THE EFFECTIVE MATURITY PROFILE OF A MORTGAGE PORTFOLIO

Determining the effective maturity of a mortgage over its complete economic life time by taking into account all contractual repayments and non-contractual prepayments

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PREFACE

This thesis is written as a finalization of the master Financial Engineering and Management. I started looking for a master assignment this spring and I am thankful that the ABN AMRO Hypotheken Groep B.V. offered me the chance to perform this assignment at their company. Writing this thesis does not only mark the end of my master's degree in Financial Engineering and Management at the University of Twente, it also marks the end of my time as a student. I have had five great years in which I have learned a lot and had a lot of fun. I have tried to apply as much of the knowledge and skills gained during my study to this thesis. I would like to thank my supervisors for helping me with this.

First, I would like to thank Bram Toebast for his support, ideas and comments. He and his manager, Mark Geubbels, also involved me in some projects which were not directly related to this thesis but were very interesting. This also gave me a better understanding of working in a financial institution like ABN AMRO Hypotheken Group B.V. Next, my gratitude goes to Toon de Bakker and Berend Roorda who guided me through this thesis. I believe our discussions only made this thesis better. I would like to thank the ABN AMRO Hypotheken Groep B.V., and especially balance management for having me as a full-fledged colleague. I have had interesting discussions with Vincent van Bergen, Martijn Schalke and Bram Kuijvenhoven of the ALM department, Daniël Linker helped me with various subjects and thanks to all the other colleagues who helped me but are not mentioned here.

Last but certainly not least I would like to thank my family and friends for their support during this thesis. Without them it would not have been possible.

Bornerbroek, September 26th, 2013

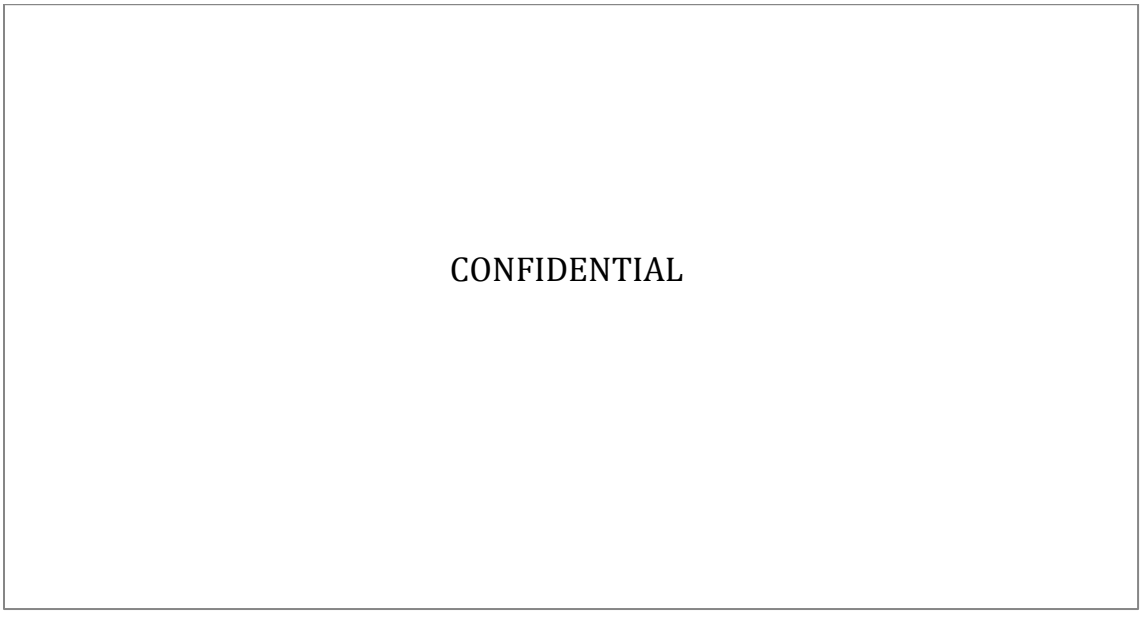
MANAGEMENT SUMMARY

This thesis is written in response of a request by the ABN AMRO Hypotheken Groep. In terms of financial risks, liquidity risk was considered as one of the least significant types before the financial crisis; focus was mainly on the interest rate risk. However, liquidity risk rose sharply since the financial crisis.

This (increase in) liquidity risk has an impact on, among other things, AAHG's funding strategy, total costs of risk, the bank's capital buffer and the risk premium that is to be included in the mortgage client rates. A mismatch in liquidity between a bank's assets and liabilities, i.e. a maturity mismatch, is one of the most important components of liquidity risk. With that in mind, gaining (better) insight into the effective maturity (*Dutch: liquiditeitstypische looptijd*) is of great importance.

Based on the above the main research objective of this thesis is as follows: *Determining the effective maturity of a mortgage over its complete economic life time by taking into account all contractual repayments and non-contractual (i.e. behavioural) prepayments.* By analysing an historical data set which holds data on the (p)repayments made in the last six years it was found that the effective maturity is affected by so called *liquiditeitstypische* prepayments which include relocations, complete prepayments and curtailments.

The main research objective is achieved by computing the future contractual repayments and the *liquiditeitstypische* prepayments for the current portfolio. The first could be determined using the known parameters of the current loan parts. An Excel macro was developed to compute the future *liquiditeitstypische* prepayments. By combining these payments, the outstanding balance of the current portfolio is as in the figure below. The weighted average effective maturity at origination is XX respectively XX months for the ABN AMRO and Florius label. The used queries and macros can easily be reapplied in future analyses.



MANAGEMENT SUMMARY – DUTCH

Deze thesis is geschreven naar aanleiding van een verzoek door de ABN AMRO Hypotheken Groep. In termen van financiële risico's werd liquiditeitsrisico lange tijd als niet of minder significant beschouwd; de focus lag voornamelijk op renterisico. Echter is liquiditeitsrisico sinds de financiële crisis fors toegenomen.

De stijging in liquiditeitsrisico heeft onder andere invloed op AAHG's funding strategie, de totale risicokosten, de voorzieningen die de bank moet nemen en de in te prijzen risico opslagen in de hypotheektarieven. Een mismatch in liquiditeit tussen de activa en passiva van een bank, een zogenaamde maturity mismatch, is een van de belangrijkste componenten van liquiditeitsrisico. Met dat in gedachten is beter inzicht in de liquiditeitstypische looptijd gewenst en van groot belang.

Op basis van bovenstaande is de doelstelling van deze thesis als volgt: *Het bepalen van de liquiditeitstypische looptijd van een hypotheek over de gehele economische levensduur waarbij zowel de contractuele aflossingen als de niet-contractuele, gedragsmatige, vervroegde aflossingen in acht worden genomen.* Een historische data set met gegevens over alle contractuele en vervroegde aflossingen in de laatste zes jaar is geanalyseerd. Hieruit blijkt dat de liquiditeitstypische looptijd wordt beïnvloedt door zogenaamde liquiditeitstypische vervroegde aflossingen die verhuizingen, algehele en gedeeltelijke aflossingen omvatten.

De doelstelling van deze thesis kan worden behaald door het bepalen van de toekomstige contractuele en liquiditeitstypische vervroegde aflossingen voor de leningdelen in de huidige portfolio. De contractuele aflossingen kunnen worden bepaald door gebruik te maken van de beschikbare parameters, als hoofdsom en akterente. Een Excel macro is ontwikkeld om de toekomstige liquiditeitstypische vervroegde aflossingen vast te stellen. Door deze twee typen aflossingen te combineren is het mogelijk het verloop van de schuldrest over tijd weer te geven. De gewogen gemiddelde liquiditeitstypische looptijd van een hypotheek is XX respectievelijk XX maanden voor de ABN AMRO en Florius labels. De toegepaste queries en macro's kunnen eenvoudig worden gebruikt in toekomstige analyses.

CONFIDENTIAL

ABBREVIATIONS

AAB	ABN AMRO BANK N.V.
AAHG	ABN AMRO HYPOTHEKEN GROEP B.V.
ALM	ASSET-LIABILITY MANAGEMENT
ARM	ADJUSTABLE-RATE MORTGAGE
BCBS	BASEL COMMITTEE ON BANKING SUPERVISION
BIS	BANK FOR INTERNATIONAL SETTLEMENTS
CDO	COLLATERALIZED DEBT OBLIGATION
CMBS	COMMERCIAL MORTGAGE-BACKED SECURITY
CMO	COLLATERALIZED MORTGAGE OBLIGATION
CPR	CONDITIONAL PREPAYMENT RATE
DWH	DATA WAREHOUSE
EIR	EFFECTIVE INTEREST RATE
EONIA	EURO OVERNIGHT INDEX AVERAGE
EURIBOR	EURO INTERBANK OFFERED RATE
FRM	FIXED-RATE MORTGAGE
FRP	FIXED RATE PERIOD
FTP	FUNDS TRANSFER PRICING
IASB	INTERNATIONAL ACCOUNTING STANDARDS BOARD
IFRS	INTERNATIONAL FINANCIAL REPORTING STANDARDS
ILAAP	INTERNAL LIQUIDITY ADEQUACY ASSESSMENT PROCESS
IRS	INTEREST RATE SWAP
LCR	LIQUIDITY COVERAGE RATIO
LEL	LIFETIME EXPECTED LOSS
LIBOR	LONDON INTERBANK OFFERED RATE
LSC	LIQUIDITY SPREAD CURVE
LTFV	LOAN-TO-FORECLOSURE-VALUE
LTV	LOAN-TO-VALUE
MBS	MORTGAGE-BACKED SECURITY
MOR	MATCHED OPPORTUNITY RATE
NHG	NATIONALE HYPOTHEEK GARANTIE
NSFR	NET STABLE FUNDING RATION
O/N	OVERNIGHT
PD	PROBABILITY OF DEFAULT
RMBS	RESIDENTIAL MORTGAGE-BACKED SECURITY
SMBS	STRIPPED MORTGAGE-BACKED SECURITY
SMM	SINGLE MONTHLY MORTALITY
SPE	SPECIAL PURPOSE ENTITY
SPV	SPECIAL PURPOSE VEHICLE
SQL	STRUCTURED QUERY LANGUAGE
VAR	VALUE AT RISK
WACC	WEIGHTED AVERAGE COST OF CAPITAL
WOZ	WAARDERING ONROERENDE ZAKEN

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CHAPTER ONE – INTRODUCTION

This first chapter introduces the topic that is being investigated in this thesis. Next to an explanation of the background, this chapter includes research questions and an approach of how to answer these. Relevant literature will also be discussed, as will the most important definitions. A brief outline of the structure of this thesis concludes this chapter.

1.1 BACKGROUND

The Second World War had just come to an end when Jacob Wiersema founded the 'Bouwspaarkas Drentsche Gemeente' in 1946. The organization became a huge success and it developed itself into 'Bouwfonds Nederlandse Gemeenten'. Its purpose was creating a public savings fund helping the poor ones among us to finance their own house. In 1964, the 'Amsterdam Bank' merged with the 'Rotterdam Bank' into AMRO bank, and the 'Nederlandsche Handel Maatschappij' merged with the 'Twentsche Bank' into ABN bank. Twenty-seven years later, in 1991, the merger between ABN and AMRO resulted in the current ABN AMRO bank which acquired all the shares of the 'Bouwfonds Nederlandse Gemeenten' in 2000. The current name ABN AMRO Hypotheken Groep (AAHG) was first used in 2006 when 'ABN AMRO Hypotheken' merged with 'Bouwfonds Hypotheken'.

The ABN AMRO Hypotheken Groep (AAHG) is specialised in developing, lending and managing mortgages; it is a wholly owned subsidiary of the parent organization ABN AMRO Bank. The mergers mentioned above combined with many years of experience resulted in AAHG being one of the largest mortgage lenders in the Netherlands. It provides mortgages to approximately 850,000 households, which represents 25% of the total Dutch mortgage market. In 2012, the total mortgage portfolio value was EUR 153.9 billion which is almost 40% of the total assets of the ABN AMRO Bank. The three main brands of AAHG are ABN AMRO, Florius and MoneYou mortgages. Its mission is to enable careless living for their clients by means of useful and understandable financial products and sound advice.

The department where this thesis is performed at, balance management, is responsible for optimizing the ratio between risk and return of mortgages and supporting ABN AMRO Bank in optimizing its capital and liquidity positions by secured funding. Financial risk is a very broad term and consists of different types of risk. During the financial crisis of 2007 – 2008 it turned out that these risks had been priced incorrectly, allowing the mortgage market to grow larger than it otherwise would have.[1] One of the types of risk that had been specifically underestimated is liquidity risk; it has increased significantly since the financial crisis.[2,3] This phenomenon also affected AAHG (see figure 1) and it has now become one of the most important risks for the bank.

[1] Simkovic [2009], p. 259
[2] BlackRock [2012], p. 7
[3] Vickery & Wright [2010], p. 4

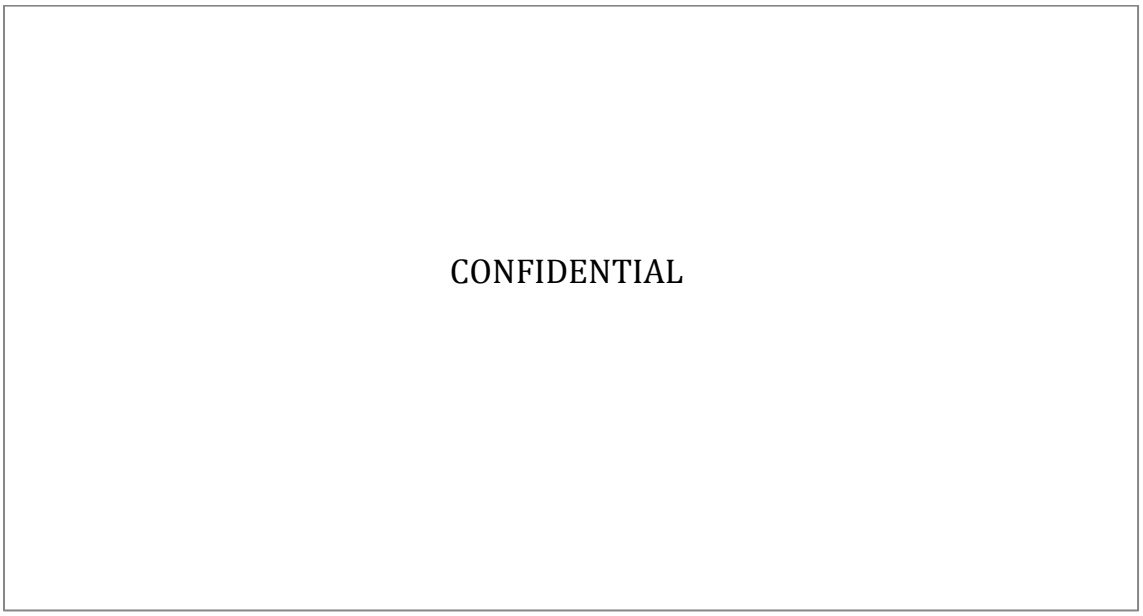


Figure 1 – Historical 5-years liquidity spread including trend line – Source: Internal document ABN AMRO

The (increase in) liquidity risk has an impact on, among other things, AAHG's funding strategy, total costs of risk, the bank's capital buffer and the risk premium that is to be included in the mortgage client rates. Liquidity risk consists of funding liquidity risk and market liquidity risk.[4] A mismatch in liquidity between a bank's assets and liabilities, i.e. a maturity mismatch, might lead to serious problems, which we have seen in the financial crisis at several banks, e.g. Lehman Brothers, Bear Sterns and Fortis. With that in mind, gaining (better) insight into the effective maturity (*Dutch: liquiditeitstypische looptijd*) is of great importance. This thesis investigates the topic of the effective maturity of AAGH's mortgage portfolio, and its impact on the various activities AAHG performs on a daily basis.

1.2 RESEARCH QUESTIONS

The general problem statement that AAHG had for this thesis, already contained some relevant questions they found worth investigating. However, these were rather general (in the sense that these did not question the issues that are at the root of the problem that AAHG is facing) and there are multiple approaches possible in dealing with the questions asked. To overcome these issues, the general problem was discussed with several colleagues. These discussions resulted in a more specific problem statement and research questions, and it narrowed the scope of this thesis. The paragraphs below briefly describe how the general problem statement as defined by AAHG was transformed into research questions that are to be answered in this thesis.

As mentioned in the introduction, the significance of liquidity risk has rapidly increased since the financial crisis. An important component of this risk is a potential maturity mismatch between a bank's assets and liabilities. This is where AAHG's (general) problem statement kicks in: initiated by the situation described in the introduction, AAHG wants to gain better insight in the effective maturity of their mortgage portfolio. But what does AAHG really want to know? What is their core problem; gaining 'better insight' is still quite vague. Once the effective maturity is known, what will AAHG do with it? As said, liquidity risk impacts AAHG's daily operations and other departments will

[4] More on that in section 1.4

benefit from a better understanding of the effective maturity. This also came to light in the discussions held; each department had their own issues that could be linked to this thesis and that they found worth investigating. A graphical representation of these linkages can be found in appendix B in the form of a mind map.

Depending on the time available, as many of these links as possible will be investigated in this thesis. However, at this point a clear and properly delineated research question should be formulated. Based on the discussions, literature[5] and priorities at AAHG the following research question will be investigated in this thesis; the relating subquestions will help solving the main research question.

RESEARCH QUESTION

What is AAHG's effective maturity (profile)?

RESEARCH OBJECTIVE

Determining the effective maturity of a mortgage over its complete economic life time by taking into account all contractual repayments and non-contractual (i.e. behavioural) prepayments.

SUBQUESTIONS

1. What is AAHG's contractual maturity (profile)?
2. What factors influence the effective maturity (profile)?
3. How can prepayments be modelled? [in co-op with ALM]
4. What is the impact of taking into account effective maturity with regard to regulatory requirements?

In order to determine AAHG's effective maturity profile, the contractual maturity profile needs to be understood first which includes all contractual repayments. The next step/subquestion involves identifying all the factors, i.e. non-contractual payments, that affect this maturity. After this identification, this thesis looks into the numerical influence that these factors have; in other words, the effective maturity will be computed. Next, the results are to be incorporated into a basic parameterized model reflecting the expiration pattern of a mortgage over time. Interesting in this aspect are the differentiating characteristics (e.g. mortgage type, loan-to-value, fixed interest rate period) that affect the expiration pattern and to what extent (i.e. performing a sensitivity analysis). The fourth subquestion considers (upcoming) regulation and current market developments. Figure 2 below represents the structure of this thesis. The rectangles represent data that is to be computed, the data required for the angled forms is available in AAHG's data system.

[5] See section 1.4

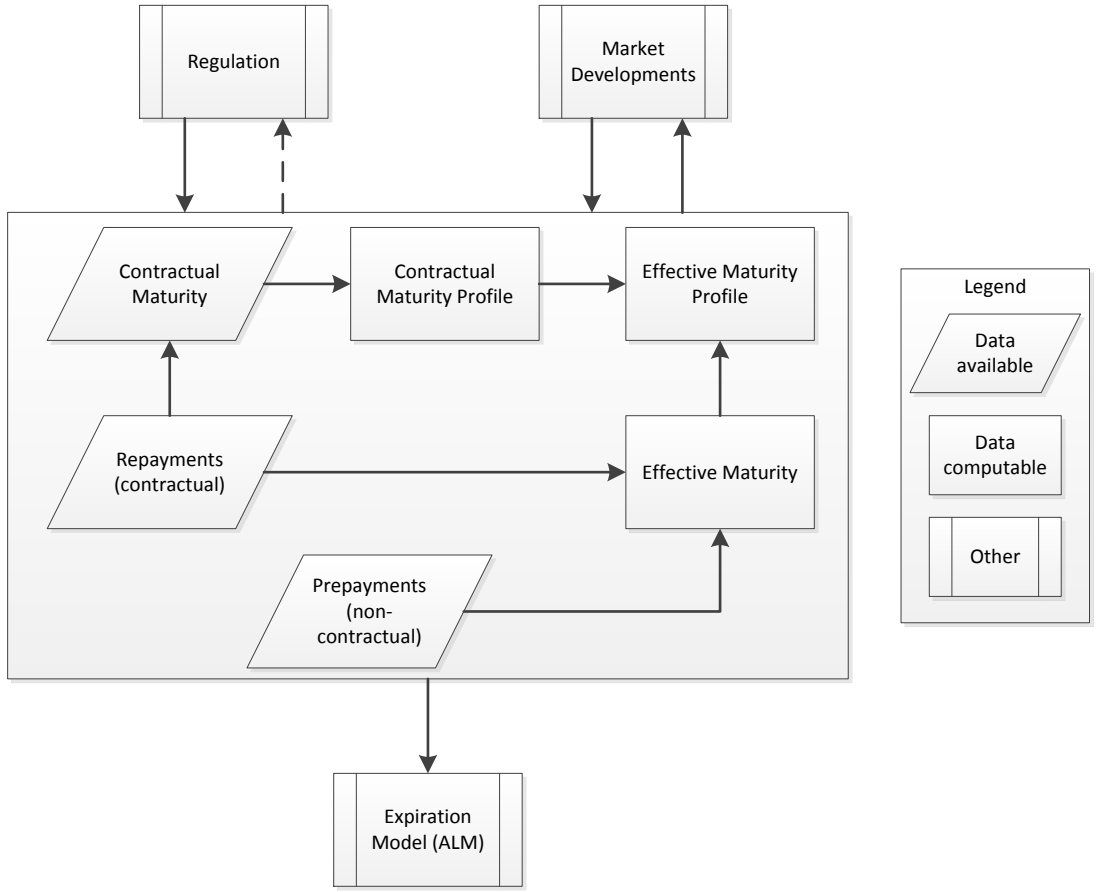


Figure 2 – Structure of this thesis

Since the research question above is to be answered by making observations, it can be classified as an empirical question. The subquestions include both descriptive (*what is going on?*) and explanatory (*why is it going on?*) questions. Being able to answer the explanatory questions require the descriptive questions to be answered first; that is, the current situation needs to be described first before any explanation about that situation can be given. The research approach is discussed in more detail in the next section.

The first subquestion is a descriptive question. Answering this question will give insight in the contractual maturities for the outstanding mortgages which varies from 0 to circa 30 years. There are, in fact, four distinctive types of maturity. The first is the contractual maturity at origination, which is the total contractual amortization period of a mortgage that is recorded in the contract. This maturity might deviate from the true observed maturity, e.g. a client might completely repay its mortgage prior to the contractual end date; this is the so-called effective maturity. These two types of maturity can also be computed for the active portfolio (on-going mortgages), in which it is not the maturity at origination that matters, but the residual contractual or effective maturity.[6] Besides knowing these maturities in absolute values (and its statistical characteristics like variance and spread), it is interesting to understand the expiration patterns of the maturities. The latter can be done by means of a maturity profile[7]. The figure below is merely an indication of such a profile; it is a fictional image and it is only meant to give one an idea of what is to be computed later on. The vertical bars represent the (expected) contractual cash inflows for various maturities.

