit from favourable interest rate. Thus, callability exposes the lender only to negative interest rate changes by increasing the unsymmetrically of interest rate changes. This nature of callability greatly affects the valuation of the reverse mortgage and increases the interest rate risk for the lender whereas decreases it to the borrower. (Bohen & Ehrhard 1994)

To examine the relationship of interest rate risk, withdrawal methods, reimbursement plans and interest capitalisation, Boehm and Ehrhard (1994) suggest modelling the reverse mortgage instruments as a portfolio of assets and liabilities. For the lender, the assets are interest payables and reimbursements of principal from the borrower to the lender and the liabilities are principal payments from the lender to the borrower. The portfolio thinking enables examination of the interest rate risk separately to assets and liabilities to get a deeper understanding of the interest risk and its impact to the value the instrument. (Bohem & Ehrhard 1994) In the different withdrawal methods, the timing and quality of the liabilities differs. For instance, in a single disbursement there is a large liability at the start of the loan period and in tenure there is periodical small liabilities during the whole loan period. The timing and quantity of assets is dependent on the reimbursement method, interest payables and interest capitalisation. By combining different withdrawal methods with different reimbursement methods, capitalisation and non-capitalisation, one can see that a reverse mortgage is a portfolio always containing short-term liabilities and long-term assets. Bohem and Ehrhard (1994) states that in a instrument that has short-term liabilities and long-term assets, the interest rate risk is emphasised by the rollover of liabilities. He also points out that any instrument with rollover of liabilities has a disadvantage to lender when the interest rate level rises. However, the impact is opposite to the borrower.

Bohem & Ehrhard (1994) states that the interest risk rises from the mismatch in the maturities as the short-term liabilities are less interest sensitive due to shorter maturity whereas the long-term assets have high interest sensitive. As the portfolio contains fewer sensitive liabilities and very sensitive assets, he argues that the whole portfolio is very sensitive to interest rate changes. The interest rate sensitivity is higher with greater mismatch in maturities and amounts. Therefore, disbursement methods which are forward loading, such as single disbursement, are more interest sensitive than withdrawal methods which distribute liabilities for a longer period, such as tenure and term withdrawal plans. In the case of assets, the opposite is true as more forward loading reimbursement plans are less interest sensitive. This means that bullet repayment bears less interest rate risk than other reimbursement plans. (Bohem & Ehrhard 1994)

Interest payables of the loan are also assets for the lender and thus non-capitalisation which is more forward loading compared to capitalisation products is less interest sensitive and thus has less interest risk. Capitalisation-non-capitalisation increases the interest rate sensitivity of reverse mortgage also through compounding. This is because the capitalised interest starts to compound, and in compounding interest even a slight change in the interest rate can have large consequences to the outstanding loan amount at the maturity. Therefore, the interest rate risk of interest capitalisation is tied heavily to cross-over risk. Interest capitalisation decision is also an optimisation question between default risks during the maturity and cross-over risk. In non-capitalisation products as interest rates rise the default risks during the maturity increases. Capitalisation of interest also affects the liabilities which increases the liability-asset maturity mismatch further. This is because interest income is taxable income which must be paid to tax authorise even if the interest has not been paid yet. (Bohem & Ehrhard 1994) Thus in capitalisation product where cross-over risk realises the net loss of the lender can be bigger than the outstanding loan amount.

The choice of who bears the interest rate risk in reverse mortgage is made though fixed-variable interest rate configuration. The decision who bears the interest rate risk also determines who gets the benefits of carrying the risk. (Määttää & Valkonen 2008, 16) According to financial economics theory the bearer of the risk must have a compensation for the risk. In fixed interest the interest rate risk is carried by the lender. As interest rise the value of the instrument decreases for financer and as a compensation for the risk the lender benefits off from decreasing interest and collects a higher interest. In variable interest , the interest rate risk is carried by the borrower. As interest rise the interest payables increase and as compensation of this risk the borrower pays a smaller interest but also benefits from decreasing interest. In the variable interest lenders decrease in the value of cash flows is compensated with higher interest payables, and vice versa. (Bohem & Ehrhard 1994)

However, in variable interest rate products the lender is exposed to basis risk. Basis risk is the risk concerning the imperfect correlation of interest basis of assets and liabilities. Basis risk realises when the basis of liabilities, capital which the lender is borrowing, and the assets, the capital which the lender lending, are not matching. This can occur for example if the lender has borrowed money with LIBOR interest and lends the money in EURIBOR interest. The risk is that these two basis do not move in unison. ERUOBOR can decrease which decreases the return on lent capital while LIBOR rates increase which will increasing the cost of capital. (Basel committee on baking and supervision 2004, 5) This risk is greater in the variable interest rate as the lending base is floating compared to fixed rate products where the interest is known and does not fluctuate.

In the fixed interest rate the interest rate risk concerns more yield curve risk, which is caused by the slope and shape of short-term and long-term interest rates (Basel committee on baking and supervision 2004, 5). The yield curve risk realized when the anticipated yield curve does not realise, and the yield curve changes in an unfavourable direction. This risk affects both the determination of fixed interest, which is composed on the basis of current interest rates and anticipated interest rate changes. (Basel committee on baking and supervision 2004, 5) Thus for the lender the decision on fixed and variable interest rates is also a decision does the lender prefer exposition to basis risk or yield curve risk. If the product is a capitalisation product the decision on fixed and variable interest also is a trade-off of cross-over risk and value risk. This is because as variable interest has a higher cross-over risk due to uncertain interest level which can compound the product into cross-over. In fixed interest products the cross-over risk is smaller as the cumulated interest can be calculated in forehand, if the product has fixed maturity. However, in the fixed interest products there is no chancing interest payments to compensate the value changes if interest level changes.

Variable interest rates, as mentioned earlier, are far more used than fixed interest rates. For borrower's point of view one could think that the lower interest rate are the appealing factor. For the lender, the appealing factors for variable interest are lower interest rate, liquidity and hedging. According to Shao (2014) variable interest rate collateralised instruments are far more liquid in secondary markets, which enables the lender to sell the entire interest rate risk forward. Risk concerning variable interest rate risk are easier to hedge, because there are far more instruments to hedge base risk compared to yield curve risk. One reason is also the fact that the benefit of carrying interest rate risk in fixed interest instruments is limited by the callability of the instrument, which is hard to reduce due to regulation in many countries. (Boehm et al 1994)

The lender can also reduce the interest rate risk by reducing the net principal limit which increases the leeway in capitalisation instruments, reduces the capital and value exposed. (Shan 2009) The lender can also require a third-party insurance to be mandatory. (Consumer financial protection bureau 2012) However, when minimizing the interest rate risk, one must remember the balance of risk and return. Return on investment is the reward of taking risks and this is true also to reverse mortgage. The greater the maturity mismatch between liabilities and assets in reverse mortgage the greater the interest risk and return. This is because the interest return of the instrument is based on interest payables. Naturally for interest payables to exist there needs to be mismatch in the maturities of assets and liabilities and the greater the mismatch in time and amount the bigger are the interest payables and the interest rate risk. This is also true in the case of interest capitalisation as the compounding interest increases risk. Thus, the lender must have exposure to interest rate risk if he or she wants to obtain interest rate returns.

In addition the instrument configurations, the interest rate risk affects the cross-over risk also through the value of the underlying as interest rates and real estate prices are negatively correlated. (Määttää and Valkonen 2006) This exposure to interest rate risk can be further increased by shared appreciation scheme as the lender has part of his return tied to the collateral. In non-appreciation instruments without third party guarantee the risk of cross-over due to interest rate risk is realised when interest rate is higher than the appreciation of the collateral and the outstanding loan amount is close to maximum claim amount. In shared appreciation the interest rate risk is realized only if the interest rate level is higher than the appreciation of collateral. (Bohem & Ehrhard 1994)

2.4.3. Occupant risk

Occupant risk, or counter risk for the borrower, is the risk imbedded in features of counterpart or change in behaviour of counterpart in the loan agreement. Most of the risk involved with the counterpart in reverse mortgage are borrower specific as the counter risk involved in the borrower is far larger than the counter risk involved in the lender. This is why this part of the chapter mainly concentrates on the occupant risk of the lender. The occupant risk can be divided into longevity risk, risk of adverse selection, mobility risk, moral hazard, default risk, counter risk, and rollover risk and default risk.

The main risk in occupant risk is the longevity risk which is the risk involved in flexible maturity instruments with a tenancy guarantee. The name of the risk comes from the termination clauses of flexible instruments, which terminate latest when the borrower dies. Thus, when the borrower lives long the maturity can be prolong greatly increasing the cross-over risk through interest rate risk exposure. (Kinser 1999, 84) According to Kumar et al. et al. (2008) longevity risk is the single most important risk in valuation, risk pricing and risk management in flexible maturity instruments. The longevity risk can be managed on both aggregate and non-aggregate levels. (Kumar et al. 2008). On non-aggregate level the longevity risk can be reduced only by limiting the set of qualified borrowers and thus reverse mortgages usually have a term that the borrower must be over a certain age to be granted with the loan (Kinser 1999, 84). Other non-aggregate risk management method is to price the risk in risk premium, purchase a third-party insurance or adjusting the initial principal. (Kumar et al. et al. 2008; Bourassa et al. 2003) On aggregate level, the risk can be estimated accurately by stochastic methods. The models usually include a drift to capture advances in medicine and changes in lifestyle, as they increase the expected lifetime. (Lee & Carter 1992) A recent development in aggregate hedging of longevity is the introduction of survivor bonds and swaps which the lender can enter. In survivor derivates the lender pays a premium to a third-party insurer who promises to compensate losses in the cases where there is a larger than expected number of survivors. (Kumar et al. 2008)

Adverse selection is the case where one of the parties has more information and uses this information against the counter party. The unsymmetrical information influences a variety of risk in reverse mortgage such as anti-selection and house price risk. The borrower has a more information on the condition of collateral and future maintenance, longevity and default risk. The borrower has hidden information on his future income and health, mobility and moral hazard, as well as; the borrower has hidden information about his own intentions. Therefore, the adverse selection has a larger affect to the riskiness of reverse mortgage than in traditional forward loans. The risk of adverse selection in reverse mortgages is larger also in the scene as the lenders exposed more once the hidden information is relieved, compared to forward loans. Adverse selection is amplified especially in longevity risk as borrowers that live longer apply proportionally more reverse mortgages compared to the aggregate population. (Shao 2014)

Mobility risk is the risk of refinance or pre-eminent maturity of the instrument. In these cases, the instrument matures due to action by the borrower pre-eminent before the set maturity or fulfilment of maturity covenants restrictive or natural such as death. (Kumar et al. 2008) This risk can be managed by pricing the mortgage and planning the configuration of the instrument. In pricing the lender estimates stochastically the proportion of the borrowers in the portfolio who are going to refinance the loan. Whereas in the configuration the borrower can increase the incentive to refinance the loan by adding pre-eminent maturity cost and by non-callability. (Boehm & Ehrhardt 1994) There is also a moral hazard related into the pre-eminent termination in instruments that are not callable. As the borrower can intentionally violate the covenants of the instrument to terminate the loan agreement. This can be the case if the interest rate environment is unfavourable to the borrower and the lender does not want to adjust the interest rate or terminate the loan agreement pre-eminent.

Other moral hazard of the borrower concerns the collateral, also known as maintenance risk. Maintenance risk is the largest moral hazard problem in reverse mortgages especially in insured and NNEG instruments. Moral hazard of the borrower concerning the collateral rises from the payoff of the borrower in non-resource loans, as the borrower does not have any financial incentive to sustain the value of the collateral if the instrument is in cross over. The same dilemma is in shared appreciation as shared appreciation reduces the financial incentive to sustain the value of the collateral. Thus, the borrower can postpone the maintenance of the collateral adding to the decrease in value. (Wang et al. 2008; Kumar et al. 2008) This risk can be decreased by adjusting the initial principal limit so that the borrower will receive capital from the house upon maturity and by covenants. (Wang et al. 2008) However, the monitoring of maintenance can be difficult to arrange and it can be costly. Therefore, some lenders require a maintenance plan to the collateral and some even designated proportion of the withdrawable amount to be used to maintenance expenses. (Kulkosky 2002) Other moral hazard of the borrower relates to hidden costs of the instrument, such as collateral insurance and tax payables. These can expose the value of the collateral to depreciation. These moral hazards can be decreased by lender audit. (Kumar et al. 2008)

Default risk is the risk that either party defaults on the loan. For the borrower, this risk is small as bank defaults are not as common as consumer defaults, but it is a risk that the borrower needs to consider. In the occasion of bank default, the borrower may be forced to sell the house or refinance the loan in an unfavourable market condition, which could greatly affect the financial situation of the borrower. (Waarshawsky 2017) From the bank's perspective default of a borrower realises when the borrower cannot pay direct or indirect expenses of the loan agreement, interest payables or the borrower is not able to cover living expenses, which forces the borrower to sell the house and pre-eminentterminate the loan agreement (FCCA 2021). The default risk is naturally higher in low solvency borrower and in higher in high expense instruments, for example in non-capitalization instruments with high interest expenses. Default risk is also higher in long maturity instruments as the uncertainty of borrowers' income increases due to natural aging of borrowers.

The rollover risk is the risk concerning the maturity and termination of the agreement where either party of the agreement would like to prolong the maturity or sign a new agreement regarding the outstanding principal. This can be the case in some reverse mortgages as lenders manage their risk and exposure with short maturity loan agreements, for example a 10-year maturity, with the option to sign a new agreement when the first agreement matures. In these cases, the borrower has a risk that the lender loses the interest to rollover the agreement, i.e. sign a new fixed maturity agreement or enter a amortisation agreement instead of bullet reimbursement. In this case the borrower is forced to sell the collateral to cover the dept. Also, the lender could face rollover risk in a situation where there is a NNEG and the instrument matures in an unfavourable market condition when the loan agreement is in cross-over. In these situations, it could be favourable to the lender to continue the agreement and receive interest's payment while waiting the more favourable market conditions to mature the instrument. The most usual rollover in reverse mortgages is the situation where the borrower dies and the heiress favour a amortisation plan. Rollover risk can be influenced by the exit plan of the loan agreement and with the covenants of the loan agreement.

2.4.4. Additional risks

Additional risks concerning reverse mortgage are risks that are not related to the interest rates and the real estate market. These risks involve overall market condition, political risk and litigation risk. The overall market condition affects the real estate market, interest rates, as well as the solvency of borrowers, but on top of these the overall market condition affects the solvency of the lender. One market environment change that is related to the valuing of collateral which is not covered earlier is the risk concerning rental yields. This risk is a special risk in revisions and it is realized when the rental yields increase higher than the expected when signing the revision agreement. As the revision discount is calculated to be the equivalent of the value of lease for life agreement, increasing rental yields increase the required rate of return for the loan agreement decreasing its value. (Alai et al. 2014).

Another way the overall market conditions can affect the loan agreement is by decreasing the solvency and capital requirements of the lender. Reverse mortgage holders are more sensitive to these changes. As we discussed earlier on the reverse mortgages accounting practises the reverse mortgages expose the lender for large off-sheet liabilities (Bohem & Ehrhard 1994). This can be seen as a risk in the lender's financial planning if the off-sheet liabilities are not taken into account in solvency stress tests. The future liabilities can expose the lender into loss of financial solidity in times of poor overall market conditions. The off-sheet liabilities can also lead to hedging mismatch, where the hedging position of the lender is not effective. This risk realises when the lender does not account or can't accurately estimate the full exposure which the liabilities create. (Bohem & Ehrhard 1994).

The lender is also under political risk as changes in regulation and taxation can affect greatly the operating environment affecting future nominations of reverse mortgage or existing ones. These regulatory risks can relate to mandatory insurance or NNEG clauses, liabilities or asset values in balance sheet and the handling and valuation of collateral. Litigation risk is the risk that the loan agreement signed does not protect the parties as was intended. Litigation risk is the highest in situations where the collateral ownership is handed over to the lender in a case of violation of restrictive covenants, insolvency in cross-over station or rollover the loan to heiress of the primary borrower. The litigation risk can also realise if the restrictive covenants or grants involved in the instrument do not work as intended due to poor loan agreement missspecifications. This risk can be mitigated by careful loan agreement procedures. (Kumar et al. 2008)

One risk related to collateral value and borrower default risk is the risk that the underlying must be taken over by the lender. This risk realizes when the borrower defaults on the loan. The risk related to the take-over realized as higher termination cost of the loan agreement as the divestment of the underlying for the lender is time consuming and costly due to transfer tax and other transaction costs. During the time between he takeover and divestments the lender is also directly exposed to value changes of the underlying and bears all cost’s related to the ownership of the estate, such as taxes, maintenance cost, remuneration and insurance costs.

2.5. Reverse mortgage markets and offering in Finland

According to Puhtila (2015) reverse mortgage is not very well known or utilised instrument in the Finnish banking sector. The popularity of the instrument is hard to measure due to lack of data, but one indication of the instrument’s popularity can be drawn from the accessibility to the instrument. Reverse mortgage was first introduced to Finish markets by Hypoteekkiyhtistys in 2003. In less than a decade in 2008 the instrument was offered by Hypoteekkiyhtistys and all commercial banks (Määttä & Valkonen 2008). Based on a market study into the current market’s status, the reverse mortgage market is facing head wind. Currently Hypoteekkiyhdistys, which is a mortgage specialised lending bank, and four commercial banks Aktia, Danske Bank, Nordea and Osuuspankki offer the instrument over the counter (Hypoteekkiyhdistys 2020a; Aktia 2021a; Danske Bank 2021; Nordea 2021; Osuuspankki 2020a). Whereas four commercial banks Handelsbanken, Oma Säästöpankki, S-pankki and POP pankki offer the instrument under the counter if requested, and one commercial bank Ålandsbanken has discontinued the instrument (Handelsbanken 2020; Oma Säästöpankki 2020; S-Pankki 2020; POP pankki 2020; Ålandsbanken 2021).

The offering of reverse mortgage in Finland follows pure vanilla HECM loan framework. The offering of individual banks deviates greatly from each other. According to Puhtila (2015) this is the result of the banks fitting the instrument into their existing instrument mixes. To examine the existing reverse mortgage offering an interview study and examination of online material was conducted. The results of the market study can be found from table one at the end of this chapter. All other commercial banks except Nordea, Danske Bank and Ålandsbanken were interviewed for the study. Due to the nature of the offering, only the offerings of Aktia, Danske Bank, Nordea, Osuuspankki and Hypoteekkiyhtistys are examined in more dept. This is because the under the counter offering is highly custom-made to fit each borrower's financial state and needs. Therefore, Handelsbanken, Oma Säästöpankki, S-Pankki and POP pankki's instruments are excluded from the examination.

The offering of the five over the counter offeror's follows well the HECM loan framework. Hypoteekkiyhtistys and Nordea offer the instrument to all consumer segments and for any purposes. Osuuspankki and Danske bank offer the loan only to senior clients and renovation, but unlike Osuuspankki which has a 60-year age limit Danske Bank has no limitations over age. Aktia does not have any restrictions over the borrower and offers the loan to senior clients, consumption and renovation. In previous studies all banks have had area restrictions over collateral, which is due to collateral location diverging value trends (Puhtila 2015). This is still true to Hypoteekkiyhtistys, which focuses only to capital area, and Osuuspankki, which focuses only to growth municipalities. Danske Bank does not disclose any restrictions on their web-pages. Aktia and Nordea state that each collateral will be studied upon granting. The maximum loan-to-value ratios of Nordea are between 30 percent and 65 percent depending on region, Osuuspankki has 70 percent, and the rest of the providers grant a maximum of 50 percent. (Hypoteekkiyhdistys 2020a; Hypoteekkiyhdistys 2020b; Nordea 2021; Osuuspankki 2020a; Osuuspankki 2020b; Danske Bank 2021; Aktia 2020a; Aktia 2021b)

The only bank which offers a flexible maturity is Osuuspankki, and according to Osuuspankki's interview the majority of granted loans are granted with a flexible maturity. Hypoteekkiyhdistys has a 20-year maturity limit, and the rest of the providers have a 10-year maturity. Due to the consumer finance law all the granted loans are callable. Aktia and Osuuspankki are the only two banks which do not have cost related to refinance or pre-eminent reimbursement. Other banks have cost varying form 25 Euro to 250 Euros. Other cost of the loan regard granting and closing costs which vary between 100 and 800 Euros. All banks except Hypoteekkiyhdistys have a monthly cost of 2,3 to 6 Euros a month and several other service costs which rise from withdrawals, reimbursements, depositing and interest revisions. (Hypoteekkiyhdistys 2020a; Hypoteekkiyhdistys 2020b; Nordea 2021; Osuuspankki 2020a; Osuuspankki 2020b; Danske Bank 2021; Aktia 2020a; Aktia 2021b)

None of the commercial banks state that the usage of the collateral is the primary way to reimburse the loan, which is probably due to the usage of the loan, as majority of the loans are raised for renovation. However, an exception is Hypoteekkiyhdistys which offers loans mainly to senior clients and states that the usage of the collateral is the primary reimbursement plan. This and the long initial maturity compared to other providers, is probably why Hypoteekkiyhdistys states that it agrees to rollover loans very rarely whereas rest of the banks offer rollover loans. Otherwise, the reimbursement happens mainly as a bullet reimbursement with all banks. Amortization as a reimbursement plan is offered as an over-the-counter solution only by Aktia. Aktia and Osuuspankki are the only banks which offer term withdrawals. However, according to Aktia, majority of withdrawal plans are bullet type. In both Aktia and Osuuspankki term withdrawal is offered only to senior clients, Aktia having exceptions in well-reasoned cases. (Hypoteekkiyhdistys 2020a; Hypoteekkiyhdistys 2020b; Nordea 2021; Osuuspankki 2020a; Osuuspankki 2020b; Danske Bank 2021; Aktia 2020a; Aktia 2021b)

Aktia, Osuuspankki and Hypoteekkiyhtistys are the only three to offer fixed interest. The interest charged lays between 1-3 percent, which according to Osuuspankki is exceptionally low interest for a decade long fixed maturity instrument. According to Osuuspankki interview the level of interest is tied mainly to the borrower, length of the maturity and to the interest rate level on markets. According to the interview with Osuuspankki and Hypoteekkiyhdistys, the fixed interest offered to loans is very sensitive to quick changes in the expected interest rate level. All banks offer a variable interest which in all the cases is tied to 12-month EURIBOR, except for Nordea which uses Nordea prime interest. Osuuspankki offers also the three and six-month EURIBOR. The margins of the banks vary significantly based on the usage of the loan. Renovation and consumption loan having the highest margins. On the aggregate level the margins vary between 1 to 3,5 percent. Osuuspankki and Aktia are the only banks to offer capitalization of interest. However, Aktia offers capitalization only to one-year bullet loans and does not offer the capitalization of loan costs. (Hypoteekkiyhdistys 2020a; Hypoteekkiyhdistys 2020b; Nordea 2021; Osuuspankki 2020a; Osuuspankki 2020b; Aktia 2020a; Aktia 2021b)

Table 1 Results of Finnish reverse mortgage offering interview.

		Aktia	Danske Bank	Nordea	Osuuspankki	Hypoteekkiyhdistys
Instrument name		Käänteinen asuntolaina	Kotilaina	Asuntojousto	Käänteinen asuntolaina	käänteinen asuntolaina
Active offering		Yes	Not actively	Not actively	Not actively	Not actively
Usage of loan		Senior, consumption, renovation	Senior, renovation	No restraints	Senior, renovation	No restraints
Borrower restrictions		No	No	No	Over 60 years	Mainly to retired
Estate restrictions		Growth centres, Fully or nearly mortgage free	No restrictions	No restrictions	Areal restrictions, Fully or nearly mortgage free	Capital area, Mortgage free
Loan-to-value ratio		0,5	0,5	30-65 % depending on region	0,7	0,5
Maturity	Fixed	10	10	10	Negotiable	20
	Flexible	No	No	No	Most offered	No
Callability	Callable	Yes, no cost	Yes, 250 € cost	Yes, 200 € cost	Yes	Yes, 25 € cost
	Non-Callable	No	No	No	No	No
Withdrawal	Bullet	Yes	Yes	Yes	Yes	Yes
	Line of credit	No			No	No
	Term	Yes	Yes		Yes	No
	Tenure	No			No	No
	Life annuity	No			No	No
	Contra account	Yes		Yes	Yes	No
Reimbursement	Bullet	Yes	Yes	Yes	Yes	x
	Amortisation	Yes			No	
	Rollover	Yes	Yes	Yes	Yes	Very rarely
Interest & cost	Fixed	2-3 % on consumption loan			1-2 %	10 v 0,4- ==> 1 %
	Variable	EURIBOR 12 + 1,5 % (2 % renovation/consumption)	EURIBOR 12 + borrower marginal	Nordea prime + 3,5 %	EURIBOR 3, 6, 12 + 0,5-1.5 %	EURIBOR 12 + 2-2,5 % and in consumption loans + 4 %
	Direct cost	800 € + 2,3 €/m	300 € or 0,6 % of laon amount + 2,7 €/m	100 € + 6 €/m	200-600 € + 2-3 €/M	No
Capitalization	Non-capitalization	Yes	Yes	Yes	Yes	Yes
	Capitalization	Yes on bullet loans with under 1 year matueity	No	No	Yes	No
Resourceness	Non-resource	Yes	Yes	Yes	Yes	Yes
	NNEG	No	No	No	No	No
	Third party	No	No	No	No	No
Appreciation	Non-Appreciation	Yes	Yes	Yes	Yes	Yes
	Appreciation	No	No	No	No	No
Data gathering	Interview	Yes	No	No	Yes	Yes
	Source	Aktia a 2021; Aktia b2021	Danske Bank a 2021	Nordea a 2021	Osuuspankki a 2020; Osuuspankki b 2021;	Hypoteekki yhdistys a 2020; Hyoptekkiyhdistys b 2021

	Handelsbanken	Oma Säästöpankki	S-Pankki	Ålandsbanken	POP pankki
Offering	Offers only on request	Offers only on request	Offers only on request	Does not offer	Offers only on request
Interview	Yes	Yes	Yes	Yes	Yes
Source	Handelsbanken 2020	Oma Säästöpankki 2020	S-pankki 2020	Ålandsbanken 2021	Pop pankki 2020

Base on the market study the usage of the loan is directed more to renovation loans diverging from the HECM-plan. Puhtila (2015) sees this as a result of cultural differences and the high demanding nature of the loan. The demanding nature of the loan reduces the offering of the instrument by banks, which can be also seen in the market development. A similar market development has occurred in the reverse buy-out instruments which were offered by Hypoteekkiyhdistys from 2003 to around 2010 when the instrument was placed on hold for indefinite time (Hypoteekkiyhdistys 2020a).

3. FOREST EQUITY AND REVERSE FINANCE

This chapter forest equity is studied through the framework of reverse forest finance. The aim is to study the collateral properties of forest equity, the valuation and value of forest equity as a collateral, the forest owners and their needs, as well as the collateral risk and borrower risk in the case of forest equity as a collateral in reverse forest finance product. As illustrated in the previous chapter of the literature review in chapter one, there are eight different configurations which produce 960 different product combinations. In addition, the numerous instrument combinations there are several terms and practices used by lender that modify the instrument. In order to be able to study efficiently the reverse forest finance product some configurations and some combinations of the configurations need to be excluded to narrow down the study. The configurations to be excluded is not arbitrary but necessitated by the difference of forest equity and real estate. This chapter aims to execute an examination how the configurations and terms and practices of reverse mortgage fit into forest equity and introduce areas of forest equity and forestry which are deemed to be important in the examination of reverse forest finance.

Furthermore, in this chapter, the risks of reverse forest finance product are examined. As studied in the reverse mortgage chapter the risk of reverse finance product rise from cross-over risk for which the main root risks are collateral value risk, interest rate risk, and occupant risk. During the examination of this chapter both the collateral risk and occupant risk are studied in the framework of reverse forest finance. Interest rate risk will be examined latter chapters.

The first section of this chapter illustrate what is forest equity and what is the actual underlying value bearing factor in the collateral and what properties does the underlying collateral have. In addition, the suitability of reverse mortgage configurations is examined. In the second section of the chapter the collateral valuation is examined. In this part restrictions on the qualifiable properties and the risk concerning the collateral value are examined. In the third section the forest owners are examined, and the possible needs of forest owners is hypothesised. In this part also borrower risk is studied and some restrictions on the qualifiable borrower are studied. The examination of forest owners also presents a market study of reverse forest finance product.

3.1. Forest equity as collateral and restrictions imposed to reverse finance

Forest equity is a real investment commodity which comprises of individual forest estates. Forest estate is defined in the Finnish real estate formation law 2.1 § (Kiinteistönmuodostamislaki 554/1995) as “independent unit of land ownership, which is by real estate register law (Kiinteistörekisterlilaki 392/1985) or by other register unit marked in real estate register as a separate unit. Real estate comprises of area, share of common areas and common benefits as well as easements and private specific benefits belonging to the real estate.” In this thesis forest equity is defined as forest accruable land[1] which consists of forest estates defined in the real estate formation law. Due to the scope of the thesis, forest equity is considered to comprise of a single uniform forest estate. To examine the forest equities usage as collateral, the nature and characteristics of forest equity needs to be examined.

Forest equity is defined by physical land. This forest land has both physical and abstract characteristics, which define the estates properties (Airaksinen 2008). The physical characteristics of forest estate are location, soil composition and biological mass present in the estate (Ärölä et al. 2019, 15). These physical characteristics further create abstract characteristics for the forest estate. These abstract and physical characteristics generate forest equity unique contemporaneous asset structure which enables several values and ways to yield value. Forest equity’s contemporaneous asset structure means that forest equity is simultaneously a product, means of production and factor of production, depending on the usage of the forest. (Airaksinen 2008) To study forest’s collateral behaviour the asset structure and different value generation ways of forest equity need to be studied.

According to Gregersen et al. (1995) forest estates yield three different values direct value, indirect value and passive value. These values coexist to some degree but on a fundamental level they substitute each other in use. (Gregersen et al. 1995; Airaksinen 2008, 19) The importance of the examination of forest value is inflated by Holopainen and Viitanen’s (2009) view that not all values created by forest equity are priceable or capitalizable. Both of which are properties that are highly important prerequisites for the lender to price and capitalise on

[1] Forest equity and forest estates are studied in the thesis only through direct ownership and are strictly restricted to refer forestry land. Forest estates are considered to be at least two hectares of uniform area, consists of only forest cultivable land and excluding all constructed improvements unrelated to forestry. Forest estates definition also excludes common areas, common benefits and easements to restrict the scope of the work.

the value of the collateral. The values of forest substitute each other in the use of the owners preferred value and affects the potential value and value yielding of forest and hence the collateral value of the estate. Therefore, the owner's preferences toward the forest usage affects greatly the usage of forest estate as collateral.

In passive value generation the forest is seen as a single entity which has share value of existing and hidden option values (Airaksinen 2008). From lender point of view passive value of forest does not create collateral value. The option values of forest have uncertain maturity and uncertain call price and thus the option value of forest is impossible to price or value. The same is true to the share value of existing. This is because the share value of existing does not produce any cash flows by itself and therefore is impossible to price or capitalize upon. Therefore, the passive value does not generate value which would fulfil the requirements for collateral value.

The same is true with indirect value, where the forest is also seen as a single entity. Indirect value is generated when forest is used as means of service or used directly as a product itself. (Gregersen et al. 1995) According to Paananen et al. (2009) the freedom to roam rights, enforced by the criminal law give everyone the right to use the forest to recreation which makes the benefit non-exclusive (Paananen et al. 2009; Rikoslaki 38/1889). Any benefit which is non-exclusive does not have a market and thus do not have a reasonable monetary value. Obviously one can do business by selling non-exclusive properties of forest and generate cash flows, but the added value of non-exclusive commodity to such service is diminutive compared to other factors that add value to the service. An exception to this is hunting and professional tourism which are exclusive rights, thus they are capitalizable and principal (Paananen et al. 2009). However, both are tied to the business which generates the cash flow. Therefore, in these cases the forest only enables the service rather than generates the value of service. Forest's indirect values could serve as a collateral value but the reimbursement plan of loan principal would be cantered around the solvency of the business and not around the usage of collateral as in many reverse mortgage products.

Lastly the direct value generation which creates value through biological growth in the form of timber, plants, berries, mushrooms, and other eatables as well as thorough exclusion of ground material. When direct value is examined the forest is seen as a combination of investment asset, which underlying value adding factor is biological growth and a separatable commodity, which is the result of the value generation. Both the asset and the commodity have separate markets. (Airaksinen 2008)

Similarly, as in the indirect value, part of the direct value generation is non-exclusive such as berries, mushrooms and other eatable plants, which are non-exclusive and thus they do not have collateral value (Paananen et al. 2009; Rikoslaki 38/1889). However, the ground materials, timber and other non-eatable plants are exclusive, and thus are priceable and capitalizable (Paananen et al. 2009). As the reverse forest finance product is developed to forest owners, the value of ground materials can be excluded from the examination. This is because the valuation or extraction of ground material is not possible for the forest owner and require organised large-scale business to determine the value and to capitalize upon the value. According to Paananen et al. (2009) the value of other exclusive plants than timber, have a very low value compared to timber. Therefore, the other non-eatable plants than timber can be excluded from the study and be considered as secondary values[2]. Thus, the only value yielding factor, which generates priceable and capitalizable value, is the biological growth inherent to forest ground and the only commodity which bears value is timber. To be able to examine the collateral properties of forest equity the two separatable commodities, timber and forest land, are examined separately in more depth in the following chapters.