[6] Additional information about the types of maturity is provided throughout this thesis, e.g. in section 1.4.1 and 3.1
[7] Again, more information will be provided later on; here it is just meant to concretise the ideas a bit

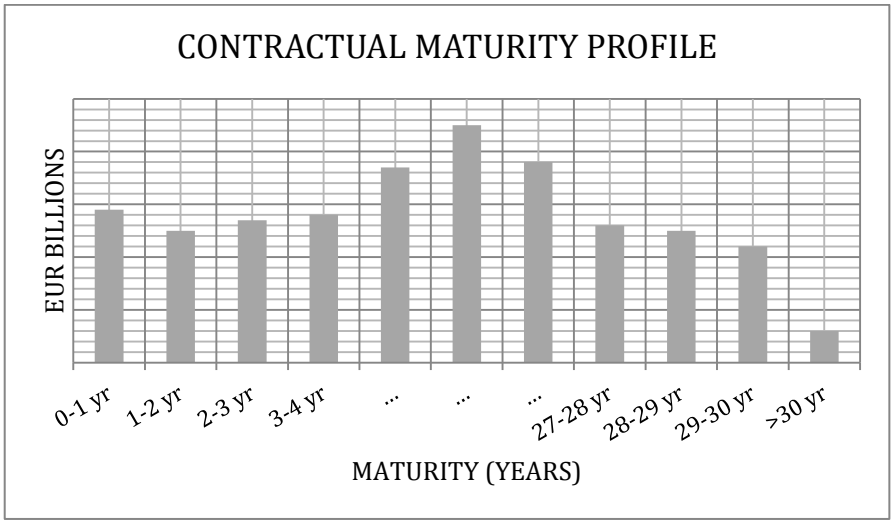


Figure 3 – Contractual maturity profile (fictional)

The second subquestion analyses the factors that influence the effective maturity, both in a theoretical and in a practical way by computing the absolute effective maturity (non-contractual payments taken into account), and its statistical characteristics. Besides variance, spread, sensitivity, etc. this also comprises weighing the effective maturity to the principal. By answering this question the difference between the contractual, from the first subquestion, and the effective maturity can be given. The graph from above can be transformed into an 'effective maturity profile', which takes any behavioural factors into account. Since non-contractual payments shorten the (residual) effective maturity, in theory the histogram will 'shift towards' the left. The vertical bars now represent the (expected) contractual and non-contractual cash inflows, for the various maturities. The first two subquestions serve two purposes, first AAHG wants to improve the understanding of their clients' profile (*Dutch: klantbeeld*). It wants to know what clients they are dealing with, how these clients act and how they can best act upon that. Second, the results can be used in pricing the 'non-FTP' components (see figure 8).

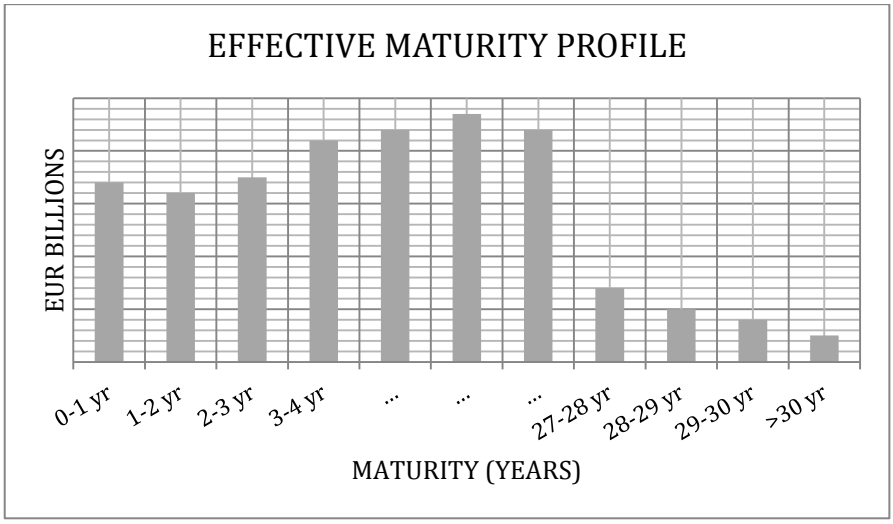


Figure 4 – Effective maturity profile (fictional)

Many, if not all, factors identified in the second subquestion can probably be classified as non-contractual payments. During a meeting with the Asset-Liability Management (ALM) department, it

became clear that they, ALM and the modelling department, already had several models available on non-contractual payments, e.g. prepayments, and maturity. However, most of these are based on the (fixed) interest rate period (*Dutch: rentetypische looptijd*). In cooperation with ALM the results from the first two subquestions will be used as input for any future, improved prepayment and liquidity models; more attention should be given to liquidity risk. An improved understanding of clients' behaviour enables ABN AMRO to adjust (optimize) its funding strategy.

The last subquestion looks into the impact of having to take effective maturity into account with regard to regulatory requirements. Among other regulation, ILAAP, IFRS 9 and Basel III are being implemented in the short term, this can have its impact on the effective maturity. If more financial institutions get a better understanding of effective maturity, this might partially function as input of future regulation.[8] This link is not that strong, so a dashed arrow is used in figure 2. Next to that, the housing market is currently subject to various developments. The section on this fourth subquestion also pays attention to current (market) developments, but no specific subquestion is defined for that. Taken together the purpose of this section is to enable AAHG to improve its compliance with regulation, make the modelling of regulation more accurate and act upon market developments.

The overall relevance of this thesis is that there is only little research available on effective maturity. Until recently, focus was on the (fixed) interest rate period (*Dutch: rentetypische looptijd*) but due to increased liquidity risk and upcoming regulation effective maturity (*Dutch: liquiditeitstypische looptijd*) became more important. There are quite some articles available on prepayments and their impact on the duration of a mortgage, which is then used as an interest-rate sensitivity instrument. However, duration differs from effective maturity and it is not this thesis' purpose to use this latter as an instrument for interest-rate sensitivity; which might be an idea for further research though.

This thesis focuses on the Dutch mortgage market and AAHG's portfolio in that market. AAHG's portfolio includes multiple brands/banks and labels. This thesis will not consider all labels, mainly due to data availability this thesis focuses on the ABN AMRO and Florius mortgages. These two account for about EUR 90 billion of the EUR 153.9 billion total mortgage portfolio value in 2012. The results of this thesis will probably be applicable to other mortgage brands and markets as well (which is not a goal in itself, but it would be nice if possible). Both historical and current data (*Dutch: lopende hypotheken*) will be analysed, and a prognosis for the (near) future will be given. The time frame is thus quite broad. As for this thesis itself, the topic will be researched during a period of approximately six months. Besides the time available and data availability there are no significant limitations that restrict this research. If any limitations occur during this thesis, these might function as ideas for further research.

1.3 RESEARCH APPROACH

As mentioned, the main research question is an empirical question. The first subquestion and the numerical part of the second can be classified as quantitative questions since these can be answered via statistical techniques, the other subquestions are more qualitative. However, this distinction has no implications for the research method that will be used in this thesis. According to De Vaus [2001], it is erroneous to equate a particular research design with either quantitative or qualitative methods.

[8] Bank regulation is often drafted in consultation with prominent bankers

Both methods complement each other; quantitative outcomes will help answering qualitative questions and vice versa. As a result, both methods will be used.

The (most) descriptive subquestions will be answered first, the current situation will be described. After that, the explanatory subquestions are discussed. Qualitative data is mainly collected by interviews and discussions with colleagues. The quantitative data is collected via the data sets already available in AAHG's databases. During this thesis it will be clear whether it will be necessary to collect additional quantitative data that is not readily available in any of AAHG's databases. Next, statistical techniques will be used to analyse these quantitative data, e.g. sensitivity analysis. Literature will also be used, the next section looks into any relevant and usable (scientific) articles. As for the time necessary (available) to complete the steps mentioned above, there is a provisional schedule in appendix A.

1.4 LITERATURE REVIEW

This section reviews the readily available literature and research on the topic that is investigated in this thesis. Since the research question of this thesis is quite specific, there will probably be little literature available that investigates a comparable situation. However, because reinventing the wheel is useless, this section reviews the literature that can be used as a foundation for this thesis. Where applicable, (additional) literature will be used throughout this thesis, the most important/basic literature will be discussed here. Any internal knowledge that has already been gathered at AAHG will be discussed later on. The reviewed literature is listed per subquestion to which the literature applies.

WHAT IS AAHG'S CONTRACTUAL MATURITY PROFILE?

- In analysing whether risk management is a science, Davidson [2012] states that households and entrepreneurs are willing to enter into a money contract because each party thinks it is in their best self-interest to fulfil the terms of the contractual agreement and be able to predict and control with some legal assurance cash inflows and outflows. As Keynes [1936] already found, by entering into contractual agreements people assure themselves a measure of predictability in terms of their contractual cash inflows and outflows. A contractual maturity profile can be used to understand AAHG's contractual cash inflows.
- General literature will also contribute in understanding and answering this subquestion.

WHAT FACTORS INFLUENCE THE EFFECTIVE MATURITY PROFILE?

- Ambrose & Sanders [2002] employed a competing risks model to examine the default and prepayment behaviour of commercial loans underlying CMBS deals, using empirical data. They found that changes in the yield curve have a direct impact on the probability of mortgage termination; an increase in the slope of the yield curve lowers the probability that the mortgage will terminate. Also, mortgages with a higher loan-to-value (LTV) at origination are more likely to prepay. Ambrose & Sanders [2002] did not find any statistical relationship between LTV and default. Their main findings might be useful in the second subquestion, keeping in mind that this article dates from pre-crisis, it analyses CMBS deals instead of RMBS deals and only 33 CMBS deals are analysed.
- A study performed by Calhoun & Deng [2000] analyses the differences in termination between fixed- and adjustable-rate mortgages. They identify two types of termination being

default and prepayments. Calhoun & Deng [2000] found that the basic option theory is valid for both fixed-rate mortgage (FRM) and adjustable-rate mortgage (ARM) borrowers, which holds that borrowers will exercise embedded call (prepayment) or put (default) options when either of these alternatives becomes financially attractive. These terminations affect the effective maturity, so this article might be interesting. However, Dutch borrowers usually do not have the option to exercise a put option on their house, i.e. there is a full recourse to borrowers.

- Young et al. [2010] explored the effective maturity mismatch between assets and liabilities of a bank. Over the years, long(er)-term assets such as mortgages and MBSs made up an increasing portion of bank assets while the share of short-term assets decreased. This should imply that, on average, banks' assets are becoming longer in term. However, Young et al. [2010] found that since the mid-1990s, assets were perceived as having become effectively shorter-term.

HOW CAN PREPAYMENTS BE MODELLED?

- Alink [2002] performed explanatory research on prepayment variables and the effects of them on asset & liability management and securitisation. This article is quite interesting since it touches upon multiple aspects of this thesis. First, it analyses the variables of mortgage prepayments which is useful in answering the second subquestion. Second, Alink [2002] models prepayments using these variables. Also, his research applies the prepayment model in the context of ALM and securitisation. All this is done in the Dutch mortgage market.
- Charlier & Van Bussel [2001] have empirically analysed the prepayment behaviour of Dutch mortgagors. They call for a prepayment model that incorporates the typical Dutch market and contract characteristics. A prepayment model is developed for savings and interest-only mortgages. The results indicate that prepayment rates depend on interest rates and the age of the mortgage contract. Their findings might help in answering this subquestion, keeping in mind that the types of mortgages they analyse are affected by new regulation.
- Another article that empirically investigates the Dutch mortgage market and prepayments is written by Jacobs et al. [2005]. They state that the risk of prepayment makes the duration of a portfolio of mortgages stochastic which has implications for the funding strategy of the mortgagee. According to their analysis prepayment behavior depends on the type of mortgage, size of the loan, and the age of the mortgagor at the time the contract is signed.
- According to Kuijpers & Schotman [2007], the valuation of the prepayment option in Dutch mortgages is complicated due to specific characteristics (comparable with the ones mentioned in the article above). Their article proposes a model that can be used for determining both the optimal prepayment strategy and the value of embedded prepayment options. This article is interesting because it analyses the Dutch situation.
- Lam [2002] presents a model specifically meant for MBS issuers that incorporates various types of risk into one single model. Based on the results of his model, Lam [2002] identifies four variables by which issuers can manage the risk level of their portfolios, which are the collection account balance, the overcollateralization ratio, the net residual value and the liquidity advance.

WHAT IS THE IMPACT OF TAKING INTO ACCOUNT EFFECTIVE MATURITY WITH REGARD TO REGULATORY REQUIREMENTS? [INCLUDING DEVELOPMENTS]

- According to Bervas [2006], current risk management tools do not adequately take market liquidity risk into account. The market used to believe that transactions can be settled at current prices without any notable delays or transaction costs. Due to various developments this turned out not to be the case; note that this article is from pre-crisis, so this phenomenon only worsened. Bervas [2006] provides adjustments to methods for incorporating market liquidity risk into the existing risk control tools. The developments described in this article might affect AAHG's maturity profile as well; Bervas' [2006] findings can also be helpful in answering the previous subquestion.
- Hancock & Passmore [2011] investigated whether the Federal Reserve's MBS purchase program lowered mortgages rates. They found that only announcing the program already reduced mortgage rates by about 85 basis points and that mortgage rates were significantly lower at the end of the program. Recently, the Dutch government has looked into selling MBSs to pension funds, which are in general very creditworthy.[9] This development might impact mortgage rates which again, at least according to some articles reviewed, affect the prepayment rates.

GENERAL LITERATURE

- Aalbers [2009] investigated whether globalization and Europeanization have led to the deterritorialization of European mortgage markets. As ABN AMRO was the first to gain access to the Italian mortgage market in 2005 and because ABN AMRO would like to be active in different funding markets, this article might be useful. The author concludes that EU policies have not resulted in a single European mortgage market, but that globalization of mortgage firms will reach higher levels in the near future.
- BlackRock [2012] discusses the risks of reduced market liquidity since the financial crisis. In their article, BlackRock advises investors to adjust to the new world of trading by using liquid, exchange-traded hedges. The financial crisis showed that liquidity is king, the article introduces new ways in dealing with the (il)liquidity challenge. The article also states that dealer positions in US MBSs have gradually increased since 2008. This is not a scientific article, it is published by BlackRock, a leading investment corporation. It will primarily be used to gather information about liquidity risk in general.
- Bucks & Pence [2006] have researched homeowners' understanding of their house values and mortgage terms. They found that most homeowners appear to report their house values and broad mortgage terms reasonably accurately. However, adjustable-rate mortgage borrowers appear to underestimate or not know how much their interest rates could change, especially borrowers with less income or education. These findings might be useful for this thesis in a sense that AAHG does not benefit from borrowers not knowing their mortgage terms. If interest rates rise, these borrowers might experience financial difficulties resulting in increased mortgage defaults.
- Funds transfer pricing (FTP) is a process used in banking to measure the performance of the different business units of a bank. At ABN AMRO, FTP will measure a business' contribution to the net interest income. In his article about FTP, Dermine [2011] states that the foundation approach is no longer sufficient; he proposes an advanced approach that takes

[9] http://fd.nl/dowjones/221854-1304/dnb-positief-over-plan-hypotheekobligaties-voor-pensioenfondsen_bron_dow_jones

into account five issues which have previously been ignored. FTP is an integral part of ABN AMRO's risk policy; Dermine's [2011] article will help when discussing this concept into more detail.

As said, the articles reviewed in the paragraphs above are meant as a foundation for this thesis; additional literature might be used in the upcoming sections. There is little literature on first two subquestions, this is partly because these are descriptive and partly because there is simply little literature available which again indicates the relevance of this research.

1.4.1 DEFINITIONS

Besides a literature review, the most important and most used terms in this thesis have been defined below. Defining these terms serves multiple purposes. First, it avoids ambiguities and it stimulates a proper delineation of this research. Secondly, the Dutch mortgage system is rather unique and thus the definitions used in the (often America-focused) literature might differ from the ones that apply to the Dutch situation. The latter is also the reason that most definitions were set in consultation with colleagues from different departments; the Dutch terms are in parentheses.

CONTRACTUAL MATURITY (CONTRACTUELE LOOPTIJD)

The total contractual amortization period of a mortgage as recorded in the contract.

RESIDUAL CONTRACTUAL MATURITY (RESTERENDE CONTRACTUELE LOOPTIJD)

The residual contractual amortization period of a mortgage expressed as the time between the contractual end date and the current date.

AVERAGE CONTRACTUAL MATURITY (GEM. CONTRACTUELE LOOPTIJD)

The weighted average of all the contractual maturities of the mortgages in a portfolio computed by weighting each mortgage's contractual maturity by the principal of the mortgage; maturity shortening features are not taken into account.

EFFECTIVE MATURITY (LIQUIDITEITSTYPISCHE LOOPTIJD)

The period between the first cash-out flow, as seen from AAHG, and the last cash-in flow after which AAHG has no further contractual obligations towards the client/after which no further cash flows take place.

RESIDUAL EFFECTIVE MATURITY (RESTERENDE LIQUIDITEITSTYPISCHE LOOPTIJD)

The residual effective maturity of a mortgage expressed as the time between the effective end date and the current date.

AVERAGE EFFECTIVE MATURITY (GEM. LIQUIDITEITSTYPISCHE LOOPTIJD)

The weighted average of all the effective maturities of the mortgages in a portfolio computed by weighting each mortgage's effective maturity by the principal of the mortgage.

FIXED RATE PERIOD (RENTEVASTE PERIODE)

The period for which the interest rate payable is fixed. After the fixed rate period ends, the interest rate will either continue on a variable rate or a new fixed rate period will be set.

REPAYMENT (AFLOSSING)

A principal amortization made by the client, it includes all the contractual payments, both the monthly principal payments as the, if applicable, final principal payment at maturity (as dictated by the amortization schedule). It does not include interest payments.

PREPAYMENT (VOORUITBETALING/EXTRA AFLOSSING)

A principal amortization made by the client on top of the regular (contractual) monthly amount of principal that is to be paid (as dictated by the amortization schedule). It thus involves behavioral, non-contractual payments on a loan part. There are roughly two types being a full or partial prepayment.[10] In case of a (bank)spaar mortgage, extra savings are also classified as a prepayment.

LIQUIDITY RISK (LIQUIDITEITSRISICO)

BIS [2008] distinguishes two types of liquidity risks: "Funding liquidity risk is the risk that the firm will not be able to meet efficiently both expected and unexpected current and future cash flow and collateral needs without affecting either daily operations or the financial condition of the firm. Market liquidity risk is the risk that a firm cannot easily offset or eliminate a position at the market price because of inadequate market depth or market disruption." Nauta's [2013] simplified definition, that covers both aspects, will be used in this thesis: "Liquidity risk is the risk that an event occurs that forces the bank to liquidate some of its assets."

LIQUIDITY PREMIUM (LIQUIDITEITSPREMIE)

A compensation to take illiquid assets on the balance sheet. The compensation is required for the risk of being forced to sell these assets in a liquidity stress event. Such a forced sale will result in a price lower than the fair value, which results in a loss.[11] Also called: liquidity spread.

LIQUIDITY SPREAD CURVE (LSC)

A collection of liquidity spreads that correct the base rate in such a way that it resembles the bank's cash funding curve for an unsecured funding transaction in the international financial markets. The liquidity spread is expressed as a mark-up or discount on the base rate. As the contractual maturity lengthens, the liquidity spread increases since long-term contracts are less liquid.

DURATION (DURATION)

A measure of the sensitivity of percentage changes in the mortgage's value to changes in interest rates; it is in fact a weighted average of the times when payments are made.[12]

EFFECTIVE DURATION (EFFECTIEVE DURATION)

A measure of the sensitivity of percentage changes in the mortgage's price to changes in its yield taken into consideration all available maturity shortening features.

1.5 OUTLINE

This first chapter introduced the topic and research questions that are to be answered in this thesis. After the research approach had been clarified, relevant literature had been discussed and definitions were set. The next chapter will introduce the fundamental concepts regarding mortgages. The purpose of the second chapter is to make one familiar with the concepts and terms used later on in this thesis. After chapter two, each of the four subquestions will be discussed in a separate chapter which will all start with a brief overview of relevant literature on that specific subject. Also, these chapters end with a partial conclusion and a brief discussion of the current developments that relate to the subject that is central in that specific chapter.

The contractual maturity profile of AAHG will be identified in chapter three. Once the effective maturity has been operationalized in terms of measurable variables, the fourth chapter analyses the

[10] More on the types of prepayments in section 4.2
[11] Nauta [2013], p. 13
[12] Hull [2009], p. 140

influence that various factors (might) have on this effective maturity. Again, both theory and real-life data will be used. Prior to analysing the effects, the concept of prepayments will be discussed in more detail. In order to answer these first two subquestions, data is required that is either already available or needs to be computed. Data collection will thus be part of these chapters, both quantitative as qualitative. Chapter four also includes analysing the collected data, by means of statistical techniques.

The fifth chapter is about modelling prepayments which will be done in cooperation with ALM. Liquidity risk should be given more attention in the models; this chapter also identifies the variables that are significant for the used data set. The sixth chapter concerns the effects of (upcoming) regulatory requirements. This chapter also looks into current (market) developments and its impact. The current portfolio is analysed in a separate chapter, the contractual and effective maturity profile is computed for the current portfolio. The main research question is actually answered in this chapter.

Chapter eight includes conclusions and recommendations; the answers of the subquestions will be combined. A discussion of the results and suggestions for further research is also included in this chapter.

CHAPTER TWO – MORTGAGE BASICS

The previous chapter introduced the general problem that AAHG is currently facing. The research question and subquestions derived from that problem statement were also discussed. A first step towards answering these questions is clarifying the underlying mortgage basics. Together with the definitions from section 1.4 this will improve the overall understandability of this thesis. Assuming AAHG's employees are aware of these basics, upcoming sections will be kept short.

2.1 MORTGAGES AND THEIR CHARACTERISTICS

2.1.1 WHAT IS A MORTGAGE?

In short, a mortgage is a security for a loan. One of the first definitions was given by Santley v. Wilde [1899]: *"A mortgage of real property comprises a transfer (conveyance) of a legal or equitable estate in the borrower's land to the mortgagee, with a provision that the mortgagee's interest shall lapse upon repayment of the loan plus interest and costs."* More modern literature defines a mortgage as a loan secured by the pledge of a specific piece of real estate property.[13]

ABN AMRO defines a mortgage as being the sum of the following four components: (1) the client borrows an amount from the bank, (2) the client pays interest over this amount, (3) the client has to repay the amount borrowed and (4) the assurance that the client will repay the amount borrowed by giving the bank the right sell the pledge/security (often the house bought with the loan) in case the client does not (re)pay the interest or the loan. A distinction between residential and non-residential (commercial) real estate can be made. AAHG's portfolio includes both residential and non-residential mortgages, this thesis focuses on residential mortgages. A mortgage actually consists of one or more loan parts (*Dutch: leningdeel*). For example, a client may have a mortgage of EUR 300.000 consisting of two loan parts, EUR 200.000 in an *annuïtair* mortgage and EUR 100.000 in an *aflossingsvrij* mortgage. Different loan parts can have different amortization schedules. Over time, a loan part consists of one or more fixed-interest rate periods. During each fixed-interest rate period, a client pays the interest rate that was determined at the start of the period.

2.1.2 TYPES OF MORTGAGES

As is the case with other financial products, the market (mortgage lenders) has been very creative in developing various types of mortgages. As mentioned in section 1.2, this thesis focuses on ABN AMRO and Florius mortgages. Depending on whether the client already has an ABN AMRO mortgage and on the time between the mortgage offer and the mortgage contract (*Dutch: snelheid van passeren*) there are different types of mortgages available. However, it is the method of amortization that is more relevant when classifying the types of mortgages available. Broadly spoken, there are four methods which are: *annuïteiten hypotheek*, *aflossingsvrije hypotheek*, *lineaire hypotheek* and (*bank)spaar hypotheek*; terms are in Dutch since there is no one-to-one English term. As of 2013, (*bank)spaar* mortgages are not being sold anymore. However, since this was a popular type of mortgage it will be taken into account. The characteristics of the different types of mortgages will be explained in the next section.

[13] Hu [2001]

2.1.3 MORTGAGE CHARACTERISTICS

While some characteristics are common to all the four types, others depend on the specific type of mortgage; table 1 below provides an overview of the most important characteristics, split out per type. These are the current characteristics, the historical data that is analysed in the next chapter includes loan parts that were originated under different characteristics; attention will be given to the differences that are significant.

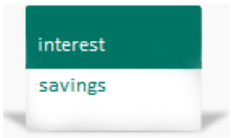
CHARACTERISTICS	*ANNUÏTAIR*	*(BANK)SPAAR*	*LINEAIR*	*AFLOSSINGSVRIJ*
SHORT DESCRIPTION	Fixed gross monthly payment (interest + principal); ratio shifts towards principal over time	Fixed gross and net monthly payment (interest + savings)	Decreasing gross monthly payment (interest + principal); monthly principal is fixed, interest decreases	Fixed gross monthly payment (interest only)
MAX. AMOUNT (DEPENDS ON INCOME CLIENT)	Max. 103% of market value of house + 2% real estate transfer tax	Max. 103% of market value of house + 2% real estate transfer tax	Max. 103% of market value of house + 2% real estate transfer tax	Max. 50% of market value of house
MATURITY	15-30 years	15-30 years	15-30 years	15-30 years
INTEREST RATE	Fixed or variable	Fixed; gross interest payable equals interest received on savings	Fixed or variable	Fixed or variable
FIXED RATE PERIOD	1/2/3/5/6/7/10/12/15/17/20/25/30 years[14]			
INTEREST DEDUCTION	Maximal deduction at beginning, tax advantage decreases over time; max. 30 years	As of 2013, interest is not deductible anymore[15]	Tax advantage decreases over time; max. 30 years	As of 2013, interest is not deductible anymore[15]
REPAYMENT	Loan will be completely repaid at maturity	Loan will be completely repaid at maturity with savings	Loan will be completely repaid at maturity	Client repays complete principal at maturity
PREPAYMENT	ABN AMRO: No penalty if prepayment <10% per year[16] Florius: No penalty if prepayment is paid by client's equity[16]			
GRAPH				

Table 1 – Mortgage types and characteristics

Some of these characteristics will influence the effective maturity. The impacts, if any, will be analysed in chapter 4; based on intuition the maturity, interest rate, fixed rate period (interest rate

[14] Depending on the label
[15] http://www.rijksoverheid.nl/onderwerpen/koopwoning/nieuwe-regels-hypotheek
[16] Exact conditions differ per type of mortgage, more info can be found at https://www.abnamro.nl/nl/prive/hypotheken/extra-terugbetalen.html and https://www.florius.nl/consument/klanten/boetevrijextraaflossen

reset) and (p)repayments will probably affect the effective maturity. The effective maturity might also differ by brand/label (ABN AMRO vs. Florius).

As of 2013, the maximum loan that clients can obtain will gradually be lowered, in terms of LTV, to 100% in 2018 (2013: 105%) including real estate transfer tax (*Dutch: overdrachtsbelasting*). This means clients can only get a mortgage with a value up to the market value of their house.[15] The Dutch government introduced this limitation to avoid clients not being able to pay off their mortgage. Concerning the maturity, the Dutch government allows mortgages with a maximum maturity of 35 years; AAHG offers mortgages with maturities running from 15 to 30 years.[17]

The interest rate payable by the client can either be fixed or variable (floating); in case of a fixed interest rate, there is a period set (varying from one to thirty years) for which the rate is fixed. Variable rates are partly based on base market rates like the EURIBOR or LIBOR. Section 2.3 discusses the components of the client rates, including the FTP, in more detail. A variable rate mortgage can be interpreted as a one-month fixed rate mortgage. After each month, the client has several options, the same options a fixed rate client has at the end of the fixed rate period. In case the client does not do anything, AAHG will set the same fixed rate period. The client can also alter, shorten or lengthen, the fixed rate period. He/she can also switch to a variable interest rate. Fourthly, the client can adjust his mortgage type at the end of a fixed rate period. Partly or completely repaying the mortgage is also one of the options, without any penalties. The last option the client has is switching banks, again without any penalties. Considering all these options an interest rate reset is an important aspect of mortgages and managing them. In practice, variable rate clients do not adjust their mortgage that often because of the notary fees.

The Dutch government budget of 2013 included quite some measures that affect the housing market. Two of the three most important measures have already been mentioned being the maximum mortgage (100% of LTV) a client can obtain and the fact that maximally 50% of the mortgage can be of the type *aflossingsvrij*. The third measure concerns home mortgage interest deduction; Dutch homeowners can deduct the mortgage interest paid from their taxable income. As of 2013, this arrangement only applies to mortgages of the type *annuïtair* or *lineair*; this results in *aflossingsvrij* mortgages becoming less popular. In case of an *annuïtair* mortgage, the interest payable decreases over time (as the graph indicates) resulting in a decreasing interest deduction. The net monthly costs for the client will thus increase. For a *lineair* mortgage, the interest payable, and thus the interest deduction, also decreases over time.

Both the *annuïtair* and *lineair* mortgages incur (monthly) principal payments which are used to pay off the complete loan obtained by the client. In case of a (*bank)spaar* mortgage, the complete loan will be repaid at maturity by the monthly savings made. The fourth type of mortgages is quite exceptional in terms of the repayment characteristic. As the Dutch term suggests, the mortgage is *aflossingsvrij*, i.e. there amortization and only interest is paid. The client is responsible for paying off the loan at maturity for which there are several methods possible. A sale of the client's security (his house) is an often used method, others include a new mortgage, a life insurance, endowment policy or investment account (*Dutch: beleggingshypotheek*).

[17] Some *aflossingsvrij* mortgages have got a maturity of 75 years/900 months

Discussing the last characteristic from table 1, prepayments, a distinction should be made between the two brands that are investigated in this thesis. Florius claims to be the first mortgage lender that charges no penalty for (additional) prepayments.[18] ABN AMRO does not charge a penalty as long as the yearly prepayment is less than 10 per cent of the total initial loan part. As the client prepays a lump sum the loan balance gets smaller resulting in less interest payable per month. A client can also choose to continue paying the same monthly amount, but now for a shorter period of time. The most important mortgage characteristics have been clarified, the next section is about the market in which these mortgages are traded.

2.2 THE RESIDENTIAL MORTGAGE MARKET

It was the US government owned corporation Ginnie Mae that was the first to issue a new type of bond in 1968: a mortgage-backed security (MBS). Until the late 1970s, government owned corporations held the exclusive right to manage the market in mortgage-backed securities. After it had been privatised, the market grew enormously; the total volume of the private MBS market in 1984 was USD 11 billion, in 2007 it was close to USD 3 trillion.[19]

An MBS is in fact a special type of bond. A number of mortgage loans, sold by a commercial bank to its clients, are pooled. In case this pool is not sold to external investors it serves as part of the liquidity buffer. In case the pool is sold, the proceeds serve as funding. As ABN AMRO keeps bearing part of the (credit) risk even if the pool is sold, all the bank's MBS are on-balance. If the risk is transferred to the investors, the MBS is off-balance. The paragraph below discusses an off-balance situation, which is most common in the US.

Each loan in the pool pays interest and principal (except for *aflossingsvrij*) until it matures, is prepaid or goes into default. These cash flows from the loans are paid to the investors, after servicing fees have been subtracted by the commercial bank. The figure below depicts the structure of the simplest form of a MBS.

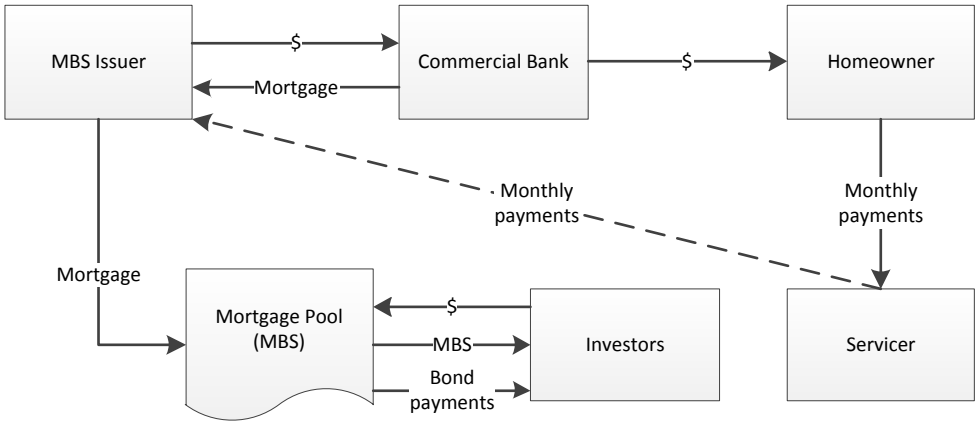


Figure 5 – MBS Structure

Different types of MBSs can be identified, depending on the method of passing the cash flows to the investors. In the basic form, called pass-through securities, cash flows are simply passed on to

[18] Provided that these prepayments are financed by the clients' own equity
[19] Johnson & Kwak [2010]

investors on a pro rata basis. Pass-through MBSs are either backed by mortgages on commercial (CMBS) or residential property (RMBS); this thesis focuses on the latter. Other types include collateralized mortgage obligations (CMO), stripped mortgage-backed securities (SMBS), to-be-announced securities (TBAs) and covered bonds. Not all these types will be discussed here, but one will be explained since its popularity has increased (at least up till the crisis) and AAHG makes use of it: collateralized mortgage obligations (CMO). A CMO is a type of collateralized debt obligation (CDO) in which the assets that back the security consist of a pool of mortgages. This pool of mortgages or MBSs is sold to a so called special purpose vehicle (SPV). To purchase these MBSs, the SPV issues bonds to investors which are divided into different tranches depending on the risk characteristics. The cash flows arising from the underlying mortgages are used to pay (after servicing fees have been subtracted) the investors. Senior tranches are paid before mezzanine and junior/equity tranches and any losses are first borne by junior/equity tranches, next by mezzanine and finally by senior tranches. Since the senior tranches bear the least risk, the yield is the lowest; this goes the other way around for junior/equity tranches. Many different types of CDOs (CMOs) have been developed, but this is the basic structure.

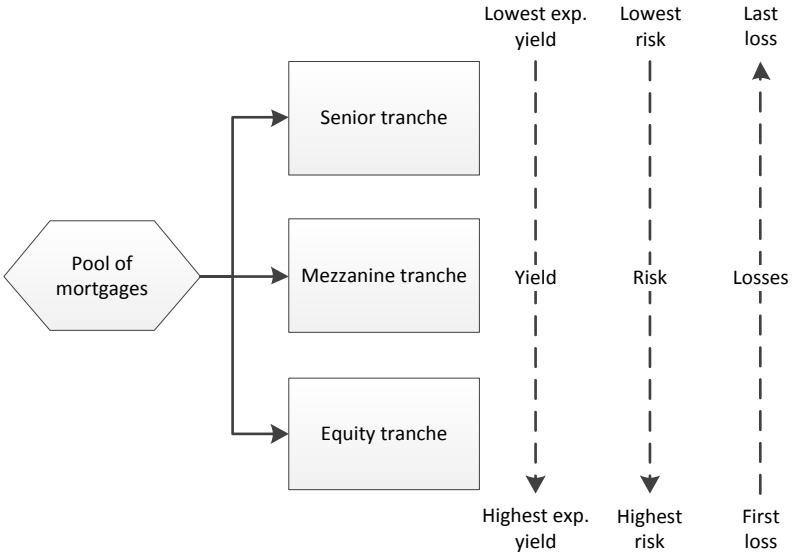


Figure 6 – CDO tranches

Except for *aflossingsvrij* mortgages, monthly payments include principal which means that the face value of the RMBS is reducing over time. In theory, this also results in RMBSs having a shorter effective maturity than (standard) bonds. Depending on the characteristics of the mortgages within a pool, rating agencies rate the RMBS. During the subprime mortgage crisis it turned out that the ratings underestimated the risks involved.

Partly because of this underestimation of the involved risks, the RMBS market is heavily regulated and it is not certain how this regulation will evolve in the near future. This on-going uncertainty is causing a cautious attitude among investors towards RMBSs, which is reflected in the spreads that need to be paid. More on regulation is in section 6.2.

2.2.1 SITUATION IN THE NETHERLANDS

Securitization is an important source of funding mortgages. According to Aalbers [2009], 15% of the Dutch mortgage market was securitized in 2005 and this share increased year by year until the crisis hit. The Dutch *Centraal Bureau voor de Statistiek* (CBS) stated that the overall gross mortgage debt in the Netherlands was nearly EUR 670 billion at the end of 2011.[20] This enormous amount is partly offset by high savings (EUR 332 billion) and pension reserves (EUR 1,140 billion). In the table below, one can see that the total RMBS market in the Netherlands accounted for EUR 269.1 billion. Keeping in mind that these figures are from the fourth quartile of 2012, approximately 40% of the Dutch mortgage market is securitized.

OUTSTANDINGS BY COLLATERAL AND COUNTRY (2012:Q4) – EUR BILLIONS							
	ABS	CDO	CMBS	RMBS	SME	WBS	TOTAL
AUSTRIA			0.2	1.9			2.1
BELGIUM	0.1		0.3	71.2	18.5		90.1
FINLAND	0.3						0.3
FRANCE	21.4		3.0	16.7	3.1		44.3
GERMANY	33.1	2.5	15.6	17.0	6.3	0.1	74.5
GREECE	16.1	1.9		6.4	9.8		34.2
IRELAND	0.3	0.3	0.4	51.2	2.1		54.2
ITALY	55.4	4.8	10.0	98.3	30.3	1.4	200.3
NETHERLANDS	5.7	1.6	3.0	269.1	9.8		289.2
PORTUGAL	6.2			29.1	5.3		40.6
RUSSIA	0.4			1.7			2.1
SPAIN	19.5	0.6	0.5	127.3	57.9		205.9
TURKEY	2.3						2.3
UK	41.6	7.6	66.9	295.4	8.5	56.3	476.2
OTHER	3.7	2.7		0.3	0.5		7.1
PAN-EUROPE	3.7	32.0	17.4	0.2	4.7	0.2	58.2
MULTINATIONAL	1.5	109.5	2.1		1.2	0.6	115.0
EUROPEAN TOTAL	211.3	163.4	119.4	985.9	158.0	58.5	1696.4

Table 2 – Securitization outstandings – Source: AFME [2012]

As mentioned before, the Dutch mortgage market is quite different from other markets; it contains some unique features. On average, the LTV of Dutch RMBS pools lies around 90%, compared to a European average of 70%. In spite of such high LTVs Dutch RMBS has historically had among the lowest level of arrears.[21] Among others, factors that cause the good mortgage performance are the tax deduction of interest payments, the lender friendly legal system and the full recourse to borrowers in case a loss is incurred upon foreclosure. The Dutch mortgage market performing well results in a low spread on its RMBS; figure 7 below shows the spread on 3-5 year RMBS, rated AAA. Despite the fact that investors are less enthusiastic due to upcoming regulation like Solvency II and Basel III, the RMBS market has recovered slightly in 2012.

[20] http://www.cbs.nl/en-GB/menu/themas/macro-economie/publicaties/artikelen/archief/2012/2012-3680-wm.htm
[21] Fitch [2012]

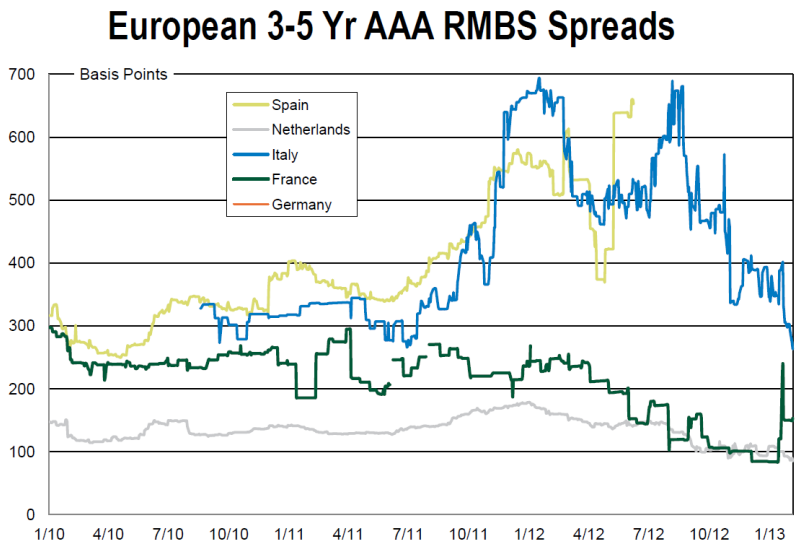


Figure 7 – RMBS spreads – Source: AFME [2012]

AAHG benefits from the Dutch mortgage market performing well; it contributes to it as well of course. It recently issued a RMBS named 'Goldfish' which securitizes Dutch home loans guaranteed under the government's *Nationale Hypotheek Garantie* (NHG) program.

[CONFIDENTIAL]

2.3 OTHER BASIC CONCEPTS

Next to mortgages in general, the different types and characteristics, and the market on which they are traded, there are some other basic concepts that require additional explanation. This section looks into FTP and the liquidity spread curve (LSC); it also explains the NHG concept.

As said, funds transfer pricing (FTP) is a process used in banking to measure the performance of the different business units of a bank.

[CONFIDENTIAL]

CONFIDENTIAL

Figure 8 – Components FTP and integral cost price – Source: Internal document ABN AMRO

[CONFIDENTIAL]

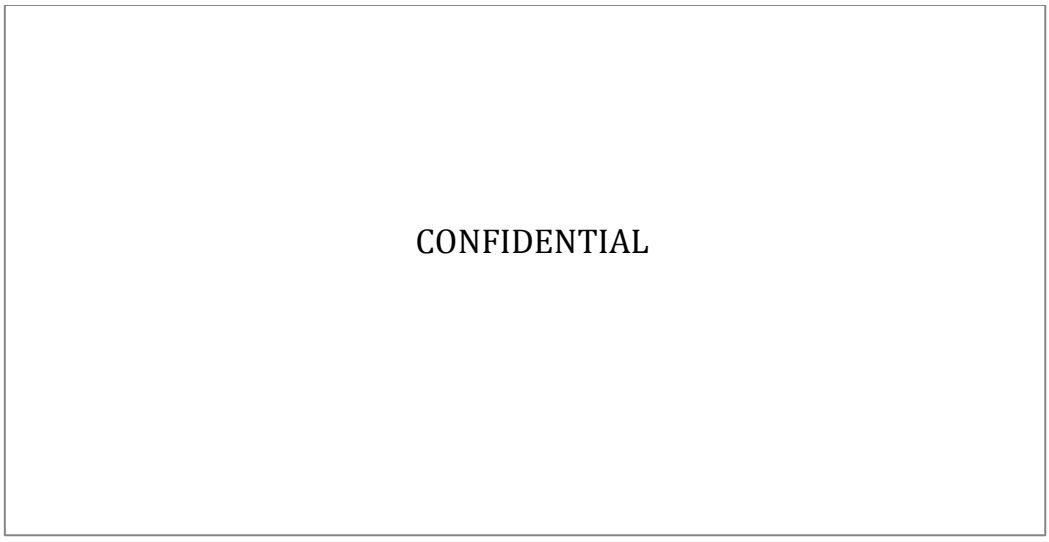


Figure 9 – ABN AMRO's LSC as of April 1st 2013 – Source: Internal document ABN AMRO

[CONFIDENTIAL]

The last concept that will be clarified is the *Nationale Hypotheek Garantie* (NHG) which is an insurance on mortgages with a maximal value of EUR 320,000. In case the client is no longer able to pay his mortgage and the house is sold for less than the value of the mortgage, the NHG pays the remaining outstanding debt to the mortgage lender. In case the client meets certain conditions the debt will be absolved. The client pays a single premium which is a fixed percentage of the total value of the mortgage. Since the mortgage lender knows for sure that the complete mortgage is repaid, i.e. his risks have decreased, the lender is able to offer the client a lower interest rate. Up till now, the premiums paid have been sufficient to pay off any remaining debts, however, the number of clients that call upon the guarantee is increasing.[22]

2.4 PARTIAL CONCLUSION AND DEVELOPMENTS

A short introduction to mortgages; that is probably how this chapter can be described best. Since this chapter was rather descriptive, there are few conclusions drawn here. The different types of mortgages of AAHG, and their characteristics, were identified. What impact these characteristics have on the effective maturity will be analysed in the next chapter. Next, the (residential) mortgage market, securitisation and some basic concepts were explained. [CONFIDENTIAL]

Concerning (recent) developments on the topics from this chapter, Dutch government regulation affects the mortgage market and thus AAHG's activities. The maximum LTV will be lowered to 100% and interest deduction will be limited. As for the RMBS market, investors are more careful due to upcoming regulation. Spreads in the Netherlands are low compared to other countries, but Fitch [2012] foresees an increase in arrears and states that any negative rating action on the Dutch state can affect the NHG-backed securities. [CONFIDENTIAL]

[22] https://www.nhg.nl/organisatie/nieuws/nieuws-detailpagina/persbericht-nhg-cijfers-eerste-kwartaal-2013-onder-grote-invloed-van-eindejaarsrally.html

CHAPTER THREE – CONTRACTUAL MATURITY PROFILE

This chapter discusses the first subquestion; looking back at the structure of this thesis (figure 2) this chapter thus deals with the contractual maturity that is based on contractual repayments. Analyses on the current portfolio are in chapter 7, this chapter is based on historical data. Different statistical characteristics will also be analysed. The outcomes of this chapter will be used as an input for the next chapter.

3.1 THEORETICAL BACKGROUND

A maturity profile is usually applied to debt, in which case it is a graphical representation of the amount of money that is due to be paid at the different maturities. Instead of debt (liabilities), it can also be applied to assets; it then depicts the amount of money that is to be received at the different maturities. In other words, it provides insight in the contractual inflows of liquidity. As Keynes [1936] stated, by entering into contractual agreements (here: lending mortgages), AAHG assures themselves some predictability in terms of contractual cash inflows and outflows. A maturity profile is rather easy to understand, hence, there is little theoretical explanation available and necessary. In this thesis, the second application is used; the maturity profile will represent the amount of money that is to be received at the different maturities.