3.1.1. Timber as collateral

The biological growth of an estate is tied to the physical land and its physical characteristics geographical location; soil composition, which includes the water economy and mineral structure of the estate; and the species grown. These characteristics create natural limits to the amount of biological growth, both in growth rate and the amount of accumulative growth, and timber reserves. However, the biological growth can be enhanced by forest cultivation strategy and good forest management and vice versa the biological growth can be diminished by poor management. (Mielikäinen 2018; Puttonen et al. 2018; Airaksinen 2008, 19) According to Linna (2012, 27-32) biological growth is reasonably predictable and accumulates compounding

[2] Secondary values of forest are defined in the thesis as additional value bearing factors of forest. The secondary values are excluded from collateral value and serve as a margin to the lender.

returns. The value of the accumulated growth is the product of timber volume and the price of timber, which is typically expressed as stump price[3] (Uotila 2011).

The biological growth, value development, nominal and real term cash flows, and present value of timber are presented in the below figure 5 on a hypothetical one-hectare forest estate over one turn-over time[4]. The forest growth data is based on MOTTI simulation of uniform spruce forest, which is forested with traditional single aged turn-over method in Southern-Finland. The data is gathered from Ärölä's forest simulation presented in Tapion taskukirja and interpolated to a continuous data series (Rantala and Korhonen 2018).

In the figure the amount of timber is indexed and presented in percent of log and pulp with red and blue areas respectfully[5]. The amount of timber prior the terminal harvest is 366 cubic meters, presented with 100 percent in the figure. The biological growth, light green line, is calculated as percent change of cubic meters due to biological growth. From the figure we can also see the cash flows from operations. The cash flows are presented by stacked columns in nominal terms by dark red and light green bars, and in real terms by light red and dark green bars at year zero. The nominal cash flows include forest silviculture and management cost as well as timber sale revenue[6].The timber value and annual value increase due to timber growth are presented by black and lilac lines respectfully. Lastly the red line represents the forest owners required rate of return, which is also used as a discounting factor in the real values of the figure. This same simulation will be used later in the thesis to study the reverse forest finance product.

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[3] Stump price is a timber price quote used in vertical trade, where the timber is sold as it stands in the forest. Stump-price includes the value of the timber minus estate specific harvesting and logistical costs. (Uotila 2011)
[4] Turnover time is the time from forest restock, forest planting, to terminal logging, when most of the timber is harvested. (Mielikäinen 2018) In Finland turnover times vary between 60-90 years (Pukkala 1997).
[5] Timber is measured by cubic meters and classified by diameter into saplings less than eight centimeters, pulp less than 10 centimeters, small log less than 16 centimeters and log. Timber is traded in 10-15 commodity classes depending on species the main being energy wood, pulp, and log. (Melkas 2018)
[6] Forest siviculture maintaines the vitality of the estate and optimises the value growth and forest growth. Four main steps of cultivation are restocking including forest groundwork, plantation by seeding, natural seeding, or planting saplings; sapling nurture, including hay work and sapling clearing; thinning; and terminal logging. (Ruotsalainen 2005, 9) Forest management is forest planning and inventorying.

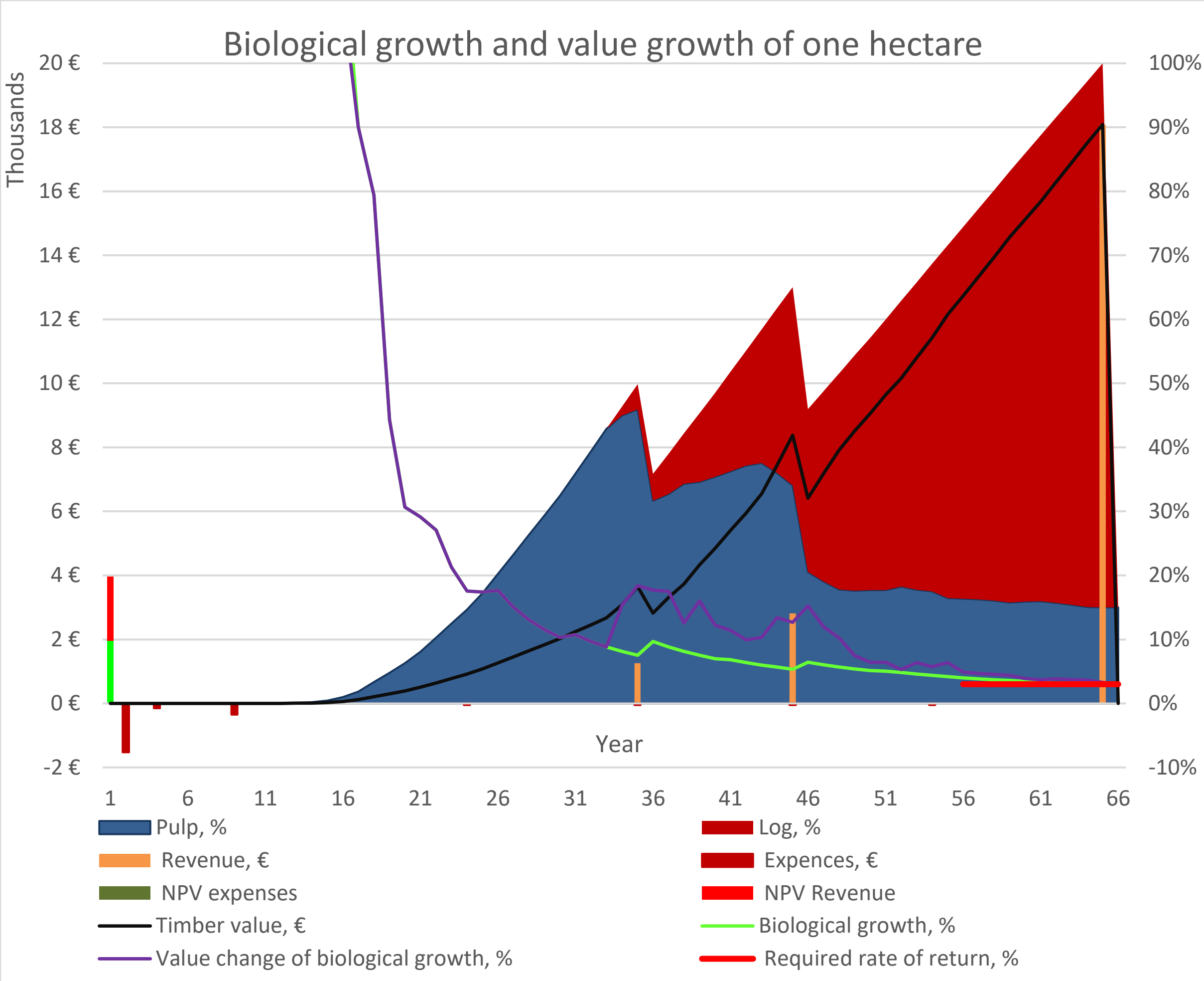

Figure 5 Timber and value growth and cash flows of a one-hectare estate from year one to 65.

Several interesting findings can be drawn from the above figure that affect the usage of reverse financing to forest equity. These findings are unstable value development of forest estate due to biological growth, the compounding growth of timber volume, turnover-time which is determined by the investors required rate of return, the divergence of value growth and timber growth, as well as the large difference between nominal and real cash flows. The key interest in all these points is the effect that they have on the collateral properties of forest. The effect is manifested by the quantity and timing of cash flows. The cash flows of the forest estate create restrictions for reverse forest finance product's configurations.

From the collateral point of view, the value development of forest seen from figure 5 conflicts with generally used restriction of collateral value: low volatility and good value retaining. Forest value is intrinsically cyclical due to biological growth and turnover periods. However, these characteristics also give forest a desirable characteristic as collateral. According to

Caulfied (1998) the value of forest increases non-negatively with compounding interest if no risks realise. This property of forest lowers the riskiness of the collateral value and cross-over risk of the loan significantly in reverse financing. However, the cyclical value development creates restrictions for the maturity as the value of timber will reduce to zero at terminal harvest. According to Äijälä et al. (2014) and Liljeroos (2017) in modern forestry the forest turnover-time is determined by investors required rate of return by timing the terminal harvest at the point where the value growth of the timber equals investors required rate of return. Thus, the maturity is restricted by lender's restraint to maturity, which is the thermal logging, which is determined by the borrowers required rate of return and biological growth.

On top of these restraints the lender and the borrower must determine the length of the loan agreement, which is one of the key risk determinants in reverse financing for both parties. Naturally, the maturity cannot be longer than a single turnover time, and the withdrawal date cannot be in the first years of the turnover time as the value of the timber is close to zero. By examining the maturities of existing reverse finance products, the maturity of reverse forest finance product could be between 10-20 years prior the terminal harvest. From collateral value risk and cross-over risk point of view, the loan maturity should exclude the last thinning[7] added with few years of margin. The reason for this is moral hazard problem with thinning, increased environmental risk due to thinning and reduction in forest growth uncertainty and terminal value estimates.

Thinning bears risk as a poorly executed thinning can impact the expected value of the estate in two ways by being too small or too excessive. Firstly, too small thinning does not create enough space for the timber to grow reducing growth in volume and in quality. Quality growth reduction comes in the form of low log percent and in other metrics, which reduces the price per cubic meter at terminal harvest. (Ruotsalainen 2005) Secondly, too large thinning reduces the thermal harvest size. Things also increase the risk of natural hazards[8], which increase the collateral value risk (Nielsen 2004, 47). Finally, if the loan is granted prior the thinning the

[7] Single turn-over period has one to three thinnings, in which roughly 30-40 % of timber is harvested to enable beater growth circumstances and to increase quality in form of rising log percentage. Thinning generates roughly third of the timber sale revenue. Thinnings contribute greatly to the value growth of forest but poor implementation of thinning can also greatly reduce the expected value growth. (Huuskonen et al. 2018,148)
[8] As the thinning removes timer from the forest the forest is more exposed to storm winds and snow burden, which are two leading natural hazards in frequency and in severity. (Nielsen 2004, 47)

borrower could encounter moral hazard problem as the borrower has an incentive to execute a large thinning to pull out as much of the collateral value as possible.

Based on above, the collateral value and the cash flow from timber sales at terminal harvest are contingents to a successful thinning. This creates uncertainty of estimated value at terminal harvest is greatly reduced after the last thinning. Therefore, the last thinning should be excluded from the duration of maturity. In the simulation case above the optimal duration of the loan agreement would be between 47 to 64 years which equals to 17 years. Due to the nature of forest, the configuration option of flexible maturity does not present itself as a viable option. However, a strictly fixed maturity could also be impractical. This is due to the nature of timber sales, which will be examined later in the chapter 3.2.2. Therefore, a fixed maturity with a slip is the optimal choice for the lender.

The same restriction of value cyclicity that restricts maturity also restricts the possible reimbursement plans and rollover of the reverse forest finance instrument. As the value of the collateral is released by a single lump cash flow at the same time as the value of the collateral reduces to zero, the product is forced to use bullet reimbursement. This is because the collateral value is zero after the terminal harvest, which leaves no collateral value to assert the amortisation period. Similarly, this restricts the rollover of the loan to be unsuitable. If the loan is rolled over after thermal harvest the new loan is left uncollateralized leaving amortization to rely heavily on the borrower's solvency rather than the usage of collateral.

Compared to maturity, reimbursement, and rollover restrictions, the withdrawal method is less restricted. The only restriction is the semi fixed maturity which prohibits the tenure withdrawal method. This leaves single disbursement, line of credit, term, and modified tenure as feasible options. Compared to traditional reverse finance collateral, real estate, forest offers a desirable property of non-negative compounding value growth which offers a lower cross-over risk in forwardly distributed withdrawal methods. The compounding and non-negative growth of forest ensures that the cross-over risk of short liabilities decrease over time, which is not the case in typical real estate collaterals. This effect of biological growth also reduces the riskiness of capitalized interest, as long as the interest of the loan is smaller than the value growth of biological growth. This is because the cross-over risk of capitalised interest decreases as the collateral value grows faster than the outstanding principle. Therefore, both capitalisation and non-capitalisation products are feasible and capitalisation products could even be promoted in the case of forest equity, compared to real estate.

The rising value of forest estates also make the shared appreciation schemes an interesting option for the lender. However, the premium or compensation of shared appreciation for the borrower should be substantial due to the high probability of the shared appreciation option to expire as in-the-money option[9]. Yet, this does not create a restriction to the usage of shared appreciation. The same is true to third-party and non-negativity-guarantee granted products. However, forest equity lacks short-selling options which hinders the usage of collateral value guarantees. The usage of value guarantees is also made difficult by the nature of forest equity, as the value guarantee is not just guaranteeing a value but guaranteeing profit of timber sale for the borrower. This makes the pricing and risk of guarantees difficult to determine, compared to real estate. Therefore, shared appreciation, third party guarantee and non-negative guarantee are excluded from the examination. This restriction is also maid partially based on the market study of reverse mortgage, as according to the interviews none of the reverse mortgage provides in Finland used derivative nature features in their products.

3.1.2. Forest land as collateral

As highlighted earlier, forest land has three physical characteristics: area, location, and soil composition. These characteristics determine the abstract characteristics of forest land, the biological growth. The biological growth is the underlying factor which creates priceable and capitalizable value to forest equity by accumulating timber. It is important to note that the biological growth's value is derived by the price of timber. Therefore, the value of the estate is derived with the help of timber prices and the estates capability to produce timber i.e., the physical characteristics. This creates a question of what the value of the biological growth is, or in other words, what the true value of the underlying physical characteristics of the estate are.

In general terms there are two schools of thought within the forestry research, forest interest and land interest schools of thoughts, which have a different approach to appreciating and

[9] In-the-money option is an option whose underlying price is above the strike price of the option. (Brealey et al. 2011, s. 513-516)

valuing forest equity. The first school argues that the value of the forest ground is the main driver of forest estate value. In other words, this so called land interest school, argues that as timber cannot exist without the forest ground the expected value of timber growth is inherited from the forest ground. The second school argues the opposite that the main value driver of forest estate is timber present on the forest ground and the expected future value of the value growth should be addressed to the timber. These contradictory arguments are not arbitral as they determine how the forest is valued, what is the value bearing factor in forest and in the case of reverse finance what the underlying collateral of the loan is.

The land-interest school of thought argues that each stand[10] is a separated unit with individual cost and revenue profile, as well as own forest management plan. Therefore, each stand is economically separate from other stands. The land-interest school of thought argues that each stand as its own economic unit has two factors of production, the forest ground and the timber, which form two separatable assets that should be valued separately. Whereas the forest-interest school of thought recognises only one factor of production, the timber. Forest-interest school argues against land-interest with two arguments. Firstly, the land is in use for forestry, thus value for any substitute uses must be zero. (Ahonen 1970, 37-38) Secondly, they argue that the forest cannot grow without forest ground and therefore the two assets are not separatable assets. The second argument means that forest ground enables the growth with varying growth speeds. Therefore, when the forest is valued the goodness of the soil is implicitly valued with the timber. (Viitala 2002; Ahonen 1970, 37) The fundamental question between the two schools of thought is what should direct the value addition of biological growth, timber or forest ground.

Both schools agree on the fact that the biological growth is the underlying value driver, but what is the lender's point of view. What creates the collateral value of the forest equity, timber or biological growth? The land interest school of thought argues that forest equity should be valued firstly by the available timber present on the estate and the value of the forest ground should be added to the present value of the timber to derive the present value of the equity (Nyssönen 1999; Airaksinen 2008). According to Paananen et al. (2009, 47) the forest land school of thought argues that the forest land value is the residual value of the equity after thermal harvest. The residual value is calculated with Faustmans land interest model which is

[10] Stand is a homogeneous area within the forest estate which has homogeneous growth factors, timber reserves, and forest management plan. (Ahonen 1970, 37-38)

the perpetuity value of the cash flows generated by the forest estate. (Paananen et al. 2009, 47) From figure 5 we can see the residual value of the forest ground at year zero where the present value of cash flows of one turnover-time is roughly 2 000 Euros per one hectare. When this value is compared to the timber value in any time point after the first thinning, we can see that the value of forest land is marginal to the overall value of the estate.

Therefore, from the lender's point of view, the forest lands importance to collateral value is marginal. Forestland has also some characteristics which make it less desirable as collateral. Forest estates have a very low liquidity (Ärölä et al. 2019, 43). Liquidity is weakened by forest estates non-transportability which makes the asset truly local. (Linna 2012, 27-32) Forest land has also a very large price variation depending on location and characteristics which increase the risk of the collateral value (Ärölä et al. 2019, 88). In addition to the large variation in price, dependent on location, the value of forest land according to Tilli et al. (2008) is negatively correlated with interest rate level. This increases the interest rate exposure of the lender as both the underlying and the value of future assets depend on interests. Forest estates have also very high transaction costs, which are caused by four percent wealth tax, land registration cost, notary cost, legal document costs, real estate reward, cost of mapping and valuation. (Tilli et al. 2008) According to Virtanen (1992, 19) the forest estate market is far from perfect competition, which decreases the price transparency making the valuation of forest land difficult. However, forest estates also have some positive characteristics like non-producibility, which makes the asset scarce and supports the price through skewness between demand and supply. (Linna 2012, 27-32) The scarceness and skewness of forest estates also support the low volatility of forest estates and steady price development (Tilli et al. 2008).

Due to low value compared to timber and undesired characteristics as collateral, forest land is not considered as a good collateral to reverse forest finance product. Therefore, the value of the forest land is excluded from the determination of the collateral value and regarded as a secondary value. According to the forest interest school of thoughts, the value of the forest land is implicitly priced together with the forest value. Based on the above, the lender has exposure to forest land value even if the forest land value is not considered as part of the collateral value.

3.2. Collateral valuation and collateral value risk

This chapter examines the collateral valuation and the risks concerning collateral value. Collateral value risk, as examined prior in reverse mortgage chapter 2.3.1, consists of valuation risk and price risk. The examination starts by introduction to forest valuation by examining forest valuation approaches and valuation process in the part one. In the second part, the valuation risk of forest equity of the chosen collateral valuation method is examined. Lastly, the price risk of forest equity is examined taking into account risk mitigation tools and restrictions on acceptable estates as collateral.

3.2.1. Valuation of the collateral

As concluded above the biological growth and timber reserves are the only priceable and capitalizable values of forest and forest land value is considered as secondary value to collateral value. The forestry literature refers to these values as forest economic value, which is the basis of forest equity valuation. (Hannelius 2001; Paananen 2009; Viitanen & Falcenback 2014; Airaksinen 2008) However, as one of the key outcomes of the thesis is to determine the collateral value method for forest equity reverse finance instrument, the consideration of feasibility of the forest economic value as collateral value need to be studied in more detail.

According to Hannelius (2001), the question of “what is the true forest economic value”, is a subjective question. This is due the forest economic value is the sum of present value and present value of future cash flows (Hannelius 2001). In the present value of future cash flows the discounting factor used is investor specific required rate of return which mirrors the risk appetite of the investor. (Paananen et al. 2009) This poses a dilemma for valuing as the present value cash flows of forest investments are very sensitive to discount factor due to long maturity mismatch of few discrete cash flows. This forest economic value method depends heavily on the given investors required rate of return. According to Viitanen and Falkenbach (2014), this leads the most of forest valuation methods to determine the fair value of the estate. Fair value is the price at which a responsibility or a possession is transferred between professional willing parties in line with their interests. (Viitanen and Falkenbach 2014) In other words, fair value is an estimate of the market value. According to Viitanen and Falkenbach (2014) market value of estate is the monetary amount at which the estate would be exchanged between willing independent buyer and seller in reasonable time on free markets on a value date after adequate marketing and careful consideration of both parties. It is the seller's interest to sell the estate with the highest price which forms the market value of the estate. As the forest economic usage is the best use with the highest value, the market value of the estate is argued to reflect the forest economic value. (Viitanen and Falkenbach 2014)

According to Paananen et al. (2009), there are two ways to value forest estates: the market based hedonistic approach and the present value of future cash flows which can further be divided into profit method and sum value method. All the models aim to value the forest economic value of the estate either directly from market data in the hedonistic methods or by forestry simulations in cash flow methods. (Holopainen & Viitanen 2009) According to Paananen et al. (2008, 30), the valuation methods can be aligned with the two schools of thoughts. The difference in thought reflects into the valuing method and the way uncertainty is handled in valuation. Forest equity valuation always involves uncertainty which is caused by long-time span of timber turnover rate, uncertainty in initial values, uncertainty of biological growth, environmental uncertainty and initial assumptions of valuation model. The different valuation disciplines highlight different fundamentals in the valuation and thus they yield different values for the plot. (Holopainen & Viitanen 2009, 135-136) This is why it is important to know the valuation reason and choose the right valuation method to comply with the valuation targets. Many scholars also suggest using several different valuation methods concurrently in valuation. (Paananen et al. 2008; Holopainen & Viitanen 2009; Oksanen-Peltola 1994) Following figure summarizes different schools in forest valuation and the method they prefer.

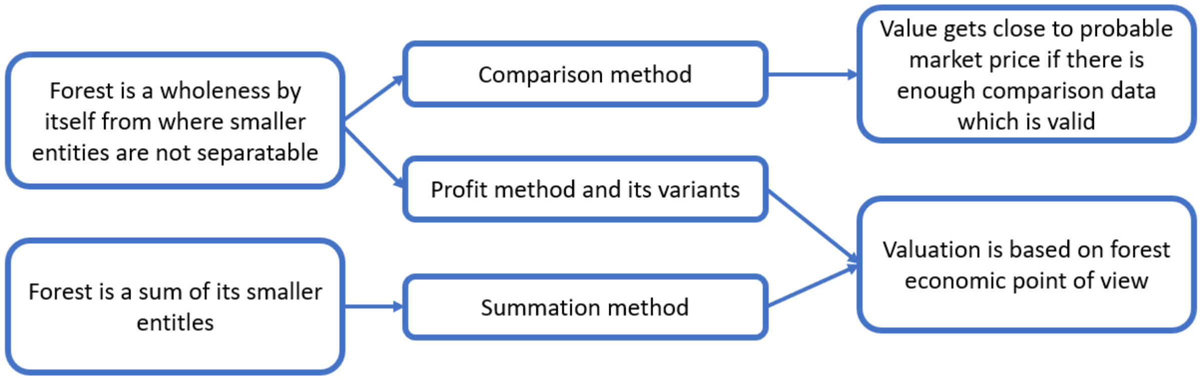

Figure 6 Figure presenting different schools of forest equity valuation and their methods. (Paananen et al. 2009, 30)

The hedonistic models, also known as comparison methods, are based on comparison of estate characteristics to characteristics of recently transacted comparable representative estates. The hedonistic models can be divided into direct and indirect method. The direct methods are used when there is available representative comparison data. The direct methods can be further divided to regression models and simple average models. Indirect models, also known as experience-based comparison, relay more heavily on valuator experience and market knowledge and are used when there is not abundant comparable representative transaction. (Myhrberg 1992; Paananen 2009)

Theoretically as the forest economic value is the highest value of forest then market value should be equal to forest economic value. Thus, the hedonistic models are based on assumption that markets are efficient in valuing forest estates (Paananen et al. 2009). The restriction of comparison methods is the comparison data, which must have similar or close enough characteristics, geographical resemblance and have timely close transaction. (Myhrberg 1992) Hannelius (2000, 39) states that as long as the market stays stable the historical time span of comparability can be extended quite far by calculating the present value of historical market prices. Even though comparison method is the most used method for real estate valuation it is not widely used in the forest equity valuation. The reason for this is the scarcity of comparison data. (Virtanen 2002; Paananen 2009) The majority of scholars agree that comparison methods are not developed enough and the amount of comparable data is not adequate for the comparison methods to be reliable enough for forest estate valuation by themself (Paananen et al. 2009; Hannelius 2001; Viitanen & Falenback 2014; Virtanen 2002).

The compelling characteristics of comparison methods is the usage of realized market data, which reflects the price that the buyers and sellers have agreed. By using the realized market price comparison models can intrinsically take into considerations other values of forest estate beside forest economic value. (Hannelius 2000; Paananen 2009; Kasso 2011) Comparison method also displays the net price of the estate, whereas the profit methods display the gross value of the estate. This means that the valuator does not have to consider the cost of transaction to calculate the fair market value i.e., taxation and transaction costs, which is a desirable characteristic to the lender. (Airaksinen 2008) Viitanen and Falenback (2014) point out also the importance of comparison method following the international valuation standards, which is also required by financial oversite of the lender. The downside of comparison method is the lack of comparable data and plots which do not have a market and thus are not applicable to comparison methods. Another downside is that the values derived from comparison methods outdate quickly as they are not as heavily dependent on the forest state analysis. A restrictive downside of comparison methods is the inability to value the future value of the plot at a future value date and the inability to value plots which do not have markets or representative transactions. (Paananen et al. 2009)

Cash flow methods calculate the forest economic value of a forest estate as the combination of present value of the estate and the present value of future expected cash flows based on simulations of initial values of the estate. (Holopainen and Viitanen 2009; Paananen 2009) Cash flow methods are the most flexible valuation methods, and they can be applied in all valuation cases, even in estates with no markets and with estates with no comparable transactions. (Myhrberg 1992; Paananen 2009) With cash flow methods it is possible to determine the value of ownership, the legal value, or the lost value of some action or event for compensation as well as the fair value of the estate (Hannelius 2001). Paananen et al. (2009) argues that cash flow methods are the only valuation method which has the theoretical background of deriving the true forest economic value. Cash flow methods are not a typical real estate valuation method and it does not feature any market data and differs from international real estate valuation standards. (Holopainen and Viitanen 2009, 139)

Cash flow methods can be divided into two categories of profit methods and the summation method. The main difference between profit method and summation method is the way the forest is seen to accumulate profit. Summation method is based on Faustman's land interest theory which thinks that the trees pay interest to the ground and the ground is the source of the biological growth. This implicitly leads to thinking that the forest must be divided into smaller stands which have a uniform ground composition and timber reserve. Whereas the profit methods argue that the forest can be valued with the help of normal forest[11] (Ilvessalo 1965).

Profit methods can be further divided into cost method, harvest quantity method, and discounted cash flow method. From these methods the cost method and harvest quantity method are special cases of profit methods discounted cash flow. The profit method is a discounted cash flow method where the revenue cash flows from timber sale and subsidies and the cost cash flows

11 Normal forest is a hypothetical forest with uniform distribution of different aged forest, which pays an equal annual interest to the owner called forest interest. (Pesonen & Soimasuo 1998, 44-45)

from operations, management, and other expenses, are discounted to present value and summed up to give the net present value, i.e. the present value of the future cash flows to the owner. (Paananen et al. 2009; Hyytäinen 2007, 29) The profit method can be executed to derive either the net value or gross value of the estate (Airaksinen 2008).

Cost method is a simplified special case of discounted cash flow method. In cost method the revenue cash flows are ignored, and the valuation is based on assumption that a buyer is not willing to pay more than the cost to manufacture the property. This method is used also in real-estate to value highly specialised buildings. The same logic is not implicitly viable for forest equity, as forest estates are scarce and cannot be produced. (Myhrberg 1992; Virtanen 1990, 60) However, Myhrberg (1992) points out that the cost method can be used to saplings and recently planted forest. Recently planted saplings and forest can be seen as investments, and the cost method argues that the buyer is not willing to pay more than the initial investment made. In these cases, cost method can be used, because the harvest matures so far in the future that uncertainty of cash flows is too high and discounting the cash flow is not reasonable over such long-time span. (Myhber 1992, 157-158) Discounting cash flows of samplings systematically derive lower values to estates than observed on the market. (Myhber 1992, 157-158; Paananen 2008). Paananen et al. (2009) argues that estimating future market condition of cost structure and harvest revenue over several decades is not advisable and thus cost method should be used for saplings.

Harvest quantity method is also a simplified discounted cash flow method which counts only the revenue side cash flows ignoring cost. Harvest quantity method is used to estates which have a large proportion of harvest mature timber. The method argues that the estate should be valued only by its harvest mature timber and timber which is soon harvest mature and any value the plot brings after harvesting is considered as excess return. This valuation method does not count the costs of managing the forest and thus is only applicable to low forest maintenance. (Paananen et al. 2009, 29) The method is also not usable in the plots where there is only little or no harvest ready timber, because the method would undervalue the plot compared to market valuation.

Liljeroos (2017, 74-75) argues that the profit method does not have to count in the value of the ground, because the model is based on the biological growth of timber which is directly linked to the goodness of the soil and geographical location. Thus, the difference in biological growth factors intrinsically continues information of heat sum and soil composition. Therefore, the price of the ground is implicitly included in profit valuation method. According to Liljeroos (2017) this is especially true to plots which are scarce in harvest mature timber and less true to plots which have a lot of harvest mature timber. (Liljeroos 2017, 74-75) The lack of ground value also excludes the potential value of separating waterfront plot sectioning, ground soil value et cetera. The drawbacks of profit method are the lack of market price data, accuracy of forest management plan and forest simulations, determination of discounting rate and the lack of forest ground value and its development. (Paananen et al. 2008; Holopainen and Viitanen 2009, 136-138) Due to the lack of market data the model ignores all other values as well as value of the ground and the price development of the ground. This means that the model examines exclusively only the cash flows generated from the ownership of the estate, which are generated from forest economy. (Holopainen & Viitanen 2009, 138)

Summation method is a variation of cash flow methods and the most used valuation method in Finnish markets (Liljeroos 2019, 61; Liljeroos 2017). According to Airaksinen (2008, 31) and Hannelius (2015) summation method is based on Martin Faustman's model of forest ground valuation introduced in 1840 and represents the land-interest school of thought. The reasons why summation method is so well established in Finnish markets is due to its easy and simple utilization. In addition, the method is legalized in property law and through the rulings of the highest court. (Hannelius 2000, 42) Summation method sees the forest as collection of smaller stands which can be valued separately from each other, which deviates summation method from other cash flow methods. The method relies heavily on detached valuation of stands by applying unit cost calculation to count the value for each stand which are summed up to derive the value of the entire estate. (Oksanen-Peltola 1994; Hannelius 2001; Airaksinen 2008; Paananen 2009)

Second major distinction between cash flow methods and summation method is the utilisation of forestry tables, instead of forest simulations. Forestry tables are readily made value tables for stands with given soil composition and timber development class. The values presented in forestry tables are readily discounted to present value. (Oksanen-Peltola 1994, 9) The value of each stand composes of two values, the value of the ground and the value of the timber on the stand. The timber value of each stand is calculated with respect to the dominant timber species and development class. The development classes used in summation method are clear land, saplings, growth timber and harvest mature timber. (Airaksinen 2008, 31; Paananen 2009, 47) The ground is valued with Faustman's model of perennating a single turn over. In the model the biological growth of timber is thought to create a cost to the ground and it is thought to pay rent to the stands which is discounted to present value and then perpetuity. (Hämäläinen 1989, 191) In summation method each stands value is looked up from forestry table and then summed up to summation value. A value correction term is either added to or deducted from this summation value, depending on area and forest region to derive the fair price of the estate. (Holopainen and Viitanen 2009; Paananen 2009; Airaksinen 2008; Airaksinen1998)

The tables are based on historical long-term timber growth, cost and stump price data. (Paananen et al. 2009; Oksanen-Peltola 1994) According to Oksanen-Peltola (1994, 9), the long-term growth study is performed with regular and well managed single aged timber managed by single aged cultivation strategy on mineral soil for each forest area. (Paananen et al. 2009; Oksanen-Peltola 1994, 9; Liljeroos 2017. 62-70) The stump price as well as cost side inputs of forest restocking costs, forest cultivation costs, forest sale expenses, taxation, insurance and forest management cost are taken from forest statistical yearbook. The stump prices are calculated with 10-year averages and the cost side inputs with various averages. Both the stump price and costs are transformed into real terms with wholesale price index. (Oksanen-Peltola 1994, 9)

Saplings can be valued either by cost method, same as in discounted cash flow method, or by forestry tables which are based on the present value of expected future value. (Ahonen 1970, 51) Value of growth timber is calculated as the value of timber at valuation date and the present value of the future value of the timber at terminal logging. The harvest mature timber is valued by harvest quantity method, as in the discounted cash flow method, with the expectation of taking the restocking cost into consideration. (Hämäläinen 1989,19; Paananen 2009, 47; Ahonen 1970, 51)

The forestry tables are mathematically transformed from mineral soil to other soils to address the valuation of diverse soil compositions (Ärölä et al. 2019; Paananen 2009). The valuator needs to use consideration in assimilating the soil compositions which are not included in the forestry charts. (Paananen et al. 2009) The method of calculating or assimilating different soils to mineral soil rises two problems that critics of summation method point out. Firstly, the biological growth can be inflated in poorer soils and secondly, the inflation of biological growth inflates the value of the ground. (Hämäläinen 1989).

Value correction is made to align the summation value with the market value. Value correction is exercised because summation method systematically derives higher values for estates than observed on the market. Theoretically the value correction term is containing characteristics which decrease the value of the plot. (Holopainen and Viitanen 2009; Paananen 2009; Airaksinen 2008; Airaksinen 1998) The main factors to decrease value of the plot are poor forest management, large quantity of sapling and young growth timber, poor soil composition, remote location, poor road access or in other way hard harvest location, small or uneconomical shape. (Ärölä et al. 2019; Oksanen-Peltola 1994) Some scholars argue that the value correction term is needed to compensate the discount rate of forestry tables.

According to Ärölä et al. (2019), the discount rate used in Tapio's forestry table is between 1-4 percent and varies between different soils and forest region (Oksanen-Peltola 1994). Airaksinen (2008), Oksanen-Peltola (1994), Paananen et al. (2009), Hannelius (2001) and Liljeroos (2017) regard the discount rate to be too low compared to required rate of return of forest investors and think that the discount rate is one of the reasons for inflated summation values of estates. The value corrections applied are between 0 percent to minus 40 percent and on average -15 percent to -25 percent (Ärölä et al. 2019; Airaksinen 2008). Ärölä et al. (2019) argues that the value correction should be approximately +/- 20 percent on strands which have harvest mature timber as this would equal the profit tax of forest capital earnings. According to Airaksinen (2008), every organization have their own guidelines on the magnitude and methodology of implementation of the value correction term. This is because there are no guidelines how to perform the value correction. (Airaksinen 2008) Viitanen (2017) argues that based on above the value correction bears subjectivity as the valuators use the best practice of represented organisation, areal knowledge, professional skills and know-how in the determination of value correction.

It is noticable that summation method is designed only for forest economic value and thus any characteristics that affect the value which are not forest economic, such as closeness to population center or summer cottages must be valued separately with other methods. (Ärölä et al. 2019) According to Airaksinen (2008), the fact that summation method displays the gross value of the estate can be a downside in some valuation cases. Ärölä et al. (2019) and Paananen et al. (2009) argue that the heavy reliance to unit costs calculus underestimate the costs for majority of stands. The biological growth models are also based on regularly and well managed estates with singe aged stands on good mineral soil, which rarely is the case for estates on markets (Ärölä et al. 2019; Paananen 2009). Airaksinen (2008) lists the benefits of simplicity of the method, which makes the summation method easy to teach, reason and simple to use. The method does not require only simple calculus which can be done over pen and paper or with any spreadsheet software. The method is also solidified in law. (Airaksinen 2008; Paananen 2009).

To conclude the valuation methods, there are three main method to value forest which all have a different methodology to derive a fair value for forest equity. All the methods have their pros and cons and due to different valuation approaches they value different aspects of forest while ignoring other aspects. Due to this all methods generate slightly different values. As stated, before the collateral value should consist of the present value of ownership of the forest to the borrower i.e., the value of the future cash flows which rise from the forestry. To find a suitable model, the valuation methods need to be compared with each other. However, some scholars have raised concern of the overall trustworthiness of all forest valuation approaches. Oksanen-Peltola (1994) argues that forest valuation is not reliable due to highly theoretical calculation procedures which are difficult to apply in practice, the complexity of forest estates, and multidisciplinary experiences needed in valuation, which put the valuation result under risk of subjective opinion. (Oksanen-Peltola 1994) Regardless of this viewpoint, this study trusts that a fair value of forest can be derived with existing forest equity valuation methods.

Hedonistic models present the aggregated market view of forests economic value if the assumption of rational and perfect markets apply. However, as stated earlier the forest estate market is not perfect. The forest economic value of hedonistic models displays also other than forest economic values and they do not count the future value of the estate, which is also the interest of the lender due to the long maturity of the products. Considering the criticism of inadequate development and shortages of comparison data, the comparison method does not seem feasible to value forests collateral value with restrictions given to it.

This leaves profit and summation method. As the collateral value should be the net value of the forest to the owner, the profit method is the preferred between the two models. Even though the summation value can be converted to net value of forestry by deduction the unit values of forest land of the summation value and by applying the correction term correctly, as Airaksinen (2008) argues, there are other shortcomings in summation method. The accuracy of forestry tables, due to assumptions and restrictions, and the value correction term give the summation method uncertainty, which is not welcomed. Even though, summation values are found to reflect well the market prices of forest estates, the changes required to derive the net forestry value of the estate can increase the uncertainty of the model.

Therefore, the valuation method to value forest's collateral value should be primarily profit method as it is the most flexible and relies solely on the cash flows of forestry and forestry simulations instead of generalized growth extrapolations. However, as many scholars call for utilization of multiple models to derive trustworthy value estimate, a confirmatory method should be utilised (Paananen 2009, 25-26; Airaksinen 2008; Holopainen & Viitanen 2009). The role of confirmatory model is firstly to confirm that the value estimate of profit method is not inflated, and secondly to calculate the secondary values of the estate. As the underlying collateral is to secure the lender capital and the lender can in insolvency situations resort in recover the collateral to cut losses by selling the collateral on markets the hedonistic model or summation model both are suitable to derive the secondary value for the lender.

Besides valuation methodology, Paananen et al. (2009, 26-27) argues that all the valuation methods follow the same generic process which consists of six contingent stages.

1. Determination of valuation time and purpose of valuation
2. Determination which valuation method should be used
3. Gathering of initial values
4. Forest evaluation on site
5. Analysis and calculations from data and recommendations for forest management
6. Reporting and presentation of forest management plan and value

The first step is to determine the valuation purpose and the value date. The value date is the time when the valuation is wanted to be known and answers the question, do we want to have the present value of the forest or an estimate the future value of the estate at some point in time. The purpose of the valuation must be also determined as it effects on the valuation method used. In the second step the valuation method or methods are chosen. (Paananen et al. 2009) According to Airaksinen (2008), the choice is not arbitral nor ideological as some valuation targets can have restriction on which type of valuation method can be utilized. Paananen et al. (2008, 76-77) lists examples of estates which do not have a market like transmission lines and cannot use hedonistic models and estates which have a market but cannot be valued with cash flow methods, like estates close to urban areas.

Gathering initial values and forest evaluation on site start the numerical process of valuation. These two steps can be combined or done separately depending on the data gathering methods used. The gathering of initial values can be done by aerial photography, laser scanning, simulation of previous evaluation values, onsite measurements and estimations, or by combination of previous ones. Even if a distant evaluation is used, a physical evaluation on site must be done by the evaluator. This is because not all characteristics are measurable from distance. The validation of distant evaluation and on-site evaluation must be done by official valuator. The data gathering also includes gathering initial values which do not relate directly to the estate. These can be for example interest rate levels, cost data of forestry and forest ownership, price data of timber, local timber demand and its estimated changes, and gathering of comparison data. Data gathering and evaluation steps are the most important steps made in the forest valuation process as all valuation methods base on availability of accurate data on the state of the plot. (Holopainen & Viitanen 2009, 138; Mäki 2013)

The fifth step concerns the data analysis of the gathered data and the calculation to derive the value. In this step a forest management approaches are mapped and considered as the forest management has a large effect the future biological growth and cash flows. Depending on the evaluation method this step is done by simple spread sheet software or specialized forest simulation programs like MOTTI-program. The data analysis and calculations include forest simulations, cash flow calculations and profitability analysis. Lastly the valuation results are presented and the forest management plan is introduced. Paananen et al. (2009) states that the result of valuation or introduction of forest management plan is not exact truth, and it should be considered more like information to support decision making. Puukkala (1997) suggest that the forest management plan should be updated every ten years. According to Paananen (2018) 60 percent of forest owners have up to date forest management plan.

3.2.2. Collateral value risk

Collateral value risk, also known as anti-selection risk, is the most severe root risk of cross-over risk (Chen et al. 2010). Cross-over risk is the risk that the lender does not receive all the capital and payable interests of the loan. Collateral value risk is the risk that the value of the collateral does not cover the whole amount of principal i.e., withdrawn capital and capitalized interest. (Wang et al. 2008) The collateral value risk consists of valuation risk and price risk. Valuation risk is the risk that the value of the collateral is valued incorrectly, and it is thought to consist of valuation process risk and base risk. Valuation process risk realises when the collateral is valued over its real value. Price risk is the risk in the volatility of the price of the underlying collateral and it is thought to consist of systematic and unsystematic risk (Li et al. 2010). It is important to distinguish that the collateral value risk does not include the value depreciation due to borrower's action, which is counted as borrower risk. This section starts with the examination of valuation risk, in which the valuation process and the uncertainty inherit to valuation is studied. In the second part of this section the price risk of the underlying is examined as well as ways to mitigate the price risk of the collateral.

Valuation risk

According to Kumar et al. et al. (2008), the valuation risk consists of valuation process risk and base risk. Valuation process risk consists of risk concerning the valuing process and human error. Valuation process risk realises as incorrect value estimate for the collateral value. (Kumar et al. et al .2008). Base risk is, according to Li et al. (2010), the risk which arises from the difference of individual estate price and the aggregate price of estates on the market. Base risk is created by the heterogeneity of the underlying product which decreases the price transparency of real commodities. This deterioration of price transparency forces the valuator to estimate the true value of the underlying. Thus, the base risk is created by the uncertainly of the value estimate. (Li et al. 2010)

When real estate and forest equity are compared, real estate is considered as more heterogenic asset as it has a larger number of possible features which inherit heterogeneity which have a higher number of freedoms in heterogenic features. Therefore, forest equity would intrinsically be easier to estimate accurately. However, some scholars like Oksanen-Peltola (1994) state that the valuation of forest is not unequivocally trustworthy. When this discord is compared to real estate valuation accuracy stated by many scholars, one can see that there is much more trust in the real estate valuation methods than in forest equity valuation methods. This finding emphasises the importance of valuation risk in forest equity valuation compared to real estate. To examine the valuation risk, the chosen valuation approach of profit method is examined through Paananen's (2009) six step valuation process.

In the first step the value date and valuation purpose are determined. The value date determines the date to which all cash flows are discounted or forwarded. The purpose of valuation determines which value is to be calculated. The most important value date of the collateral in reverse forest finance product is naturally the granting date of the loan as the granting date the borrower receives the first withdrawal. However, due to the forest equity's cyclical nature of value the lender is also interested in value evolution over the length of the maturity. This is especially important in capitalised interest products where the principal amount is not stable. The valuation purpose is to establish the collateral value of the forest estate. In the second step the preferred valuation method is chosen. Profit method is the preferred method in this study. In this examination we omit the validation valuation methods from the examination.

The third and fourth steps, gathering initial values, starts the numerical process of valuation. The data gathering phase is also critical to the accuracy of the valuation, which translates to the base risk. Forest valuation is only as accurate as the data which it uses. The uncertainty of initial values is imposed by human capacity of the evaluator or by the technical restrictions of automated data gathering in laser scanning and aerial photography. According to Holopainen and Viitanen (2009, 138), the error margin of a on site evaluation is on average +/- 25 percent. The error margin does vary in comparison to how well the forest is managed, what is the average age of the forest and how experienced is the evaluator. (Holopainen & Viitanen 2009, 138) The error margin of laser scanning according to Forest centre is +/- 20percent of the overall volume of timber due to vagueness and technical restriction of the method. (Metsäkeskus 2016) Yet, the overall timber per hectare error is only +/- 3 cubic metres per hectare, average diameter +/- 3 centimetres, average height +/- 2 meters in every development class excluding saplings. The main drawback of laser scanning is the lack of age estimate of the trees which advocates an onsite evaluation. (Metsäkeskus 2016) According to Kangas and Packalen (2018), the accuracy of aerial photography, also known as photogrammetry, is on average 27percent. They argue that the overall estimate of laser scanning and photogrammetry is reduced with the increase of hectares.

Holopainen and Viitanen (2009) state that the minimum error margin is around 16 percent in well surveyed plots. This statement could be interpreted that a good data gathering process will decrease the uncertainty. Therefore, the minimum error margin, 16 percent, could be considered as base risk and the risk proportion exceeding the minimum error margin considered as valuation process risk, around 5-10 percent depending on data gathering method. Holopainen and Viitanen (2009) also illustrate that the error margin is carried from survey to all the estimates derived from the survey. A larger risk than error margin is called a systematic error which will propagate to all estimates made by the survey. (Holopainen & Viitanen 2009) The risk of systematic error translates to human error of the collateral valuation risk.

The fifth step is analysis, calculations and forest management plan. It starts with the creation of forest management plan and forest simulations according to chosen forest cultivation strategy. The forest management plan is a critical component of profit method (Hämäläinen 1989, 198). This is because the forest management plan states the approximated time and the quantity of harvests and forest management operations. The forest management plan estimates the time and quantity of costs and revenues. To tackle the heterogeneity of plots, forest management plan is made to each stand separately for one turn-over. (Hämäläinen 1989, 198) According to Holopainen and Viitanen (2009), the forest management plans can be made reasonably accurate for 20 years. Any simulations of forest growth, timing and quantity of forest management actions and harvests which realise beyond 20 years are to be considered with precaution and should be used as directional. (Holopainen and Viitanen 2009) Therefore, for the reverse forest finance product the validity time of a single forestry plan is sufficient. As the forestry plan includes the growth extrapolation of the estate, the lender is able to calculate the collateral value evolution throughout the maturity of the agreement.

According to Holopainen and Viitanen (2009, 137-138), the forest management plan and forest simulations bring uncertainty into the valuation. Therefore, the forest management plan and forest growth simulations bring additional base risk to the collateral value risk. Holopainen and Viitanen (2009, 137-138) estimate that the forest management plan and the simulation to which the forest management plan is based have a combined margin of error of +/- 15-20 percent. The error margin is due to optimization of harvest, estimation of biological growth which is based on the initial values of forest assessment. (Holopainen & Viitanen 2009, 137-138) Therefore, the combined base risk is approximately +/- 36 percent and the valuation process risk is +/- 5-10 percent depending on the data gathering method. The valuation process risk and human error risk can be mitigated by enhancing the valuation process, but the base risk can never be fully mitigated. It is also important to remember that for lender the risk concerns only the negative side of the uncertainty, as the positive side inflates the collateral value increasing margin of safety whilst the negative side decreases the value decreasing the lender’s margin of safety.

Liljeroos (2017) in contrast does not see the uncertainty of forest simulations as an issue to the accuracy of profit valuation methods. According to Mäkinen and Holopainen (2009, 388), the random error in estimation of biological growth and initial values is smaller than the price risk i.e., the development of forestry costs and price of timber. Hämäläinen (1989, 189) also points out the risk of valuator bias or moral hazard in forest management planning. The executor of forest management plan can have an incentive to arbitrary bring forward harvests to ensure more even harvest schedule or higher present value of cash flows which can lead to inflated value of the plot. (Hämäläinen 1989, 189) However, it is important to remember that if the lender is doing the valuation the moral hazard risk concerning valuation is greatly reduced.

From the forest management plan the valuator gets estimations of future timing and quantity of harvests and forest management according to each stand. The valuator needs to estimate the future price of timber and forest management actions to convert these estimations to cash flows. (Holopainen and Viitanen 2009; Luohtio 2018) Even though the forest management operations are planned for each stand separately, the operations are consolidated into larger loan agreements which are priced. Due to the consolidation, the profit method bypasses the need to utilise unit cost and detached valuation, which increases the accuracy of the valuation method. Several scholars, like Ärölä et al. (2019) and Paananen et al. (2009). Liljeroos (2017, 74), suggest that the cost of forestry and the price of timber should be calculated with present prices or with an average price. This simplification is due to the long maturity of cash flows. He argues that price estimation to such a long time is not reasonable or even possible. (Liljeroos 2017, 74)

Once the cash flows are calculated the valuator needs to decide the discount rate and discount or forward the cash flows accordingly to the value date and summed up. (Ahonen 1971; Äijälä et al. 2014) Paananen et al. (2008, 79) emphasises how important the required rate of return is to profit method. Holopainen and Viitanen (2009, 136) go as far as to state that the determination of required rate of return creates the value to the forest. According to the international valuation standards the discount rate should be in line with the market rates (Kuuluvainen & Valsta 2009). According to Paananen et al. (2009), the discount rate should also reflect the risk of the investment. A good guideline and a comfortable level of required rate of return which is used as discount rate, according to Paananen et al. (2009), Viitanen and Vastan (2009) and Airaksinen (2008), is 3-5 percent in real terms. Using this level of required rate of return gives a value which is close to the market price (Paananen et al. 2008, 79).

Holopainen and Viitanen (2009, 136) as well as Liljeroos (2017) argue that a good guideline to the required rate of return is 2-5 percent in real terms in a long term. Mäkinen and Holopainen (2009) conclude in their study that the uncertainty over the discounting factor is the largest uncertainty concerning profit methods and ill-chosen discount rate can jeopardize the valuation. The determination of discount rate is part of the valuation process risk.

The relationship of risk and discount rate is difficult in forest investment as there is no comparable investment with comparable risk and return on the markets. Hämäläinen (1989, 190) emphasises that the required rate of return is investor specific and is fixed by the views and values of the holder of forest equity. Paananen et al. (2009, 41) advises that the valuation should be done with several required rate of returns to gain insight of the net present values sensitivity to different discount rates. He also encourages to calculate the internal rate of return and to compare it with the required rate of return. (Paananen et al. 2009, 41) However, it could be beneficial to the lender to discount the cash flows with a discount rate greater or equal to the loans interest rate. This is s subject which will be studied in the next chapter in depth.

In addition, the valuator needs to make a decision over whether to include or exclude the value of saplings and recently planted forest. If they are excluded the return from saplings and recently planted forest is considered as excess return and added to the secondary value. In this case the method estimates the value of estate to owner, which was also determined as the applicable collateral value. If the saplings and recently planted forest are calculated into the value, the method estimates the fair price of the forest.

In the last step, the results of the valuation and forest management plan is introduced to decision-making process. In the examination of the valuation process the key findings from risks perspective is the uncertainty of data and estimations. The uncertainty is measured in error margin which is dived into base risk and valuation risk. The base risk of data is +/- 16 percent, and the base risk of estimations of future harvest quantity is +/- 15-20 percent. Thus, the combined base risk of future value estimates is approximately +/- 36 percent. The valuation process risk, depending on the valuation process is +/- 5-10 percent, and is created by the gathering of initial values, and simulation and forestry plan. Other additional risks are created by the determination of discount rate and valuator moral hazard. Both can be mitigated by the choosing qualified the forest valuator entity. On top of these risks there is also the human error risk in all valuation processes which is hard to quantify but it is important to notify.

The base risk is inherent to current technical restrictions and forest growth models, and thus interchangeable from lender's point of view. However, the base risk is smaller with aged forest and forests which historical growth trajectories are known, thus by limiting the collateral value to aged, well managed forest with past forest inventories the base risk can be limited and mitigated. In addition, the utilization of several data gathering methods reduces the uncertainty but adds extra cost. The valuation process risk and human error risk can be reduced by good valuation process and high professional skills.

Price risk

The price risk is a combination of systematic and idiosyncratic risk. (Patric et al. 2014) According to Schoulte et al. (2001), the systematic risk is the risk that the price levels on the aggregate market decrease resulting in decrease in underlying value. Whereas the idiosyncratic risk is the risk that the price development of a single estate diverges from the aggregate market price level development. Due to properties of forest equity, the relationship of systematic risk and profits diverges from conventional risk and return relationship. Forest equity creates value by physically growing sellable goods, timber, and this value is priced by stump price, which as mentioned earlier, is the price of timber minus the costs of harvesting and logistics. The examination of price risk of forest collateral will first examine the systematic risk and then examine the idiosyncratic risk related to forest.

According to Caulfied (1998), 60.5 percent of the value growth of forest equity is due to physical increase of quantity and quality of sellable goods, biological growth, and 33.3 percent of the value growth is due to the increase of timber prices and the rest from the appreciation of the ground value. This value growth mix of forest equity diverges the risk profile of forest equity from many other investments according to Mei, Cultter and Noordewier and Harrison (2001) (2013). They argue that the traditional relationship of expected returns and systematic risk is violated by the biological growth. Yao, Cheng and Mei (2016) agree on this and have proved that forest equity revenues diverge from this traditional assumption.

It is important to note that the systematic risk consists of only by the volatility of timber prices, which is only a part of the profit calculus. This means that the biological growth part of the revenue calculus creates systematic risk-free profit. As the price of timber is quoted as stump price, which has two systematic risks related to it, the volatility of timber price and volatility of costs. The price of timber, according to Airaksinen (2008), is derived from the demand and supply of timber. He argues that of the two market forces demand side has far more pricing power and thus the price of timber is determined solely by the demand. The demand of timber is derived demand from the global demand of lumber and mass products. (Airaksinen 2008) This means that the systematic price component of timber prices is solely determined by global economic activity. The cost side on the other hand consists of capital cost of machinery, labour cost and fuel cost of harvesting and transporting (Airaksinen 2008; Nielsen 2004). A key risk driver of systematic cost risk is inflation. Nonetheless, Lundgren (2005) points out that forest equity is very resilient against inflation as forest has a 1.44 correlation with inflation. Systematic risk of forestry is undiversifiable and impossible to predict (Suominen 2011, 11). However, the unsystematic price risks can be hedged.

A border case of systematic and non-systematic risk is the areal price of timber. Due to the low volume and weight-price ratio of timber and the spoilage duration of pulp wood the timber markets are regionally restricted. This creates demand risk and market structure risk, due to high demand pricing power which is caused by the skewness of demand and supply. (Airaksinen 2008) This risk could realise as lumber company closure which would change the areal market dynamic and timber price areal affecting the collateral value negatively. (Suominen 2003, 68)

The idiosyncratic risk of forest equity consists of two components, environmental and non-environmental risk. Environmental risks, according to Suominen (2001, 11), are unavoidable and they bear predictable uncertainty due to incidence rate. Environmental risk can be mitigated but cannot be fully avoided. Characteristic of environmental risks is that hey bear only loss if realised without the possibility of profit and due to incidence rate can be insured. The environmental risks consist of natural hazards. These environmental risks affect the volume and quality of timber, and on the other hand they can also affect the stump price level on markets if they are severe. The non-environmental price risks are risk that affect the value of single collateral value. (Suominen 2011, 11)

The areal demand and areal timber price risk could be counted as non-environmental idiosyncratic risk, or systematic risk depending on the determination. The same is not true to systematic cost risk. Due to heterogeneity of estates the effect of rising cost attributes is not even between estates, which makes the cost risk also truly idiosyncratic. This is because the logistical distances and harvestability of the estate strain less harvestable estates more than well harvestable estates (Horne 2018). Partially the same can be observed with systematic timber price risk, which exposes the estates to idiosyncratic timber mix risk. Timber mix risk is the risk that the timber price of the species grown decreases while the timber prices of other timber spices increase.

Other non-environmental risks are risks involved in the forestry operations. Forrest management, planning and plan execution were classified as valuation risk, but the forestry operations and their successful execution is a non-environmental risk as the forestry operations affect the quantity and quality of timber. One risk related to forest operations is the liquidity risk of timber. Forest equity is an illiquid asset both in estate trade and timber trade, the prior being more illiquid (Virtanen 1992; Airaksinen 2008; Linna 2012, 29-30). As the collateral is centred around the timber, other values being secondary values, the liquidity risk of timber is one key risk. The low liquidity of timber is due to harvesting restrictions and market mechanism. According to Horne (2018) majority of the timber trades are executed as vertical-trades[12] which decrease the liquidity. A typical vertical-trade can delay two thirds of the estate harvest revenue by two years. A second factor which decreases the liquidity of certain estate is the weather and season restrictions on harvesting. According to Horne (2018), some stands and entire estates are restricted to only winter or summer harvests, and some winter stands can have weather restraints such as ground frost.

With traditional risk measures the price risk of forest i.e., the volatility of timber prices, is low. (Airaksinen 2008) From the appendix 2. the price development of main timber classes can be seen. Nonetheless, in the long term the stub prices can be shown to be very stable compared to many other prices. In real terms stub-prices have stayed stable, which is partially due to decrease in cost side attributes due to automation. (Metsätilastollinen vuosikirja 2011) Linna (2012, 29-30) argues that the timber price risk is not a major risk to forest equity value due the forest ability to store the accumulated value. He argues that as the forest owner can determine the harvest time of the estate, they can delay the harvest to override any short-term unfavourable

[12] A contract over the right to harvest the estate, which is typically valid for two years. Therefore, the estate serves as a living stock for the purchaser. In a typical vertical trade the purchaser pays one third of the estimated harvest value at signing of the contract and the rest, according to actual harvest value, once the estate is harvested. (Horne 2018)

market conditions (Linna 2012, 29-30). However, from lender's point of view this kind of opportunistic behaviour could be difficult to justify as delaying the harvest would mean refinancing the loan or extending maturity of the product. Rantala et al (2017) list the long term timber price risk to be firsly the global demand of timber products and secondly the importation of timber which would affect the suppy of timber.

The environmental risk consists of natural hazards such as fires, storms, snow burden, swells, draughtiness, animals, pests and fungi (Linna 2012, 29-30). The thesis will not go in depth into the non-environmental risks. This is because the environmental risks have characteristics which makes them insurable (Rantala & Pentikäinen 2009, 56). The risk of environmental risk is small but the severity of realised environmental risk can greatly decrease the collateral value or permanently lower the expected value growth of the collateral during maturity. This is why the lender needs to include a covenant which bind the borrower to purchase insurance against environmental risks.

According to Rantala (2018), approximately 30 percent of forest is insured and the number of insured forests has steadily increased from the 90's. The insurance premium is charged according to hectares and location of the estate. The largest and most frequent settlement accumulates from storm settlements. For this thesis, a study into finish forest insurance products was executed to estimate the true cost of forest finance product. All six major Finnish insurance companies, If, Pohjola, Tapiola, Fennia, Turva and Lähivakuutus, offer forest insurance. The insurance policies of each company are very similar. Each company's policy has nearly identical damage coverage, the largest differences are on the determination and amount of compensation.

From the policies two are studied more closely in the thesis which are If's and Pohjola's insurance policies for forest equity. The reason why these two are selected is because they offer the widest coverage, and they are the only two insurance companies which gave a quote of forest insurance on the request. The quote estate is a 10-hectare single aged spruce forest located in Lappeenranta with an average age of 50 years and timber reserves of 220 cubic meters per hectare. Lappeenranta was chosen as the quote estate to reflect the highest price. According to the insurance companies the insurance premium is firstly priced according to the forest accruable land of the estate and the location (IF 2020a; IF 2020b; Turva 2020, Pohjola 2020a; Pohjola 2020b). And according to Lyytikäinen-Saarenmaa and Tomppo (2002) as well as

Annila (1999, 171-177), eastern Finland bears the highest areal risk of natural hazards to forest estates. Thus, it is relatively safe to state that a quote from Lappeenranta, which fulfils the areal restriction of empirical study, reflects also well the highest insurance premium.

The insurance of both companies covers fires, storms, snow, insects, swells, fungi, animals except moose, theft and third-party harm (IF 2020a; IF 2020b; Pohjola 2020a; Pohjola 2020b). The amount of compensation in Pohjola instrument is the maximum monetary damage to the current timber reserves or the maximum compensation amount which is the damaged timber times the insurance timber price which can be chosen to be 16, 23 or 32 Euro per cubic meter (Pohjola 2020 a; Pohjola 2020c). The compensation of If instrument is the maximum of the monetary damage to current timber reserve or the maximum insured amount, added with the lost expected growth return. The lost expected growth return is calculated as the percent value of the current timber value and average age[13]. An exception to this is forest fires which are compensated fully. (IF 2020a; IF 2020b) The minimum annual compensated amount is 15 cubic meters in both insurances, Pohjola having exceptions for smaller than 5-hectare estates (IF2020b; Pohjola 2020a; Pohjola 2020b)

The natural hazards which are not covered by the policies are value depreciation of soil, harm due to combination of air, water or soil, moose damage, rot fungi, damage or harm due to nutrition scarcity, frost, ground frost and damage to conserved areas. (IF 2020b; Pohjola 2020b) In addition, If policy does not cover roundworm damage (IF 2020b). The price of the insurances is 108 and 111 Euro per year for Pohjola and If respectively . From both insurances there are significant, almost 25percent, discount policies available. Both quotes were priced with the lowest deductible which was in both cases 500 Euros. (IF 2020b; Pohjola 2020b; Pohjola 2020c)

If the insurance policies are compared to the environmental risk, we can see that they cover nearly all cases. Vughan (1996, 30) and Rantala (2018) agree that the insurance policies cover well the environmental risks of forest equity. One major environmental risk that the policies do not cover is the risk of moose damage, which is covered by the government (Anila 1999, 171-177). However, it is important to recognise that the Pohjola policy does not cover lost expected

[13] For 25-35 average age 100%, 36-45 average age 50 % and to 46-55 average aged timber 25 % of the current value of the timber. (If)

value, and the If policy covers only partially the lost expected value of the forest. The insurance covers well only the current value of timber, and not the expected value or estate value. It is also important to recognise that the policies cover the actual value of damage only in small damages, due to maximum coverage clauses. Both findings need to be taken into consideration in the reverse mortgage product configurations.

3.1. Borrowers and borrower risk

The borrowers of reverse forest finance instrument are forest owners. According to the restrictions imposed to this thesis the reverse forest finance instrument will be developed to private forest owners. Thus, the forest ownership and private forest owners must be examined. Due to the nature of forest equity markets the owner of forest equity very greatly. For the reverse forest finance product to address the needs of the borrowers three amin forest owner groups will be examined in this chapter. In this section one of the main risk of reverse financing, the borrower risk, will be also examined.

Motivation to examine forest owners rise from the need to understand the borrower segments. This is important as the loan configurations utilized must be in line with borrower need. As will be examined the borrower risks are also borrower segment specific which further highlights the need to understand the ownership structure of forest estates and borrower knowledge.

3.1.1. Forest ownership

In Finland there is approximately 30.5 million hectares of land of which 26.2 million hectares are available to forest economy, excluding urban and conservation areas. After deduction waste land only 20.3 million hectares of forestry land is suitable to forestry and of this land only 91 percent, 18.5 million hectares, is used in forestry. From figure 7 below we can see the ownership distribution of the available forest economic land constructed with staked columns by estate size. Private individuals own majority of the forest land. Private individuals own nearly 60 percent, government owns 26 percent, companies own 8 percent of the forest land, and the rest owned by municipalities and other entities. In the below figure also the proportion of given estate size over all estates is presented by square. (LUKE a 2021)

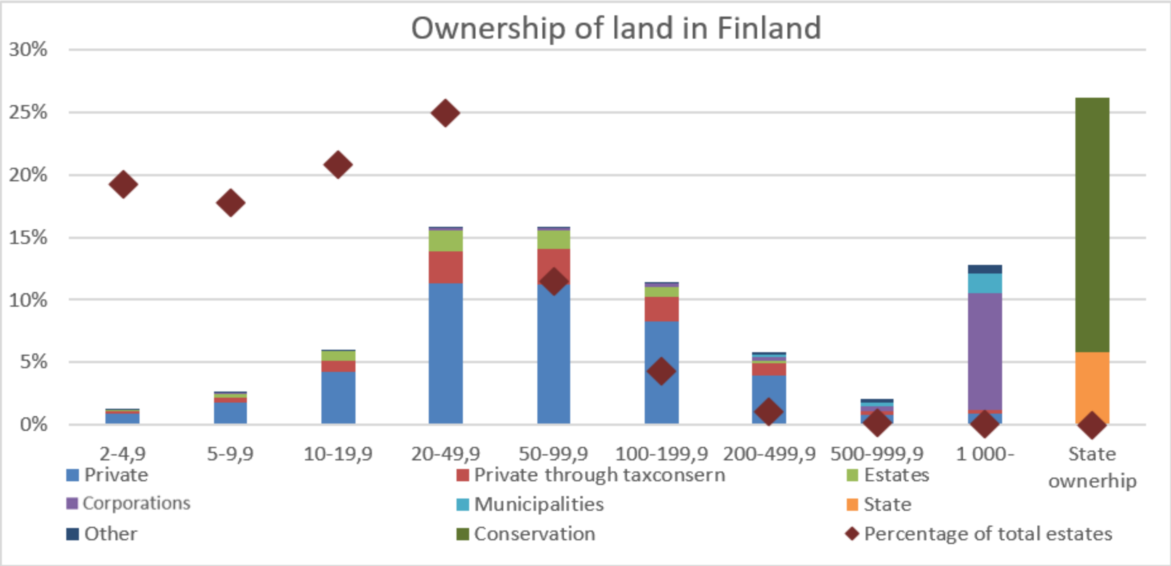

Figure 7 Forest economic land ownership in percent of hectares presented with stacked columns by estate size and the share of given sized estates per amount of estates presented with squares. (LUKE 2021a)

The difference between the staked columns and the squares represents the skewness between the number of estates by given size versus the area in hectares. There is bit over 360,000 estates of which only 0.3 percent are larger than 500 hectares, but these larger estates make up to 41 percent of the land and 21 percent of forestry land. There are also clear changes in the ownership structure at the 500-hectare mark, as the lower spectrum is mainly private individual ownership through individual, estate, or tax concern ownership. And the larger estates which are owned mainly by corporation and public sector. (LUKE a 2021) The preferred segment for reverse forest finance, individuals, directs the study to examine the individuals and their relation to forest equity to understand the borrower base. The study of private forest owners will serve as market study to the reverse forest finance product.

There are approximately 630,000 private individual forest owners. (LUKE a 2021) It is important to note that there are far more private owners than estates owned by private individuals. According to Forest centre (Haapio 2021) only 34 percent of forest owners own at least a single estate entirely. The average size of estate owned by private individuals is approximately 30 hectares (Leppänen & Torvelainen 2015, 7 M). Only 45,000 forest owners own directly over 100 hectares of forest (Haapio 2021). The average age of forest owners is 62, and half of the forest owners are above 65 years. The proportion of senior ownership is even larger as the senior owners are proportionally over presented in estate stakeholders. Senior owners make up to 47 percent of the total forest owners but due to smaller average estate size they own only 41 percent of the forest land. Forest entrepreneurs form 10 percent and agricultural entrepreneurs 5 percent of the forest owners but due to the larger average estate size they own 23 percent of the forest land. Only 10 percent of forest entrepreneurs have forest entrepreneurship as their main form of income. The rest of forest owners are employed individuals, 37 percent, and the rest add up to one percent. (Hänninen et al. 20-24)

One third of forest owners are owner occupiers and one third of forest owners live in the same municipality with their estate, the rest, 40 percent, are so called remote owners. Only 4 percent owns estates in two different municipalities. Over half of the forest owners live in sparsely populated areas, whereas one third of forest owners lived in urban areas. The owner-occupied estates are larger on average and owner-occupiers own on average more estates- They collectively own nearly half of the private forest land. (Hänninen et al. 2020, 20-24) Forest ownership has historically been very family centric as 47 percent of forest owners have inherited their forest (Hänninen 2020, 36). Majority of the forest is also co-owned between family members and only 34 percent of forest owners own at least one estate entirely (Hänninen 2020, 35-36).