ABN AMRO provides a maturity analysis of the assets and liabilities in its annual report [2012]. The note that ABN AMRO adds to that analysis is interesting: *"This is not consistent with how we view and manage liquidity, as it does not take expected client behaviour and other factors into account."* This implies that looking into the contractual maturity before the effective maturity will be analysed was the right choice; it also demonstrates the relevance of this chapter.

As said in section 1.2 there actually are four distinct types of maturities, and thus profiles. The contractual maturity, at origination and the residual maturity, can be determined rather easily for the current portfolio. It is a fixed value that does not change during the economic lifetime of a mortgage. However, the effective maturity is a dynamic value that is unknown at origination, and thus throughout the economic lifetime of a mortgage: residual effective maturity. Historical data is analysed to gain insight in the effective maturity. While analysing this data the contractual maturities will be analysed as well. Chapter 3 and 4 are based on historical data, and no statements are yet made on the current portfolio. The table below provides an overview of the different types of maturities and the section they are discussed in.

	DATA SET	MATURITY	TYPE	BASED ON	SECTION
1	HISTORICAL DATA	CONTRACTUAL	AT ORIGINATION	VARIABLE IN DATABASE	3.2
2	HISTORICAL DATA	CONTRACTUAL	RESIDUAL	N/A	-
3	HISTORICAL DATA	CONTRACTUAL	PROFILE	CONTRACTUAL REPAYMENTS	3.3
4	HISTORICAL DATA	EFFECTIVE	AT ORIGINATION	TERMINATED LOAN PARTS	4.3
5	HISTORICAL DATA	EFFECTIVE	RESIDUAL	N/A	-
6	HISTORICAL DATA	EFFECTIVE	PROFILE	TERMINATED LOAN PARTS	4.4
7	CURRENT PORTFOLIO	CONTRACTUAL	AT ORIGINATION	VARIABLE IN DATABASE	7.2
8	CURRENT PORTFOLIO	CONTRACTUAL	RESIDUAL	VARIABLE IN DATABASE	7.2
9	CURRENT PORTFOLIO	CONTRACTUAL	PROFILE	ESTIMATION	7.2
10	CURRENT PORTFOLIO	EFFECTIVE	AT ORIGINATION	ESTIMATION	7.3
11	CURRENT PORTFOLIO	EFFECTIVE	RESIDUAL	N/A	-
12	CURRENT PORTFOLIO	EFFECTIVE	PROFILE	ESTIMATION	7.3

Table 3 – Types of maturities analysed in this thesis

3.2 CONTRACTUAL MATURITY

Before a contractual maturity *profile* can be computed, including the cash inflows over time, the contractual maturity of a mortgage expressed in time needs to be determined. This contractual maturity at origination will be analysed in the paragraphs below; it makes no sense to analyse the residual contractual maturity of the historical data. In the section below, if not mentioned, contractual maturity should be interpreted as the contractual maturity at origination, i.e. the 1st maturity type from table 3 is analysed here.

3.2.1 DATA SET AND ITS CHARACTERISTICS

As said, this thesis focuses on the ABN AMRO and Florius mortgages which represent a value of circa EUR 90 billion. At the end of 2011, the overall gross mortgage debt in the Netherlands was nearly EUR 670 billion[20]; a quite significant part of that is thus being investigated. Because the data that is to be collected and analysed is recorded in numerical form, it is known as quantitative data. The objects that are being studied, mortgages and clients, are not aware of the fact that they are being studied; hence this research will not affect their behaviour. Gathering information in such a way is formally defined as unobtrusive data collection.

[CONFIDENTIAL]

Since the scope of this thesis is limited to ABN AMRO and Florius the other labels can be filtered out; the data characteristics in table 4 below are based on the remaining data. A second filter was applied to assure that the same data set is used throughout this thesis. This is because the database is still being updated and filled with new data.

CHARACTERISTIC	ABN AMRO	FLORIUS
RECORDS	[CONFIDENTIAL]	
ACCOUNTING PERIOD		
ORIGINATION DATE		
NUMBER OF UNIQUE LOANS		
NUMBER OF LOAN PARTS		

Table 4 – Characteristics data

[CONFIDENTIAL]

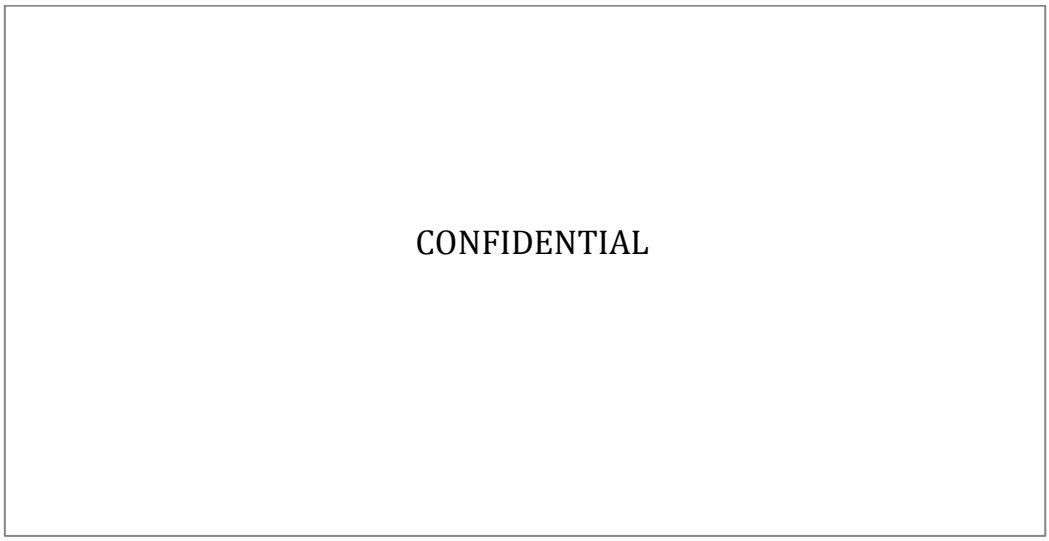


Figure 10 – Principal by year of origination

[CONFIDENTIAL]

AVAILABLE DATA AFTER APPLYING FILTERS	ABN AMRO		FLORIUS	
	BEFORE	AFTER	BEFORE	AFTER
RECORDS	[CONFIDENTIAL]			
NUMBER OF UNIQUE LOANS				
NUMBER OF LOAN PARTS				

Table 5 – Filtered data set

[CONFIDENTIAL]

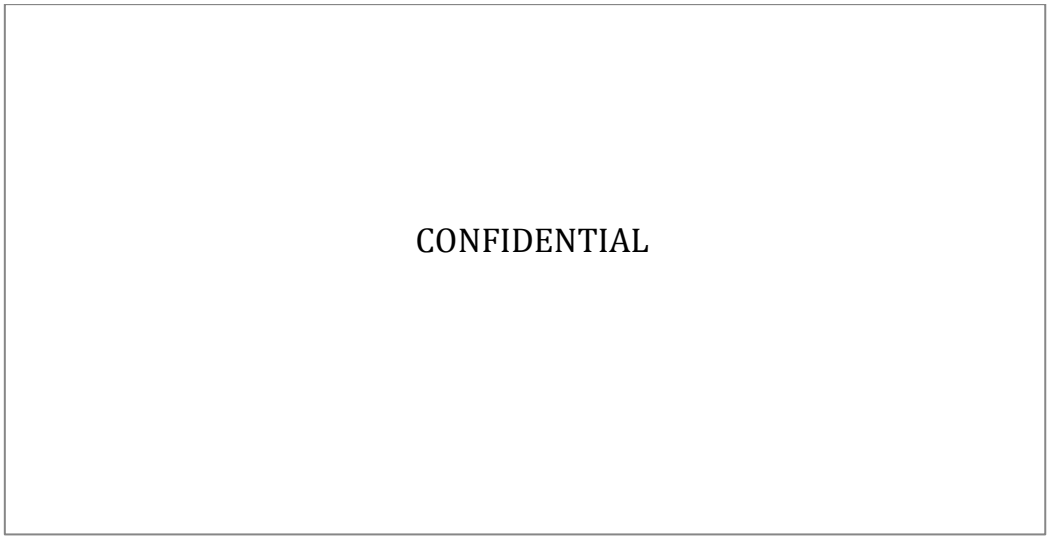


Figure 11 – Original principal per loan part (as a percentage of the total # loan parts)

[CONFIDENTIAL]

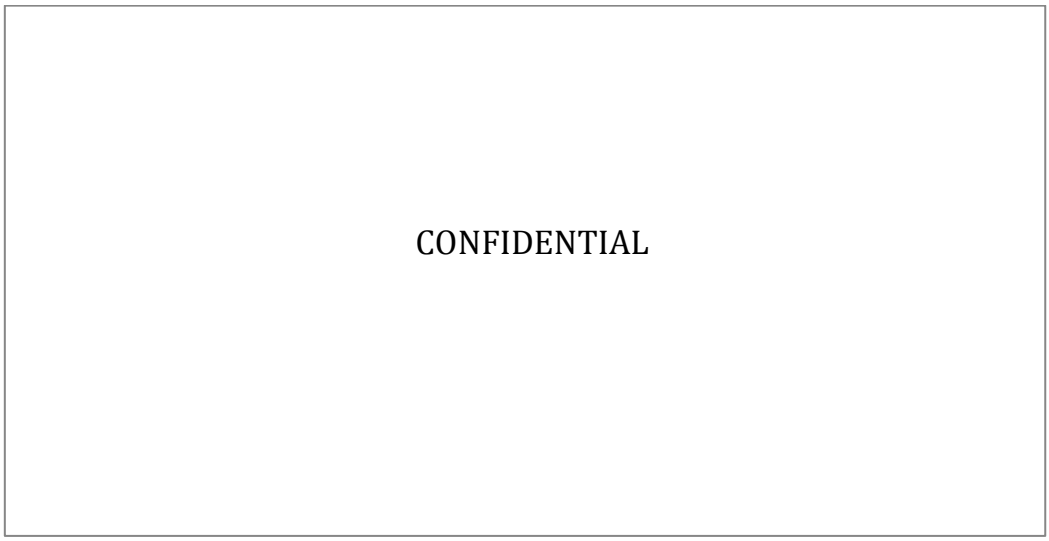


Figure 12 – Weighted fixed rate periods

[CONFIDENTIAL]

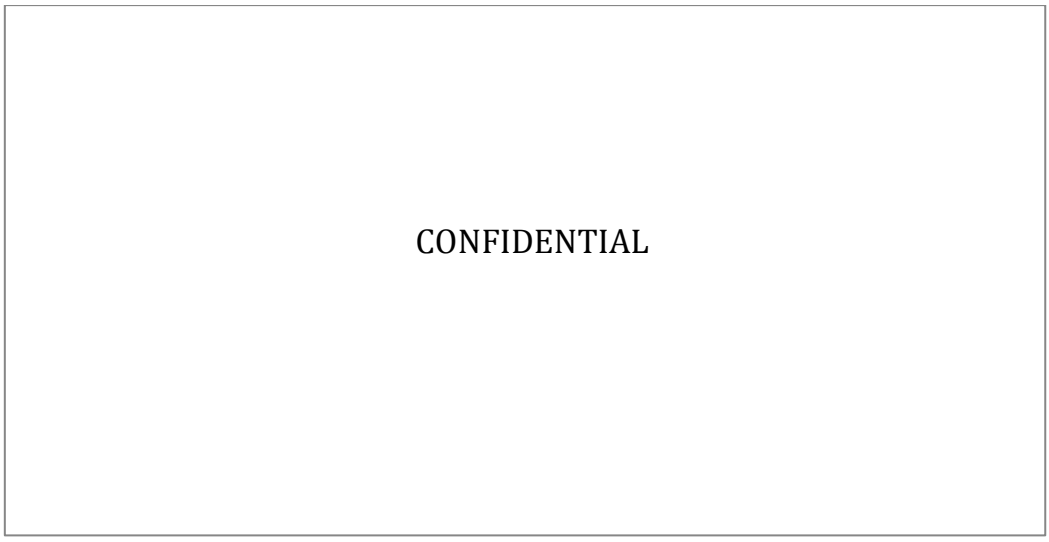


Figure 13 – Weighted type of amortization

[CONFIDENTIAL]

CHARACTERISTIC	ABN AMRO	FLORIUS
ORIGINAL PRINCIPAL[1]	[CONFIDENTIAL]	
GUARANTEED (NHG)		
FIXED RATE PERIOD[2]		
AMORTIZATION TYPE[3]		
INTEREST RATE		
Notes *(1) Averages are on loan part level* *(2) One and three month fixed rate periods are defined as variable* *(3) As a percentage of the total amount of principal*		

Table 6 – Overview main characteristics

3.2.2 OPERATIONALIZATION AND DATA ANALYSIS

A conceptual definition of contractual maturity has already been given, in order to determine how it needs to be measured, an operational definition is required as well. This partly depends on the data that is available, i.e. it should be possible to measure it. The contractual maturity was defined as the total contractual amortization period of a mortgage as recorded in the contract. The data set described above contains multiple variables that can be used to determine this contractual maturity at origination.

The tables '*DimLeningdeelPrepaymentBacktest*' and '*Leningdeel*' both contain a variable '*Looptijd*'; one can also calculate the difference between '*IngangsdatumLooptijd*' and '*Einddatum*'. The variable '*Looptijd*' from the table '*Leningdeel´* comes from a database that is closer to the source data than other database(s) or –marts. Also, a random sample proved that this variable had the least erroneous and invalid records. Using this variable the operationalization of the contractual maturity at origination is rather simple, namely: contractual maturity at origination = '*Looptijd*', expressed in months.

CONTRACTUAL MATURITY AT ORIGINATION (AVERAGE)	ABN AMRO	FLORIUS
DATA SET INCL. AFLOSSINGSVRIJ	[CONFIDENTIAL]	
DATA SET EXCL. AFLOSSINGSVRIJ		

Table 7 – Average contractual maturities

[CONFIDENTIAL]

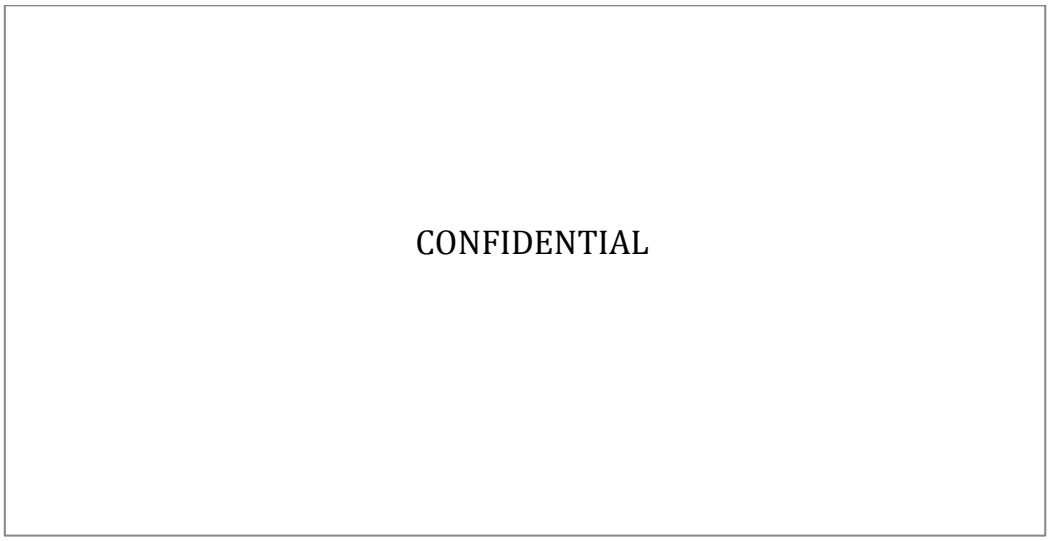


Figure 14 – Share contractual maturities

[CONFIDENTIAL]

SUMMARY STATISTICS		ABN AMRO	FLORIUS
CONTRACTUAL MATURITY AT ORIGINATION			
	AVERAGE	[CONFIDENTIAL]	
	WEIGHTED AVERAGE		
	STANDARD ERROR		
	MEDIAN		
	MODE		
	STANDARD DEVIATION		
	SAMPLE VARIANCE		
	KURTOSIS		
	SKEWNESS		
	RANGE		
	MINUMUM		
	MAXIMUM		

Table 8 – Summary statistics data set

[CONFIDENTIAL]

CONFIDENTIAL

Figure 15 – Cumulative share maturities

The same operationalization from above can be applied when determining the contractual maturity at origination for the current portfolio, i.e. the 7th type of maturity from table 3. This will be done in section 7.2.

3.3 CONTRACTUAL MATURITY PROFILE

As stated above, a contractual maturity profile depicts the cash inflows at different maturities. One should note that only contractual repayments are taken into account, non-contractual payments (including interest) are excluded. The different types of mortgages have got different types of repayment schedules.

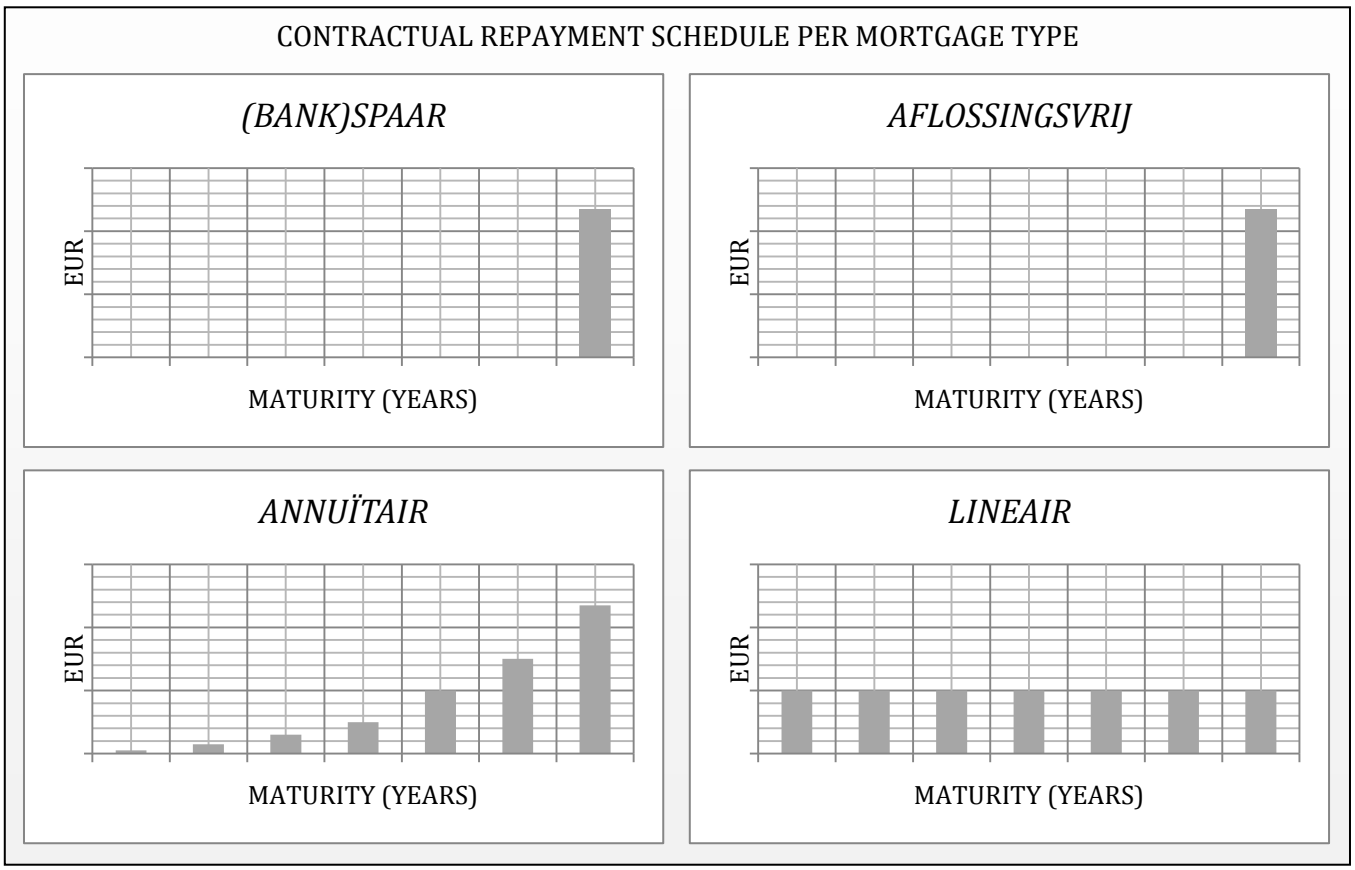


Figure 16 – Contractual maturity profiles

In case of a (*bank)spaar* or an *aflossingsvrij* mortgage, the principal is repaid at maturity, there are no contractual interim principal repayments. As for the types *annuïtair* and *lineair*, there are monthly principal repayments. The graphs above indicate how the contractual maturity profiles for the different types look like (for a single, held-to-maturity mortgage). It is not hard to imagine that the contractual maturity profile of the complete mortgage portfolio, or at least of the two labels this thesis restricts to, will look somewhat like figure 3. This is because of the different mortgage types, different maturities and on-going mortgages (*Dutch: lopende hypotheken*) that are in the portfolio.

[CONFIDENTIAL]

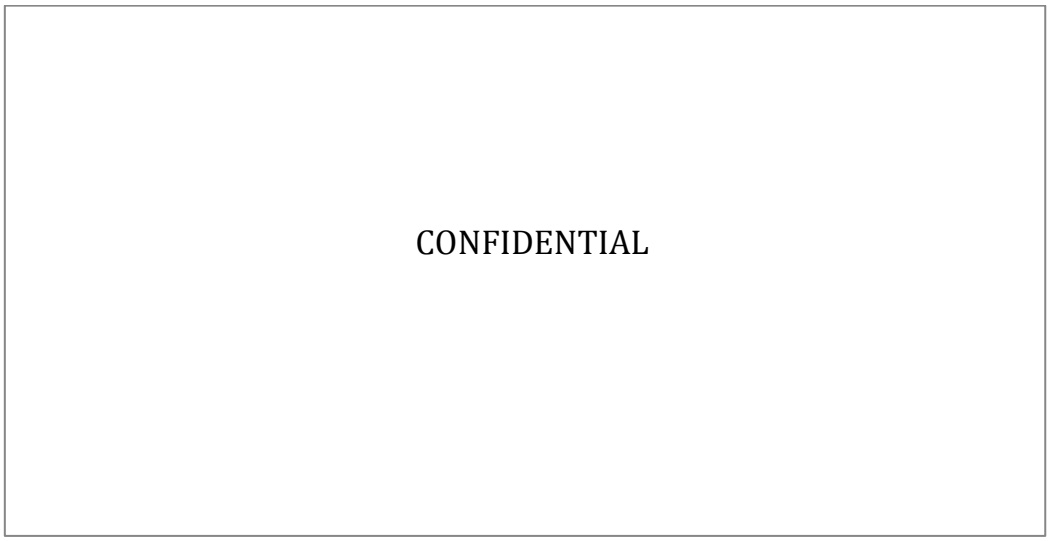


Figure 17 – Method of reconstructing a mortgage

3.3.1 OPERATIONALIZATION AND DATA ANALYSIS

The data set described in section 3.2.1, that is also used here, holds a variable that denotes the elapsed maturity of a loan part, namely '*LooptijdVerstreken*'. The contractual repayments that this section looks into are given by the variable '*ContractueleAflossing*', which is the amount of euros repaid excluding interest; as dictated by the amortization schedule. Combining these two variables makes it possible to give insight in the contractual repayments made per elapsed maturity. Insight in the contractual repayments per accounting period can be gained by using the variable '*Boekperiode*'.