Approximately 38 percent of the estates have a residential building, one fifth have other improvements such as cottages and warehouses, and the rest one third of the estates are unbuilt. Forest owners are on average higher educated than the public. A quarter of forest owners have no vocational education, quarter have a lower vocational examination and a quarter has a higher vocational examination of which 80 percent are university degrees. (Hänninen et al. 2020, 20-24) Of the forest owners, 58 percent are men but unproportionally men do forest management decisions in three out of four estates. This means that women outsource forest management to men even in cases where the decision maker is not a stakeholder. It is also typical that the forest management decisions are done by the eldest stakeholder. (Hänninen et al. 2020, 20-24, Haapio 2021) On average men own nearly ten hectares more forest than women. (Haapio 2021) According to Hänninen et al.'s study (2020, 56) forest owners have higher income than non-forest owners, even with timber sale adjustments. According to the study the financial aims of owning forest are financial stability in elderly years, financial resilience against unexpected events, to cover large purchases, continuous revenue from timber sale, inflation hedge, investment and financial leveraging, in decreasing order. (Hänninen et al. 2020, 17)

In Hänninen et al. (2020, 29-30) study, the forest owners are divided into five groups according to their relationship to forest. These groups describe the owner's relationship to the estate and the primary usage of the estate. One quarter of forest owners are multipurpose owners who grouped into financial users and to recreational users, one fifth of the forest owners describe themselves as recreational users and to financial users respectively. One tenth are described passive forest owners. From these groups multipurpose and financial users owned proportionally larger estates than the rest. An interesting finding in the study is that there is not much difference in the logging accrual between the recreational, passive or financial users measured in cubic metres per year. However, recreational users tend to harvest less timber per hectare than the financial users. (Hänninen 2020, 29-30) This suggest that there are differences in forest management approach. In Hänninen et al. study (2020, 4547), the remote owners tend to do more extensive harvest per hectare, whereas the senior owners tend to postpone harvests and do less-intensive harvests. The harvest is on average more excessive in smaller estates compared to larger estates, but the average quantities of harvest is bigger in the larger estates. (Hänninen et al. 2020, 45-47)

The ownership structure of forest equity is going through its biggest change after the land reform of independence. (Ärölä et al. 2019) This ownership change in forest estates is supported by big trends such as ageing forest owners, increasing interest toward forest as an investment asset, decrease of proportion of farmers and one estate occupants. (Hänninen 2018, 23-28) The ageing forest owners is the biggest megatrend in forest ownership. The high proportion of estate ownership of forestland is a clear signal of this structural trend. (Hänninen et al. 2020, 48; Hänninen 2018, 23-28). The amount of senior forest owners has risen from 30 percent to 50 percent in last 30 years. At the same time there has been a decrease of 60 percent in forest and agricultural entrepreneurship and the amount of owner occupants has decreased from 50 percent to 35 percent. This change can be seen also in the increase of remote-ownership and urban owners. (Hänninen et al. 2020, 37-38; Hänninen 2018, 23-28) The rate of change will be likely to increase as owners who live close to the estate have an average age of 72 years (Hänninen et al. 2020, 26; Hänninen 2018, 23-28). The relationship towards forest is also changing more to financial usage in the expense of multipurpose and recreational usage. (Hänninen et al. 2020, 41; Ärölä et al. 2019) The rising financial perspective can be seen also in the rising numbers of corporate owners and corporate ownership of forest land. There is also increased interest toward forest equity from hedge funds, cooperative societies and corporations who have been increasing their share in ownership from early1990’s till this day. (Tilli 2009)

3.1.2. Borrower segments and borrower specific risk

From the market analysis there can observed three main borrower segments: forest entrepreneurs, owners, and owner-occupiers. The owner-occupiers are considered to consist of both true owner-occupiers and owners who have a vocational property on the estate, i.e. owners that have a secondary usage to the estate than forestry. The thesis will only concentrate to the financial or partly financial users of forest. Reverse finance product is a product which is designed to free up capital from investments and the borrower can also be segmented by the usage of the loan. The usage of the loan can be divided into consumption loans, which are used to cover living expenses; investment loans, which are withdrawn to increase return of capital; and livelihood loans, which are withdrawn by forest entrepreneurs as a form of continuous income from forestry.

Investment loans are loans which enable the investor to withdrawal capital to other investment. The aim of this loan can be to increase the return on capital, increase the leverage or increase the diversity portfolio. Reverse forest finance product could be used to enhance return on capital in cases where the investors required rate of return is higher than what is typically considered as a good forest return. For instance, if the investor has a return of capital requirement of 6 percent and the forest yields on average 4-5 percent in the late growth development class the investor could withdraw some of the capital to fulfil the required capital return requirement.

Livelihood loan is a loan which is raised by forestry entrepreneur. Some forest entrepreneurs can face liquidity problems driven from the maturity mismatch typical to forest equity when they try to match short term forestry costs and living costs with long term revenue of forest equity. Reverse forest finance production could offer a solution to match the short-term payables and long-term revenues by forwarding the cash flow.

The risk concerning the borrower was called in the reverse finance theory as occupant risk. The occupant risk consists of: longevity risk that the borrower lives longer than the planned maturity of the product; adverse selection risk of hidden information of health and collateral condition;

mobility risk the risk of pre-emanate maturity due to event which terminates the loan agreement; moral hazard risk that the borrower does not maintain the collateral or neglects the collateral or borrower's responsibilities; and default risk which is the risk that the borrower cannot manage the payments of the loan or cannot cover living expenses due to the loan.

Due to the fixed maturity and general nature of reverse forest finance product there is no longevity risk. This is because there is no guarantee of occupancy or flexible maturity in the product. However, as discussed in the previous section there is liquidity risk in timber and estate markets. This liquidity risk could be parallelized with longevity risk, as in the worst-case scenario the lender could be forced to wait years for favourable weather or season for harvest. This risk can be minimized by utilizing aquation trade, vertical-trade covenants and restriction the qualifiable estates for the loan. Longevity risk is described as the main occupant risk. Another risks which could be argued to have less impact on reverse forest finance product is adverse selection risk. This is because forest could be considered to bear less hidden information, even the owner of the forest estate could have a slight information advantage. Since forest valuation is very specific since it is arguable that not nearly all forest owners have hidden information of the true value of the forest. There can also be hidden areal market information but the degree of asymmetry of areal timber or forest estate markets between the lender and borrower is unimportant.

The three main borrower risks in reverse forest finance products are mobility risk, moral hazard risk and default risk. The mobility risk of forest equity could be argued to be smaller or equal than in reverse mortgage. Mobility risk rises from three events, refinancing, change of ownership and pre-eminent thermal harvest. The prevalence of the three events is nearly impossible to estimate but by understanding the causes of the events some comparison may be done. In the event of refinancing, the risk could be argued to be larger as the interest premium of reverse forest finance instrument is larger than in reverse mortgage. Higher interest enables larger interest spread between loan interest and market interests. In addition, the forest equity holders could be argued to be more rational and more proactive in financial decisions, as they are higher educated and have more capital.

The risk of ownership changes rises from borrower descending or inheritance and secondary from selloffs of collateral estates. When the age distribution of forest owners is compared to real estate owners, the risk seems higher., When taking into account the primary usage of reverse mortgage, one could argue that the risk is equal. As forest is mainly inherited with representative forest estates being very illiquid and seldom traded the risk of borrower selling the estate is quite low compared to real estates, where inheritance and moving out of the estate results in realising the holding.

The risk of pre-eminent harvest, moral hazard and default risk are related. The risk of re-emanate harvest in reverse forest finance relates to the risk of selling the collateral. The causes for pre-eminent harvest are either borrowers need to realise the investment to obtain cash flow or capital, or a change on borrowers required rate of return. Borrower's insolvency or financial state could lead to liquidity problems or Borrower's need release capital. The risk of either is hard to estimate in relative terms. As Hänninen et al. (2020, 56) found in his study the income of forest owners is larger than the average population, which implicitly lead to greater resiliency against financial stress.

The pre-eminent harvest, without informing the lender, is also a special moral hazard risks of forest equity. Previously the forest pledge law mandated the timber purchaser to verify that the timber seller has the right to sell the timber and the purchaser beard risk in the case that the seller didn't have the right to sell the timber. However, due to the law reform (Laki metsälain muuttamisesta 1085/2013) the purchaser does no longer bear risk in the transaction. This increases the probability of moral hazard of pre-eminent timber sale risk. A milder version of the moral hazard is minor harvest which the borrower could execute in order to harvest firewood and single high value trees. However, when the moral hazard of reverse forest finance is compared to the moral hazard of reverse mortgage, it could be argued to be smaller. This is because forest equity is far less active form of capital, as forest equity does not require periodic or preventive maintenance to retain value, which is one of the key moral hazard risks in reverse mortgage the maintenance risk.

The moral hazard risk can be mitigated by choosing remote owners who are less likely to execute the so called milder moral hazards. Another way could be regular auditing of the forest estate. However, auditing is expensive. Luckily, advances in remote forest auditing like laser scanning and aerial photography could lower the cost and enable a low cot distant auditing possibility to the lender. A third way to mitigate the severity of moral hazard is collateral pricing. Limiting the collateral value to consist only the harvest mature timber and omitting all secondary values, value of other timber classes, waterfront value, value of buildings and other value from collateral value. In addition, by selecting estates with high secondary values the lender could reduce the severity of moral hazard.

4. REVERSE FOREST FINANCE PRODUCT

In this section the reverse forest finance product models are developed, presented and examined. In general terms the exploration and development of reverse finance product is conducted through an exclusion process of identifying and evaluating various risks in which key risks for the finance sector and forest owners are identified. This chapter consists of four sections. The first section presents the findings of applicable product configurations and applied loan covenants as well as restrictions on borrower and collateral are summarized and examined further. In this section, the risk of related to the product are examined further and adjusted into loan-to-value ratio. The second section examines the interest rate risk of reverse forest finance product. The third section introduces the reverse forest finance products and examines results of restricted product simulation. The aim of the restricted model examination is to further narrow the product range. The restricted model includes restrictions on loan maturity, interest conditions and borrower behaviour to enable the study of product mechanics efficiently. The fourth part examines the selected products and selected on the basis of restricted model with an unrestricted Monte Carlo simulation to enable an in-depth examination of applicable products.

The examination of the applicable products will be done in respect to lender's and borrower's risk and borrower satisfaction. Borrower satisfaction is measure in fulfilment of product cash flow need and the cost of capital. The lender's risk is measured in cross-over and default risk. The lender is assumed to have risk adverse preferences. This risk adverse behaviours boundaries include an assumption that the lender will not enter a loan agreement which has a sure cross-over risk. Other lender's and borrower's risk adverse bounds are not disclosed.

4.1. Configurations and risk adjustments to loan-to-value ratio

This section of the chapter will discuss the configurations, covenants, and restrictions as well as key parameters of reverse forest finance instrument. In this section the configurations found in the previous chapters are summarised and the rest of the configurations, which were not yet examined will be explored. In addition, the restrictions of collateral and borrower are summarised. The framework of the relationship between estate value, collateral value, maximum claim amount, initial principal limit and net principal limit are presented and examined. The chapter also defines and estimates other key parameters of the model, such as timber prices, direct and indirect costs of the product as well as interest margins.

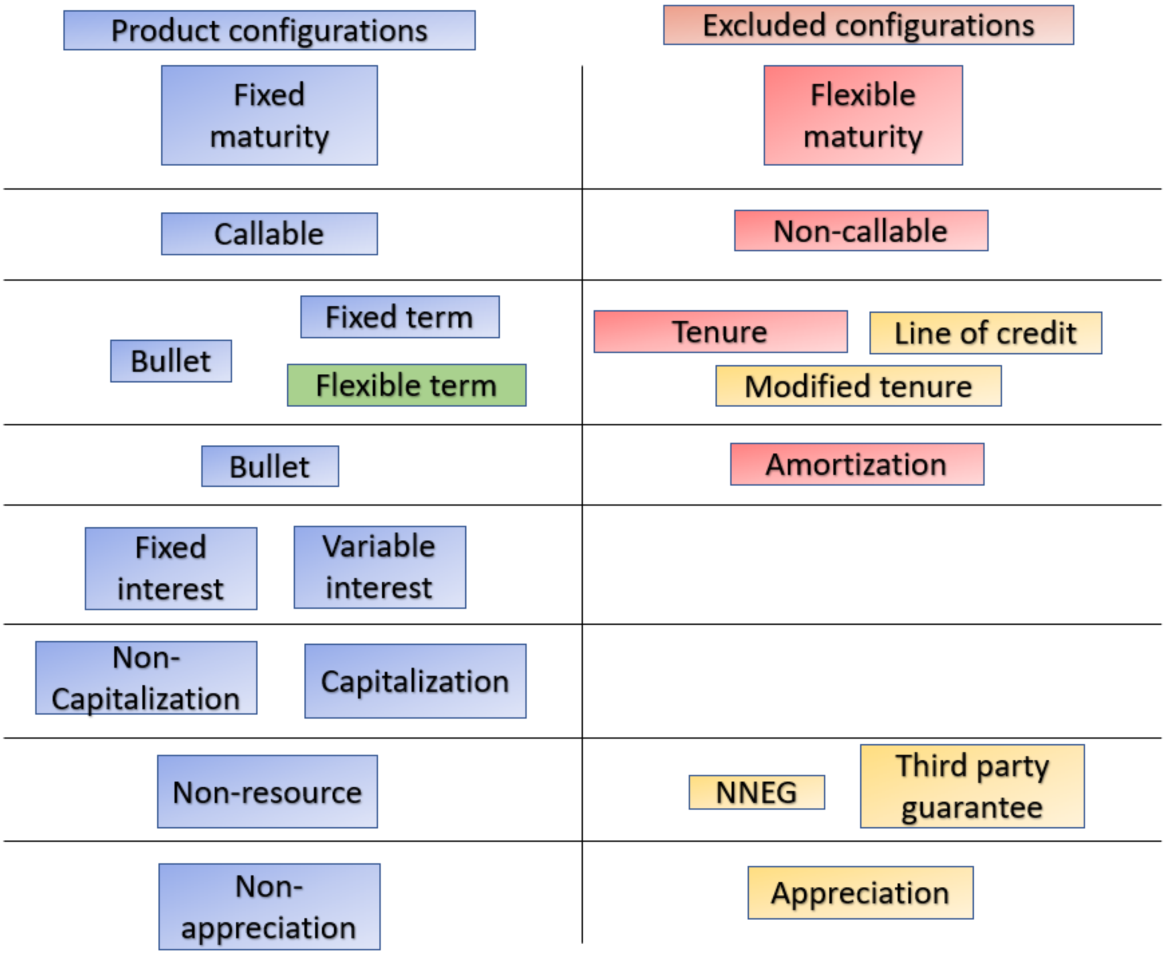

Figure 8 Applicable product configurations.

In the above figure, the product configurations found in literature are summarised. The left side of the figure presents the configurations under examination. The blue configurations are configurations which are found in the literature review and have been found to be applicable to forest equity. The green configuration of flexible term product is a configuration which is not found from literature but is found to be applicable to forest equity. The right side of the figure presents configurations found in the literature review which are excluded from the examination. The red configurations are configurations which were found inapplicable to forest equity and the yellow configurations are configurations which are possibly applicable but are excluded from the examination. From the figure 8 we can see that the amount of configuration combinations is reduced to ten possible products, as the flexible term product is only applicable in non-capitalization loan agreements. These ten products under examination are separated into three instruments, with respect to the withdrawal method, bullet instruments, fixed-term instruments, and flexible-term instruments.

All instruments have a fixed maturity, to which a slip will be introduced in this chapter. Restricted model will have strictly fixed maturity and a loan duration of 17 years. All instruments are callable which is mandated by the Finnish consumer loan regulation, which ensures the borrower's right to pay back the loan pre-eminent any time (FCCA 2021). This means that the lender is forced to bear refinancing risk. However, the restricted model will not have the risk of pre-eminent maturity. The risk and the effects of pre-eminent maturity caused by refinancing, pre-emanant termination due to borrower's action such as violation of covenant and pre-eminent harvest, will be studied further with the unrestricted model. All three instruments have the option to be issued with variable or fixed interest and with or without capitalization. The restricted and unrestricted models both lack derivative nature and the borrower's decision over the withdrawal schedule and amount during the maturity of the product.

Reverse forest finance, as described earlier, is a bullet repayment loan which initial plan of repayment method is the usage of the ownership of the forest estate to reimbursee the loan. In the previous chapter, the value creation and the value bearing of different aspects of forest was studied and based on the study the best suited collateral value for the lender is the timber. To be more precise, the present value of timber which will be harvestable at the end of the loan agreement. Therefore, the reimbursement of the reverse forest finance instruments relies on cash flow of timber sale, which is the primary collateral value. The primary collateral value will be referred simply as collateral value. Therefore, the maximum claim amount of the loan is calculated from the timber value. Other values of the estate called secondary collateral value or secondary values of the present value of expected value growth and the secondary values such as, waterfront value, ground material value, value of saplings, value of young growth forest, value of forest ground, other direct values, all indirect values, and all passive values, are deducted from the estate value to calculate the collateral value. It is important to note that the collateral value is not exact as it is only a forest economic estimate. Therefore, the collateral value bears uncertainty which needs to be taken into consideration while calculating the maximum claim amount.

The maximum claim amount is calculated by deducting uncertainty and environmental risk exposure from the collateral value. The deduction is calculated as percent of the collateral value. The deducted percent is calculated as the sum of base risk and valuation process risk. The combined error margin of base risk, error margin of data +/- 16 percent, and valuation process risks, +/- 5-10 percent, is at highest +/- 24.4 percent depending on valuation process. The environmental risks, natural hazards, are mitigated by enforcing a covenant of mandatory forest insurance. However, the forest insurance does not cover fully the value decrease of the estate in most severe losses, which forces the lender to reduce the maximum claim amount to the maximum insurance compensation. In the case of the Pohjola insurance, this amount is the timber quantity priced with 32 Euro per cubic meter. Therefore, the resulting maximum claim amount of the loan is the valuation risk adjusted amount of timber priced with the maximum insurance compensation. Pohjola insurance will be used as the pricing information in the product simulation. Pohjola's forest insurance terms fits best together with the need of reverse forest finance.

As the loan's maturity is known, the initial principal limit is equal to the maximum claim amount in the non-capitalisation instrument. However, in the capitalisation instrument the lender needs to count the additional risk of uncertain and increasing principal amount. Therefore, in the capitalisation instrument the lender needs to deduct estimate of the capitalised amount of interest from the maximum claim amount. Yet, as examined in the previous chapter 3.1.1. the value development of forest estate is reasonably predictable and grows non-negatively compounding. As the value of the collateral and principal of the capitalisation instrument increase in parallel to each other, the expected value growth of the forest estate can be taken into consideration in the deduction between maximum claim amount and initial principal limit in the capitalization instrument.

The deduction of additional risk of capitalised interest can be calculated by subtracting the estimated capitalised amount of interest from collateral value of expected growth. The collateral value of expected growth is risk adjusted expected value growth of the harvestable timber at the maturity on the estate. The risk adjusted expected value growth of timber, which will be harvestable at the maturity, is calculated by deducting the secondary values, present value of timber, base risk of both valuation and forest simulations, and valuation process risk from the forest economic value estimate. The combined base and valuation risk i.e., base risk of data and simulation and valuation process risk, is between +/- 32 to 40 percent. In the examination, +/-

40 percent risk adjustment will be used. From this risk adjusted timber quantity the maximum insured amount will be calculated to derive the lender's estimate for collateral value of expected value growth. In a case that the subtraction of estimated capitalised interest and collateral value of expected value growth is negative, the initial principal amount will be the maximum claim amount deducted with the result of the additional risk of capitalised interest. The net principal limit is calculated from the initial principal limit by subtracting the direct costs of the loan from the initial principal limit.

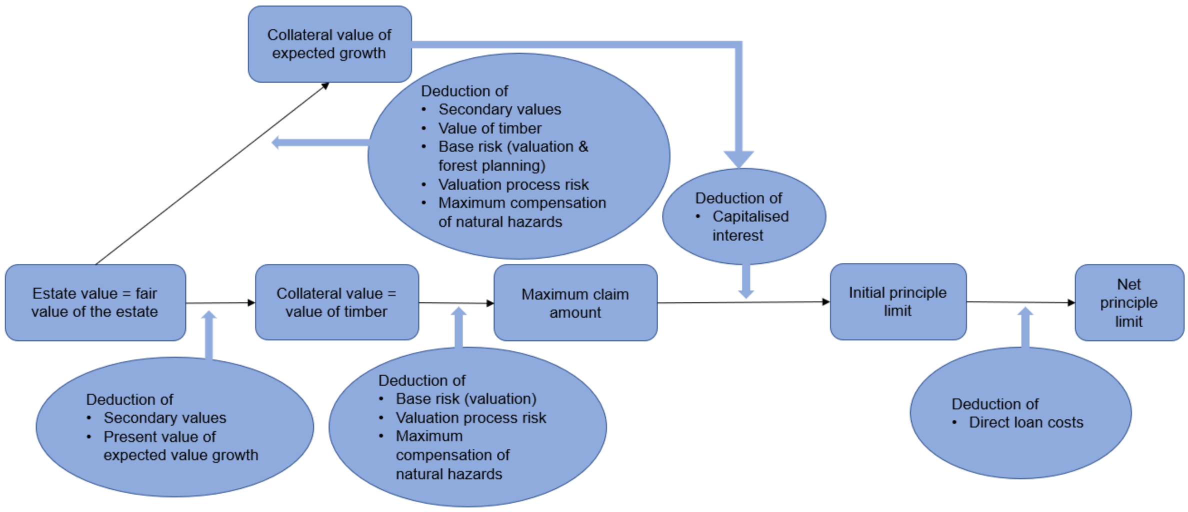

Figure 9 Determination of loan-to-value ratios of reverse forest finance product.

The reverse forest finance product has two important loan-to-value ratios, the loan-to-primary collateral value ratio and the loan-to-secondary collateral value ratio. The primary collateral value being the environmental risk adjusted value of present timber and future timber growth and the secondary collateral value being the fair value of the estate. Even though the lender regards the collateral value to be only the primary value of the estate the whole estate is held as collateral i.e., the lender has a claim to the fair value of the estate. Therefore, the loan risk can be measured both respect to the primary collateral value, the value which the lender can obtain from the cash flows of forestry, and with respect to the fair estate value, which the lender can obtain by the takeover of the whole estate. Therefore, compared to a traditional reverse mortgage the lender has an extra layer of buffer in case of insolvency of the borrower. The relationship of estimated fair value of the estate, calculated as present timber value and discounted value of future cash flow with 3 percent discount rate, and the adjusted maximum claim amount of present timber value and expected value growth are presented in figure 10 below.

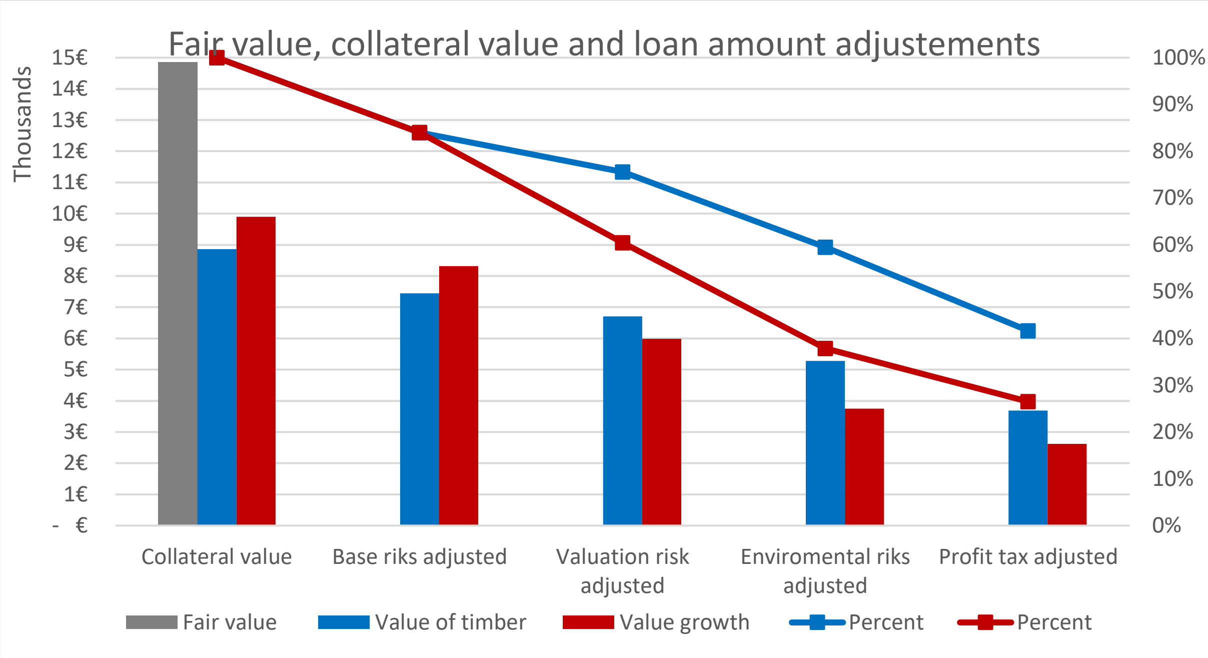

Figure 10 The relationship of collateral and principal amounts and their adjustments on hypothetical estate to illustrate the relations ship of adjustments. Values in nominal terms. Present value of timber and expected nominal value of future growth are presented also as percent with collateral value estimate as 100 percent.

Loan-to-value ratio is a key indicator of the cross-over risk of reverse mortgage product. To better understand the riskiness of the product, risk adjustments and risk which are not adjusted in the loan-to-collateral value ratio by the calculation of maximum principal limit, need to be studied. In the determination of the maximum principal limit and initial principal limit the uncertainty inherent to forest valuation, base risk and valuation risk, and the risk of natural hazards was taken into consideration. Therefore, the risks which are not adjusted are valuation risks of human error and valuator moral hazard; systematic and idiosyncratic price risk, which is the combination of timber price risk and cost risk; long term liquidity risk, risk of areal demand; short term liquidity risk, harvestability and timber sale settlement period; and borrower risk, which consists of moral hazard, pre-eminent termination risks and default risk. The risk of pre-eminent termination does not affect the cross-over risk in a negative way, and thus can be sided for now. Also, the systematic price and cost risk are unavoidable as examined earlier and thus sided for now.

Nevertheless, other risks can be mitigated by loan terms, conditions and covenants. The idiosyncratic part of price and cost risk, as well as the long-term and short-term liquidity risk, can be mitigated by restricting the set of eligible estates by areal and estate characteristic restrictions. The human error of valuation risk can be mitigated by valuation process development. The moral hazard of valuator can be mitigated by auditing valuations or by lender's in-house-valuation. Borrower related risks can be mitigated by restricting the set of eligible borrowers. The restrictions of the estate and borrower are presented in below table two. It is important to recognise that even if risk is mitigated it cannot be fully avoided. Other means to mitigate the borrower specific risks, default risk and moral hazard, is to increase the interest rate to cover the potential losses of realised borrower specific risk within a portfolio of reverse forest finance products. The borrower specific risk premium of interest will be studied later in the next section with interest rate risk.

Table 2 Restriction on eligible estates and borrowers

Collateral restrictions	Borrowers restrictions
• Large quantity of growth forest and harvest ready timber • Good harvestability and logistically well positioned • No weather restraints on harvesting • Areal sub market is stable and demand does not relay on one factory	• Solvent & can cover living expenses despite interest, direct and indirect costs of the loan • No historical insolvencies • Has also other sources of wealth

The price and cost risk, both systematic and idiosyncratic, can be measured by cross-over risk i.e., amount of price deviation from current valuation price which will put the loan into cross-over risk. Therefore, the timber price utilized in valuation must be decided. The separation of cost and price risk will be ignored in this study as the cost component of stump price is difficult to estimate due to lack of available data and the variability of cost with relation to the estate. Therefore, the timber price used in the study will be stump price. The price estimate for timber used in this study is the ten-year average of monthly average stump price index, which is the weighted average stump price of all monthly timber trades on the aggregate market. The ten-year average log price is 56.91 Euros per cubic meter and pulp price is 18.15 Euros pe cubic meter for spruce, which will be used in this study. The standard deviation of the prices is 10.2 and 1.2 Euros for log and pulp wood respectively. A figure of the monthly weighted average timber price index and price indicates of hard log wood price and pulp price in Nordic harbours can be found form the appendix 2.

As the collateral value is priced with the insurance maximum compensation price of timber, 32 Euros per cubic meter, we can see that the natural hazard adjustment also adjusts the timber price risk. When the amount of systematic price risk is quantified by calculating the price drop needed for the product to fall in cross-over risk, the log price should decrease by nearly 9 standard deviations and the pulp wood price to decrease bit over 15 standard deviations. This drop would translate to a price drop of 40 percent in log for the value of the estate to drop under the initial principal limit. The largest deviation from 10-year average price occurred in 2008 financial crises when the timber price fell 15-20 percent depending on the timber class. The idiosyncratic price risk could be quantified similarly. However, the effect of drastic drop in areal demand to areal timber prices, which is the most severe form of idiosyncratic price risk, is hard to quantify. One indication of this could be to examine the price difference in timber between low demand area such as Northern and Southern Finland which have a 15-20 percent difference in log timber and 5-20 percent difference in pulp wood prices depending on timber species. (LUKE b 2021) Even if this idiosyncratic price risk is taken into consideration, it is rather safe to argue that with collateral pricing of 35 Euros per cubic meter the lender bears minimum price risk of timber. Nonetheless, the volume of timber trade dropped significantly during the 2008 financial crises, which translates to systematic liquidity risk. The restricted model will utilize the ten-year average timber prices, whereas the unrestricted model will simulate the variation of timber prices and idiosyncratic risk.

Human error in valuation and moral hazard of valuator as well as the default risk and moral hazards of borrower are challenging to quantify. Therefore, the risk of these events is approached by quantifying the amount of total buffer of the lender. The maximum claim amount of present timber value is 37 percent of the estimated fair value of the estate, 60 percent of the present timber value, and 79 percent of the present valuation risk adjusted timber value. Whereas the maximum claim amount of expected value growth of timber is 32 percent of the estimated estate fair value, 51 percent of the collateral value, and 57 percent of the present valuation risk adjusted present value of expected value growth. Together the maximum claim amount of the timber value, both present timber and expected growth, is 69 percent of the estimated estate value, 55 percent of collateral value, and 73 percent of the valuation risk adjusted value of timber.

Therefore, the existing margin between the maximum claim amount and both fair value and adjusted collateral value is large. The large buffer and the low volatility of timber prices allows several risks to realise simultaneously without the reverse forest finance instrument to fall into cross-over. In addition, it is also important to remember that the uncertainty of valuation and simulations is into both positive and negative. For lender, the risk realises only if the variation is negative from true value, whereas a positive variation from true value increases the collateral value. However, a severe moral hazard of the borrower would automatically put the product into cross-over. Therefore, the eligible borrowers are required to have additional wealth on top of forest equity. Also, the realization of natural hazard and other risk, excluded the maximum claim amount adjusted, would result into cross-over. This is because the adjustment of natural hazards is not over adjusted. It is also important to note that all the unadjusted risks are at least partially or fully covered by secondary estate value. Therefore, the lender can mitigate these risks by selecting estates with large secondary value. Nevertheless, all risks are impossible to avoid and risk of the instrument is a precondition for the lender to obtain revenue from the product.

A special note must be given to default risk of the borrower of the unadjusted risks. The forest profits obtained from timber sale and insurance compensation revenue are taxable. Profit from forest estate is subject to 30 percent profit tax when the total annual profits are under 30,000 Euros, and 34 percent when the annual profits exceed 30,000. The cash flow impact of profit tax can jeopardise the borrower’s solvency at maturity. In the figure 10, the profit tax adjustment of 34 percent is shown. However, in the models profit tax is not adjusted from the principal limits. The reasoning is that each borrower will have their own acquisition cost or presumption acquisition cost, other capital income and cost which will affect the payable profit tax. In addition, the interest costs of the reverse finance product which are tax deductible if used for investment activities. Furthermore, the amount of profit tax would be an estimate of a 10 to 20 year ahead the single year tax burden. Consequently, the uncertainty and vagueness of the tax burden estimate is not advisable. Nevertheless, from the risk point of view, the acknowledgement of insolvency risk due to profit tax burden is important to note. The lender has also a moral responsibility to ensure borrower’s solvency to other mandatory expenses. In Finland, the forest law (Metsälaki 1093/1993) mandates that once a stand is harvested the owner of the stand needs to replant the forest. The average replanting cost of forest is depending on the replanting strategy, stand properties as well as the location of the stand. These costs vary between few hundred to few thousand per hectare. According to Äijälä (2014) a good mean value for an average stand is 1,400 Euros. The cheapest way is stand tree planting in which stand trees are left to the forest to re-seed the new three population. Consequently, this then lowers the terminal harvest quantity thus reducing cash flow at maturity.

Liquidity risks are the only risk which cannot be prevented. The short-term liquidity risk can be adjusted with the help of slip period and slip period interest. Whilst the long-term liquidity risk can be mitigated only considering the timber mix of the estate, harvestability, and the areal submarket and its future market development at the estate location. Slip period is a period of four years, starting two years prior the maturity and extending two years after the maturity of the instrument. Four years was chosen as a slip period because the average settlement period in vertical-trades is three quarters and the typical vertical harvest contract is valid for two years. During the slip time the borrower can reimburse the loan without any extra costs. The borrower can also extend the maturity of the product into the positive slip period without any other consequences than the slip period interest. Slip period interest will be added to the loan interest and charged from unreimbursed capital after the maturity of the product. After the slip period, the lender has the right to take over the collateral or estate if the lender chooses so or continue charging the elevated interest of agreed interest plus slip interest.

4.2. Interest rate risk of reverse forest finance product

As examined in the reverse mortgage section the interest rate risk is a business risk, which means that it bears uncertain positive or negative result which is deliberately taken by the lender (Suominen 2011, 10-11). Interest rate risk diverges from other risks as interest rate risk is unsymmetrical between the borrower and lender, which means that once gain is the counterparts loss. Unlike other risks the bearer of interest rate risk can, to some extent, be decided upon fixed-variable interest decision. The interest rate risk consists of value risk, the sensitivity of real value of future cash flows with respect to interest rate changes; cross-over risk, risk that the payable principal grows larger than the underlying asset due to compounding in capitalisation products; default risk; risk that the borrower does not have the solvency to meet the interest payables which have increased due to increase in base interest; and underlying value risk, which is the risk embedded in the correlation of underlying value and interest rates.

The risk of underlying value can be ignored in the case of forest. This is because according to Lundgren (2005) and several other scholars, whose opinions can be found in the chapter 3.2.2, forest equity's correlation with inflation is strongly positive, which is not the case with real estate. Therefore, rising inflation, which usually is the case in high interest level environment, increases rather than decreases the value of forest equity. Consequently, where rising inflation is a risk to reverse mortgage lender it is welcomed by reverse forest lender, in terms of collateral value. The rest three risks come in different proportions depending on choices over configurations of the product. Key configurations which affect the interest rate risk other than fixed-variable configuration are maturity, withdrawal method, reimbursement method, callability and capitalization. Of these configurations the effect of maturity can be ignored as reverse forest finance product's maturity is fixed.

The main interest rate risk is the value risk created by the quantity and maturity mismatch of liabilities and assets as well as the change in interest rates. Value risk is the only interest rate risk which bearer can be decided with the choice over fixed or variable interest to some extent. In fixed interest, the valuation risk is carried by the lender, in which case the lender is exposed to yield curve risk. Yield curve risk is the risk that the long-term yield curve structure deviates from the expected yield curve structure. In the case of variable interest, the interest rate risk is carried by the borrower. However, in the case of variable interest the lender can be exposed to interest base risk which comes in two forms, real base risk and interest base risk. Real base risk is the risk that the interest base of the instrument does not follow the time-value of money i.e., inflation. This means that in real terms the value of assets decreases more than the assets bear interest. Interest base risk it the risk in the correlation of lender 's interest bases of liabilities and assets.

In order to simplify the examination and simulation of the loan certain assumptions over the time value of money and lender's interest bases are made. The base interest, 12-month EURIBOR, is assumed to be equal to riskless interest rate and thus present the time value of money one-to-one. This assumption indicates that the base interest rate is equal to inflation in all times. The second assumption is made of the lender's liability base interest which is assumed to be 12-month EUREBOR. This ensures a one-to-one correlation in lender's interest bases and therefore eliminates interest base risk of the lender. In real world the bank's interest rate and mis-match risks are managed on the portfolio and/or overall bank level by the treasury operations. However, the assumption over the equality of inflation and 12-month EURIBOR can be applied only in ideal markets, which the real financial market is not. Therefore, in real word this assumption does not hold and therefore the discounted real values are only directional. The 12-month EURIBOR, Euro area inflation and areal inflation observed in Finland can be found from figure in appendix 3. The average difference between 12-month EURIBOR and inflation is 0.5 and 0.3, to Finnish and Euro area respectfully. Therefore, the assumption results in over discounting, which is better for the accuracy of the results than under discounting in terms of validity. Yet, a note of current inflation and market interest level must be made as currently the 12-month EURIBOR interest is below inflation.

The cross-over risk and default risk of borrower in interest rate risk are related to each other and to capitalization decision of the loan. The capitalization of interest decreases the interest payable of the borrower decreasing the default risk of the lender during the loan period, but oppositely increases the cross-over risk of the instrument. Therefore, the decision over capitalization is an optimisation of default risk and cross-over risk. The cross-over risk of reverse forest finance is higher in variable interest rate instruments.

4.3. Restricted model

In this section the bullet and term products will be introduced, and interest rate risk of different product configurations will be examined in more dept. The aim of this section is to determine which of the ten products will be the most suitable to the three borrower segment loans: livelihood loan, consumption loan and investment loan. The second objective is to determine which of the products are applicable in terms of risk exposure to the lender. Majority of the risks are already priced and adjusted into the product and thus the final examination of product risk focuses on interest rate risk. The part starts by declaring and augmenting the chosen simulation parameters of the restricted model after which the product simulation results of the reverse forest finance products are presented. After this the study turns to examine both bullet product and term products and how they satisfy the lender’s risk averseness and consumer needs.

4.3.1. Restricted model parameters

In this section the parameters of the unrestricted model will be declared and argued. A summary table of the all the parameters introduced will be found from page 98 table 3. In the thesis 50 percent of the collateral value is used as the net principal limit due to the not-adjusted risks. This net principal loan amount is approximately 30 percent of the estate value, 66 percent of the valuation risk adjusted collateral value and 84 percent of the environmental risk adjusted value. The net principal limit is equal to the typical 50 percent limit used in the Finnish reverse mortgage market. However, it is important to note that the whole estate is held as a collateral and therefore the loan-to-fair value of reverse forest finance product is significantly lower than that used in reverse mortgage industry in Finland. This is justifiable due to higher risk of forest equity as collateral compared to real estate located in growth centres.

The costs of reverse forest finance include opening cost and monthly cost. The opening cost is one percent of the loan amount, which is the maximum opening cost in consumer loans. The opening cost is high compared to existing reverse mortgage products, but it is well justifiable for specialised structured financing instrument, expected low demand level of the product and high transaction costs in the initiation of the loan. The monthly cost used in the model is five Euros which is approximately double the reverse mortgage monthly cost. The monthly cost is to cover monitoring cost of the loan as well as the extra work need to audit the collaterals to prevent moral hazards and possible natural hazards which are not reported by the borrower.

The hidden cost of the loan product includes two forest inventories, forest insurance, taxes and other mandatory cost related to the forest estate. The forest inventories include the valuation and forest planning, one during the granting process and one in the middle of the maturity of the product. The cost of forest inventories used in the model is 50 Euros per hectare. The forest estate under examination is a pure forest estate without improvements and thus the property tax can be sided. Additional mandatory costs of forest estates are for example co-operative society costs from roads et cetera. These costs are excluded from the study.

The insurance costs and compensation are aligned according to the quote of Pohjola insurance, which was chosen as a benchmark insurance for the instrument. The unit insurance premium is 10.8 Euros per hectare. The insurance policy chosen is the minimum insurance deductible, 500 Euros, and highest compensation timber price, 32 Euro. Information of the quote requested from Pohjola quote can be found under the heading 3.2.3.

Forest simulation utilized in the model is based on a simulation result of one-hectare single age spruce forest in Southern Finland presented by Ärölä in Tapion Taskukirja (Rantala &

Korhonen, 2018). Ärölä's forest simulation table can be found from appendix 5. Ärölä's simulation includes age, average height, bottom area, trunk count and timber volume, as well as harvest quantities in log and pulp wood. The data is presented in approximately five-year intervals. In the model two thinning and terminal harvest were conducted. From this data the biological growth both in quantity and percent as well as the log and pulp wood percent were interpolated with the help of Tapio taskukirja forestry tables (Rantala & Korhonen, 2018) to obtain a continuous data set. The value of timber, value changes and cash flows are calculated with timber prices of 56.91 and 18.15 for log and pulp wood respectively. The required rate of return of the forest owner for forest estate is 3 percent which has been found to be in the lower end of average forest owner required rate of return.

In the introduction of the models, the fixed interest rate used is 4 percent. Four percent was chosen based on the market study into reverse mortgage. Based on the study the interest of collateralised bullet loans, with real estate as collateral, lay between 1-3.5 percent. According to the interviews of Finnish reverse mortgage financing providers, most of the products had slightly over two percent interest. However, the slightly over two percent is misleading as majority of the reverse mortgages are renovation or consumption loans with short maturities, and thus are not a good reference point to reverse forest finance which has far longer maturity. While applying interest to a reverse mortgage product it is important to recognise the role of maturity and the uncertainty brough with it. The maturity of reverse forest finance is half to one time longer than the reverse mortgages offered and the uncertainty and risk brought with it is naturally higher. Forest, according to the interviews, is also seen as a more risker collateral than real estate located in growth centres. Due to the riskiness of forest as collateral and the longer maturity, a four percent interest is considered in this thesis to be applicable to reverse forest finance.

The interest premium used in variable interest is 2.5 percent and the variable base interest used is the 12-month EURIBOR. The interest premium in variable interest is in the higher end of charged interest premiums of reverse mortgages offered in the Finnish market and approximately one percent above of the typical reverse mortgage issued in Finland, according to the market study of reverse mortgage.

Table 3 Summary of restricted model parameters.

Model parameter			Value
Underlying estate			50-hectare single aged uniform spruce forest in southern Finland following Ärölä’s forest simulation results in Tapion Taskikirja (Rantala & Korhonen, 2018)
Loan duration			17 Years, from 47 to 64 years
Withdrawable amount		Net principal limit	50 % of primary collateral value
Cost	Direct cost	Opening cost	1 % of net principal limit
		Loan management cost	5 € / month
	Indirect cost	Insurance cost	10.5 € / ha
		Forest inventory	50 € / ha, once at the start and once in the middle of the loan agreement duration.
Insurance		Deductible	500 €
		Compensation	32 € / m^3
Timber price		Log	56.91 € / m^3
		Pulp	18.15 € / m^3
Required rate of return of forest owner			3 %
Interest		Fixed interest	4 %
		Variable interest	12-month EURIBOR + 2.5 % premium

4.3.2. Results of the unrestricted model

The results of the unrestricted model are presented in the table 4 on page 102. The examination of the bullet product and term products is done with the help of table 4 and appendix 4. In the table 4, there is three key parameters, total loan cost (TLC), which is the composition of direct cost, indirect cost, interest expenses and gain or loss of cash flows due to time-value of money; annual loan cost (YLC), which is the annual cost of dept excluding the reimbursement with relation to the net principal limit; lender internal rate of return (IRR), which is the annual return of cash flows which compose of direct cost, interest, withdrawals and principal payments; and reimbursement amount of maximum principal limit at the start of the loan agreement (%). The interest sensitivity of the products is measured with 12-month EURIBOR historical minimum of -0.3 percent and maximum of 4.8 percent added with extra 20 basis points in respective directions and the most likely interest levels of one, two and three percent. The results of two percent market interest rate level are highlighted with grey to emphasise the long-term average interest rate level, which in case of 12-month EURIBOR is 1.95 percent.

From tables one to five in appendix 4 the aggregate nominal and real cash flow amounts of each product with different market interest levels can be found. In addition, in the tables one and three the annual cash flows of fixed interest products can be found both in nominal and real terms discounted with most probable market interest level of two percent. In the table 4 the nominal total loan cost and internal rate of return are presented with blue bars whilst the real terms are presented with red and green bars. The lender's key parameters are presented with solid bars and the borrower's key parameters are presented with faded bars.

The simulation results of table 4 are under some restrictions. In the simulation, the maturity was fixed 17 years with a 100 percent single reimbursement. This means that the vertical-trade custom, which results in one third payment at the signing of the harvesting agreement and two thirds of the payment at the settle of the harvesting agreement was not modelled in. This means also that there was no slip period or slip interest applied. The simulation did not allow refinancing or pre-eminent harvests eliminating pre-eminent maturities. Natural hazards, valuation uncertainty and other valuation risks, and borrower specific risk were also disabled. The simulation was done in a constant interest and flat yield curve assumption with constant timber prices.

Table 4 Key parameters of reverse forest finance products. In the figure TLC is total cost of capital to the borrower, YLC is the yearly loan cost to borrower, IRR is the financiers internal rate of return, and percentage (%) is the outstanding principal to maximum principal limit.

			Non-Capitalization				Capitalization				
			TLC	YLC	IRR	%		TLC	YLC	IRR	%
Bullet	Fixed interest	Nominal	74 %	4,4 %	4,11 %	51 %	Fixed interest	101 %	0,4 %	4,09 %	100 %
		-0,5 %	87 %	4,59 %	4,64 %			119 %	0,38 %	4,61 %	
		1 %	52 %	3,96 %	3,08 %			70 %	0,34 %	3,05 %	
		2 %	33 %	3,61 %	2,07 %			44 %	0,31 %	2,04 %	
		3 %	18 %	3,30 %	1,08 %			22 %	0,29 %	1,05 %	
		5 %	6 %	2,78 %	-0,84 %			10 %	0,26 %	-0,87 %	
	Variable interest	-0,5 %	49 %	2,9 %	2,60 %	51 %	Variable interest	58 %	0,4 %	2,59 %	78 %
			60 %	3,01 %	3,12 %			73 %	0,38 %	3,10 %	
		1 %	66 %	3,9 %	3,61 %	51 %		86 %	0,4 %	3,59 %	92 %
			44 %	3,51 %	2,59 %			57 %	0,34 %	2,56 %	
		2 %	83 %	4,9 %	4,62 %	51 %		118 %	0,4 %	4,58 %	108 %
			40 %	4,02 %	2,57 %			55 %	0,31 %	2,53 %	
		3 %	100 %	5,9 %	5,62 %	51 %		155 %	0,4 %	5,58 %	127 %
			37 %	4,43 %	2,55 %			54 %	0,29 %	2,51 %	
		5 %	134 %	7,9 %	7,64 %	51 %		248 %	0,4 %	7,58 %	175 %
			31 %	4,99 %	2,51 %			51 %	0,26 %	2,46 %	
Term, fixed withdawal	Fixed interest	Nominal	42 %	2,5 %	4,24 %	51 %	Fixed interest	51 %	0,4 %	4,20 %	74 %
		-0,5 %	50 %	2,64 %	4,77 %			61 %	0,38 %	4,72 %	
		1 %	30 %	2,21 %	3,21 %			35 %	0,34 %	3,17 %	
		2 %	19 %	1,97 %	2,20 %			23 %	0,31 %	2,15 %	
		3 %	11 %	1,76 %	1,21 %			13 %	0,29 %	1,16 %	
		5 %	1 %	1,42 %	-0,72 %			2 %	0,26 %	-0,76 %	
	Variable interest	-0,5 %	29 %	1,7 %	2,71 %	51 %	Variable interest	32 %	0,4 %	2,69 %	65 %
			35 %	1,79 %	3,23 %			40 %	0,38 %	3,20 %	
		1 %	38 %	2,2 %	3,73 %	51 %		44 %	0,4 %	3,69 %	71 %
			26 %	1,97 %	2,71 %			30 %	0,34 %	2,67 %	
		2 %	47 %	2,7 %	4,76 %	51 %		58 %	0,4 %	4,70 %	78 %
			23 %	2,17 %	2,70 %			28 %	0,31 %	2,65 %	
		3 %	56 %	3,3 %	5,78 %	51 %		74 %	0,4 %	5,71 %	86 %
			21 %	2,31 %	2,70 %			26 %	0,29 %	2,63 %	
		5 %	74 %	4,3 %	7,83 %	51 %		110 %	0,4 %	7,72 %	105 %
			17 %	2,44 %	2,70 %			23 %	0,26 %	2,59 %	
Term, flwxibel withdawal	Fixed interest	Nominal	51 %	3,0 %	4,20 %	72 %					
		-0,5 %	61 %	3,21 %	4,72 %						
		1 %	35 %	2,66 %	3,17 %						
		2 %	23 %	2,37 %	2,15 %						
		3 %	13 %	2,11 %	1,16 %						
		5 %	2 %	1,69 %	-0,76 %						
	Variable interest	-0,5 %	32 %	1,9 %	2,69 %	63 %					
			40 %	2,00 %	3,20 %						
		1 %	44 %	2,6 %	3,69 %	69 %					
			30 %	2,32 %	2,67 %						
		2 %	58 %	3,4 %	4,70 %	75 %					
			28 %	2,69 %	2,65 %						
		3 %	74 %	4,3 %	5,71 %	81 %					
			26 %	3,01 %	2,63 %						
		5 %	110 %	6,5 %	7,72 %	97 %					
			23 %	3,51 %	2,59 %						

Before going into specific products few findings from table 4 can be made on general level. As according to literature review, the capitalization products, especially the variable interest capitalisation products, have significant cross-over risk seen as risen reimbursement to maximum principal limit. In addition to the analysis in reverse mortgage section of this work, the decision over capitalization from lender point of view is a trade-off between default risk and cross-over risk. For the borrower, the trade-off between non-capitalisation and capitalization products is a trade-off between future cost and current cost of the loan capital, as can be seen from the diagram the TLC is higher in the capitalization products whereas the YLC is lower and vice versa. For the borrower, the interest rate risk is also magnified in capitalisation products, which can be observed as the lower sensitivity of TLC in non-capitalization products.

According to literature review, the lender does not bear interest rate risk in the variable interest rate products. In the results of table 4 this can be observed by the low interest sensitivity of lender’s IRR with respect to market interest changes in variable products compared to fixed products. The negative base interest scenario is an exception in the interest sensitivity. This is due to lender’s covenant on negative base interest, which is widely used in finance after the year 2011 Euro crisis when negative interest rates were introduced to the financial markets (Nordea; Danske bank; Aktia; OP). In the simulation the negative interest rate is not netted into the chargeable interest, this means that if the base interest is negative the lender charges only the risk premium from the borrower. However, the negative base interest affects the value of the cash flows which can be seen as an increase in the real TLC and IRR. The non-negative base interest covenant therefore increases the borrowers interest rate risk. This can be observed in variable interest products where the real TLC (later RTLC) is higher than the nominal TLC (later NTLC). This increased the interest rate risk is called negative base interest risk. The covenant also transfers some of lender’s yield curve risk of fixed interest product to the borrower. This can be observed from the negative market interest scenarios where the borrower’s real TLC is higher than the nominal TLC.

A surprising finding is also the difference between the relationship of TLC and IRR between non-capitalization and capitalization products, both in real and nominal terms. In the non-capitalization products, the TLC is naturally lower due to smaller overall interest expenses, whereas in the capitalisation product the TLC is higher. However, counterintuitively the lender’s IRR is larger in non-capitalisation product than in capitalisation product. A second surprising finding is the relationship of YLC and TLC in variable interest non-capitalization products, where the TCL decreases as interest rates rise, whereas the YLC increases.

The fundamental difference between bullet and term products is the withdrawal phase of the principle, which affects the asset-liability structure of the loan. Due to the difference in asset-liability structure of the loan, the interest rate risk is magnified in the bullet products compared to term products in all configurations. This interest sensitivity can be observed in the rate of change of lender's IRR to market interest change. The IRR reduction per interest change in in the bullet products is larger than in capitalization products. Nevertheless, the magnification is opposite in the negative market interest environment where term product sensitivity is higher. The withdrawal method together with the capitalisation configuration are the two most important determinants to which consumer segment and to which need the product is directed as these two configurations determine the cash flows of the loan during the maturity prior to reimbursement.

To examine the lender's interest rate exposure the interest composition of fixed and variable interest must be examined. According to Nikkinen et al. (2002, 94-95) lender's required rate of return composes of risk-free interest rate i.e., the time value of money, and interest premium. In variable interest, the premium is 2.5 percent which can be further dived into two, risk premium of the product and lender's return. If a similar risk premium is used in reverse forest finance as in reverse mortgage, which according to Alai et al. (2014) is one percent, the lenders returns equal 1.5 percent over withdrawn principle. For the fixed interest product, a similar interest composition can be assumed in which case the four percent fixed interest can be divided into 1.5 percent return on withdrawn principle, one percent product risk premium and a 1.5 percent compensation of time value of money.

The risk premium of the product, according to Alai et al. (2014), and Bohem & Ehrhard (1994) is a compensation of borrower specific risk of borrower's moral hazard and default risk of the instrument. According to literature review, the return of the risk premium on the product covers the loss due to borrower's moral hazard and borrower defaults on interest expenses, on a well-diversified portfolio. Therefore, if the lender obtains an interest return of one percent on withdrawn principal the return on a portfolio of loan agreements, if similar interest return on every loan agreements in the portfolio is assumed, is equal to zero net return. If table 4 is examined, we can observe that the portfolio of fixed interest reverse forest finance products would return close to net zero real returns already in a three percent market interest and negative in five percent market interest. This finding emphasises the interest risk inherent in fixed interest products for the lenders. One could ask, should the premium of time-value of money be higher in fixed interest products if the real return of fixed interest products is so sensitive to interest rate changes.

There is no definite answer to this, but it is important to remember that the interest rate risk is a business risk and therefore the interest premium over the time-value of capital is a business decision of the lender. Therefore, the decision over the interest premium over the time-value of money is a deliberately taken risk of the lender which is based on the yield curve expectations of the lender. In reverse forest financing it is important to note that the long maturity of the product makes it impossible to estimate yield curve for the whole duration of the product in reasonable terms.

From the lender’s point of view, the question on interest premium over time-value of money is a double-edged sword. Too high fixed interest loan is not attractive to the borrowers and bears significant pre-eminent maturity risk, as the borrowers are likely to refinance the loan if market interest rates are low. On the flip side too low interest premium over time-value of money bears interest rate risk if the market interest rates rise. For the borrower, the fixed interest products are also a double-edged sword. It grants predictable capital costs and offers a low TLC in high interest environment, whilst it bears higher premium in low interest environment.

In the thesis the expected yield curve of the loan duration is expected to be -0.3 percent for the first three years, which is equal to the current 12-month EURIBOR. After the first three years the market interest rises 0.5 percent per year to 2.3 percent level at year seven. After the upward sloping interest period the market interests are expected to stay at 2 percent, which is the long-term average level. The expected interest curve results in a 1.4 percent annualized interest level which is close to the lender’s interest premium over time value of money used in the fixed interest rate products. Figure of the expected yield curve can be found from appendix 2. One way the interest sensitivity of fixed interest products could be reduced is to place periodic interest adjustments, nonetheless, this option is excluded from the examination of the thesis.

4.3.1. Bullet products

The cash flows of the bullet products to the borrower in tables one and two in appendix 4, consist of one large disbursement of capital together with either a large or small YLC depending on decision over capitalisation. If the consumer groups are considered, the needed cash flows of livelihood loan and consumption loan are continuous of nature. Therefore, the bullet product is not best suited for these loans. Whereas for investment loan or large single disbursement consumption loan the cash flow of bullet products fits better. However, the large single disbursement consumption loans are usually short term of nature to which reverse forest finance product is not well suited to. This is because a pre-eminent reimbursement would rely on either refinancing or pre-eminent harvesting, in which case the borrower would deviate from the forest management plan and the required rate of return of the forest investment. If the reverse forest finance product would come together with a counter account which had the same base interest as the outstanding principle, the short-term single disbursement consumption loan would be more reasonable. In this cease the borrower could deposit gradually the withdrawn amount. However, this solution would resemble the line-of-credit withdrawal method, which is excluded out from this study. Also due to high direct and indirect costs of reverse forest financing the line-of-credit would be uneconomical to finance short-term capital-intensive borrowing. Therefore, the reverse forest finance is not considered to be a good product for single disbursement consumption loan. If investment loan is considered, the bullet product is the most viable product as the investment consumers need single disbursement. The question is which configuration serves best the needs of the investment consumer and the lender's risk adverse preferences. The lender's point of view and borrower's point of view over different configurations is examined in the following part of this section.

The decision over non-capitalisation and capitalisation products is mainly a trade-off between cross-over risk and default risk. From lender's point of view, it is reasonable to assume that the investor consumer has adequate solvency to cover interest expenses both with the gains on the investment and other income. Therefore, the investor borrower solvency is high, and the default risk of investor borrower is assumed to be low in this study. Thus, the trade-off between the risks is not so drastic as it would be with a consumption bullet loan. Also compared to reverse mortgage the cross-over risk in capitalized reverse forest finance products is not as significant, as the value of the underlying increases with a compounding interest in-parallel with the outstanding principle. The estate used in the model has an annualized value growth during the loan period of 4.3 percent, and if the uncertainty over the future value growth is taken into consideration the annualised value growth is from 3.9 to 4.7 percent. Therefore, as long as the interest of the bullet loan is smaller than the annualized value growth of timber the outstanding principal does not growth into cross-over, with the assumption that no unadjusted risks realise.

This said we can observe that the assumption holds for fixed interest capitalization product. However, as we can see from table 4 that the variable interest capitalization product bears significant cross-over risk for the lender. Even with the most likely scenario of market interest level of 2 percent, the product falls into cross-over. Therefore, from lender's point of view the variable interest capitalization product does not fulfil the requirements of risk adverse behaviour, leaving the fixed interest capitalization product as the only bullet capitalization product to be offered.

When the non-capitalization products are examined, the lender faces the option to carry yield curve risk or default risk. When the worst-case scenarios of variable interest non-capitalisation products is examined, the YLC of nearly 8 percent and TLC of 134 percent presents itself as a significant default risk scenario. On the contrary with the worst-case scenario of fixed interest non-capitalization product the lender faces a -1.8 percent real return over a portfolio of similar loan agreements, if assumption of one percent risk premium of product is fulfilled. Therefore, the risk in both options is significant and into the same direction.

The magnitude of the risk can be estimated with the probability of different yield curves and default rate percent of borrowers in 7.9 percent nominal YLC. The thesis does not take a stand over this optimisation and contents on equal risk. However, as examined in the reverse mortgage part, the variable interest is hedgeable and liquid, which means that the lender can sell or reduce the default risk of the borrower. Variable interest also mitigates the risk of refinancing. It is also important to remember that borrower's default risk concerns only the payable interest whereas the principal itself can be paid more than easily with the revenue of the underlying, as the reimbursement is only 51 percent of the maximum principal limit. Therefore, from the lender's point of view, the variable interest bears a lower overall risk.

From borrower's point of view, the borrower can choose a non-capitalization product with fixed or variable interest or fixed rate capitalisation product. The decision over non-capitalization and capitalization products is a trade-off of between maturity of the cost of dept and real total cost of capital (RTLC). In other words, if the borrower prefers a low YLC, long maturity of cost, the borrower would choose the capitalization product in exchange to higher real TLC. In choosing so the borrower decides to carry magnified yield curve risk, as the interest level lowers the real total cost of capital increases quicker than in fixed interest non-capitalisation product. However, compared to variable interest non-capitalisation product the borrower carries negative risk in low yield curve environment and positive upside in high yield curve environment.

This yield curve risk of borrower is nevertheless reduced by the borrower’s option to refinance the loan. The borrower decision over the refinancing of fixed interest capitalization product is the optimisation of preferred maturity of cost and negative risk in low yield curve environment to RTLC. If the refinancing decision is considered, the borrower will refinance the loan if the negative utility of increased RTLC is larger in absolute terms than the utility of smaller YLC. If the borrower is to refinance the loan, the borrower will opt to variable interest non-capitalisation loan as it has lower RTLC and nominal YCL than the fixed interest capitalization loan. The RTLC is higher and nominal YLC is lower in interest environments below 2 percent.

From borrower’s point of view the non-capitalization products have a trade-off between the combination of high cost both in YLC and RTCL, fixed interest, and the combination of low risk and the combination of low YLC and RTLC and high risk, variable interest. The risks in variable interest rate for borrower is large interest rate risk compared to small yield curve risk which realises in negative market interest rate environment. The borrower’s decision over the fixed and variable non-capitalisation product is based on borrower’s expectations of the future yield curve and risk appetite over changes in YLC. If the borrower expects low interest environment, the borrower chooses the variable interest product, whereas if borrower expects high interest environment in the future or is a risk adverse borrower, the fixed interest scheme will be chosen. For the borrower, the yield curve risks of fixed interest product are reduced by refinancing option, in which case the borrower will opt for a variable interest.

4.3.2. Term products

Similarly, to bullet products the cash flows of fixed interest term products for both fixed and flexible term products can be found from figures three, four and five in appendix 4. Where the bullet products were found to be suitable to investment loan the term products can be found to better suit livelihood loan and consumption loan. This is because of the continuous cash flow structure of periodic withdrawals matches the need of forest entrepreneurs and senior forest owners.

Prior the examination of the individual products' suitability and risks related to each one as well as for the counterparts a note of the key parameter values must be discussed. For the term product, the YLC parameters for non-capitalization products represent the average annual expense. In the parameters, the direct and indirect costs are displayed in the value similarly to bullet product, but the interest expense is represented as the mean interest expense over the maturity of the loan agreement. This is because the amount of interest bearable principal increases during the maturity of the product. In the case of the fixed term non-capitalization products the principal increases linearly from around 12,000 to 206,000. Therefore, the interest expense rises from 480 Euros in fixed interest and from 300-600 Euros in variable interest at year one, to the same level charged by the non-capitalized bullet products. Therefore, the interest expenses can be tough to rise from 0 percent to equal the bullet loan in non-capitalization fixed interest term product over the loan maturity. However, the same kind of logic cannot be used in capitalisation products, due to compounding, and in flexible term products, due to fluctuating withdrawal amounts.

Due to the different asset-liability structure of the term products the interest risk inherent in term products deviates from the interest rate risk of bullet products. If the interest rate sensitivity of IRR values is examined, we can see that that with the fixed interest assumption the term products seem to be less interest rate sensitive. This suggest that the term products have a lower interest rate risk than bullet products. However, this is not the case as the decrease in interest rate sensitivity does not fully represent the interest rate risk for term products. Due to inconstant asset-liability structure, the interest rate risk exposure is not constant during the maturity. In fact, the interest rate exposure is minimal at the start of the loan, where the assets that bear interest rate risk are small, whereas nearer the maturity the interest rate exposure is high. When the interest rate risk is considered, the amount of risk is proportional to the amount of uncertainty over market interest rates. As the uncertainty increases with time, the interest rate risk increases towards the end. Due to the increase of interest-bearing assets, the assets do not benefit to same extent from favourable interest rate levels during the first years of the loan agreement, whereas the assets share nearly equal amount of disadvantage near the maturity when the interest rate risk is the highest. This increases the yield curve risk of the lender and borrower.

Due to the nature of the consumer segment of term products, forest entrepreneurs and senior forest owners without cash flow, the default risk of term products is more critical risk than in bullet loan. If the non-capitalization fixed term loans are inspected from appendix 4 figure three, the decrease in total cash flow for borrower during the loan period can be seen. This, both increases the default risk and ambivalence the needs of the borrowers. Already with a market interest rate level of 3.5 percent the borrower's withdrawals are not sufficient to cover the loans costs near the maturity. Therefore, with market interest rate level greater than 3.5 percent the loan does not meet the needs of the borrower and exposes the lender to significant default risk. If the fixed interest product is examined a similar problem of falling net cash flow of the product can be observed. Therefore, the non-capitalised fixed term products do not present themselves as viable products in terms of risk or borrower's needs.

This could be compensated with flexible term withdrawals, in which the amount of withdrawal increases with the interest expenses of the loan to compensate the falling net cash flow of the product. When the environmental risk adjusted net principal limit is examined from appendix 4, the amount of withdrawable capital increase during the loan can be seen. Therefore, the amount of term withdrawals can increase in parallel with the environmental risk adjusted net principal limit without jeopardizing the lender's risk adverse bounds.

This solution would resemble a lot a capitalization product, as in essence the withdrawal amount increases in parallel with the interest expenses. When the two products are examined next to each other, the borrower's and lender's net cash flows look exactly the same. Even though, the lender's net cash flow is the same in both scenarios the cross-over cash flow is larger, due to interest payable and increased withdrawals. This increased cross-over cash flow eliminates the lender's interest rate risk of compounded interest and the interest rate risk of tax payables as the lender receives the interest by adding liabilities to the borrower. As examined in the reverse mortgage part, the lender is taxed on the interest earnings annually, even though the cash flow of the interest is realised in the future. This exposes the lender's tax payables under value risk as the interest tax is a liability related to the product (Bohem & Ehrhard 1994). In addition to the reduced interest risk exposure, lender's liquidity is increased. The flexible term withdrawal however increases the default risk and moral hazard of the borrower. However, the lender can eliminate the increase of the borrower specific risk by withholding the interest payable directly from the withdrawal. Therefore, the rising term withdrawal would be less risky to the lender than the capitalization product.

From the key parameters reduced risk of flexible term product compared to the capitalized fixed term products is not clear and need explanation. If the fixed interest scheme of capitalized bullet product and term withdrawal product is examined, both have equal interest sensitivity, TLC and nearly identical cross-over risk of 72 and 74 percent. Neither one of the products has a cross-over risk due to fixed interest, with the assumption that no unadjusted risk realises. Therefore, the difference in risk lays in the yield curve risk of the products. However, both products seem to have the same interest rate sensitivity. This is because the IRR counts the internal rate of return of the products cash flows and does not contain the information on what the lender does with the gained interest payables. Therefore, if the lender would invest the occurred interest with the current market interest the lender would eliminate the yield curve risk of the increased withdrawal amount. The lender would hedge the yield curve risk of the increased withdrawal amount. As a consequence, the risk of fixed interest flexible withdrawal term product is equal to the non-capitalization fixed interest fixed term product.

In the case of variable interest product, the risk difference is created by the combination of risk difference in both cross-over risk and default risk of the borrower. If the variable interest fixed withdrawal capitalized term product and the variable interest variable term products reimbursement to maximum principal limit are studied, we can see that the flexible non-capitalized term product has a smaller cross-over risk. The capitalised product falls into cross-over with a market interest level of 4.54 whereas the flexible withdrawal product falls into cross over in 5.3 percent market interest level. However, it is noticeable that if the market interest level increases to 5.3 percent and if the amount of interest would be added to the withdrawn amount the loan would fall into cross-over. Therefore, a limit to annual increase of term withdrawal must be made. A good maximum limit is 5 percent as the expected increase of the net principal limit of the estate is 5 percent. Then, if the annualized increase of principal is less than 5 percent and the assumption that no unadjusted risk realise, the product will not fall into cross-over. However, by applying a maximum limit to the rise of withdrawals the lender is exposed to default risk of the borrower. The default risk of the flexible term withdrawal product would realise only by negative net cash flow scenario of the borrower at a market interest rate level of 11 percent. Consequently, the default risk of flexible withdrawal variable interest term product is marginal.

When the two flexible withdrawal term products and four fixed withdrawal products are compared, the flexible withdrawal term products present themselves as superior both in terms of risk and borrower satisfaction. Between the variable and fixed interest flexible term products, the trade-off in risk for the lender is in net withdrawn yield risk and manageable cross over and default risk. Due to the increased yield curve risk of the term product and current yield curve expectations, the variable interest product is considered less risker option for the lender.