[CONFIDENTIAL]

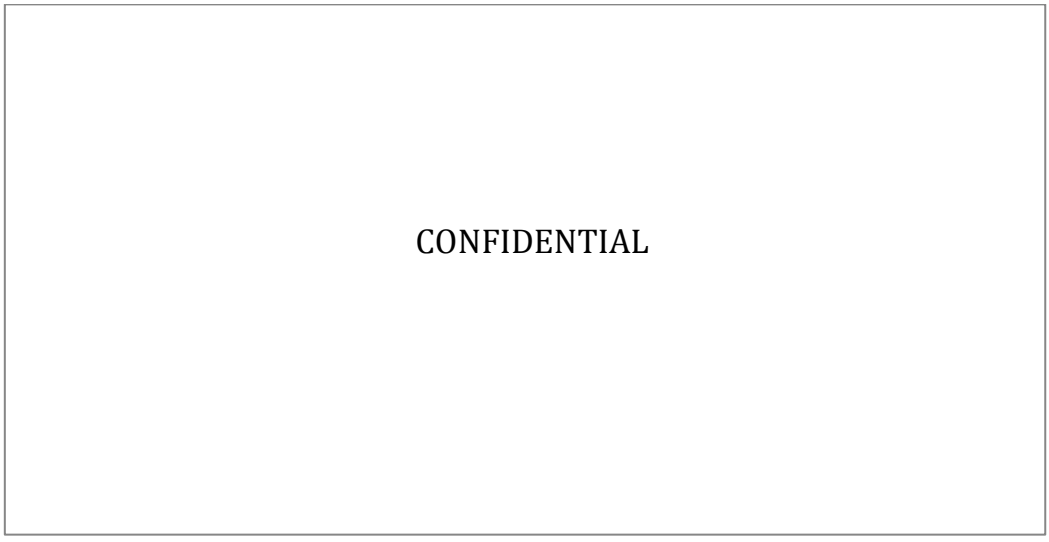


Figure 18 – Total contractual repayments

[CONFIDENTIAL]

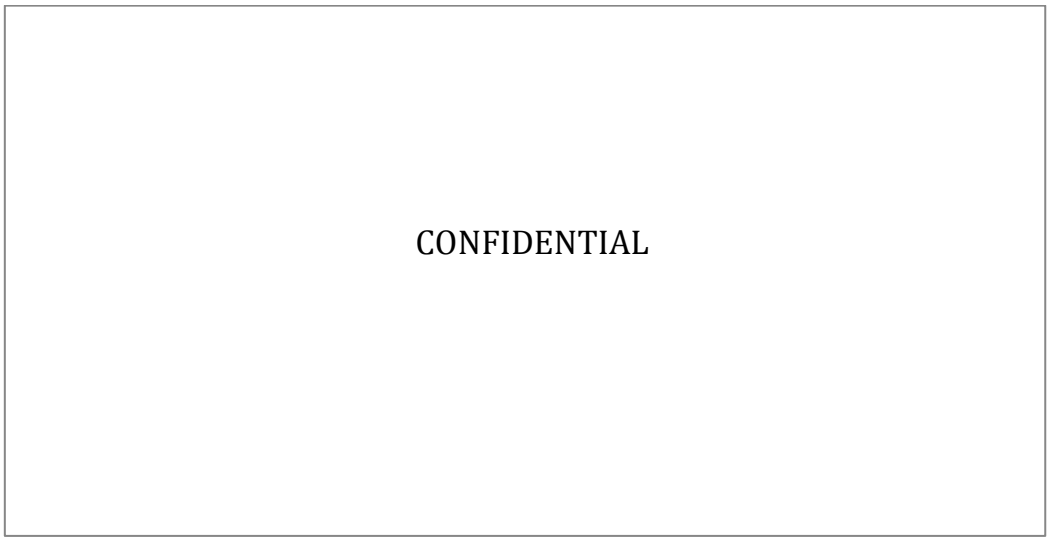


Figure 19 – Average contractual repayments

[CONFIDENTIAL]

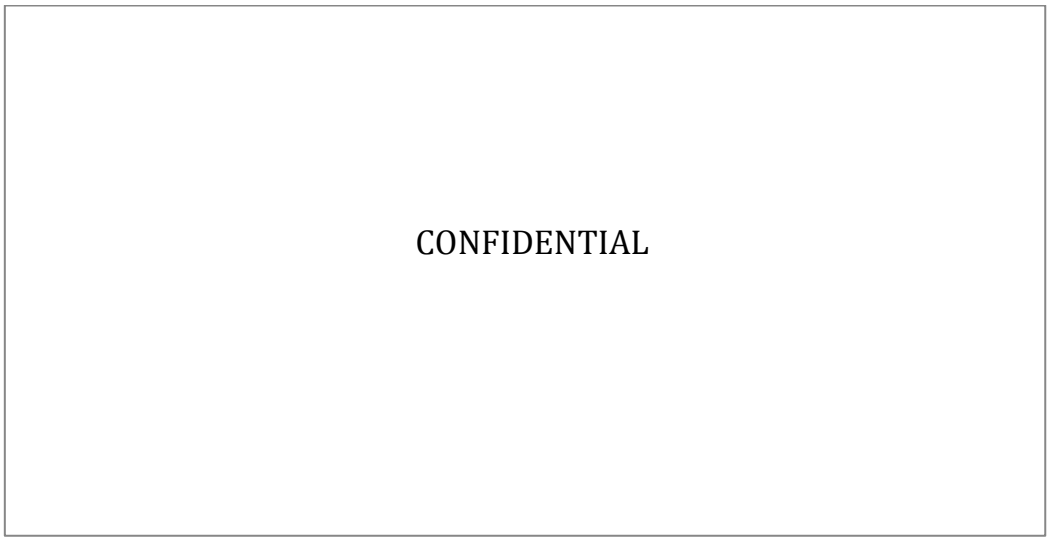


Figure 20 – Average contractual repayments (*annuïtair*)

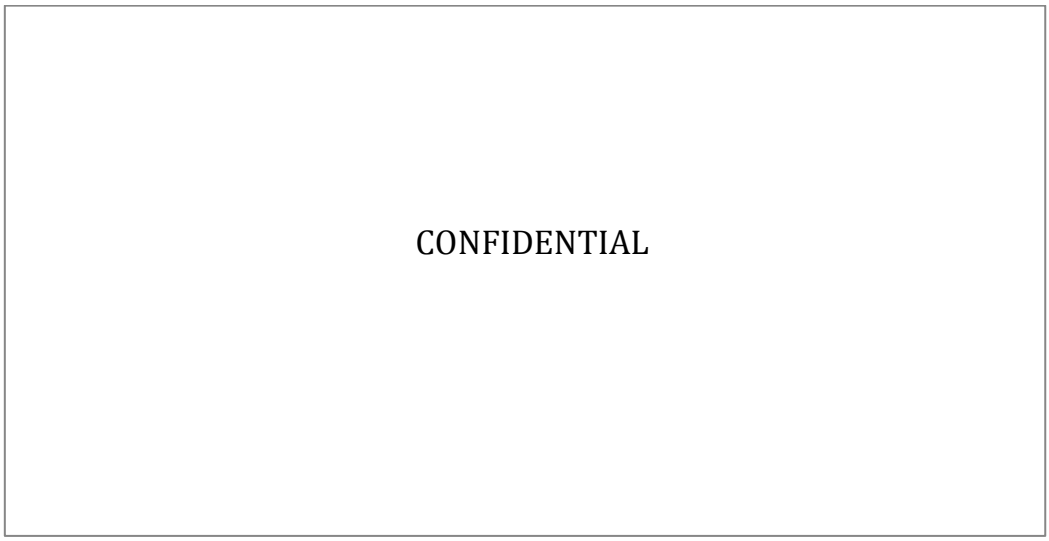


Figure 21 – Average contractual repayments (*lineair*)

[CONFIDENTIAL]

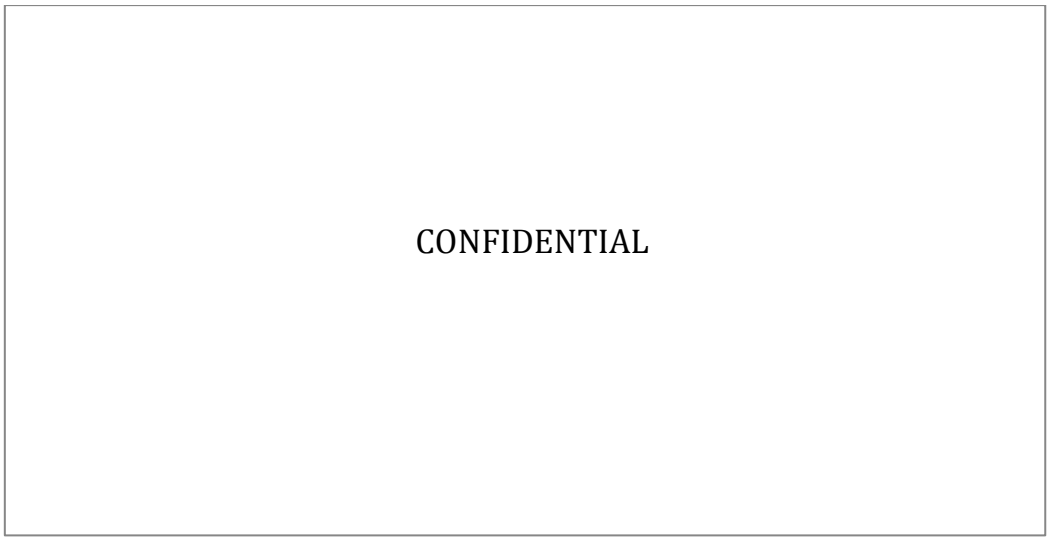


Figure 22 – Contractual maturity profile

[CONFIDENTIAL]

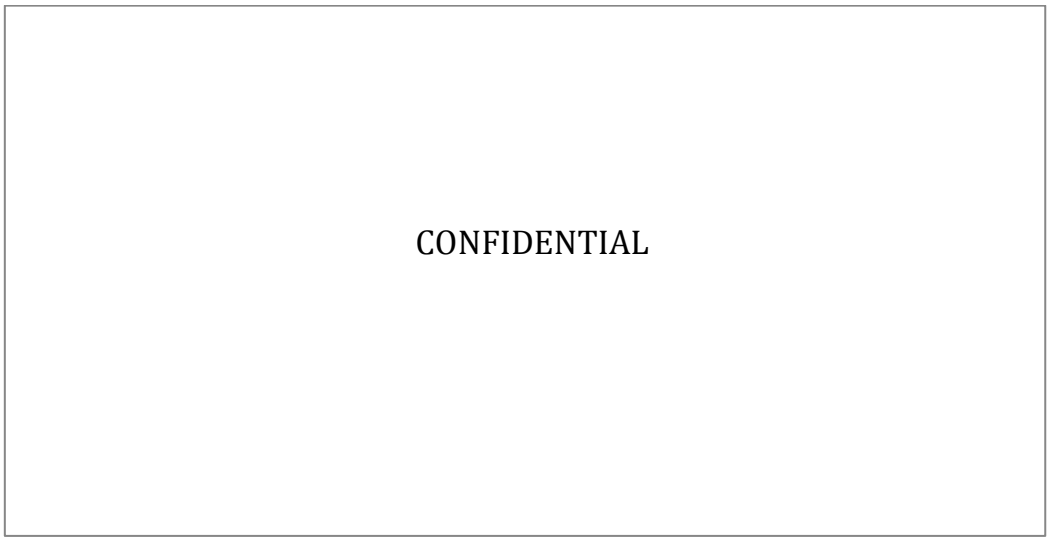


Figure 23 – Average contractual repayments per accounting period

[CONFIDENTIAL]

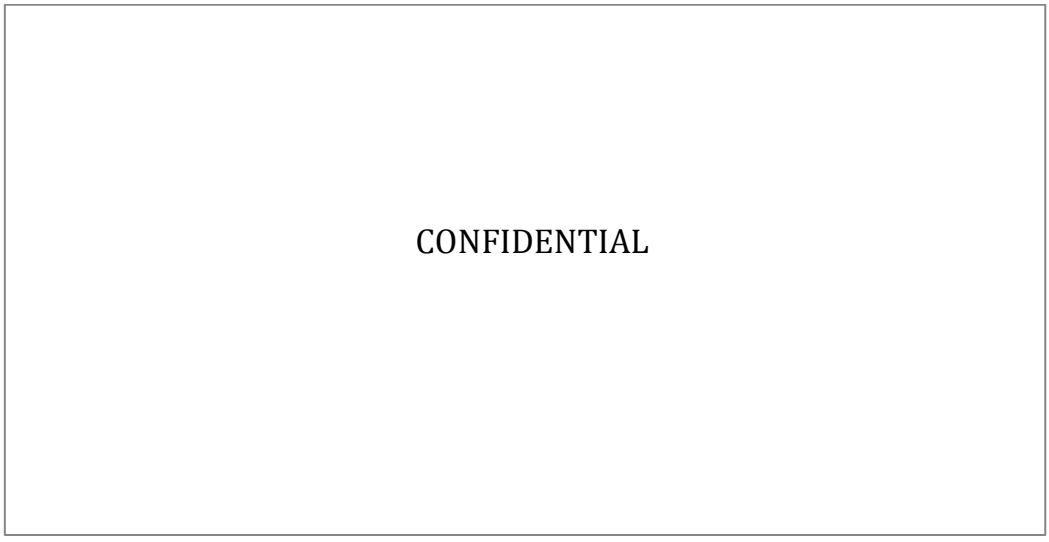


Figure 24 – Average contractual repayments (*annuïtair*)

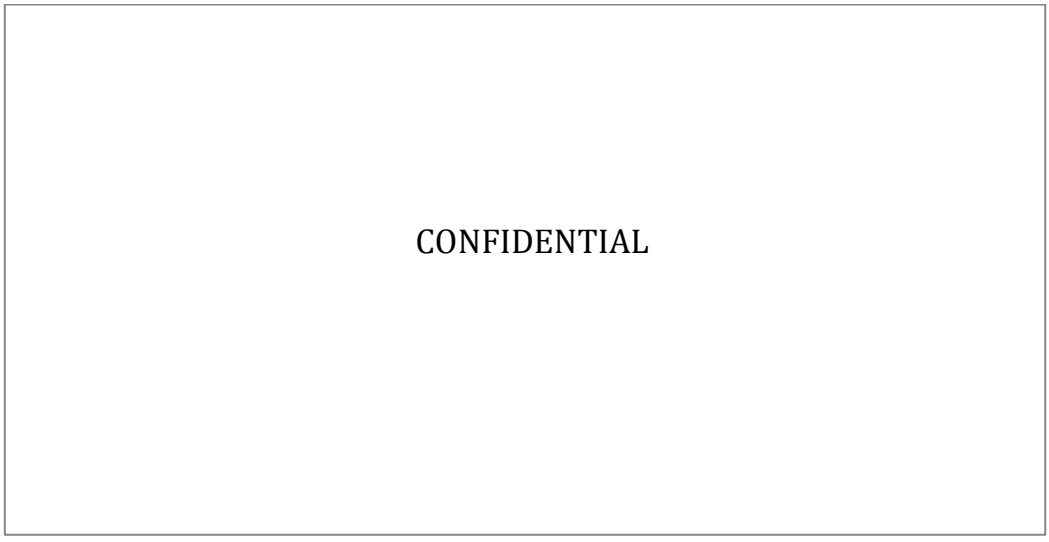


Figure 25 – Average contractual repayments (*lineair*)

Even more relevant for the remainder of this thesis is how these contractual repayments compare to the outstanding principal. This also helps better understanding the magnitude of the contractual repayments. The repayment rate (y-axis) is in basis points.

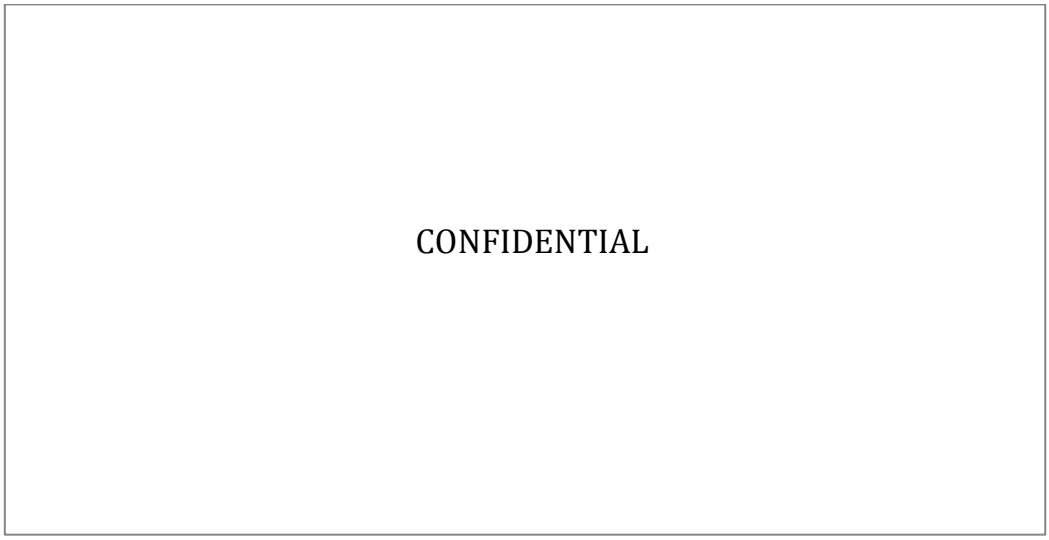


Figure 26 – Contractual repayment rate

[CONFIDENTIAL]

3.4 RESIDUAL CONTRACTUAL MATURITY PROFILE

Besides calculating the total contractual amortization period of a mortgage, i.e. the contractual maturity, and the contractual cash inflows in that period (the contractual maturity profile) it is interesting to have a look at the *residual* contractual maturity (profile). However, as mentioned in section 3.2 and in table 3, it makes no sense to analyse the residual contractual maturity for the historical data. The residual contractual maturity denotes the time between the contractual end date and some start date, e.g. the current date. It can only be determined as of one point in time, by setting this *start date* equal to the current date, the residual contractual maturity for the current portfolio can be determined. All analyses on the current portfolio are in a separate chapter, thus so is the residual contractual maturity.

Both the residual and the contractual maturity at origination are fixed values that can be computed for current portfolio applying the operationalization from section 3.2.[23] This is not the case for the residual contractual maturity profile.[24] The to-be received contractual cash inflows during the residual maturity are unknown. Computing this residual contractual maturity profile will be done in chapter 7, the theoretical background is outlined below. The reason for choosing this sequence is that understanding the theory on the residual contractual maturity profile helps understanding the effective maturity that is discussed in the next chapter.

[CONFIDENTIAL]

[23] No operationalization for the residual contractual maturity was given yet, but this is relatively simple using the available variables from the data set
[24] The word 'residual' can in fact be omitted here, if applied to the current portfolio it already is 'residual'

3.5 PARTIAL CONCLUSION AND DEVELOPMENTS

As the name suggests, Asset-Liability Management (ALM) is about monitoring and managing assets and liabilities. ALM's main task is finding an optimal trade-off between risk, return and liquidity. Their focus is on risks arising due to mismatches between assets and liabilities. A mismatch can occur in the (expected) amount of money that is to be received/paid as a result of the assets and liabilities held. It is not only the amount of money that matters though, it is important that the times that these amounts come due match. This potential mismatch can be analysed via a maturity analysis, which is included in ABN AMRO's annual report [2012].

[CONFIDENTIAL]

As for the (recent) developments, ALM has become increasingly important; especially since the financial crisis. The following quotes from Davidson [2012] validate this statement.

"*In the last quarter of a century, large financial underwriters have created public markets, which, via securitization, appeared to convert long term debt instruments (some of them very illiquid, e.g., mortgages) into the virtual equivalent of high yield, very liquid money market funds and other short term deposit accounts.*"

"*The purpose of liquid assets traded on organized and orderly financial markets is to provide a security blanket against one's inability to meet a contractual obligation outflow. Thus when the market for mortgage backed derivatives that were advertised to be 'as good as cash' i.e., perfectly liquid (and triple A rated) collapsed, the loss of so much liquidity caused panic (a reflexivity response) in other markets for assets that had been previously thought to be very liquid.*"

Davidson [2012] indirectly stresses the need for a (financial) institution to understand its contractual obligations and its ability to meet those. These can be met by contractual benefits; a maturity profile gives insight in the contractual in- and out-flows and has thus become increasingly important in this context. Investors are also becoming more interested in this concept, many large corporations now provide a maturity profile on their website.[25]

This chapter did not completely answered the first subquestion since AAHG's current contractual maturity profile was not computed; as said before, analyses on the current portfolio are in chapter 7.

[25] For example: http://www.basf.com/group/corporate/en/investor-relations/creditor-relations/bonds/maturity-profile

CHAPTER FOUR – EFFECTIVE MATURITY PROFILE

The previous chapter analysed the contractual maturity by taking all contractual repayments into account. Historical data was used to create a so called maturity profile of the cash inflows over time, as dictated by the formal amortization schedules. One can think of various factors that might shorten (or lengthen) this contractual maturity; the effective maturity takes all maturity shortening (adjusting) features into account. The first section of this chapter discusses the possible factors that (might) influence the effective maturity. A separate section will be dedicated to the factors that can be classified as prepayments. Next, sections three and four operationalize the effective maturity (profile) and subsequently analyse the 4th and 6th type of maturity from table 3. Based on historical data, the effective maturity at origination (4th type) and an effective maturity profile (6th type) are computed using information on loan parts that were terminated in the available accounting period. Arguments for analysing historical data can be found in section 3.5; as said before: one needs to understand the past to understand the present. Finally, the last section includes a partial conclusion and a discussion on current developments.

4.1 THEORETICAL BACKGROUND

Many articles have been written about the possible types of maturity adjusting features[26]; caution is required however. The situations described in the articles and the underlying data that is used often strongly differ from the situation and data to which this thesis applies. Also, it is important to compare the definitions that are used.

Since the 1990s, long-term assets such as mortgages made up an increasing portion of bank assets while the share of short-term assets (like cash) decreased. Despite this, Young et al. [2010] found that assets were perceived as having become effectively shorter-term. They gave no causes for this changed market perception though; nor did they analyse whether maturity shortening (adjusting) features caused their observation. Young et al. [2010] only do speculate, they state that the increased marketability of mortgages may have played an important role. Section 2.2 did indeed found that the (residential) mortgage market grew enormously in the last decade(s) of the 20th century.