4.4. Unrestricted model and the cooperative effect of risk

Of the ten instrument configurations found applicable to reverse forest finance four instruments fulfil the lender's risk averse behaviour and consumer segment needs. In the previous section, the instruments were simulated in with restriction. In this section, the four instruments selected are variable and fixed interest non-capitalization bullet loan, fixed interest capitalization bullet loan and the variable interest flexible term non-capitalized loan are simulated with more realistic parameters. The main aim of this further examination is to validate the riskiness of the models by simulating cooperative effects of the identified risks. The objective is also to examine and estimate the mean value of the instrument to lender and mean cost of capital to borrower and the variation of them.

4.4.1. Unrestricted model parameters

In the further simulations, the simulation values are the same as in the previous restricted simulation in insurance parameters, interest parameters of fixed interest, and interest margin as well as in cost parameters of direct and indirect cost. The restricted model is enhanced with modelling the primary collateral value and valuation risk, uncertainty of maturity as well as introduction of systematic and idiosyncratic price risk. The loan is granted based on Ärölä's forest simulation values, which is used as the forest economic estimate of the true hidden value of the estate. To model the valuation risk, the true estate values are simulated from the Ärölä's forest simulation values from year 47 to maturity. The true values include current forest values at year 47 and growth projection of the values, which represent the "real values underlying values". These real underlying values will be revealed to the borrower and lender at maturity of the instrument when the instrument settles. Prior to maturity both lender and borrower regard the values of Ärölä's model to be the fair forest economic estimation of the estate from which all values regarding the loan are calculated.

This way the model can simulate the valuation risk which consists of base risk, valuation process risk and human error. The valuators moral hazard is excluded from the examination. The valuation risk is modelled with error margins of the values. The error margins for each simulation round for valuation error, growth estimate and valuator human error will be generated by normally distributed random number. The mean and standard deviation of the error margins can be found form table 5.

The unrestricted simulation also includes both systematic and idiosyncratic price risk. The systematic timber price risk is modelled with a normally distributed random variable for both log and pulp wood, for more information see tables 1 and 2 in the appendix 2. The idiosyncratic price risk is modelled with a five percent occurrence of 20 percent price deduction for both log and pulp wood. The maturity of the instrument varies between 62-66 years according to random integer variable representing the slip period to model the short-term liquidity risk due to vertical-trade custom and harvestability. A two percent slip interest is used for positive slip periods. The cash flow of timber realises in two patches according to the vertical-trade custom. One third of the cash flow realises one year prior the maturity and two thirds realise at the maturity. The lender has seniority to both cash flows. Natural hazards and pre-eminent maturity due to pre-eminent harvest maturity are simulated with their own random integer variable and both have a five percent occurrence. The impact of natural hazards is simulated as cubic meters of timber lost and with permanent decrease in log percent to capture quality loss. The amount of timber lost is a uniform random variable between 5-100 percent which is deducted from the timber reserve. The deduction is done in the same proportion to timber classes as the current proportion of log timber and pulp wood at the time of occurrence. After quantity deduction of timer, a 0-100 percent uniform distribution random variable of quality reduction is made to the amount of leftover log timber to capture possible quality reduction. No changes to future biological growth or quality growth are made.

The market interest rate follows a geometric browning motion (later GBM) with the expected yield curve as drift. The starting value of the GBM is -0.3 to which 0.5 percent drift will be applied in years 50-54. In the model, there is also a pre-eminent maturity due to refinancing of the loan which occurrences with 50 percent likelihood per year when the years market interest is 2 percent lower than the expected yield curve. The independent increments of GBM is inverse of normal distribution with mean of zero and variance of 15 basis points.

Table 5 Simulation parameters of unrestricted model. Notation of normal distribution is (mean, variance).

Parameter	Value	Risk
Valuation uncertainty	Normal distribution (1, 0.12)	Valuation risk base risk and valuation process risk
Uncertainty of future growth	Normal distribution (1, 0.1)	Valuation risk: simulation risk
Valuator human error	• Occurrence 5 % • Normal distribution (1, 0.11)	Valuation process error: human error
Slip period	Random variable from -2 to 2 years	Liquidity risk
Slip interest	2 % charged from positive slip	
Natural hazard	• Occurrence of 5 % • Loss of timber in cubic meters, uniform distribution 5-100 % • Decrease in quality of leftover timber, uniform distribution 0-100 %	Natural hazard
Pre-eminent maturity	Occurrence of 5 %	Risk of pre-eminent harvest
Refinancing risk	Occurs 50 % of the time in fixed interest instruments if modelled market interest deviates from yield curve by 2 %.	Risk of pre-eminent maturity due to refinancing
Interest rate	Geometric browning motion with a drift equal to expected yield curve. Independent increments of N^{-1} (0, 0.15)	Interest rate risk: yield risk, value risk.
Log timber price	Normal distribution (56.91 €/m^3, 10.2 €/m^3)	Systematic price and cost risk
Pulp wood price	Normal distribution (18.51 €/m^3, 1.2 €/m^3)	
Idiosyncratic price risk	Occurrence 5 %, a 20 % reduction in both log and pulp price	Idiosyncratic price risk

The unrestricted model captures the valuation risk with the exception of valuator moral hazard, idiosyncratic and systematic price risk, risk of natural hazards, risk of pre-eminent maturity due to pre-eminent harvest and refinancing, short-term liquidity risk due to vertical-trade and harvestability, as well as partially the interest rate risk. The model excludes the borrower’s default risk due to interest, direct and indirect cost, borrower’s moral hazard towards the collateral or mandated indirect costs, pre-eminent maturity due to other reasons than pre-eminent harvest or refinancing, and long-term liquidity risk. Due to the market interest simulation the interest rate risk is only partially modelled. This is due to the assumption of one-to-one correlation of inflation and market interest, the assumption of one-to-one correlation of lender’s liability and asset interest bases, and the usage of a single yield curve in GBM drift. Therefore, the model totally excludes lender’s real base and interest base risk and borrower’s real base risk. The usage of single yield curve in interest modelling results into significant underestimation of yield curve risk for both borrower and lender. This underestimation of yield curve risk reflects also into the amount of refinancing risk of the lender.

4.4.2. Simulation results

The main simulation of the unrestricted model provides values for reimbursement to maximum principal limit, crossover of cross-over trenches, value of the loan agreement to lender and total cost of capital to borrower. By elevating reimbursement to maximum principal limit and crossover of cross-over trenches, we are able to grasp the lender's actual cross-over risk with given simulation restraints. By elevating of loan agreement value to lender and the total cost of capital to borrower, we can grasp the lender‘s and borrower's interest value risk and partially yield curve risk.

Based on the unrestricted model, the four instruments have a very low cross-over risk. The cross-over risk of the four instruments will be studied with the help of table 6 and figure 11. In the table 6, the number of loan agreements both in absolute and percent of loan agreements that crossed the cross-over thresholds of maximum principal limit of the loan agreements, current actual net principal limit, and realised cross-over at maturity. In the figure 11, the reimbursement to maximum principal limit of the loan agreements is displayed.

Table 6 Crossover ratios of cross-over thresholds.

Threshold	Fixed interest	Variable interest	Capitalization	Term
Cross over threshold maximum principal limit	0 (0 %)	0 (0 %)	4 796 (48 %)	59 (0.6 %)
Cross over threshold of current net principal limit	14 (0.1 %)	12 (0.1 %)	72 (0.7 %)	48 (0.5 %)
Matured in cross over	0	0	54 (0.5 %)	29 (0.3 %)

In the fixed and variable interest instruments, no cross over risks realised and no maximum principal threshold crosses occurred. Both instruments had a 0.1 percent probability to cross the threshold of current actual net principal limit, at least once during the maturity of the instrument. All of these threshold crosses were caused by mid-to-high severity natural hazard during the first one third of the loan period combined with the valuator human error in a manner which did not result into full termination of the loan agreement. In these cases, the current environmental risk adjusted timber value fell below the outstanding loan amount. However, in all the cases the forest value growth grew larger than the outstanding loan amount prior the maturity. Due to simulation restrictions, each loan agreement could face only one natural hazard event. If the model would have allowed to more than one natural hazard event per loan agreement some of the 0.1 percent threshold crosses could have matured in cross-over.

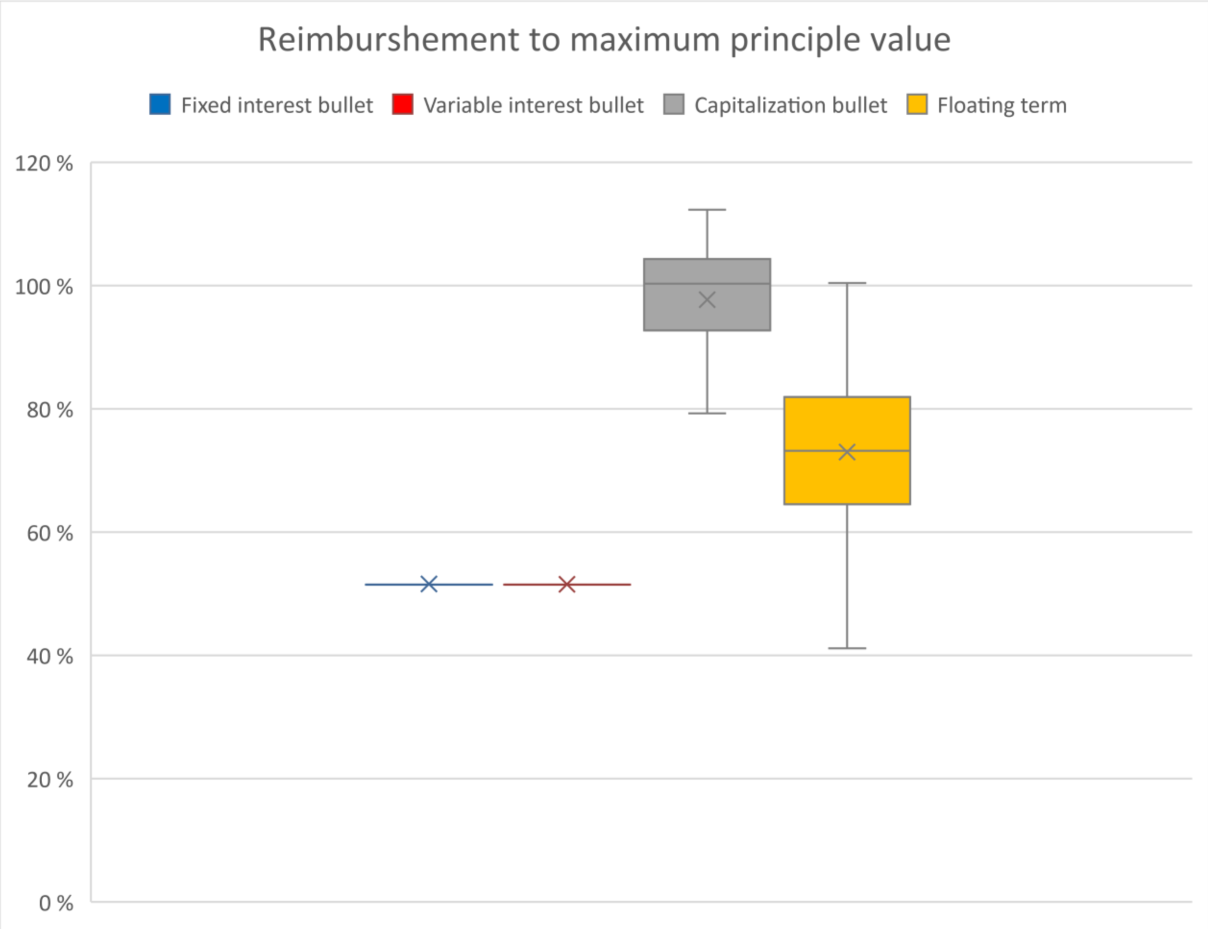

Figure 11 Reimbursement to maximum principal limit.

When the capitalization and term instrument cross-over risk, presented in the table six and figure 11, are examined, we can see that the cross-over risk is significantly higher than in the fixed and variable bullet instruments. When the figure 11 is examined first, we can see that both instruments have a range of possible loan-to-value ratios that can occur. This is intuitive for the term instrument due to variable interest, but less intuitive to capitalization instrument as the capitalization instrument has fixed interest. However, due to the applied slip period, the amount of capitalised interest periods as well as the amount of capitalised interest fluctuates due to the inconstant maturity and slip interest charged. Therefore, nearly half and all the positive slip loans, crossed the maximum principal threshold.

In comparison to term instruments, the maximum principal limit was crossed only in combinations of exceptionally high market interest of 5 percent annualized interest over loan period and positive slip period duration. The term instruments flexible withdrawal had a maximum threshold of 5 percent annualized withdrawal, which was supposed to prevent the principal to grow into cross-over. Yet, the threshold was calculated to fixed maturity without a slip period and the extra withdrawals during the slip period was sufficient to cause cross-over risk.

When the cross-over of current net principal limit is examined, the risks of capitalization instrument get reduced greatly and close to the level of term instrument. In both instruments the cross-over of current net principal level occurs in the very last years of the instruments, which is due to annually increasing outstanding principle. In capitalization instruments, this is caused by mid to high severity natural hazards near maturity or the combination of positive slip with high realized valuation risk in any of human error, the base risk or forest growth simulation. In the term instrument the cross-over of net principal limit was caused by same risks realising with the addition of moderately high market interest level of annualized 1.8 percent. The realised cross-over risks of both instruments occurred in the same circumstances as the threshold crossing of current net principal limits with combination of high severity natural hazard.

However, the severity of realised cross-over risk in both instruments is modest, as the amount of capital in cross-over was on average 21,000 in both instruments. In relative terms, the cross-over is approximately 10 percent of the loan capital in the given loan. In capitalization instrument this amount of cross-over value could be expected to be reimbursed from the investor borrower. Yet, in the term instrument for the senior consumer group there could be difficulties to find wealth or liquidity to cover the cross-over. If the capital in cross-over is measured against the total loan capital under simulation, the amount of cross-over capital is a negatable 0.04 percent in capitalization and 0.03 percent in term instrument. If the realised cross-over and mechanism which cause the cross-over are considered, it is safe to say that the cross-over risk is negatable in both instruments. This is due to the root cause for cross-over is not systematic but a combination of several factors affecting in simultaneously. The probability of several risk realising simultaneously with the severity required is low and even if the risks realize the financial exposition is small.

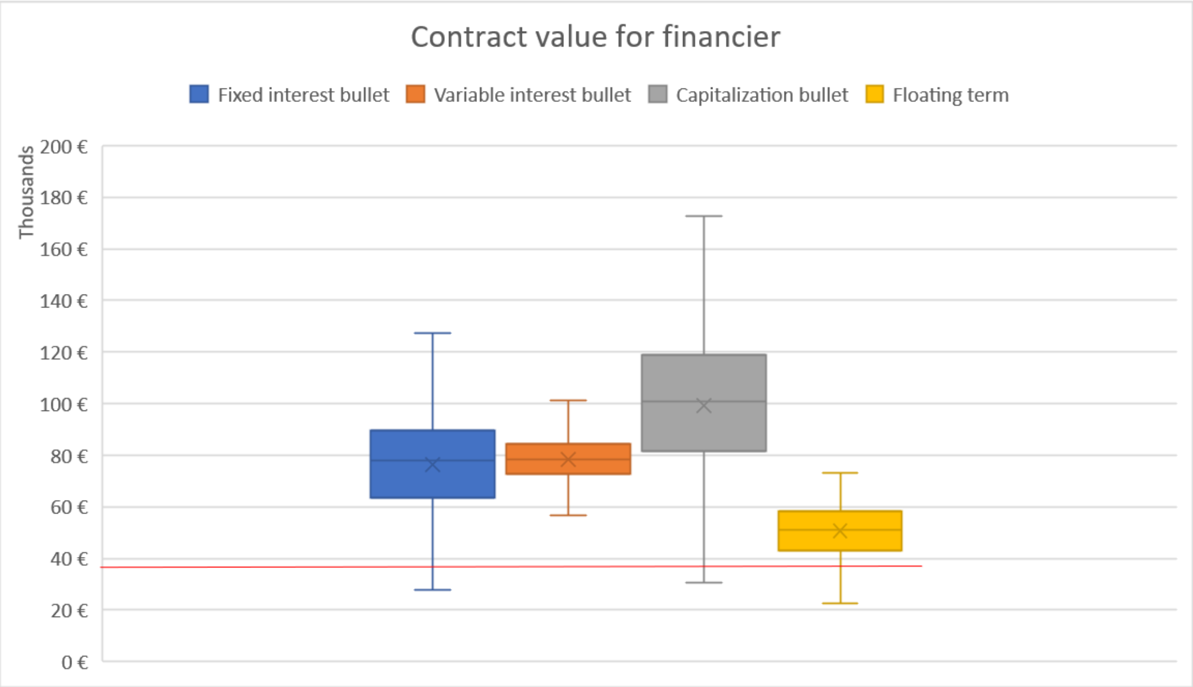

Figure 12 Loan agreement value in real terms to lender.

In terms of instrument value to lender, the variable interest instruments are the safest whereas the fixed interest instruments have a far larger sensitivity to market interest changes. It is important to note that due to the decisions taken in the simulation of market interest rates the negative yield risks involved in fixed interest instruments is not represented fully. Due to this restriction, the risk of negative present value in fixed interest instruments is not show in the model. In both fixed instruments there can be seen a significant upside for the lender, even with the modelled refinancing risk.

A surprising finding is the underperformance of the term instrument compared to variable interest instrument, regardless of the same interest base and margin. This difference is explained by larger maturity mismatch in terms of asset size. When the real returns are compared against the risk premium of the instrument risks, marked with the red line in figure 12. We can see that the variable interest instrument has significantly larger risk to net negative real returns on portfolio level. For both fixed interest instruments approximately 5 percent of the loans returned lower than one percent return, whereas for the term instrument the same number is nearly 9 percent. This result emphasises the additional interest rate risk related in the flexible term instruments.

The internal real annualized rate of return of the instruments were 1.9 percent, 1.9 percent, 2.3percent and 1.3 percent from left to right with respect to the figure 12. The sufficiency of one percent risk premium of instrument risk in relation to each instrument's borrower risk could be hypothesis to be unequal. For instance, the term and capitalization instruments do not bear any interest default risk. Consequently, the real net return on portfolio of instruments is not linear with the internal real annualized rate of return. However, this is left to further studies. With the given yield curve, real base, and interest base assumptions, it is safe to say that the instruments would fulfil the lender's risk adverse boundaries.

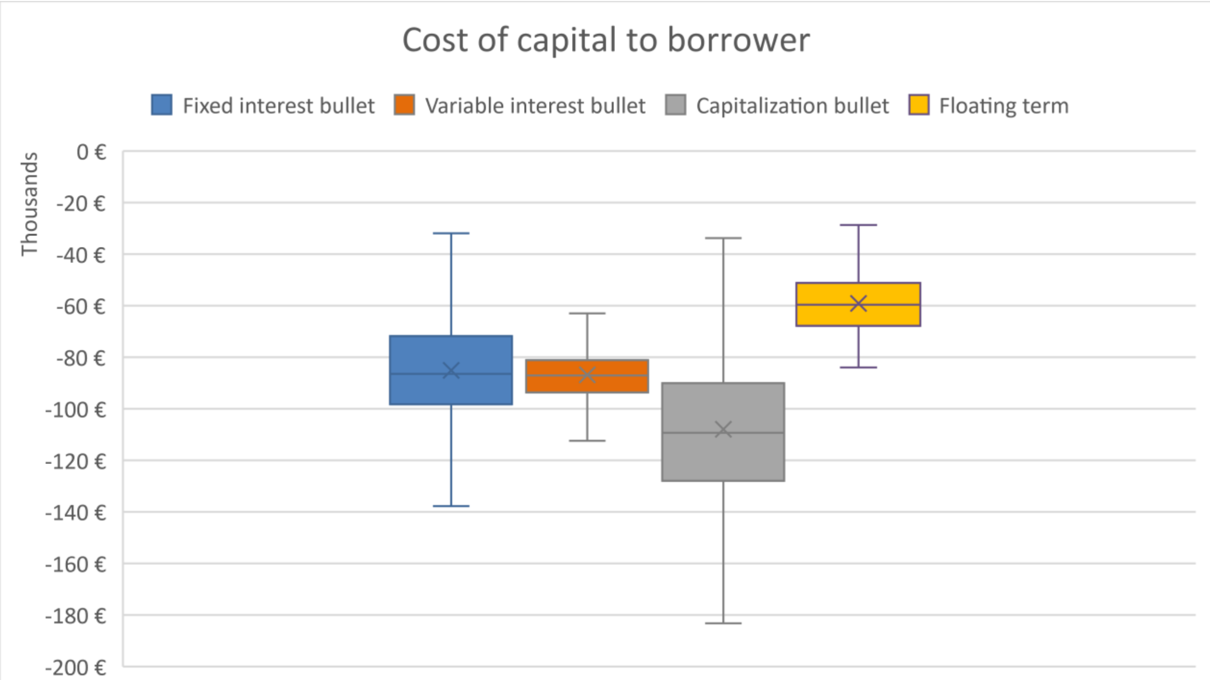

Figure 13 Cost of capital to borrower in real terms.

The cost of capital of the four instruments can be seen from the figure 13. The average cost of capital, including the time value of reimbursement, and average annual cost in relative terms in brackets is 41 percent (2.2 %), 42 percent (2.1 %), 52 percent (2.5 %) and 29 percent (1.5%) according to the order from left to right in the figure 13. From the figure 13 we cans see that the fixed interest instruments bear far larger uncertainty in cost of capital to borrow. This uncertainty is nevertheless just the uncertainty in the real cost of capital. If the cost of capital would be seen in nominal terms, the uncertainty of cost of capital would be in favour of fixed interest instruments. This is because the base interest charged is discounted fully due to real base assumption. However, the uncertainty of fixed interest instruments is not either present fully due to yield curve assumption. Therefore, the uncertainty of the costs and the costs themselves are directional. In likewise manner to the value of loan agreement of lender, the term instrument presents itself as a cheap option to the borrower.

Based on the unrestricted model, with given interest restrictions, both the lender and the borrower would prefer the variable interest non-capitalization bullet instrument over the fixed interest non-capitalization bullet instrument. The variable interest instrument offers the same cross-over risk and default risk for the lender, with higher real returns which have a smaller uncertainty. Whilst for the borrower the variable interest non-capitalization bullet loan offers a smaller uncertainty and smaller real cost of capital. The variable interest option in non-capitalisation bullet loan comes with slightly higher annual cost of capital compared to the fixed interest rate option. However, the trade-off between the real cost of capital versus the higher annual nominal cost is marginal with the given interest restrictions.

5. CONCLUSIONS

This study is an exploratory work on developing reverse finance product into forest equity. This exploratory process was conducted through a careful literature review and cross-breeding of reverse mortgage products into forest equity. To support this developmental process a market study of reverse mortgage offering in Finnish lender markets was executed. Based on this literature review and market study eight main instrument configurations of maturity, withdrawal, reimbursement, charged interest, capitalization, callability, resourceless and appreciation were identified, which some had several options within the configuration. In addition, several terms and utilized covenants were identified. As part of the literature review, risks of reverse mortgage were examined and were found to consist of cross-over risk which is primarily caused by collateral value risk, borrower specific risk and interest rate risk and secondly of other risks such as tax exposure and legislative risk. Based on the market study, benchmark instrument cost and interests were obtained, as well as insight to industry practices.

In applying reverse mortgage instrument configurations to the particular properties of conventional forest equity, a literature review of forest equity properties and characteristics was also conducted. In the forest equity examination, the forest equity value and values applicability to collateral were examined though reverse finance point of view. In the developmental process, the properties of forest equity were compared to reverse mortgage configuration to examine which configurations are applicable to forest equity. In the forest equity examination, forest was found to have a set of unique properties, such as contemporaneous asset structure which generates partially substituting values of passive, indirect and direct value. Based on the study, the different values of forest were classified to be unapplicable to collateral value. Passive and indirect value was deemed to be applicable to secondary collateral value, and majority of direct value, the timber and biological growth, was deemed to be applicable to primary collateral value. To be more precise the forest equity's primary collateral value in case of reverse forest finance was found to be the timber cash flows obtained from the terminal harvest.

Due to the specific properties of collateral values of forest and the need to value both primary and secondary values of forest separately, the valuation approaches of forest equity were examined. Based on this examination the best valuing method to value both the primary collateral value and the secondary collateral value of forest equity was found to be profit method with few adjustments. As part of the forest equity collateral characteristics and valuation examination, the collateral risk of forest equity was examined. The collateral risk was found to consist of value risk and environmental risk. The value risk was found to consist of valuation risk, which is the combination of valuation process risk, base risk, and price risk, which is the combination of idiosyncratic and systematic price and cost risk.

The cyclical non-negatively compounding value growth of forest, which is caused by forest turnover time and biological growth, was found to restrict some reverse mortgage configurations to be unapplicable to forest equity. Unapplicable instrument configurations were flexible maturity, tenure withdrawal, and rollover of the loan. Also based on the forest equity examination and Finnish reverse mortgage market study, the configurations of shared appreciation, non-negative guarantees and third-party guarantees were excluded from the study. In addition, a decision to exclude line of credit and modified tenure from the examination was done. Due to the cyclicity and the development of uncertainty and risk during the value cycle of forest, the maturity of the instrument was restricted to be at maximum of 20 years and to occur between the last thinning and thermal harvest. In addition, a covenant of slip period was found to be useful in applying the reverse mortgage framework to forest equity.

Finally, in the literature review the forest owners were studied to identify consumer segments and their possible needs toward reverse forest finance instrument as well as to examine the borrower specific risk related to reverse forest finance. Three interesting consumer segments of investors, seniors, and forest entrepreneurs were identified, and their possible needs for reverse forest finance was hypothesised to be investment loan for the investor segment and consumption loan for senior and forest entrepreneur segments. The needs of the borrower segments were hypothesized to consist of single disbursement for the investor segment and continuous steady cash flow for senior and forest entrepreneur segments. The borrower specific risk of reverse forest mortgage was found to deviate from typical reverse mortgage both in number of risk and severity of risks, as forest equity borrower risk consist of only moral hazard, without maintenance risk, pre-eminent maturity and default risks.

Based on the literature review of reverse mortgage and forest equity and the examination of configuration applicability to forest equity, applicable reverse forest finance configuration options were narrowed down to ten instruments that were categorised according to withdrawal method to bullet instruments, fixed term instruments and flexible term instruments. All the instruments have a fixed maturity with a slip period and can be offered with fixed or variable interest and the first two can be either non-capitalization instruments or capitalization instruments. All the instruments were callable, due to regulation, and none of the instruments have rollover option.

To fulfil the hypotheses of lender's risk averse preferences, risks of the instrument were minimized by adjusting the maximum principal limit, introducing restrictions on qualifiable collaterals and eligible borrowers, as well as introducing certain covenants. The cornerstone of the instrument was to ensure that cash flows of thermal harvest, the primary collateral value, are sufficient to reimburse the outstanding principle. Thus, nearly all risks that bear uncertainty and potential of loss were adjusted with the maximum principal limit, net principal limit, with interest charged or with covenants.

Risks that were adjusted with the maximum principal limit are collateral value risks of base risk, valuation process risk and price risk, and the risk of natural hazards. The borrowers default risk and moral hazard were adjusted with interest premium of instrument risk and covenants on auditing the collateral. The short-term liquidity risk is mitigated with the introduction of slip period and slip interest. The long-term liquidity risk is adjusted with the secondary collateral value. The interest rate risk of yield risk, real base risk and interest base risk which are root risks to value risk were adjusted by the interest charged, and the cross-over risk of interest rate risk was adjusted by adjusting the net principal limit. With these adjustments the lender's risk exposure for the instrument was reduced and quantified. The restrictions on borrower eligibility included restriction on solvency and financial resiliency, to adjust the default risk and moral hazard risk of the borrower. The restriction on collateral included the value relationship of primary and secondary collateral value amounts, harvestability and location as well as the areal timber market, to lower the short- and long-term liquidity risk, idiosyncratic price and cost risk and cross-over risk. Covenants introduced to reverse forest finance included negative interest netting and forest insurance to adjust the interest rate risk exposure and natural hazard risk.

The ten instruments were examined with the help of two simulations, restricted simulation, and unrestricted simulation. The restricted simulation was conducted with constant prices, maturity, interest, and costs without uncertainty over collateral values. Based on the restricted analysis six of the ten applicable instruments were found to violate the lender's risk adverse preferences or unable to satisfy the borrower's needs and therefore were found to be unapplicable instruments. The variable interest bullet capitalization instrument was found to have too high cross-over risk and to have a higher overall proportional risk compared to variable interest counterpart and was deemed unfit. The flexible term non-capitalized instruments did not satisfy the borrower's needs and therefore were found to be unfit. The fixed term capitalization instrument was found to have higher proportional risk compared to variable interest term instruments, whilst at the same time the variable interest instruments were found to deliver equal borrower satisfaction. In the fixed interest fixed term capitalization instrument, the cross-over risk was higher than in the variable interest flexible term instrument, whilst the fixed interest fixed term capitalization instrument had larger yield curve risk compared to fixed interest flexible term instrument. This was also the case in the variable interest rate instruments. Therefore, the fixed term capitalization instruments were found to be less attractive option to the lender and were found unfit.

After the restricted model examination, four instruments were deemed fit to reverse forest finance and those were studied with unrestricted Monte Carlo model to study the cooperative action of risk. The main interest in the unrestricted model was to examine how the cooperative action of risks affect the cross-over risk, value of the loan agreement and cost of capital to borrower. Based on the unrestricted model, all four instruments fulfilled the financier's risk adverse preferences in both cross over risk and value risk. However, with the given restraints over simulated interest, the variable interest non-capitalization bullet instrument was found to be superior in risk exposure and borrower satisfaction over the fixed interest non-capitalisation instrument.

Therefore, based on the examination the reverse mortgage instrument framework is applicable to forest equity. However, some of the instrument features utilized by reverse mortgage are not suitable to reverse forest finance. Also due to the difference in nature between forest equity and real estate, some additional restrictions on qualifiable collateral must be made. In addition, the determination of collateral value, maximum principal limit and net principal limit differs greatly from the reverse mortgage. The risk profiles of reverse mortgage and reverse forest finance instruments also differs. Reverse forest finance instrument bears some risks, such as liquidity risks, which are not present in the reverse mortgage instrument. However, reverse mortgage has some risks which the reverse forest finance does not have, such as collateral value risk due to interest rates and maintenance moral hazard. There are also several risks which have differences in the severity, magnitude and occurrence.

Based on the examination the reverse forest finance instrument is applicable in the Finnish markets. However, further study must be made on the instrument. Future research objectives could include the examination of configurations found applicable to forest equity, but which were excluded from this study, such as shared appreciation, third party guarantees, non-negative guarantees, line of credit and modified tenure. Further study of risks and especially interest rate risk is needed. Due to assumptions over yield curve, real base risk and interest base risks, the thesis excluded several interest rates risks sources which lower the applicability of this study. Also, further study could explore the possibility of applying the instrument to non-direct ownership forms of forest and other forest owner groups.

Interesting research questions would also be the utilisation of reverse forest finance together with shared appreciation and timber trade or reverse forest buy-out schemes. Reverse forest finance instrument, if utilized in large numbers, could have also potential to transform the timber markets, as reverse forest finance could enhance the tax efficiency of forest investments and returns of forest portfolios. These effects could intensify the forest owners to delay harvest to obtain larger log percent’s which could affect the timber markets in Finland.

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7. APPENDIX

Appendix 1.

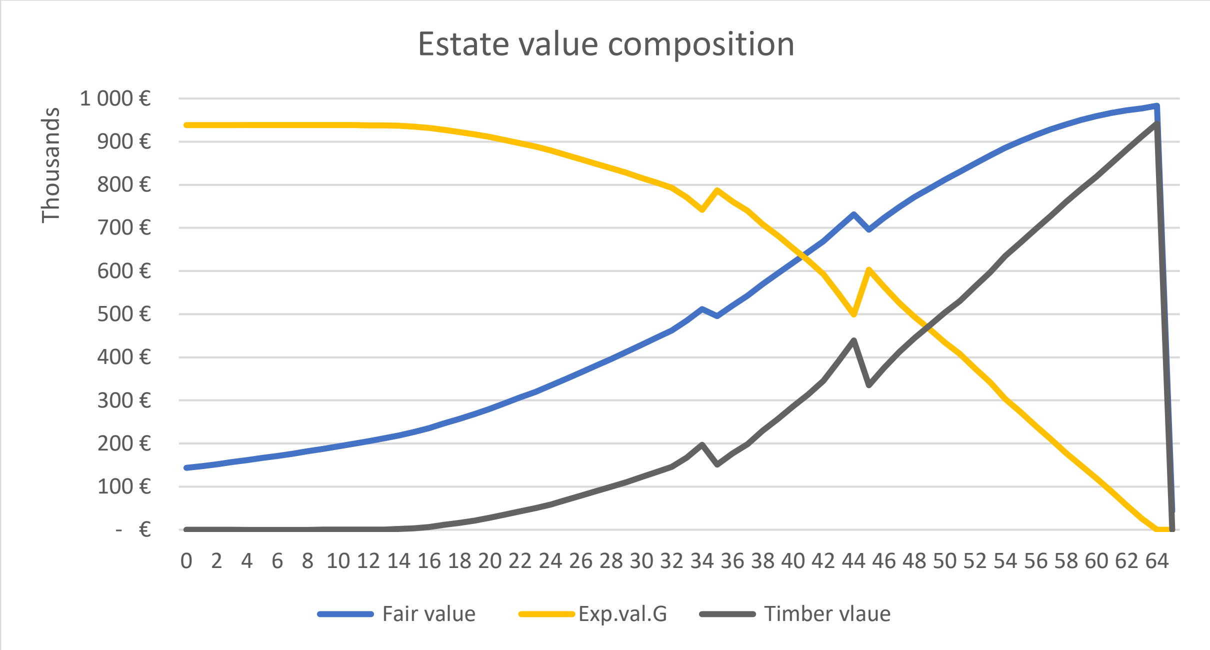

Figure 1 of appendix 1. The fair value estimate, current timber value and nominal value of expected value growth of timber. The fair value of estate is estimated by counting the current timber value added with the discounted value of future cash flows minus the current value of timber, with 3 percent required rate of return, added with the perpetual value of future cash flows with 3 percent interest rate.