The articles by Ambrose & Sanders [2002] and by Calhoun & Deng [2000] both identify two factors that can cause a mortgage to terminate (prematurely), being defaults and prepayments. While Ambrose & Sanders [2002] analyse and model the behaviour of these two factors, Calhoun & Deng [2000] investigate whether the basic option theory can be applied to mortgage terminations. Calhoun & Deng's [2000] article turned out to be less useful than first thought, namely, the basic option theory is not directly valid for the Dutch market due to prepayment (call option) penalties and the lack of a put option (default).[27] As for Ambrose & Sanders' [2002] article, although it is important to understand the behaviour of maturity shortening features, the available features are to be identified first; that is, there might be other factors besides defaults and prepayments.

Imagine a client that repays his/her mortgage as dictated by the amortization schedule, he/she only makes contractual payments. In this case no maturity shortening features are applied and the

[26] See section 1.4
[27] There is a full recourse to borrowers

effective maturity equals the contractual maturity. Then, by broadening the definition of prepayments a bit,[28] it can be said that the contractual maturity is only affected by prepayments. Using this approach, the second subquestion, identifying the factors that influence the effective maturity, is thus answered by: prepayments. A logical step would now be to identify the underlying variables of prepayments. Alink [2002] traces the variables that influence mortgage prepayments in the Netherlands. Prepayments can be approached from an interest-rate-risk point of view or from a liquidity-risk point of view. The first was dominant over the last years (focus on the (fixed) interest rate period (*Dutch: rentetypische looptijd*)), but as mentioned before the latter is becoming increasingly important. This distinction in points of view can be translated to new definitions.

PREPAYMENT FROM AN INTEREST-RATE-RISK POINT OF VIEW (RENTETYPISCHE PREPAYMENT)

A prepayment is any event causing the (future) cash flows to deviate from what would be calculated using contractual features such as notional, coupon, interest end date and amortization scheme (type and end date). Only cash flows until the next interest reset are relevant.[29]

PREPAYMENT FROM A LIQUIDITY-RISK POINT OF VIEW (LIQUIDITEITSTYPISCHE PREPAYMENT)

A principal amortization made by the client on top of the regular (contractual) monthly amount of principal in which there is an actual inflow of liquidity towards AAHG/ABN AMRO. All cash flows over the (effective) maturity of a mortgage are relevant, also the cash flows after the interest reset date.

Some events, e.g. curtailments,[30] cause the (future) cash flows to deviate from the original amortization schedule *and* result in an actual inflow of liquidity; these events can be categorised as both a *rentetypische* and a *liquiteitstypische* prepayment. Others, e.g. a prepayment on the interest reset date, is a *liquiditeitstypische* prepayment only. Section 4.3.1 discusses the categorization of the various sorts of prepayments in more detail. The variables that influence these mortgage prepayments are treated first.

4.2 PREPAYMENTS

Alink [2002] states the following in his study: "*It is tempting to think that the risk of a borrower no longer being able to pay his mortgage payments poses the largest risk for a lender. History shows, however, that these credit losses in Dutch mortgage portfolios are limited. Losses due to prepayments of a loan are a much bigger risk for a lender.*" Motivated by this phenomenon, Alink [2002] looked into the variables that influence mortgage prepayments in the Netherlands and how these can be used in a predictive prepayment model. He identifies different types of prepayments, e.g. borrower repays the mortgage loan partially before next interest re-fixing date, or a borrower repays the mortgage loan on interest re-fixing date in full. Other articles propose a more general classification of the types of prepayments. Becketti [1989] classifies three types being refinancing, relocation and default. A group of prominent UK financial institutions[31] identify four types of prepayments: refinancing, repayment (as in: curtailment), moving house (relocation) and default. Considering a default as a relocation (in case of an execution sale) this thesis distinguishes three types of

[28] By defining every event in which (part of) the principal flows back to the bank as a prepayment, the effective maturity is only affected by prepayments
[29] Source: ALM's Dutch Residential Mortgage Prepayment Model 6.0
[30] Curtailments are partial prepayments
[31] Including Barclays and the Bank of Scotland; Perry et al. [2001]

prepayments, in line with ALM's latest prepayment model: relocation, refinancing and curtailment. In case of a *(bank)spaar* mortgage, curtailments also include prepayments on the savings part/account. From a risk point of view, a default cannot directly be classified as a relocation; especially these days when it is unlikely that an execution sale will be sufficient to pay off the loan. However, because of the available classification in the available data and consistent with ALM, a default is considered as a relocation.

4.2.1 DETERMINANTS OF PREPAYMENTS

[CONFIDENTIAL]

As said, Alink [2002] traced the possible variables of mortgage prepayments in the Netherlands. His study is quite recent and includes a literature review of relating articles, also, it applies to the Dutch market specifically. Based on this literature review and on interviews with experts on the Dutch mortgage market, Alink [2002] identifies no less than 28 possible variables.[32]

POSSIBLE DETERMINANTS OF PREPAYMENTS	
Refinancing incentive	Housing price developments
Steepness of the yield curve	Burnout
Level of interest rates	Seasonality
Seasoning	Payment to income rate
Age borrower	Total income
Rural area	Two or one age earner
Property type	Tax rate
Loan purpose	Family size
Level of documentation	First time home buyer
Owner type	Years of current residence
Loan-to-Value	Education
Length of job tenure	Loan size
Credit score	Number of people in family
Newly build/existing house	Mortgage rank

Table 9 – Possible determinants of prepayments – Source: Alink [2002]

After briefly reviewing each of these variables, Alink [2002] limits the set above to 21 possible variables; subsequently, this set is reduced to 14 single variables that all significantly affect mortgage prepayments. The next step Alink [2002] takes is determining which of these 14 are significant in a multi-variable model. Due to correlation effects, not all variables that are found significant in the single-variable analysis are significant in the multi-variable model. Ultimately, there are 7 remaining variables being incentive, loan-to-foreclosure value (LTFV), property type, mortgage rank, age of the borrower, mortgage type and interest type. Most of these variables have been explained earlier and should be clear; property type indicates whether the collateral is an house, apartment or other type, mortgage rank is the legal rank by which the mortgage loan is registered in the mortgage book (*Dutch: Kadaster*).

[32] Alink [2002], p.50

Ambrose & Sanders [2002] found the future interest rate, LTV and rural area to be significant in CMBSs. Studies that focus on the Dutch market, like Charlies & Van Bussel [2001], identify significant variables like seasoning, incentive, burnout, seasonality, mortgage type and property type. Other articles might conclude that variables X, Y and Z are significant. Alink [2002] reviewed U.S. and Dutch literature, interviewed experts and held a survey under borrowers; his set of possible variables is very broad. Despite the fact that Alink's [2002] study is on Dutch mortgages and his data characteristics match this thesis' data characteristics reasonably, it cannot be concluded that the same variables are significant here. The mortgage market, prepayment behaviour, the whole economy has in fact changed since the financial crisis. It is, however, also not the purpose of this section to identify significant variables. The purpose of this section is identifying the (possible) underlying variables of prepayments. The identification of these variables is a first step towards ALM's action points. It also functions as input for the third subquestion; the next chapter determines which of the underlying variables are significant for this thesis' data and how these can be incorporated in ALM's current (prepayment) models.

4.2.2 PREPAYMENT RATES

Prepayment rates can be measured in various ways, in order to be consistent with the common usage within ABN AMRO the terminology from ALM's latest prepayment model is used. Prepayments can be expressed as a fraction of the outstanding principal at the beginning of the month; the single monthly mortality (SMM) rate is then defined as in the text box below. Using the formulas below, this rate can be converted to (and from) a yearly prepayment rate known as the conditional prepayment rate (CPR) which denotes the annualised monthly prepayment rate.

MEASUREMENT SCALES PREPAYMENTS

$$\text{SMM} = \frac{\text{unscheduled repayments during month}}{\text{outstanding principal at begin month} - \text{scheduled repayments during month}}$$

$$\text{SMM} = 1 - \sqrt[12]{1 - \text{CPR}} \qquad \text{CPR} = 1 - (1 - \text{SMM})^{12}$$

4.3 EFFECTIVE MATURITY

Chapter three discussed the contractual maturity (profile) based on historical data. Having introduced the theoretical background in prepayments and the underlying variables above, this section now analyses the effective maturity; again based on historical data. The effective maturity profile is discussed in section 4.4.

The effective maturity (*liquiditeitstypische looptijd*) is affected by every event in which (part of) the principal flows back to the bank. Looking back at the definitions in section 4.1, it can be said that the effective maturity is thus affected by prepayments from a liquidity-risk point of view, i.e. by *liquiditeitstypische* prepayments.

4.3.1 OPERATIONALIZATION AND DATA ANALYSIS

[CONFIDENTIAL]

REASON PREPAYMENT (CODE 4)	*RENTETYPISCH*	*LIQUIDITEITSTYPISCH*	NO PREPAYMENT
4.0 Onbekend	[CONFIDENTIAL]		
4.1 Geen vervroegde aflossing			
4.2 Verhuizingen			
4.3 Interne oversluiting			
4.4 Algehele aflossing			
4.5 Omzetting			
4.6 Diverse redenen			
4.7 Gedeeltelijke aflossing			

Table 10 – Extract from memo in appendix F

[CONFIDENTIAL]

[CONFIDENTIAL]

Figure 27 – Additional restrictions to determine the *liquiditeitstypische* prepayments

[CONFIDENTIAL]

SUMMARY STATISTICS		ABN AMRO	FLORIUS
EFFECTIVE MATURITY AT ORIGINATION			
	AVERAGE	[CONFIDENTIAL]	
	WEIGHTED AVERAGE		
	STANDARD ERROR		
	MEDIAN		
	MODE		
	STANDARD DEVIATION		
	SAMPLE VARIANCE		
	KURTOSIS		
	SKEWNESS		
	RANGE		
	MINUMUM		
	MAXIMUM		

Table 11 – Summary statistics effective maturity

WEIGHTED AVERAGES PER MORTGAGE TYPE		
	AFLOSSINGSVRIJ	[CONFIDENTIAL]
	ANNUÏTAIR	
	LINEAIR	

Table 12 – Weigthed average effective maturity per mortgage type

[CONFIDENTIAL]

EFFECTIVE MATURITY AT ORIGINATION		ABN AMRO	FLORIUS
	AVERAGES PER CONTRACTUAL MATURITY		
	240 MONTHS	[CONFIDENTIAL]	
	300 MONTHS		
	360 MONTHS		
	900 MONTHS		

Table 13 – Effective maturity at origination

[CONFIDENTIAL]

4.4 EFFECTIVE MATURITY PROFILE

The contractual maturity profile from section 3.3 only took contractual repayments into account. By including behavioural, non-contractual payments, i.e. prepayments, an effective maturity profile can be constructed. Again, the different types of mortgages have got different types of repayment schedules (see figure 16). But now, there are dozens of possible prepayment scenarios that influence these repayment schedules. In the figure below, the striped bars represent the contractual repayments as dictated by the amortization schedule; the grey coloured, completely filled bars represent possible prepayments.

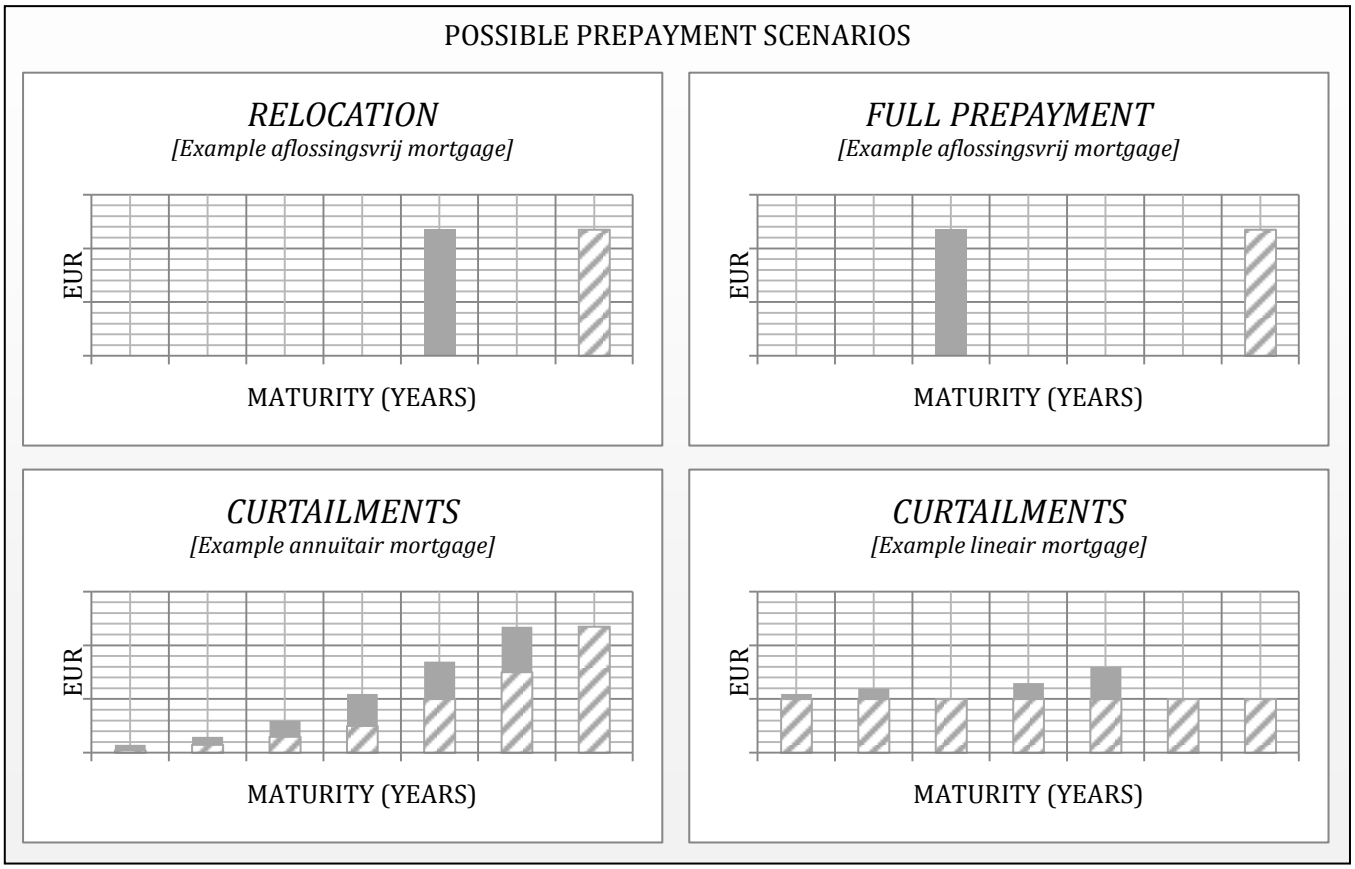


Figure 28 – Possible prepayment scenarios

A client may, for example, relocate or fully prepay the loan prior to the contractual end date; he or she might also make curtailments during the lifetime of a loan part. All these examples shorten the effective maturity. As in section 3.3, the data set that is used is not sufficient to completely analyse a held-to-maturity mortgage and thus the reconstruction method from section 3.3 is reused. The main research objective of this thesis is determining AAHG's effective maturity profile, for the current portfolio though; this section looks into the effective maturity profile based on historical data.

4.4.1 OPERATIONALIZATION AND DATA ANALYSIS

Just as the data set holds a variable that denotes the contractual repayments ('*ContractueleAflossing*'), there is a variable that represents the non-contractual prepayments, namely '*VervroegdeAflossing*'. By combining this variable with the elapsed maturity of a loan part and with the accounting period an effective maturity profile can be composed. However, only the *liquiditeitstypische* prepayments are of interest here; *rentetypische* prepayments that are no

liquiditeitstypische prepayment are to be excluded (according to table 10 this goes for '*interne oversluiting*' and '*omzetting*'). Figure 27 already gave the restrictions that should be added to the query in order to filter out the *rentetypische* prepayments. But in order to give an idea of the amount of the various prepayments, and how these developed over time, two graphs have been computed. The years 2007 is not included since data on this year is not completely available. The conditional prepayment rates (CPR) for the different prepayment reasons are in one-year moving averages.

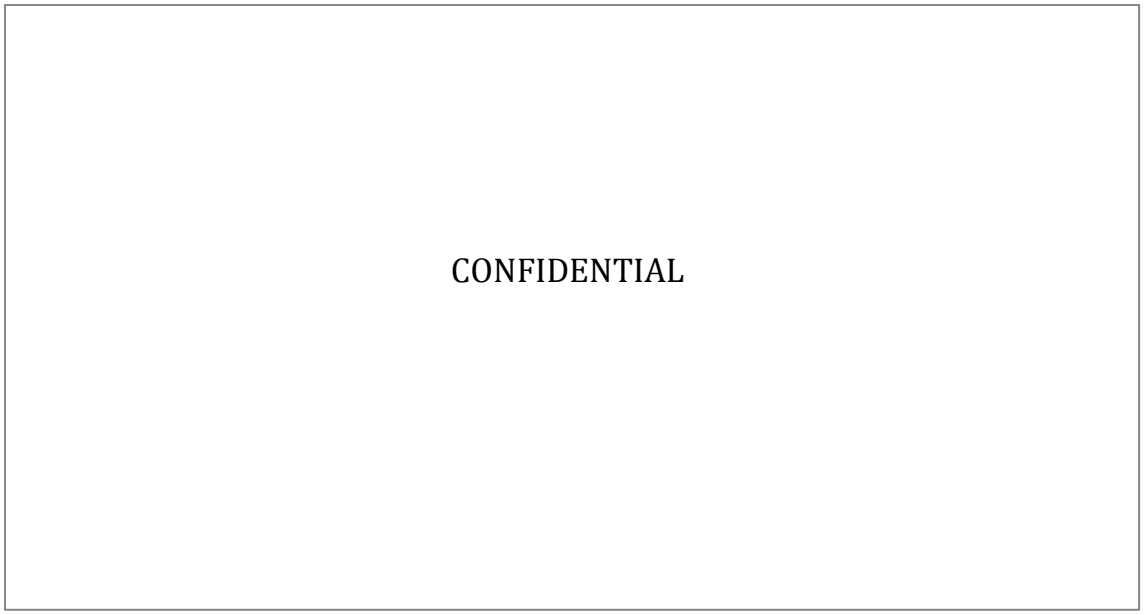


Figure 29 – CPRs of prepayment reasons AAB

[CONFIDENTIAL]

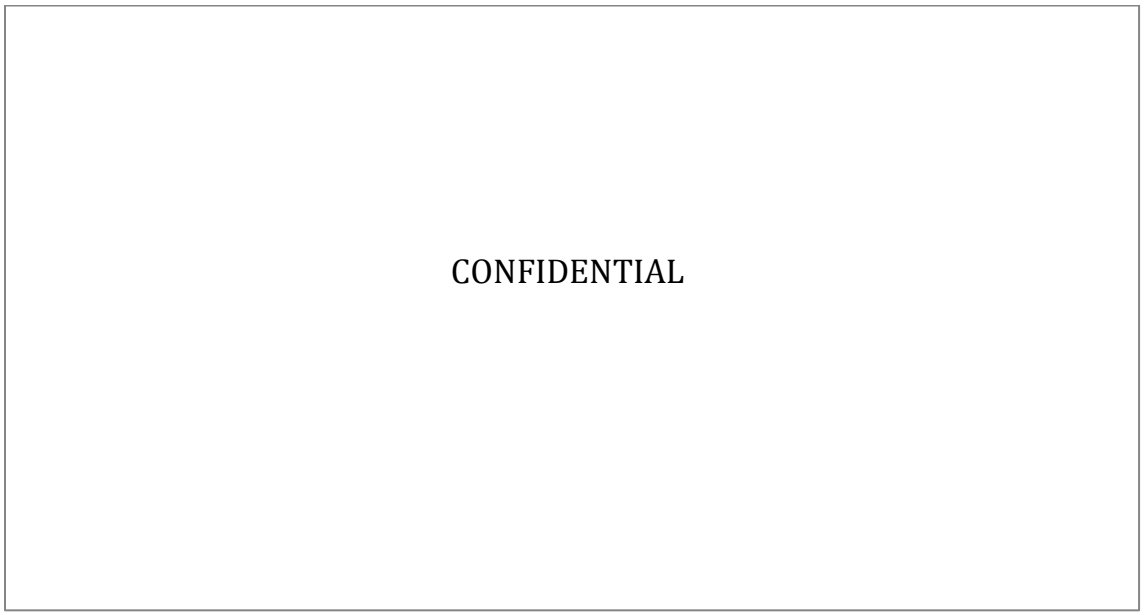


Figure 30 – CPRs of prepayment reasons Florius

[CONFIDENTIAL]

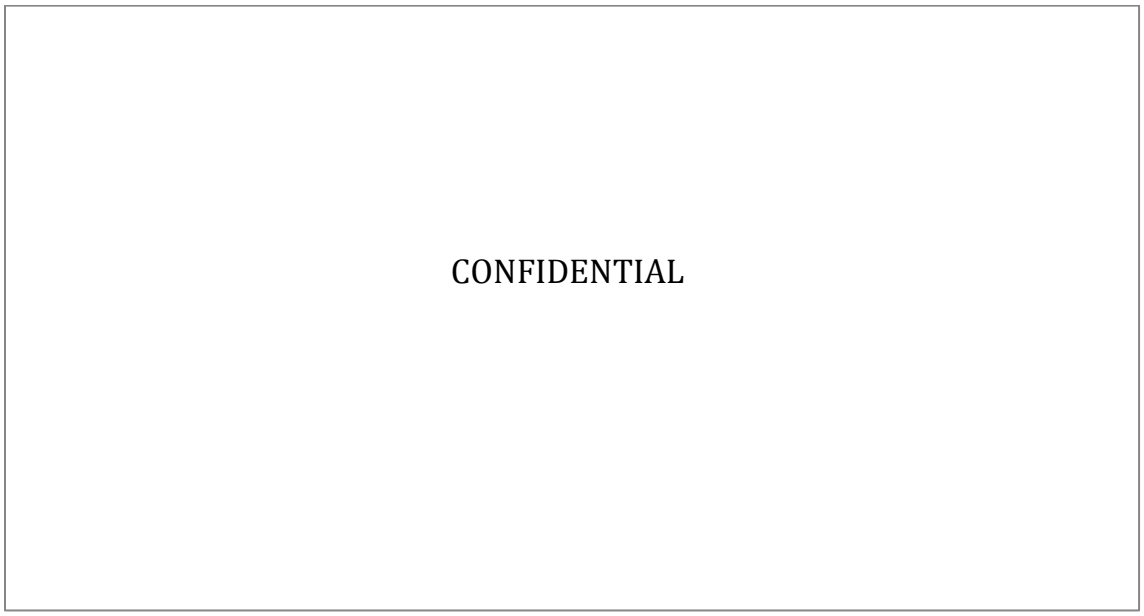


Figure 31 – Total *liquiditeitstypische* prepayments

[CONFIDENTIAL]