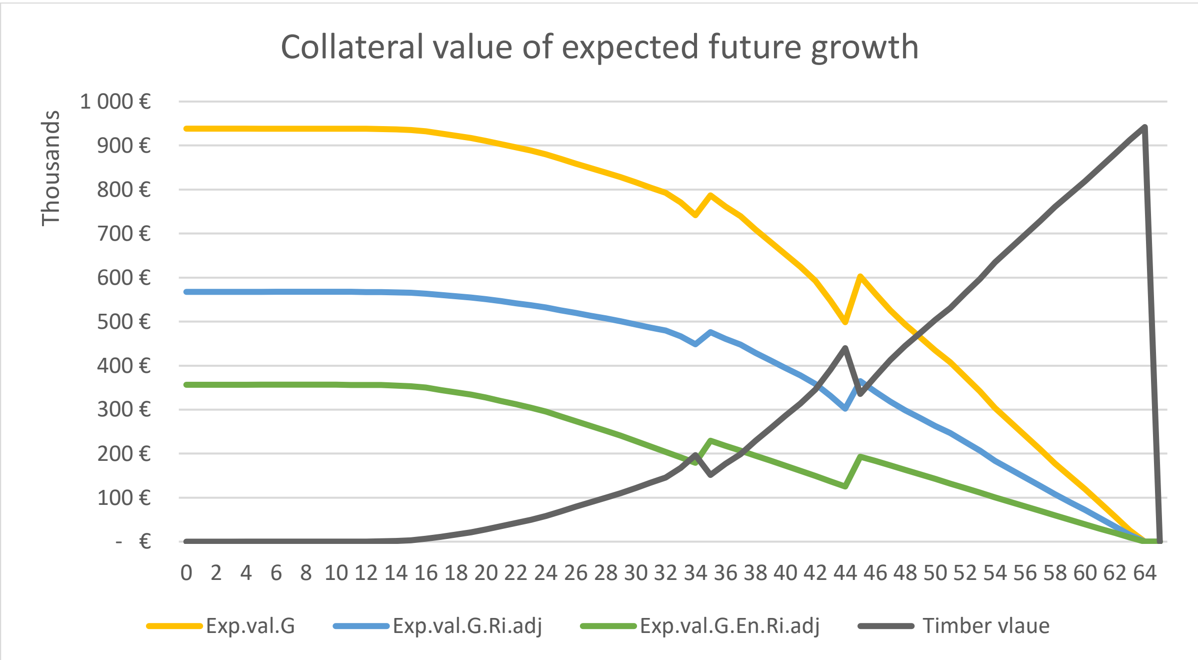

Figure 2 of appendix 1. The relationship of expected value growth and expected value growth adjusted with the valuation risk and environmental risk compared with the value of current timber.

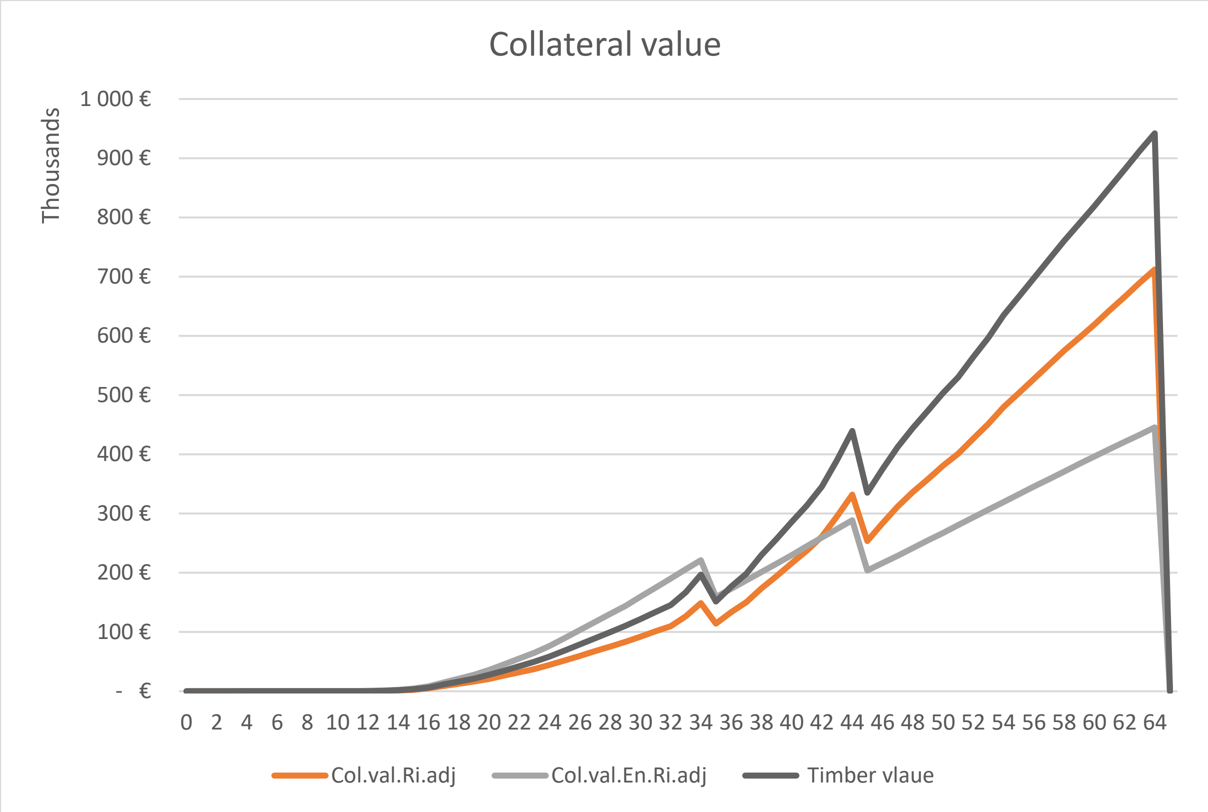

Figure 3 of appendix 1. The relationship of current timber value and current timber value adjusted with the valuation risk and environmental risk. Interesting finding in this figure is that the environmental risk adjusted value of the current timber is higher than the actual value of current timber prior the firs thinning. This is because the maximum compensation of the insurance is timber quantity times maximum compensation amount of 35 Euros which his higher than the price of pulp wood. However, this deviation does not affect the reverse forest finance model as the loan period lays between the last thinning and terminal harvest.

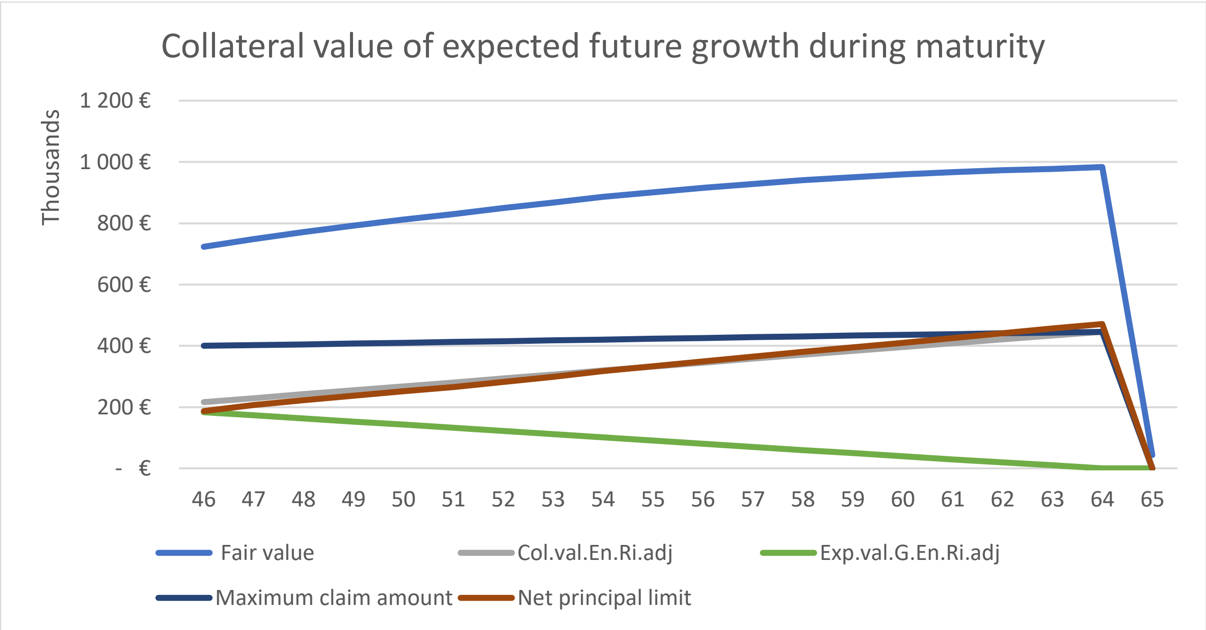

Figure 4 of appendix 1. The key collateral value ratios during the loan period.

Appendix 2.

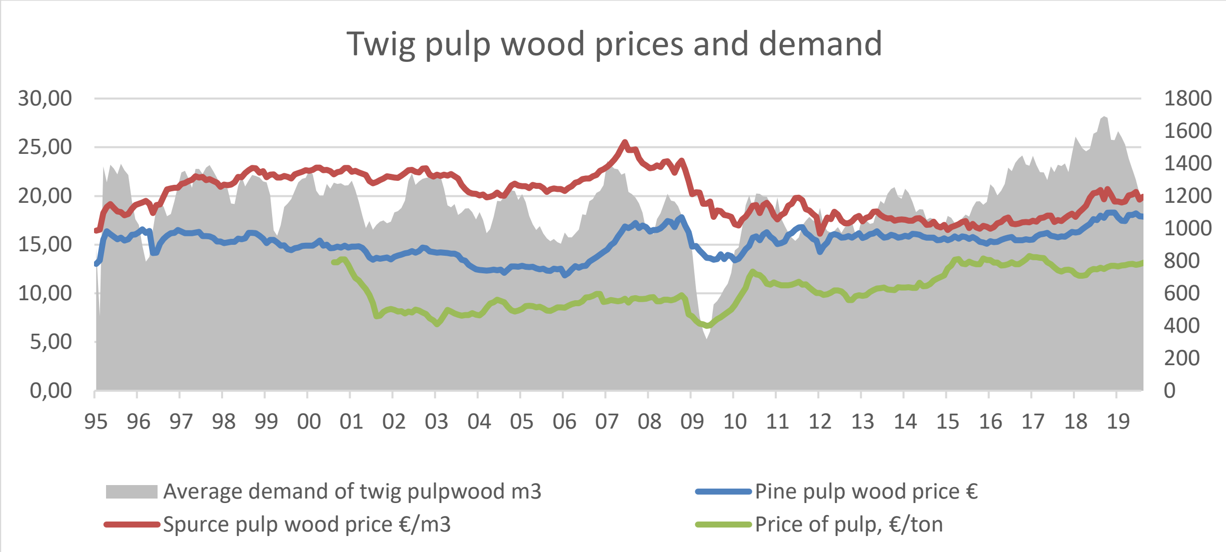

Figure 1 of appendix 2. Twig pulp demand and pulpwood prices on aggregate level in Finland and pulp mass price in North Sea ports (LUKE b 2021; Index Mundi (a) 2020).

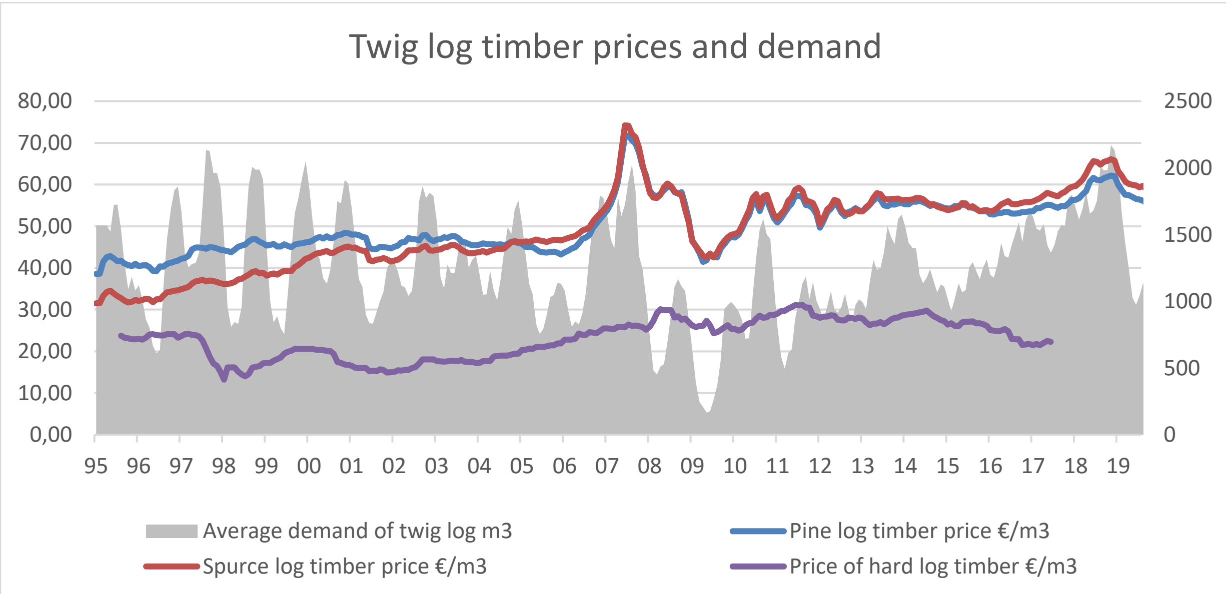

Figure 2 of appendix 2. Twig log timber demand and prices on aggregate level in Finland and the global prices of hard log wood (LUKE b 2021; Index mundi (a) 2022; Index Mundi (b) 2020).

Appendix 3.

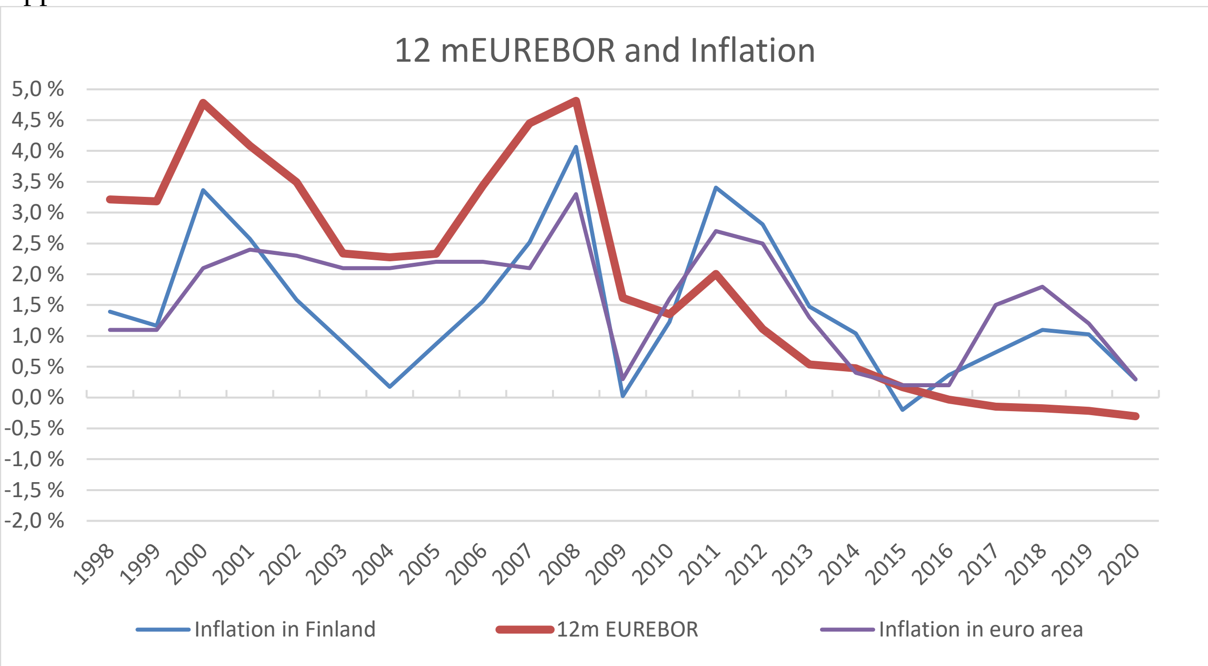

Figure 1 of appendix 3. The relationship of 12-month EURIBOR, Euro area inflation and inflation in Finland. (Suomen pankki 2021; TK 2021; ECB 2021)

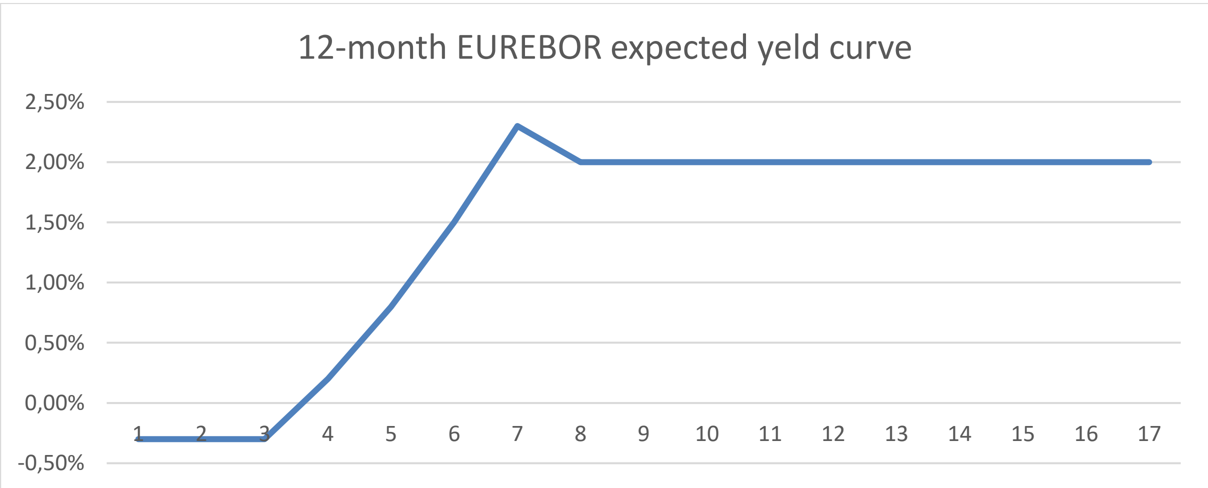

Figure 2 of appendix 3. The expected yield curve.

Appendix 4.

Table 1 of appendix 4. Fixed interest bullet instrument cash flows and key parameters.

Bullet product, Fixed interest, Non-capitalization — Nominal terms

	Borrower							Lender	
Year	Total cash flow	CF forestry	CF direct cost	CF indirect cost	CF interest	CF principal payemnts	Principal	Total cash flow	CF liabilities
1	201 163 €	-2 500 €	-2 123 €	-540 €	- €	206 326 €	206 326 €	-204 203 €	-206 326 €
2	-8 853 €	- €	-60 €	-540 €	-8 253 €	- €	206 326 €	8 313 €	- €
3	-8 853 €	- €	-60 €	-540 €	-8 253 €	- €	206 326 €	8 313 €	- €
4	-8 853 €	- €	-60 €	-540 €	-8 253 €	- €	206 326 €	8 313 €	- €
5	-8 853 €	- €	-60 €	-540 €	-8 253 €	- €	206 326 €	8 313 €	- €
6	-8 853 €	- €	-60 €	-540 €	-8 253 €	- €	206 326 €	8 313 €	- €
7	-8 853 €	- €	-60 €	-540 €	-8 253 €	- €	206 326 €	8 313 €	- €
8	-8 853 €	- €	-60 €	-540 €	-8 253 €	- €	206 326 €	8 313 €	- €
9	-8 853 €	- €	-60 €	-540 €	-8 253 €	- €	206 326 €	8 313 €	- €
10	-11 353 €	-2 500 €	-60 €	-540 €	-8 253 €	- €	206 326 €	8 313 €	- €
11	-8 853 €	- €	-60 €	-540 €	-8 253 €	- €	206 326 €	8 313 €	- €
12	-8 853 €	- €	-60 €	-540 €	-8 253 €	- €	206 326 €	8 313 €	- €
13	-8 853 €	- €	-60 €	-540 €	-8 253 €	- €	206 326 €	8 313 €	- €
14	-8 853 €	- €	-60 €	-540 €	-8 253 €	- €	206 326 €	8 313 €	- €
15	-8 853 €	- €	-60 €	-540 €	-8 253 €	- €	206 326 €	8 313 €	- €
16	-8 853 €	- €	-60 €	-540 €	-8 253 €	- €	206 326 €	8 313 €	- €
17	-8 853 €	- €	-60 €	-540 €	-8 253 €	- €	206 326 €	8 313 €	- €
18	726 860 €	942 039 €	-60 €	-540 €	-8 253 €	-206 326 €	- €	214 639 €	206 326 €
Total	783 874 €	937 039 €	-3 143 €	-9 720 €	-140 302 €	- €		143 445 €	- €
%	380 %	454 %	-2 %	-5 %	-68 %	0 %		70 %	0 %
TLC	74 %		Percent of maximum limit			51 %		IRR	4,11 %

Bullet product, Fixed interest, Non-capitalization — Real terms 2 % discount rate

Year	Total cash flow	CF forestry	CF direct cost	CF indirect cost	CF interest	CF principal payemnts	Principal	Total cash flow	CF liabilities
1	197 219 €	-2 451 €	-2 082 €	-529 €	- €	202 281 €	202 281 €	-200 199 €	-202 281 €
2	-8 509 €	- €	-58 €	-519 €	-7 933 €	- €	198 314 €	7 990 €	- €
3	-8 342 €	- €	-57 €	-509 €	-7 777 €	- €	194 426 €	7 834 €	- €
4	-8 179 €	- €	-55 €	-499 €	-7 625 €	- €	190 614 €	7 680 €	- €
5	-8 018 €	- €	-54 €	-489 €	-7 475 €	- €	186 876 €	7 529 €	- €
6	-7 861 €	- €	-53 €	-480 €	-7 328 €	- €	183 212 €	7 382 €	- €
7	-7 707 €	- €	-52 €	-470 €	-7 185 €	- €	179 619 €	7 237 €	- €
8	-7 556 €	- €	-51 €	-461 €	-7 044 €	- €	176 097 €	7 095 €	- €
9	-7 408 €	- €	-50 €	-452 €	-6 906 €	- €	172 645 €	6 956 €	- €
10	-9 313 €	-2 051 €	-49 €	-443 €	-6 770 €	- €	169 259 €	6 820 €	- €
11	-7 120 €	- €	-48 €	-434 €	-6 638 €	- €	165 941 €	6 686 €	- €
12	-6 981 €	- €	-47 €	-426 €	-6 507 €	- €	162 687 €	6 555 €	- €
13	-6 844 €	- €	-46 €	-417 €	-6 380 €	- €	159 497 €	6 426 €	- €
14	-6 710 €	- €	-45 €	-409 €	-6 255 €	- €	156 370 €	6 300 €	- €
15	-6 578 €	- €	-45 €	-401 €	-6 132 €	- €	153 303 €	6 177 €	- €
16	-6 449 €	- €	-44 €	-393 €	-6 012 €	- €	150 298 €	6 056 €	- €
17	-6 323 €	- €	-43 €	-386 €	-5 894 €	- €	147 350 €	5 937 €	- €
18	508 918 €	659 577 €	-42 €	-378 €	-5 778 €	-144 461 €	- €	150 282 €	144 461 €
Total	586 238 €	655 076 €	-2 922 €	-8 096 €	-115 639 €	57 819 €		60 742 €	-57 819 €
%	284 %	317 %	-1 %	-4 %	-56 %	28 %		29 %	-28 %
TLC	33 %							IRR	2,07 %

Bullet product, Fixed interest, Capitalization — Nominal terms

	Borrower							Lender	
Year	Total cash flow	CF forestry	CF direct cost	CF indirect cost	CF interest	CF principal	Principal	Total cash flow	CF liabilities and assets
1	201 163 €	-2 500 €	-2 123 €	-540 €	- €	206 326 €	206 326 €	-204 203 €	-206 326 €
2	-600 €	- €	-60 €	-540 €	-8 253 €	- €	214 579 €	60 €	- €
3	-600 €	- €	-60 €	-540 €	-8 583 €	- €	223 162 €	60 €	- €
4	-600 €	- €	-60 €	-540 €	-8 926 €	- €	232 089 €	60 €	- €
5	-600 €	- €	-60 €	-540 €	-9 284 €	- €	241 373 €	60 €	- €
6	-600 €	- €	-60 €	-540 €	-9 655 €	- €	251 027 €	60 €	- €
7	-600 €	- €	-60 €	-540 €	-10 041 €	- €	261 069 €	60 €	- €
8	-600 €	- €	-60 €	-540 €	-10 443 €	- €	271 511 €	60 €	- €
9	-600 €	- €	-60 €	-540 €	-10 860 €	- €	282 372 €	60 €	- €
10	-3 100 €	-2 500 €	-60 €	-540 €	-11 295 €	- €	293 667 €	60 €	- €
11	-600 €	- €	-60 €	-540 €	-11 747 €	- €	305 413 €	60 €	- €
12	-600 €	- €	-60 €	-540 €	-12 217 €	- €	317 630 €	60 €	- €
13	-600 €	- €	-60 €	-540 €	-12 705 €	- €	330 335 €	60 €	- €
14	-600 €	- €	-60 €	-540 €	-13 213 €	- €	343 548 €	60 €	- €
15	-600 €	- €	-60 €	-540 €	-13 742 €	- €	357 290 €	60 €	- €
16	-600 €	- €	-60 €	-540 €	-14 292 €	- €	371 582 €	60 €	- €
17	-600 €	- €	-60 €	-540 €	-14 863 €	- €	386 445 €	60 €	- €
18	539 536 €	942 039 €	-60 €	-540 €	-15 458 €	-401 903 €	0 €	401 963 €	401 903 €
Total	728 599 €	937 039 €	-3 143 €	-9 720 €	-195 577 €	-195 577 €		198 720 €	195 577 €
%	353 %	454 %	-2 %	-5 %	-95 %	-95 %		96 %	95 %
TLC	101 %		Percent of maximum limit			100 %		IRR	4,09 %

Bullet product, Fixed interest, Capitalization — Real terms 2 % discount rate

Year	Total cash flow	CF forestry	CF direct cost	CF indirect cost	CF interest	CF principal	Principal	Total cash flow	CF liabilities and assets
1	197 219 €	-2 451 €	-2 082 €	-529 €	- €	202 281 €	202 281 €	-200 199 €	-202 281 €
2	-577 €	- €	-58 €	-519 €	-7 933 €	- €	206 247 €	58 €	- €
3	-565 €	- €	-57 €	-509 €	-8 088 €	- €	210 291 €	57 €	- €
4	-554 €	- €	-55 €	-499 €	-8 247 €	- €	214 414 €	55 €	- €
5	-543 €	- €	-54 €	-489 €	-8 408 €	- €	218 619 €	54 €	- €
6	-533 €	- €	-53 €	-480 €	-8 573 €	- €	222 905 €	53 €	- €
7	-522 €	- €	-52 €	-470 €	-8 741 €	- €	227 276 €	52 €	- €
8	-512 €	- €	-51 €	-461 €	-8 913 €	- €	231 732 €	51 €	- €
9	-502 €	- €	-50 €	-452 €	-9 088 €	- €	236 276 €	50 €	- €
10	-2 543 €	-2 051 €	-49 €	-443 €	-9 266 €	- €	240 909 €	49 €	- €
11	-483 €	- €	-48 €	-434 €	-9 447 €	- €	245 633 €	48 €	- €
12	-473 €	- €	-47 €	-426 €	-9 633 €	- €	250 449 €	47 €	- €
13	-464 €	- €	-46 €	-417 €	-9 822 €	- €	255 360 €	46 €	- €
14	-455 €	- €	-45 €	-409 €	-10 014 €	- €	260 367 €	45 €	- €
15	-446 €	- €	-45 €	-401 €	-10 210 €	- €	265 472 €	45 €	- €
16	-437 €	- €	-44 €	-393 €	-10 411 €	- €	270 677 €	44 €	- €
17	-428 €	- €	-43 €	-386 €	-10 615 €	- €	275 985 €	43 €	- €
18	377 761 €	659 577 €	-42 €	-378 €	-10 823 €	-281 396 €	0 €	281 438 €	281 396 €
Total	564 942 €	655 076 €	-2 922 €	-8 096 €	-158 231 €	-79 116 €		82 038 €	79 116 €
%	274 %	317 %	-1 %	-4 %	-77 %	-38 %		40 %	38 %
TLC	44 %							IRR	2,04 %

Non-capitalization summary

		Borrower						Lender	
		Total cash flow	CF forestry	CF direct cost	CF indirect cost	CF interest	CF principal payemnts	Total cash flow	CF liabilities
Nominal		783 874 €	937 039 €	-3 143 €	-9 720 €	-140 302 €	- €	143 445 €	- €
		380 %	454 %	-2 %	-5 %	-68 %	0 %	70 %	0 %
		TLC	74 %		Percent of maximum limit		51 %	IRR	4,11 %
-0,5 %	Real	846 439 €	1 025 846 €	-3 207 €	-10 198 €	-147 558 €	-18 445 €	169 210 €	18 445 €
		410 %	497 %	-2 %	-5 %	-72 %	-9 %	82 %	9 %
		TLC	87 %					IRR	4,64 %
1,0 %	Real	675 567 €	782 822 €	-3 027 €	-8 855 €	-127 164 €	31 791 €	98 400 €	-31 791 €
		327 %	379 %	-1 %	-4 %	-62 %	15 %	48 %	-15 %
		TLC	52 %					IRR	3,08 %
2,0 %	Real	586 238 €	655 076 €	-2 922 €	-8 096 €	-115 639 €	57 819 €	60 742 €	-57 819 €
		284 %	317 %	-1 %	-4 %	-56 %	28 %	29 %	-28 %
		TLC	33 %					IRR	2,07 %
3,0 %	Real	512 432 €	549 061 €	-2 828 €	-7 427 €	-105 496 €	79 122 €	29 202 €	-79 122 €
		248 %	266 %	-1 %	-4 %	-51 %	38 %	14 %	-38 %
		TLC	18 %					IRR	1,08 %
5,0 %	Real	400 696 €	387 521 €	-2 666 €	-6 312 €	-88 615 €	110 768 €	-19 487 €	-110 768 €
		194 %	188 %	-1 %	-3 %	-43 %	54 %	-9 %	-54 %
		TLC	6 %					IRR	-0,84 %

Capitalization summary

		Borrower						Lender	
		Total cash flow	CF forestry	CF direct cost	CF indirect cost	CF interest	CF principal payemnts	Total cash flow	CF liabilities and assets
Nominal		728 599 €	937 039 €	-3 143 €	-9 720 €	-195 577 €	-195 577 €	198 720 €	195 577 €
		353 %	454 %	-2 %	-5 %	-95 %	-95 %	96 %	95 %
		TLC	101 %		Percent of maximum limit		100 %	IRR	4,09 %
-0,5 %	Real	779 954 €	1 025 846 €	-3 207 €	-10 198 €	-206 656 €	-232 488 €	235 695 €	232 488 €
		378 %	497 %	-2 %	-5 %	-100 %	-113 %	114 %	113 %
		TLC	119 %					IRR	4,61 %
1,0 %	Real	639 226 €	782 822 €	-3 027 €	-8 855 €	-175 619 €	-131 714 €	134 741 €	131 714 €
		310 %	379 %	-1 %	-4 %	-85 %	-64 %	65 %	64 %
		TLC	70 %					IRR	3,05 %
2,0 %	Real	564 942 €	655 076 €	-2 922 €	-8 096 €	-158 231 €	-79 116 €	82 038 €	79 116 €
		274 %	317 %	-1 %	-4 %	-77 %	-38 %	40 %	38 %
		TLC	44 %					IRR	2,04 %
3,0 %	Real	503 047 €	549 061 €	-2 828 €	-7 427 €	-143 036 €	-35 759 €	38 587 €	35 759 €
		244 %	266 %	-1 %	-4 %	-69 %	-17 %	19 %	17 %
		TLC	22 %					IRR	1,05 %
5,0 %	Real	408 044 €	387 521 €	-2 666 €	-6 312 €	-118 009 €	29 502 €	-26 836 €	-29 502 €
		198 %	188 %	-1 %	-3 %	-57 %	14 %	-13 %	-14 %
		TLC	10 %					IRR	-0,87 %

Table 2 of appendix 4. Variable interest bullet instruments key parameters.