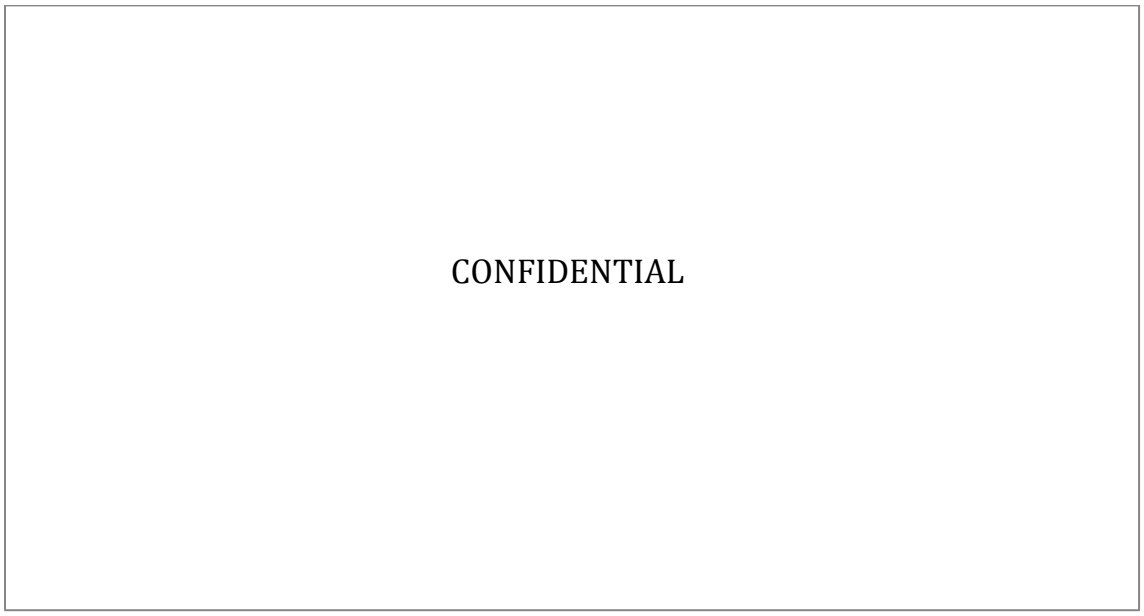


Figure 32 – Average *liquiditeitstypische* prepayments

[CONFIDENTIAL]

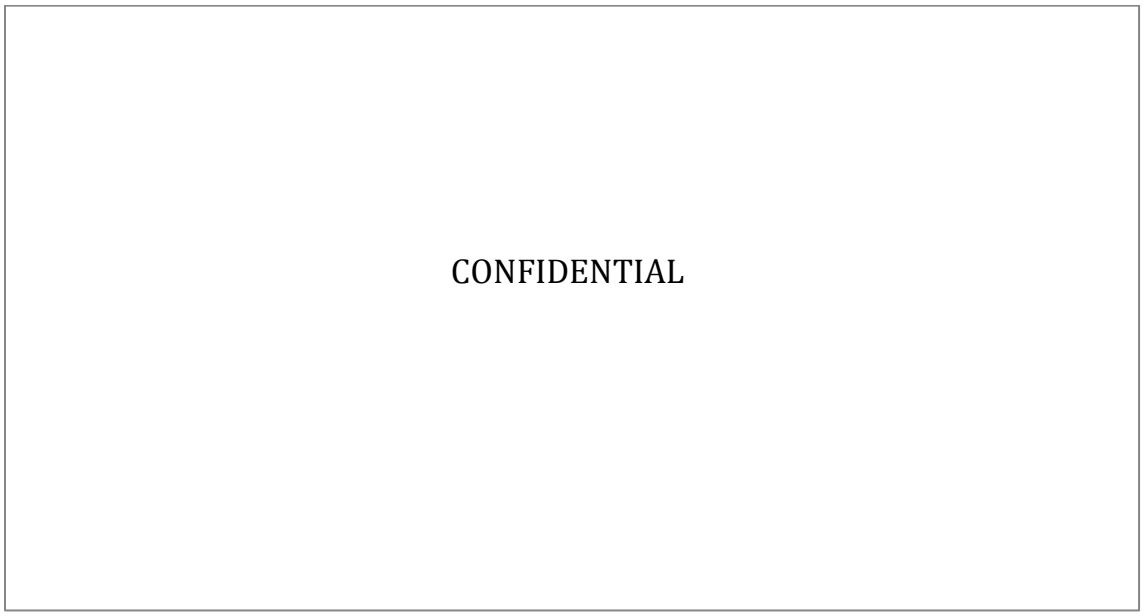


Figure 33 – Total liquiditeitstypische prepayments

[CONFIDENTIAL]

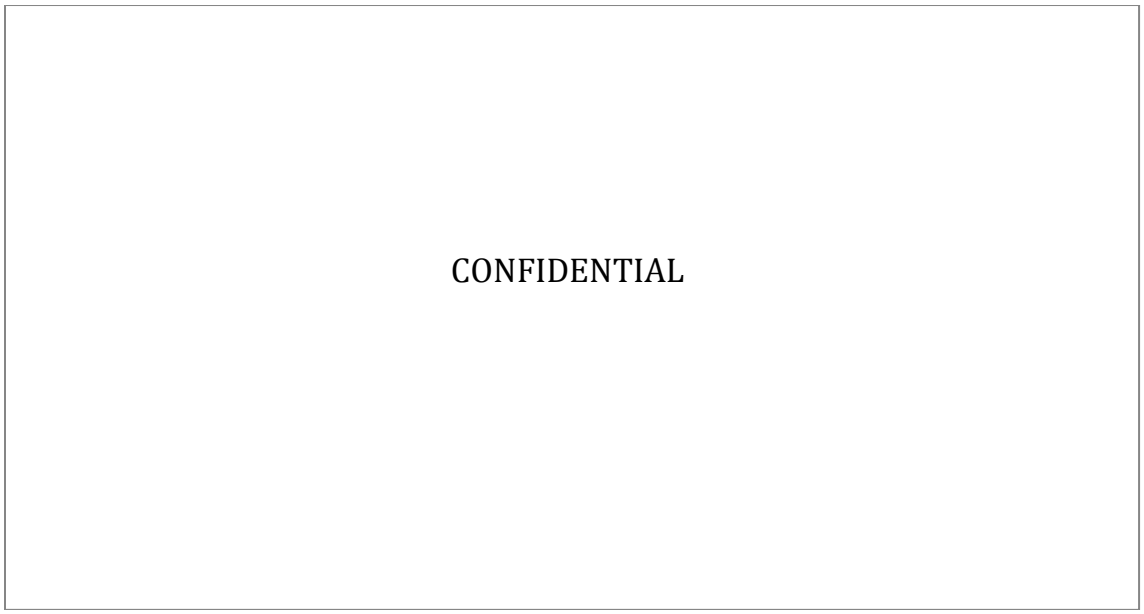


Figure 34 – Average liquiditeitstypische prepayments

[CONFIDENTIAL]

4.4.2 CLOSER ANALYSIS LIQUIDITEITSTYPISCHE PREPAYMENTS

[CONFIDENTIAL]

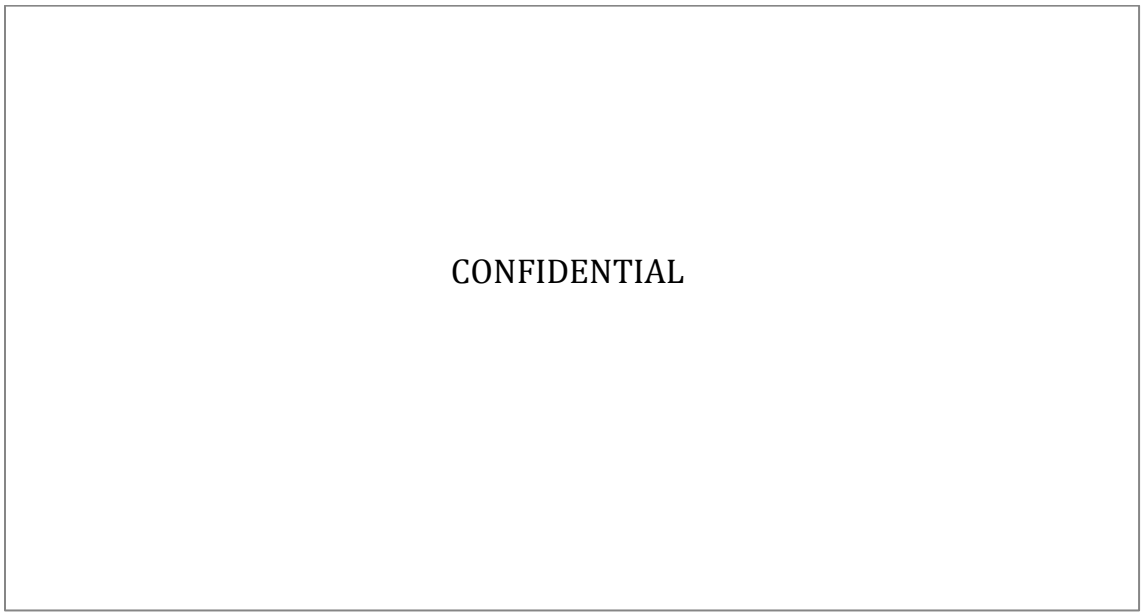


Figure 35 – CPR *liquiditeitstypische* prepayments (AAB)

The CPRs from figures 35 and 36 above and below are the same as in figures 29 and 30, the patterns are explained there as well. This additional analysis looks for any remarkable patterns.

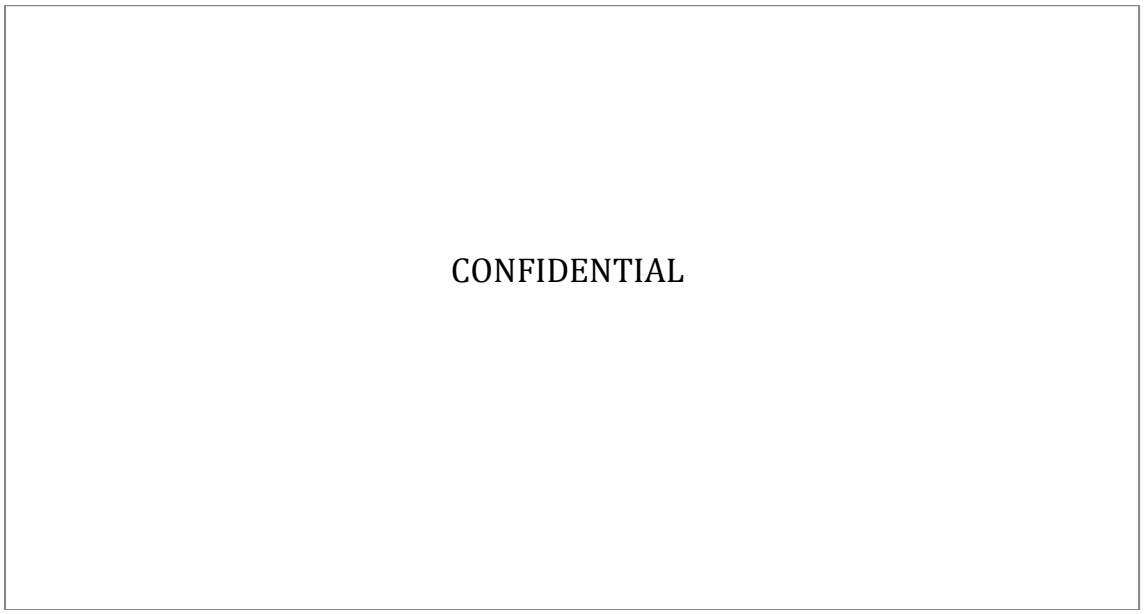


Figure 36 – CPR *liquiditeitstypische* prepayments (Floriuis)

[CONFIDENTIAL]

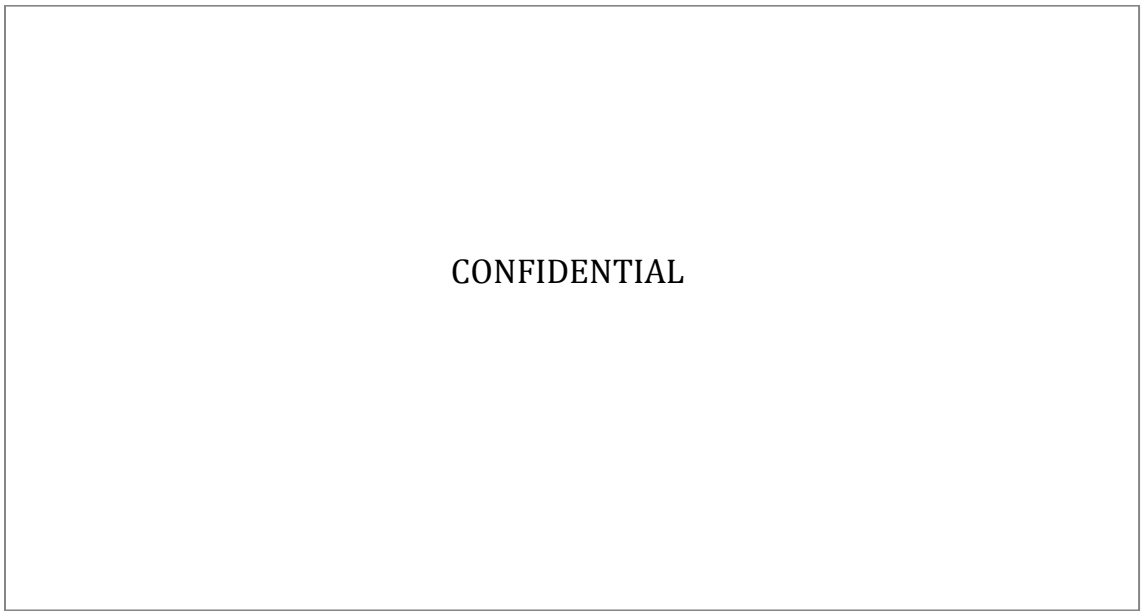


Figure 37 – Prepayment rates plotted against the age of the borrower

[CONFIDENTIAL]

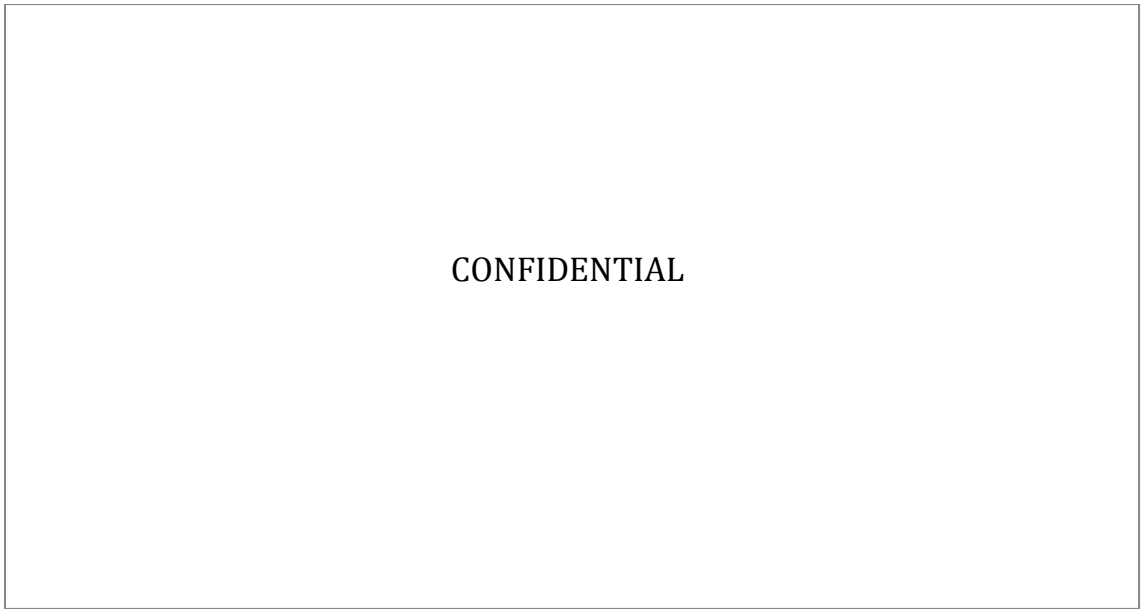


Figure 38 – Prepayment rates plotted against various mortgage rates

[CONFIDENTIAL]

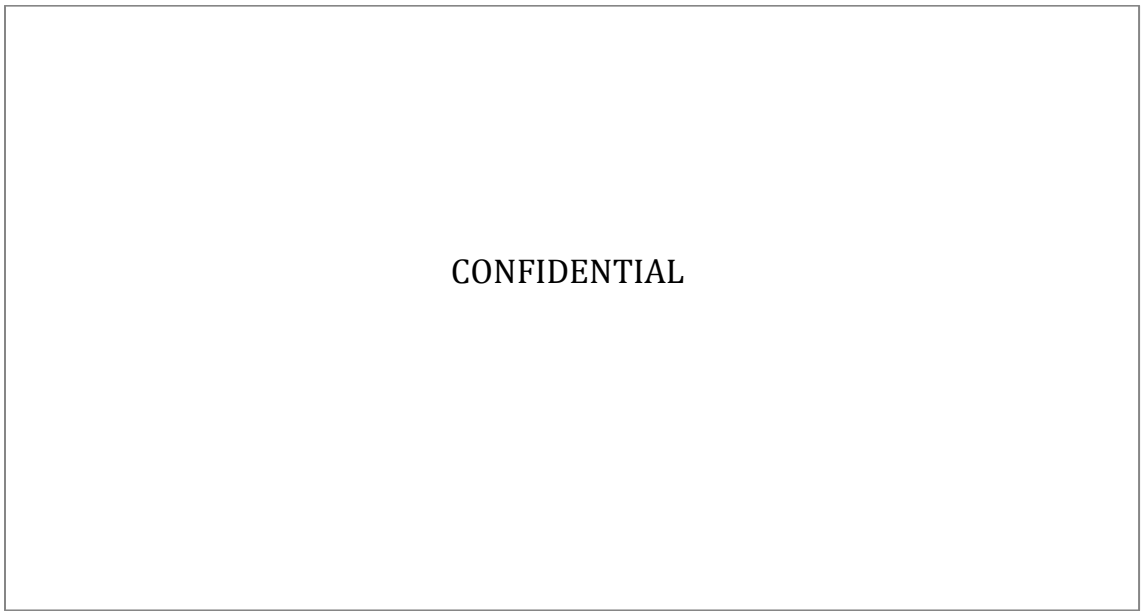


Figure 39 – Prepayment rates per month

[CONFIDENTIAL]

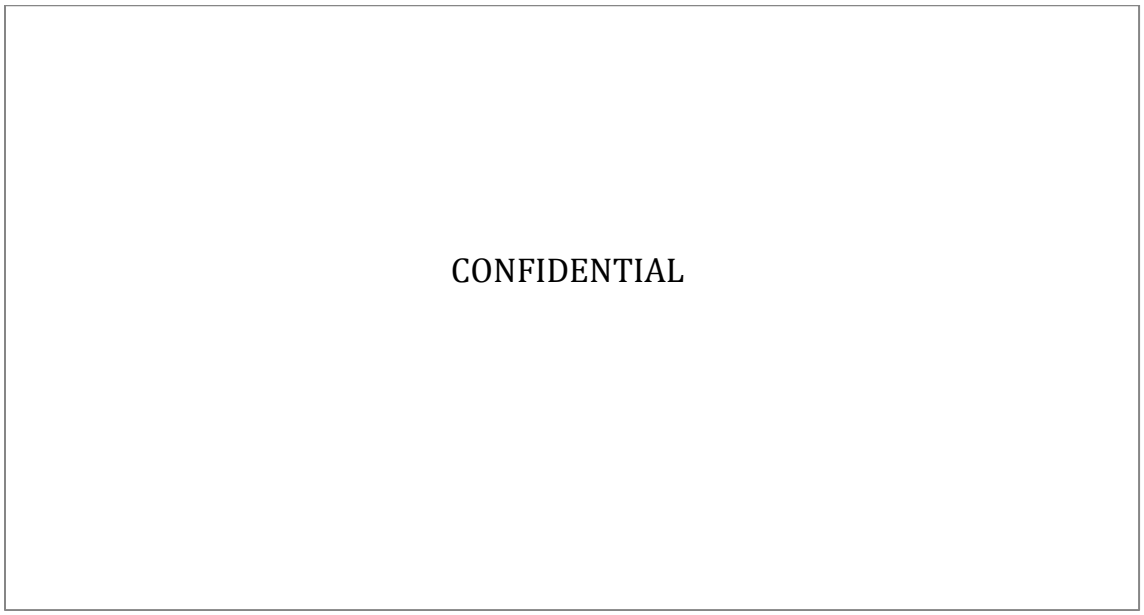


Figure 40 – Prepayment rates per loan age

4.4.3 EFFECTIVE MATURITY PROFILE

As said, an effective maturity profile includes both the contractual repayments and the non-contractual prepayments. The contractual repayments were analysed in chapter three, the prepayments in the sections above. From a liquidity-risk point of view it was found that the *liquiditeitstypische* prepayments are most interesting here. By combining these two types of payments, an effective maturity profile can be constructed. One should note that if the term 'total

payments' is used, this thus includes the *liquiditeitstypische* prepayments plus the contractual repayments. In fact, by the definition of *liquiditeitstypische* prepayments, the 'total payments' now match the actual cash inflows. Either absolute values (euros) or (p)repayment rates can be used. As said before, CPRs are not additive, but SMMs are. The following formula was applied:

$$Total\ payment\ rate = 1 - (1 - SMM^{total\ payments})^{\wedge 12}$$
$$where\ SMM^{total\ payments} = SMM^{liquiditeitstypische\ prepayments} + SMM^{repayments}$$

[CONFIDENTIAL]

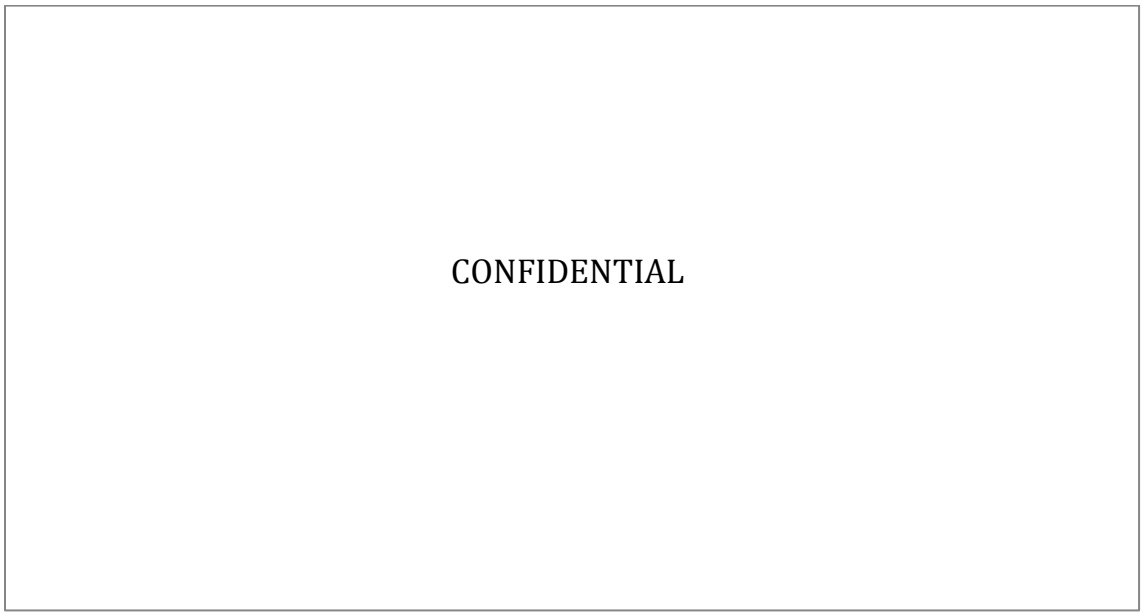


Figure 41 – Total payments per month

[CONFIDENTIAL]