Bullet poduct, Variable interest Non-capitalisation		Borrower						Lender	
		Total cash flow	CF forestry	CF direct cost	CF indirect cost	CF interest	CF principal payemnts	Total cash flow	CF liabilities
-0,5 %	Nominal	836 487 €	937 039 €	-3 143 €	-9 720 €	-87 689 €	- €	90 832 €	- €
		405 %	454 %	-2 %	-5 %	-43 %	0 %	44 %	0 %
		TLC	49 %		Percent of maximum limit		51 %	IRR	2,60 %
	Real	901 774 €	1 025 846 €	-3 207 €	-10 198 €	-92 224 €	-18 445 €	113 875 €	18 445 €
		437 %	497 %	-2 %	-5 %	-45 %	-9 %	55 %	9 %
		TLC	60 %					IRR	3,12 %
1,0 %	Nominal	801 412 €	937 039 €	-3 143 €	-9 720 €	-122 764 €	- €	125 907 €	- €
		388 %	454 %	-2 %	-5 %	-60 %	0 %	61 %	0 %
		TLC	66 %		Percent of maximum limit		51 %	IRR	3,61 %
	Real	691 463 €	782 822 €	-3 027 €	-8 855 €	-111 269 €	31 791 €	82 504 €	-31 791 €
		335 %	379 %	-1 %	-4 %	-54 %	15 %	40 %	-15 %
		TLC	44 %					IRR	2,59 %
2,0 %	Nominal	766 336 €	937 039 €	-3 143 €	-9 720 €	-157 840 €	- €	160 983 €	- €
		371 %	454 %	-2 %	-5 %	-77 %	0 %	78 %	0 %
		TLC	83 %		Percent of maximum limit		51 %	IRR	4,62 %
	Real	571 783 €	655 076 €	-2 922 €	-8 096 €	-130 094 €	57 819 €	75 197 €	-57 819 €
		277 %	317 %	-1 %	-4 %	-63 %	28 %	36 %	-28 %
		TLC	40 %					IRR	2,57 %
3,0 %	Nominal	731 261 €	937 039 €	-3 143 €	-9 720 €	-192 915 €	- €	196 058 €	- €
		354 %	454 %	-2 %	-5 %	-94 %	0 %	95 %	0 %
		TLC	100 %		Percent of maximum limit		51 %	IRR	5,62 %
	Real	472 871 €	549 061 €	-2 828 €	-7 427 €	-145 057 €	79 122 €	68 763 €	-79 122 €
		229 %	266 %	-1 %	-4 %	-70 %	38 %	33 %	-38 %
		TLC	37 %					IRR	2,55 %
5,0 %	Nominal	661 110 €	937 039 €	-3 143 €	-9 720 €	-263 066 €	- €	266 209 €	- €
		320 %	454 %	-2 %	-5 %	-128 %	0 %	129 %	0 %
		TLC	134 %		Percent of maximum limit		51 %	IRR	7,64 %
	Real	323 158 €	387 521 €	-2 666 €	-6 312 €	-166 153 €	110 768 €	58 051 €	-110 768 €
		157 %	188 %	-1 %	-3 %	-81 %	54 %	28 %	-54 %
		TLC	31 %					IRR	2,51 %

Bullet product, Variable interest Capitalisation		Borrower						Lender	
		Total cash flow	CF forestry	CF direct cost	CF indirect cost	Itenrest expenses	CF principal payemnts	Total cash flow	CF liabilities and assets
-0,5 %	Nominal	816 552 €	937 039 €	-3 143 €	-9 720 €	-107 624 €	-107 624 €	110 767 €	107 624 €
		396 %	454 %	-2 %	-5 %	-52 %	-52 %	54 %	52 %
		TLC	58 %		Percent of maximum limit		78 %	IRR	2,59 %
	Real	876 212 €	1 025 846 €	-3 207 €	-10 198 €	-113 525 €	-136 230 €	139 437 €	136 230 €
		425 %	497 %	-2 %	-5 %	-55 %	-66 %	68 %	66 %
		TLC	73 %					IRR	3,10 %
1,0 %	Nominal	760 213 €	937 039 €	-3 143 €	-9 720 €	-163 962 €	-163 962 €	167 106 €	163 962 €
		368 %	454 %	-2 %	-5 %	-79 %	-79 %	81 %	79 %
		TLC	86 %		Percent of maximum limit		92 %	IRR	3,59 %
	Real	665 656 €	782 822 €	-3 027 €	-8 855 €	-147 398 €	-105 284 €	108 311 €	105 284 €
		323 %	379 %	-1 %	-4 %	-71 %	-51 %	52 %	51 %
		TLC	57 %					IRR	2,56 %
2,0 %	Nominal	694 457 €	937 039 €	-3 143 €	-9 720 €	-229 719 €	-229 719 €	232 862 €	229 719 €
		337 %	454 %	-2 %	-5 %	-111 %	-111 %	113 %	111 %
		TLC	118 %		Percent of maximum limit		108 %	IRR	4,58 %
	Real	541 037 €	655 076 €	-2 922 €	-8 096 €	-185 437 €	-103 020 €	105 943 €	103 020 €
		262 %	317 %	-1 %	-4 %	-90 %	-50 %	51 %	50 %
		TLC	55 %					IRR	2,53 %
3,0 %	Nominal	617 822 €	937 039 €	-3 143 €	-9 720 €	-306 354 €	-306 354 €	309 497 €	306 354 €
		299 %	454 %	-2 %	-5 %	-148 %	-148 %	150 %	148 %
		TLC	155 %		Percent of maximum limit		127 %	IRR	5,58 %
	Real	437 977 €	549 061 €	-2 828 €	-7 427 €	-221 823 €	-100 829 €	103 657 €	100 829 €
		212 %	266 %	-1 %	-4 %	-108 %	-49 %	50 %	49 %
		TLC	54 %					IRR	2,51 %
5,0 %	Nominal	425 000 €	937 039 €	-3 143 €	-9 720 €	-499 176 €	-499 176 €	502 319 €	499 176 €
		206 %	454 %	-2 %	-5 %	-242 %	-242 %	243 %	242 %
		TLC	248 %		Percent of maximum limit		175 %	IRR	7,58 %
	Real	281 893 €	387 521 €	-2 666 €	-6 312 €	-289 949 €	-96 650 €	99 316 €	96 650 €
		137 %	188 %	-1 %	-3 %	-141 %	-47 %	48 %	47 %
		TLC	51 %					IRR	2,46 %

Table 3 of appendix 4. Fixed interest fixed term instrument cash flows and key parameters.

Term product, Fixed interest, Non-capitalization									
Nominal terms									
	Borrower							Lender	
Year	Total cash flow	CF forestry	CF direct cost	CF indirect cost	Interest expenses	CF principal payemnts	Principal	Total cash flow	CF liabilities
1	6 974 €	-2 500 €	-2 123 €	-540 €	- €	12 137 €	12 137 €	-10 014 €	-12 137 €
2	11 051 €	- €	-60 €	-540 €	-485 €	12 137 €	24 274 €	-11 591 €	-12 137 €
3	10 566 €	- €	-60 €	-540 €	-971 €	12 137 €	36 411 €	-11 106 €	-12 137 €
4	10 080 €	- €	-60 €	-540 €	-1 456 €	12 137 €	48 547 €	-10 620 €	-12 137 €
5	9 595 €	- €	-60 €	-540 €	-1 942 €	12 137 €	60 684 €	-10 135 €	-12 137 €
6	9 109 €	- €	-60 €	-540 €	-2 427 €	12 137 €	72 821 €	-9 649 €	-12 137 €
7	8 624 €	- €	-60 €	-540 €	-2 913 €	12 137 €	84 958 €	-9 164 €	-12 137 €
8	8 139 €	- €	-60 €	-540 €	-3 398 €	12 137 €	97 095 €	-8 679 €	-12 137 €
9	7 653 €	- €	-60 €	-540 €	-3 884 €	12 137 €	109 232 €	-8 193 €	-12 137 €
10	4 668 €	-2 500 €	-60 €	-540 €	-4 369 €	12 137 €	121 368 €	-7 708 €	-12 137 €
11	6 682 €	- €	-60 €	-540 €	-4 855 €	12 137 €	133 505 €	-7 222 €	-12 137 €
12	6 197 €	- €	-60 €	-540 €	-5 340 €	12 137 €	145 642 €	-6 737 €	-12 137 €
13	5 711 €	- €	-60 €	-540 €	-5 826 €	12 137 €	157 779 €	-6 251 €	-12 137 €
14	5 226 €	- €	-60 €	-540 €	-6 311 €	12 137 €	169 916 €	-5 766 €	-12 137 €
15	4 740 €	- €	-60 €	-540 €	-6 797 €	12 137 €	182 053 €	-5 280 €	-12 137 €
16	4 255 €	- €	-60 €	-540 €	-7 282 €	12 137 €	194 189 €	-4 795 €	-12 137 €
17	3 769 €	- €	-60 €	-540 €	-7 768 €	12 137 €	206 326 €	-4 309 €	-12 137 €
18	726 860 €	942 039 €	-60 €	-540 €	-8 253 €	-206 326 €	- €	214 639 €	206 326 €
Total	849 898 €	937 039 €	-3 143 €	-9 720 €	-74 277 €	- €		77 421 €	- €
%	412 %	454 %	-2 %	-5 %	-36 %	0 %		38 %	0 %
TLC	42 %			Percent of maximum limit		51 %		IRR	4,24 %
Real terms 2 % discount rate									
Year	Total cash flow	CF forestry	CF direct cost	CF indirect cost	Interest expenses	CF principal payemnts	Principal	Total cash flow	CF liabilities
1	6 837 €	-2 451 €	-2 082 €	-529 €	- €	11 899 €	11 899 €	-9 817 €	-11 899 €
2	10 622 €	- €	-58 €	-519 €	-467 €	11 666 €	23 331 €	-11 141 €	-11 666 €
3	9 956 €	- €	-57 €	-509 €	-915 €	11 437 €	34 310 €	-10 465 €	-11 437 €
4	9 313 €	- €	-55 €	-499 €	-1 346 €	11 213 €	44 850 €	-9 812 €	-11 213 €
5	8 690 €	- €	-54 €	-489 €	-1 759 €	10 993 €	54 964 €	-9 180 €	-10 993 €
6	8 089 €	- €	-53 €	-480 €	-2 155 €	10 777 €	64 663 €	-8 568 €	-10 777 €
7	7 508 €	- €	-52 €	-470 €	-2 536 €	10 566 €	73 961 €	-7 978 €	-10 566 €
8	6 946 €	- €	-51 €	-461 €	-2 900 €	10 359 €	82 869 €	-7 407 €	-10 359 €
9	6 404 €	- €	-50 €	-452 €	-3 250 €	10 156 €	91 400 €	-6 856 €	-10 156 €
10	3 829 €	-2 051 €	-49 €	-443 €	-3 584 €	9 956 €	99 564 €	-6 323 €	-9 956 €
11	5 374 €	- €	-48 €	-434 €	-3 904 €	9 761 €	107 373 €	-5 808 €	-9 761 €
12	4 886 €	- €	-47 €	-426 €	-4 211 €	9 570 €	114 838 €	-5 312 €	-9 570 €
13	4 415 €	- €	-46 €	-417 €	-4 503 €	9 382 €	121 968 €	-4 832 €	-9 382 €
14	3 960 €	- €	-45 €	-409 €	-4 783 €	9 198 €	128 775 €	-4 370 €	-9 198 €
15	3 522 €	- €	-45 €	-401 €	-5 050 €	9 018 €	135 268 €	-3 923 €	-9 018 €
16	3 099 €	- €	-44 €	-393 €	-5 305 €	8 841 €	141 456 €	-3 493 €	-8 841 €
17	2 692 €	- €	-43 €	-386 €	-5 547 €	8 668 €	147 350 €	-3 078 €	-8 668 €
18	508 918 €	659 577 €	-42 €	-378 €	-5 778 €	-144 461 €	- €	150 282 €	144 461 €
Total	615 061 €	655 076 €	-2 922 €	-8 096 €	-57 994 €	28 997 €		31 919 €	-28 997 €
%	298 %	317 %	-1 %	-4 %	-28 %	14 %		15 %	-14 %
TLC	19 %							IRR	2,20 %

Term product, Fixed interest, Capitalization									
Nominal terms									
	Borrower							Lender	
Year	Total cash flow	CF forestry	CF direct cost	CF indirect cost	Interest expenses	CF principal	Principal	Total cash flow	CF liabilities and assets
1	6 974 €	-2 500 €	-2 123 €	-540 €	- €	12 137 €	12 137 €	-10 014 €	-12 137 €
2	11 537 €	- €	-60 €	-540 €	-485 €	12 137 €	24 759 €	-12 077 €	-12 137 €
3	11 537 €	- €	-60 €	-540 €	-990 €	12 137 €	37 886 €	-12 077 €	-12 137 €
4	11 537 €	- €	-60 €	-540 €	-1 515 €	12 137 €	51 539 €	-12 077 €	-12 137 €
5	11 537 €	- €	-60 €	-540 €	-2 062 €	12 137 €	65 737 €	-12 077 €	-12 137 €
6	11 537 €	- €	-60 €	-540 €	-2 629 €	12 137 €	80 503 €	-12 077 €	-12 137 €
7	11 537 €	- €	-60 €	-540 €	-3 220 €	12 137 €	95 860 €	-12 077 €	-12 137 €
8	11 537 €	- €	-60 €	-540 €	-3 834 €	12 137 €	111 832 €	-12 077 €	-12 137 €
9	11 537 €	- €	-60 €	-540 €	-4 473 €	12 137 €	128 442 €	-12 077 €	-12 137 €
10	9 037 €	-2 500 €	-60 €	-540 €	-5 138 €	12 137 €	145 716 €	-12 077 €	-12 137 €
11	11 537 €	- €	-60 €	-540 €	-5 829 €	12 137 €	163 682 €	-12 077 €	-12 137 €
12	11 537 €	- €	-60 €	-540 €	-6 547 €	12 137 €	182 366 €	-12 077 €	-12 137 €
13	11 537 €	- €	-60 €	-540 €	-7 295 €	12 137 €	201 797 €	-12 077 €	-12 137 €
14	11 537 €	- €	-60 €	-540 €	-8 072 €	12 137 €	222 006 €	-12 077 €	-12 137 €
15	11 537 €	- €	-60 €	-540 €	-8 880 €	12 137 €	243 023 €	-12 077 €	-12 137 €
16	11 537 €	- €	-60 €	-540 €	-9 721 €	12 137 €	264 881 €	-12 077 €	-12 137 €
17	11 537 €	- €	-60 €	-540 €	-10 595 €	12 137 €	287 613 €	-12 077 €	-12 137 €
18	642 322 €	942 039 €	-60 €	-540 €	-11 505 €	-299 117 €	0 €	299 177 €	299 117 €
Total	831 385 €	937 039 €	-3 143 €	-9 720 €	-92 791 €	-92 791 €		95 934 €	92 791 €
%	403 %	454 %	-2 %	-5 %	-45 %	-45 %		46 %	45 %
TLC	42 %			Percent of maximum limit		74 %		IRR	4,24 %
Real terms 2 % discount rate									
Year	Total cash flow	CF forestry	CF direct cost	CF indirect cost	Interest expenses	CF principal	Principal	Total cash flow	CF liabilities and assets
1	6 837 €	-2 451 €	-2 082 €	-529 €	- €	11 899 €	11 899 €	-9 817 €	-11 899 €
2	11 089 €	- €	-58 €	-519 €	-467 €	11 666 €	23 798 €	-11 608 €	-11 666 €
3	10 871 €	- €	-57 €	-509 €	-933 €	11 437 €	35 701 €	-11 380 €	-11 437 €
4	10 658 €	- €	-55 €	-499 €	-1 400 €	11 213 €	47 614 €	-11 157 €	-11 213 €
5	10 449 €	- €	-54 €	-489 €	-1 867 €	10 993 €	59 540 €	-10 938 €	-10 993 €
6	10 244 €	- €	-53 €	-480 €	-2 335 €	10 777 €	71 485 €	-10 724 €	-10 777 €
7	10 044 €	- €	-52 €	-470 €	-2 803 €	10 566 €	83 452 €	-10 514 €	-10 566 €
8	9 847 €	- €	-51 €	-461 €	-3 273 €	10 359 €	95 447 €	-10 307 €	-10 359 €
9	9 654 €	- €	-50 €	-452 €	-3 743 €	10 156 €	107 474 €	-10 105 €	-10 156 €
10	7 413 €	-2 051 €	-49 €	-443 €	-4 215 €	9 956 €	119 538 €	-9 907 €	-9 956 €
11	9 279 €	- €	-48 €	-434 €	-4 688 €	9 761 €	131 643 €	-9 713 €	-9 761 €
12	9 097 €	- €	-47 €	-426 €	-5 162 €	9 570 €	143 794 €	-9 523 €	-9 570 €
13	8 918 €	- €	-46 €	-417 €	-5 639 €	9 382 €	155 996 €	-9 336 €	-9 382 €
14	8 743 €	- €	-45 €	-409 €	-6 117 €	9 198 €	168 253 €	-9 153 €	-9 198 €
15	8 572 €	- €	-45 €	-401 €	-6 598 €	9 018 €	180 570 €	-8 973 €	-9 018 €
16	8 404 €	- €	-44 €	-393 €	-7 081 €	8 841 €	192 951 €	-8 797 €	-8 841 €
17	8 239 €	- €	-43 €	-386 €	-7 567 €	8 668 €	205 402 €	-8 625 €	-8 668 €
18	449 727 €	659 577 €	-42 €	-378 €	-8 055 €	-209 430 €	0 €	209 472 €	209 430 €
Total	608 086 €	655 076 €	-2 922 €	-8 096 €	-71 943 €	-35 972 €		38 894 €	35 972 €
%	295 %	317 %	-1 %	-4 %	-35 %	-17 %		19 %	17 %
TLC	23 %							IRR	2,15 %

		Borrower						Lender	
		Total cash flow	CF forestry	CF direct cost	CF indirect cost	Itenrest expenses	CF principal payemnts	Total cash flow	CF liabilities
	Nominal	849 898 €	937 039 €	-3 143 €	-9 720 €	-74 277 €	- €	77 421 €	- €
		412 %	454 %	-2 %	-5 %	-36 %	0 %	38 %	0 %
		TLC	42 %		Percent of maximum limit		51 %	IRR	4,24 %
-0,5 %	Real	923 384 €	1 025 846 €	-3 207 €	-10 198 €	-79 163 €	-9 895 €	92 265 €	9 895 €
		448 %	497 %	-2 %	-5 %	-38 %	-5 %	45 %	5 %
		TLC	50 %					IRR	4,77 %
1,0 %	Real	721 788 €	782 822 €	-3 027 €	-8 855 €	-65 537 €	16 384 €	52 179 €	-16 384 €
		350 %	379 %	-1 %	-4 %	-32 %	8 %	25 %	-8 %
		TLC	30 %					IRR	3,21 %
2,0 %	Real	615 061 €	655 076 €	-2 922 €	-8 096 €	-57 994 €	28 997 €	31 919 €	-28 997 €
		298 %	317 %	-1 %	-4 %	-28 %	14 %	15 %	-14 %
		TLC	19 %					IRR	2,20 %
3,0 %	Real	525 939 €	549 061 €	-2 828 €	-7 427 €	-51 467 €	38 600 €	15 695 €	-38 600 €
		255 %	266 %	-1 %	-4 %	-25 %	19 %	8 %	-19 %
		TLC	11 %					IRR	1,21 %
5,0 %	Real	388 762 €	387 521 €	-2 666 €	-6 312 €	-40 879 €	51 099 €	-7 553 €	-51 099 €
		188 %	188 %	-1 %	-3 %	-20 %	25 %	-4 %	-25 %
		TLC	1 %					IRR	-0,72 %

		Borrower						Lender	
		Total cash flow	CF forestry	CF direct cost	CF indirect cost	Itenrest expenses	CF principal payemnts	Total cash flow	CF liabilities and assets
	Nominal	831 385 €	937 039 €	-3 143 €	-9 720 €	-92 791 €	-92 791 €	95 934 €	92 791 €
		403 %	454 %	-2 %	-5 %	-45 %	-45 %	46 %	45 %
		TLC	51 %		Percent of maximum limit		74 %	IRR	4,20 %
-0,5 %	Real	900 994 €	1 025 846 €	-3 207 €	-10 198 €	-99 065 €	-111 448 €	114 655 €	111 448 €
		437 %	497 %	-2 %	-5 %	-48 %	-54 %	56 %	54 %
		TLC	61 %					IRR	4,72 %
1,0 %	Real	709 750 €	782 822 €	-3 027 €	-8 855 €	-81 588 €	-61 191 €	64 218 €	61 191 €
		344 %	379 %	-1 %	-4 %	-40 %	-30 %	31 %	30 %
		TLC	35 %					IRR	3,17 %
2,0 %	Real	608 086 €	655 076 €	-2 922 €	-8 096 €	-71 943 €	-35 972 €	38 894 €	35 972 €
		295 %	317 %	-1 %	-4 %	-35 %	-17 %	19 %	17 %
		TLC	23 %					IRR	2,15 %
3,0 %	Real	522 901 €	549 061 €	-2 828 €	-7 427 €	-63 620 €	-15 905 €	18 733 €	15 905 €
		253 %	266 %	-1 %	-4 %	-31 %	-8 %	9 %	8 %
		TLC	13 %					IRR	1,16 %
5,0 %	Real	391 084 €	387 521 €	-2 666 €	-6 312 €	-50 168 €	12 542 €	-9 876 €	-12 542 €
		190 %	188 %	-1 %	-3 %	-24 %	6 %	-5 %	-6 %
		TLC	2 %					IRR	-0,76 %

Table 4 of appendix 4. Variable interest fixed term instrument key parameters.

Term poduct, Variable interest Non-capitalisation		Borrower						Lender	
		Total cash flow	CF forestry	CF direct cost	CF indirect cost	CF interest	CF principal payemnts	Total cash flow	CF liabilities
-0,5 %	Nominal	877 752 €	937 039 €	-3 143 €	-9 720 €	-46 423 €	- €	49 567 €	- €
		425 %	454 %	-2 %	-5 %	-23 %	0 %	24 %	0 %
		TLC	29 %		Percent of maximum limit		51 %	IRR	2,71 %
	Real	953 070 €	1 025 846 €	-3 207 €	-10 198 €	-49 477 €	-9 895 €	62 579 €	9 895 €
		462 %	497 %	-2 %	-5 %	-24 %	-5 %	30 %	5 %
		TLC	35 %					IRR	3,23 %
1,0 %	Nominal	859 183 €	937 039 €	-3 143 €	-9 720 €	-64 993 €	- €	68 136 €	- €
		416 %	454 %	-2 %	-5 %	-32 %	0 %	33 %	0 %
		TLC	38 %		Percent of maximum limit		51 %	IRR	3,73 %
	Real	729 980 €	782 822 €	-3 027 €	-8 855 €	-57 345 €	16 384 €	43 987 €	-16 384 €
		354 %	379 %	-1 %	-4 %	-28 %	8 %	21 %	-8 %
		TLC	26 %					IRR	2,71 %
2,0 %	Nominal	840 614 €	937 039 €	-3 143 €	-9 720 €	-83 562 €	- €	86 705 €	- €
		407 %	454 %	-2 %	-5 %	-41 %	0 %	42 %	0 %
		TLC	47 %		Percent of maximum limit		51 %	IRR	4,76 %
	Real	607 811 €	655 076 €	-2 922 €	-8 096 €	-65 243 €	28 997 €	39 168 €	-28 997 €
		295 %	317 %	-1 %	-4 %	-32 %	14 %	19 %	-14 %
		TLC	23 %					IRR	2,70 %
3,0 %	Nominal	822 044 €	937 039 €	-3 143 €	-9 720 €	-102 132 €	- €	105 275 €	- €
		398 %	454 %	-2 %	-5 %	-50 %	0 %	51 %	0 %
		TLC	56 %		Percent of maximum limit		51 %	IRR	5,78 %
	Real	506 639 €	549 061 €	-2 828 €	-7 427 €	-70 767 €	38 600 €	34 995 €	-38 600 €
		246 %	266 %	-1 %	-4 %	-34 %	19 %	17 %	-19 %
		TLC	21 %					IRR	2,70 %
5,0 %	Nominal	784 905 €	937 039 €	-3 143 €	-9 720 €	-139 270 €	- €	142 413 €	- €
		380 %	454 %	-2 %	-5 %	-68 %	0 %	69 %	0 %
		TLC	74 %		Percent of maximum limit		51 %	IRR	7,83 %
	Real	352 993 €	387 521 €	-2 666 €	-6 312 €	-76 648 €	51 099 €	28 216 €	-51 099 €
		171 %	188 %	-1 %	-3 %	-37 %	25 %	14 %	-25 %
		TLC	17 %					IRR	2,70 %

Term product, Variable interest Capitalisation		Borrower						Lender	
		Total cash flow	CF forestry	CF direct cost	CF indirect cost	Itenrest expenses	CF principal payemnts	Total cash flow	CF liabilities and assets
-0,5 %	Nominal	870 939 €	937 039 €	-3 143 €	-9 720 €	-53 236 €	-53 236 €	56 380 €	53 236 €
		422 %	454 %	-2 %	-5 %	-26 %	-26 %	27 %	26 %
		TLC	32 %		Percent of maximum limit		65 %	IRR	2,69 %
	Real	944 284 €	1 025 846 €	-3 207 €	-10 198 €	-56 799 €	-68 158 €	71 365 €	68 158 €
		458 %	497 %	-2 %	-5 %	-28 %	-33 %	35 %	33 %
		TLC	40 %					IRR	3,20 %
1,0 %	Nominal	845 290 €	937 039 €	-3 143 €	-9 720 €	-78 886 €	-78 886 €	82 029 €	78 886 €
		410 %	454 %	-2 %	-5 %	-38 %	-38 %	40 %	38 %
		TLC	44 %		Percent of maximum limit		71 %	IRR	3,69 %
	Real	721 375 €	782 822 €	-3 027 €	-8 855 €	-69 392 €	-49 566 €	52 592 €	49 566 €
		350 %	379 %	-1 %	-4 %	-34 %	-24 %	25 %	24 %
		TLC	30 %					IRR	2,67 %
2,0 %	Nominal	816 703 €	937 039 €	-3 143 €	-9 720 €	-107 473 €	-107 473 €	110 616 €	107 473 €
		396 %	454 %	-2 %	-5 %	-52 %	-52 %	54 %	52 %
		TLC	58 %		maximum		78 %	IRR	4,70 %
	Real	597 806 €	655 076 €	-2 922 €	-8 096 €	-83 252 €	-46 251 €	49 173 €	46 251 €
		290 %	317 %	-1 %	-4 %	-40 %	-22 %	24 %	22 %
		TLC	28 %					IRR	2,65 %
3,0 %	Nominal	784 830 €	937 039 €	-3 143 €	-9 720 €	-139 346 €	-139 346 €	142 489 €	139 346 €
		380 %	454 %	-2 %	-5 %	-68 %	-68 %	69 %	68 %
		TLC	74 %		Percent of maximum limit		86 %	IRR	5,71 %
	Real	495 555 €	549 061 €	-2 828 €	-7 427 €	-95 152 €	-43 251 €	46 079 €	43 251 €
		240 %	266 %	-1 %	-4 %	-46 %	-21 %	22 %	21 %
		TLC	26 %					IRR	2,63 %
5,0 %	Nominal	709 628 €	937 039 €	-3 143 €	-9 720 €	-214 548 €	-214 548 €	217 691 €	214 548 €
		344 %	454 %	-2 %	-5 %	-104 %	-104 %	106 %	104 %
		TLC	110 %		Percent of maximum limit		105 %	IRR	7,72 %
	Real	340 492 €	387 521 €	-2 666 €	-6 312 €	-114 151 €	-38 050 €	40 717 €	38 050 €
		165 %	188 %	-1 %	-3 %	-55 %	-18 %	20 %	18 %
		TLC	23 %					IRR	2,59 %

Table 5 of appendix 4. Flexible term instrument and key parameters.

Term product, floating withdawal, fixed inteteres, non capitalizsed		Borrower						Lender	
		Total cash flow	CF from forestry	CF from direct cost	CF from indirect cost	CF from interest	Withdawal (+), reimburhse ment(-)	Total cash flow	Liability(-), Asset(+)
-0,5 %	Nominal terms	882 761 €	937 039 €	- 3 143,26 €	- 9 720,00 €	- 53 236,41 €	- €	44 558 €	- €
		428 %	454 %	-2 %	-5 %	-20 %	0 %	22 %	0 %
		TLC	26 %		Percent of maximum limit		60 %	IRR	2,18 %
	Real terms	957 222 €	1 025 846 €	- 3 206,69 €	- 10 197,50 €	- 56 798,71 €	- 11 044 €	58 427 €	11 044 €
		464 %	497 %	-2 %	-5 %	-21 %	-5 %	28 %	5 %
		TLC	33 %					IRR	2,70 %
1,0 %	Nominal terms	845 290 €	937 039 €	- 3 143 €	- 9 720 €	- 78 886 €	- €	82 029 €	- €
		410 %	454 %	-2 %	-5 %	-38 %	0 %	40 %	0 %
		TLC	44 %		Percent of maximum limit		69 %	IRR	3,69 %
	Real terms	721 375 €	782 822 €	- 3 027 €	- 8 855 €	- 69 392 €	19 826 €	52 592 €	- 19 826 €
		350 %	379 %	-1 %	-4 %	-34 %	10 %	25 %	-10 %
		TLC	30 %					IRR	2,67 %
2,0 %	Nominal terms	816 703 €	937 039 €	- 3 143 €	- 9 720 €	- 107 473 €	- €	110 616 €	- €
		396 %	454 %	-2 %	-5 %	-52 %	0 %	54 %	0 %
		TLC	58 %		Percent of maximum limit		75 %	IRR	4,70 %
	Real terms	597 806 €	655 076 €	- 2 922 €	- 8 096 €	- 83 252 €	37 001 €	49 173 €	- 37 001 €
		290 %	317 %	-1 %	-4 %	-40 %	18 %	24 %	-18 %
		TLC	28 %					IRR	2,65 %
3,0 %	Nominal terms	784 830 €	937 039 €	- 3 143 €	- 9 720 €	- 139 346 €	- €	142 489 €	- €
		380 %	454 %	-2 %	-5 %	-68 %	0 %	69 %	0 %
		TLC	74 %		Percent of maximum limit		81 %	IRR	5,71 %
	Real terms	495 555 €	549 061 €	- 2 828 €	- 7 427 €	- 95 152 €	51 901 €	46 079 €	- 51 901 €
		240 %	266 %	-1 %	-4 %	-46 %	25 %	22 %	-25 %
		TLC	26 %					IRR	2,63 %
5,0 %	Nominal terms	709 628 €	937 039 €	- 3 143 €	- 9 720 €	- 214 548 €	- €	217 691 €	- €
		344 %	454 %	-2 %	-5 %	-104 %	0 %	106 %	0 %
		TLC	110 %		Percent of maximum limit		97 %	IRR	7,72 %
	Real terms	340 492 €	387 521 €	- 2 666 €	- 6 312 €	- 114 151 €	76 101 €	40 717 €	- 76 101 €
		165 %	188 %	-1 %	-3 %	-55 %	37 %	20 %	-37 %
		TLC	23 %					IRR	2,59 %
Term product, flexible withdrawal, fixed inteteres, non capitalizsed		Borrower						Lender	
		Total cash flow	CF from forestry	CF from direct cost	CF from indirect cost	CF from interest	Withdawal (+), reimburhse ment(-)	Total cash flow	Liability(-), Asset(+)
-0,5 %	Nominal terms	831 385 €	937 039 €	- 3 143 €	- 9 720 €	- 92 791 €	- €	95 934 €	- €
		403 %	454 %	-2 %	-5 %	-45 %	0 %	46 %	0 %
		TLC	51 %		Percent of maximum limit		72 %	IRR	4,20 %
	Real terms	900 994 €	1 025 846 €	- 3 207 €	- 10 198 €	- 99 065 €	- 12 383 €	114 655 €	12 383 €
		437 %	497 %	-2 %	-5 %	-48 %	-6 %	56 %	6 %
		TLC	61 %					IRR	4,72 %
1,0 %	Real terms	709 750 €	782 822 €	- 3 027 €	- 8 855 €	- 81 588 €	20 397 €	64 218 €	- 20 397 €
		344 %	379 %	-1 %	-4 %	-40 %	10 %	31 %	-10 %
		TLC	35 %					IRR	3,17 %
2,0 %	Real terms	608 086 €	655 076 €	- 2 922 €	- 8 096 €	- 71 943 €	35 972 €	38 894 €	- 35 972 €
		295 %	317 %	-1 %	-4 %	-35 %	17 %	19 %	-17 %
		TLC	23 %					IRR	2,15 %
3,0 %	Real terms	522 901 €	549 061 €	- 2 828 €	- 7 427 €	- 63 620 €	47 715 €	18 733 €	- 47 715 €
		253 %	266 %	-1 %	-4 %	-31 %	23 %	9 %	-23 %
		TLC	13 %					IRR	1,16 %
5,0 %	Real terms	391 084 €	387 521 €	- 2 666 €	- 6 312 €	- 50 168 €	62 710 €	- 9 876 €	- 62 710 €
		190 %	188 %	-1 %	-3 %	-24 %	30 %	-5 %	-30 %
		TLC	2 %					IRR	-0,76 %

Appendix 5.

Ärölä's forest simulation, taken from Tapion Taskukirja (Rantala & Korhonen 2018)

Kuusi: H_{100} = 27			Kiertoaika: 64 vuotta		Harvennuksia: 2	
Syntytapa: istutettu			Korkoprosentti: 4 %			
Ikä	Valtapituus	Pohjapinta-ala	Runkoluku	Tilavuus	Hakuukertymä	
					tukkia	kuitua
v	m	m²/ha	kpl/ha	m³/ha	m³/ha	m³/ha
16	6,4	3,6	1 700	6,8		
19	7,7	6,2	1 697	23,0		
24	10,0	13,7	1 690	63,2		
29	12,2	21,7	1 679	119,0		
34	14,2	28,9	1 656	182,9	4,0	55,3
34	14,2	18,8	1 032	119,9	* hakkuun jälkeen	
39	16,0	24,9	1 025	178,0		
44	17,8	30,5	1 015	239,7	27,5	51,6
44	17,7	19,8	599	158,5	* hakkuun jälkeen	
49	19,3	24,3	596	209,6		
54	20,8	28,6	592	262,6		
59	22,1	32,6	587	315,3		
64	23,3	36,4	582	366,9	295,6	68,9