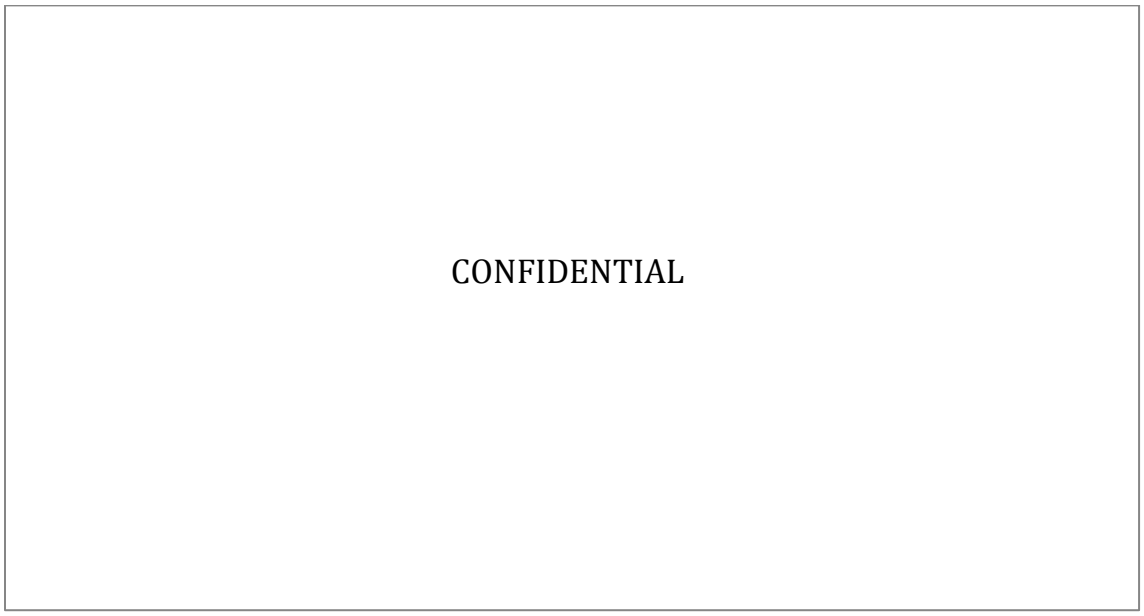


Figure 42 – Total payment rate

[CONFIDENTIAL]

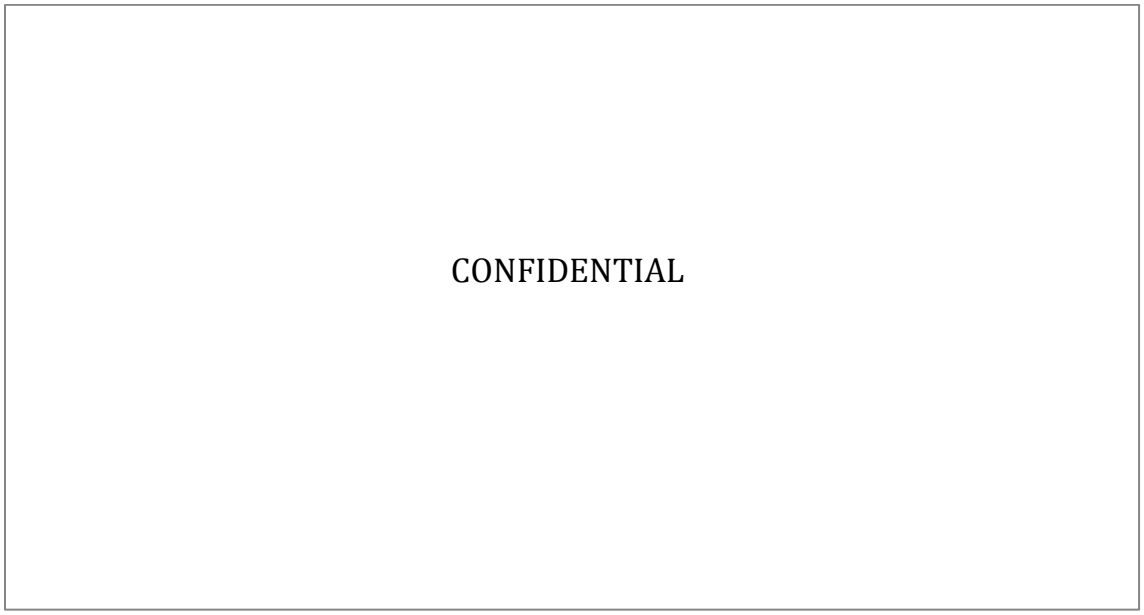


Figure 43 – Effective maturity profile

4.5 PARTIAL CONCLUSION AND DEVELOPMENTS

This chapter found that the factors that influence the effective maturity can all be classified as prepayments. After having defined two types of prepayments, *rentetypische* and *liquiditeitstypische*, section 4.2 identified the (possible) determinants of these prepayments. ALM's current prepayment model is based on three explanatory variables being seasoning (age of the loan), seasonality (period of the year) and an incentive rate. One of ALM's action points is listing all parameters which significantly impact prepayment rates. A good starting point in doing so is reviewing available literature. Alink's [2002] study turned out to be helpful since it was extensive and about the Dutch mortgage market.

[CONFIDENTIAL]

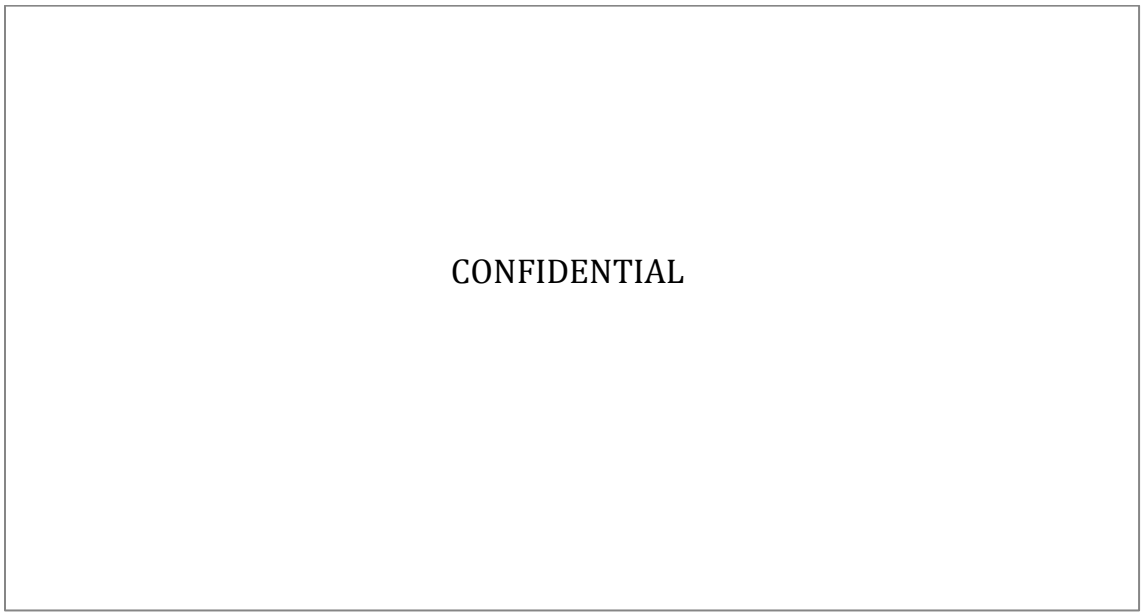


Figure 44 – Δ CPR total payments

[CONFIDENTIAL]

CHAPTER FIVE – MODELLING PREPAYMENTS

Different types of maturities and profiles have been determined for the historical data; looking at table 3, the first six have been analysed. As for the current portfolio, two types of maturities can simply be taken from the database (the contractual maturity at origination and the residual). Others are not known and involve some type of estimation. This chapter is about modelling prepayments. After the theoretical background has been discussed in section one, the second section looks into the current prepayment models of ABN AMRO. Next, section three discusses how the modelling of prepayments can be improved. Multiple linear regression is applied in order to model prepayments; other model types are reviewed briefly. The last section reviews the significant variables found that will be taken into account when analysing the current portfolio in chapter 7.

5.1 THEORETICAL BACKGROUND

Starting with a large set of possible determinants of prepayments, Alink [2002] tries to model mortgage prepayments in the Netherlands. As said in section 4.2.1, Alink [2002] finds 14 single variables that all significantly affect mortgage prepayments; seven of these turn out to be significant in a multi-variable model. As curtailments are excluded in his study, Alink [2002] is able to use a Kaplan-Meier survivorship analysis to test which single variables are significant. His multi-variable model is based on logistic regression techniques. Next to curtailments, defaults are also excluded. By considering a default as a relocation this thesis does include both curtailments and defaults.

Most US literature on modelling prepayments use an option-theoretic point of view, which is, as stated before, not directly valid for the Dutch market. Other articles, as is Alinks' [2002], develop models based on observed (historical) prepayment rates. Van Bussel [1998], Charlier [2001], Charlier & Van Bussel [2001], Hayre [2003] and Jacobs et al. [2005] all analyse the Dutch market based on observed data. All these studies find different significant variables and thus, as Kuijpers & Schotman [2007] rightly state, the valuation of the prepayment option in Dutch mortgages is complicated due to specific characteristics.

This thesis is also based on observed data; future prepayment rates are forecasted based on the historical rates. The most common technique in the articles mentioned above to test the significance of variables is survival analysis. Before the crisis in the housing market, ABN AMRO used to model prepayments by a statistical model fit on historical prepayment observations using linear regression.

5.2 CURRENT PREPAYMENT MODELS

[CONFIDENTIAL]

CONFIDENTIAL

Figure 45 – Important note

5.3 MODEL

[CONFIDENTIAL]

Available explanatory variables			
VARIABLE	PROPOSITION	TYPE	RANGE
[CONFIDENTIAL]			

Table 14 – Available explanatory variables

[CONFIDENTIAL]

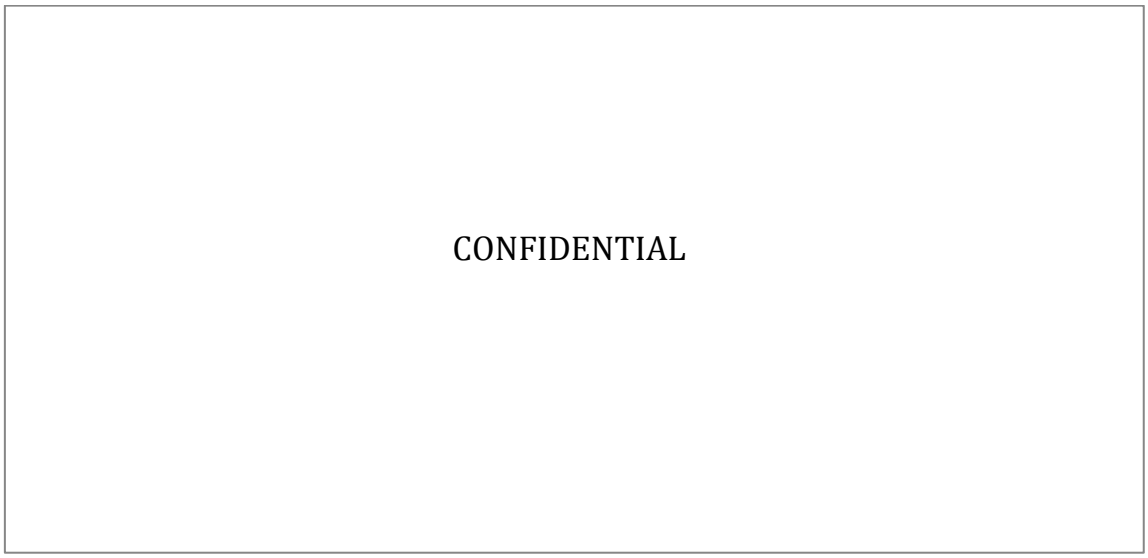


Figure 46 – Scatterplot age of borrower

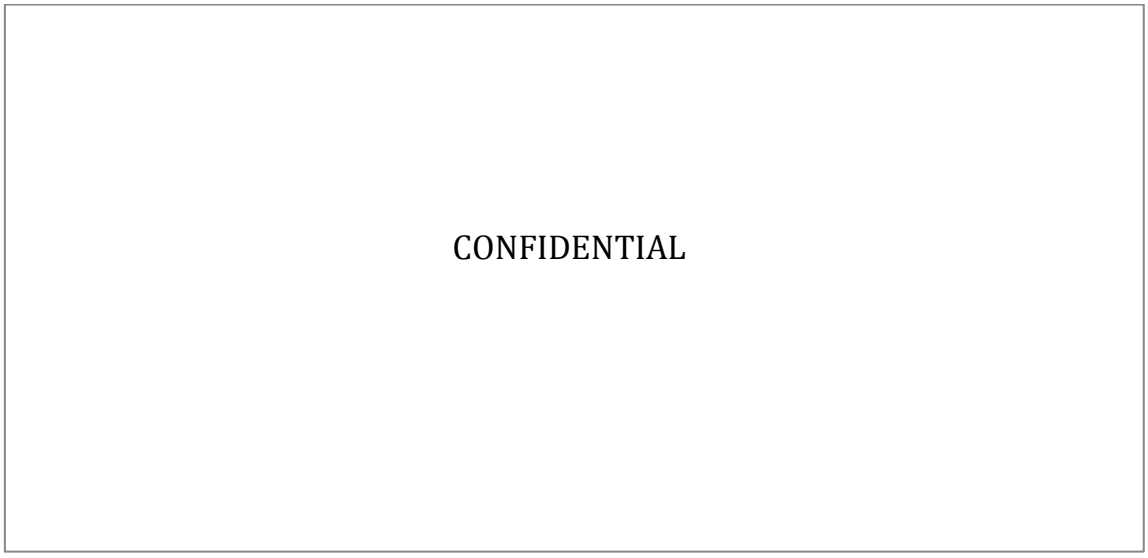


Figure 47 – Scatterplot loan age

[CONFIDENTIAL]

Possible transformations
[CONFIDENTIAL]

Table 13 – Possible transformations

[CONFIDENTIAL]

Models	
AAB	*FLORIUS*
[CONFIDENTIAL]	

Table 14 – Model and coefficients

[CONFIDENTIAL]

5.4 PARTIAL CONCLUSION AND DEVELOPMENTS

As Samuel Goldwyn once said, "*Forecasts are difficult to make – particularly those about the future*". The housing market is a volatile market, especially the last couple of years. It has been subject to various developments and new regulation (which will be discussed in the next chapter). Given that, plus the fact that borrowers do not always behave economically (i.e. option theory perfectly valid) makes the process of modelling mortgage prepayments difficult.

[CONFIDENTIAL]

CHAPTER SIX – REGULATION AND DEVELOPMENTS

Each of the previous chapters already contained a short discussion about the specific developments on the topic of that chapter. This chapter will therefore mainly be about regulation, which was in fact one of the reasons for performing this thesis. For example, IFRS 9 requires taking prepayments into account when calculating the maturity of a loan. The theoretical background is discussed first. Sections 6.2 and 6.3 are on regulation and developments respectively. As in the previous chapters, the last section contains a partial conclusion.

6.1 THEORETICAL BACKGROUND

Regulation is as old as banking self. Bank regulation is a usually a form of government regulation which subjects banks to certain requirements, restrictions and guidelines. Usually, because non-governmental regulation is become more important. Two of these international, non-governmental types of regulation are the Basel Accords and International Financial Reporting Standards (IFRS). History taught us that regulation could not prevent crises. As a result, new regulation is becoming stricter and stricter. The next section looks into the two most topical regulations, Basel III and IFRS 9, and how these might affect the mortgage market. Section 6.2 also discusses new regulation on the Dutch housing market, which has already been mentioned in some previous sections.[33]

6.2 REGULATION

Of some of the regulation it is not directly known if and how this will affect the effective maturity, this section will therefore analyse the impact of Basel III, IFRS 9 and Dutch government regulation on the mortgage market as a whole. Where applicable, effects on the effective maturity (profile) are mentioned.

6.2.1 BASEL III

The Basel Committee on Banking Supervision (BCBS) was established in 1974 and according to their website it is "*[…] the primary global standard-setter for the prudential regulation of banks and provides a forum for cooperation on banking supervisory matters.*" One of the core activities of the BCBS is issuing banking supervision accords called Basel Accords. The first, Basel I, was introduced in 1988 and held two requirements that bank capital had to satisfy: the ratio of a bank's assets to its capital had to be less than 20, and banks had to keep capital to at least 8% of the risk-weighted assets. Basel I has been subject to much criticism; it was too simple and somewhat arbitrary. In 1999, the BCBS issued new standards: Basel II, which is based on three pillars. The first pillar holds the minimum capital requirements for credit risk; the greater the risk to which the bank is exposed, the greater the amount of capital the bank needs to hold. The second and third pillars are on the supervisory review and market discipline respectively. These standards turned out to be insufficient during the financial crisis; banks took risks that were not identified by Basel II.

The existence of these new risk types made Basel II outdated and required the regulators to adjust their regulation. For instance in Basel II there was no regulation on liquidity risk, which turned out to be one of the most important risks in the financial crisis of 2008 (after Lehman's collapse) and one of the reasons, if not the reason, to write this thesis. Liquidity risk and other risk types are now included

[33] Section 2.1.3 for example

in the new Basel III regulation. Basel III is believed to further improve the stability and sustainability of the worldwide banking sector. It does so by setting new regulations, which include new capital requirements and changes in the definition of eligible capital. The following five points are identified by a BIS [2012] article.

1. Changes to bank capital ratios under the new requirements, and estimates of any capital deficiencies relative to fully phased-in minimum and target capital requirements ;
2. Changes to the definition of capital that result from the new capital standard, referred to as common equity Tier 1 (CET1), including a reallocation of deductions to CET1, and changes to the eligibility criteria for Additional Tier 1 and Tier 2 capital;
3. Increases in risk-weighted assets resulting from changes to the definition of capital, securitization, trading book and counterparty credit risk requirements;
4. The international leverage ratio;
5. Two international liquidity standards – the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR).

Basel III will have an enormous impact on the banking industry, mainly because banks need to increase the size of their buffers (regulatory capital). One way to do so is keep a healthy, if not irresponsible, profit margin on mortgages sold.[34] High mortgage rates result in low incentive rates; low incentive rates result in lower prepayment rates, which lead to an increased effective maturity.

The new liquidity coverage ratio (LCR) states that banks must have sufficient high quality liquid assets (HQLA) to survive a significant stress scenario lasting thirty calendar days. These HQLA are divided in two levels; level one includes cash and bonds issued by governments or central banks, level two includes highly-rated covered bonds, corporate bonds and RMBSs. There are strict limits to include these RMBSs though: the underlying mortgages should be full recourse loans and have a maximum LTV of 80% on average at issuance. The average LTV of Dutch RMBSs is currently about 95%; even as these securities prove to be among the safest home-loan bonds globally, they will not be categorized as part of the HQLA.[35] As a result, Dutch RMBS issuers could face higher funding costs as investors demand larger premiums to hold the debt. These issuers, like AAHG, will probably charge these additional costs to the borrowers. Also, the maximum LTV that borrowers can obtain will decrease in the near future. Additional costs decrease the incentive and thus the prepayment rates. As loans with a lower LTV tend to prepay more a decrease in the LTV will result in a decreased effective maturity. The housing/mortgage market is probably affected in various other ways by Basel III, but the impacts mentioned above are the most important ones.

6.2.2 IFRS 9

The IFRS Foundation is an independent, not-for-profit private sector organisation working in the public interest. One of their principal objectives is "*[…] to develop a single set of high quality, understandable, enforceable and globally accepted International Financial Reporting Standards (IFRSs) through its standard-setting body, the International Accounting Standards Board (IASB).*" This regulation is thus on financial accounting/reporting standards and it will have less direct impact as

[34] https://www.acm.nl/nl/publicaties/publicatie/11339/Strengere-eisen-aan-banken-leiden-tot-hogere-winstopslag-op-hypotheken/
[35] http://www.bloomberg.com/news/2013-01-10/basel-iii-punishes-dutch-over-risk-that-isn-t-mortgages.html

Basel III will have. Nevertheless, it is worth mentioning here, especially IFRS 9. IFRS 9 was published in 2009 and contains requirements for financial instruments; it specifies how an entity should classify and measure financial assets and financial liabilities. Two of the most relevant requirements are discussed here. First, whereas the provisions are currently based on the one-year probability of default (PD), IFRS 9 requires working with a PD at maturity, i.e. base provisions on the lifetime expected loss. As a result, provisions will increase, probably paid for by the bank's clients, this decreases the incentive rate, etcetera, etcetera. Secondly, IFRS 9 requires working with effective maturities of loans (and mortgages), these are the real maturities taking e.g. prepayments and interest resets into account. This is actually what is done is this thesis. This will not impact the mortgage market as such, but it indicates the relevance of this research. Also, banks will mostly pass any additional costs (that are involved in complying with IFRS 9) to its clients. A recent study by Ernst & Young [2011] showed that the current measures banks take are insufficient to absorb the expected loss requirements from IFRS 9.

6.2.3 REGULATION DUTCH GOVERNMENT

Section 2.1.3 already discussed parts of the updated regulation[36] on mortgages in the Netherlands, so this section will be kept short. According to the government, these rules are installed to prevent borrowers getting in financial trouble. First, the maximum loan that clients can obtain will be lowered, in terms of LTV, to 100% in 2018 (2013: 105%). Second, as of 2013, borrowers can only deduct the mortgage interest paid from their taxable income in case it concerns an *annuïtair* or *lineair* mortgage. Thirdly, the maximal value for NHG that was raised in 2009 is now gradually lowered to EUR 265,000. The fourth adjustment is that mortgage conditions for first-time homebuyers have been loosened. How will these adjustments influence the effective maturity? Well, the average LTV will become lower and *annuïtair* and *lineair* mortgages will become more popular. Loans with a lower LTV tend to prepay quicker and relocations are increasing for *annuïtair* mortgages, so overall Dutch regulation will cause the effective maturity to decrease.

6.3 DEVELOPMENTS

As said, each of the previous chapters already included a section on developments. These sections were on the subjects discussed in each of these chapters. This section will therefore discuss more general developments, which affect the mortgage market as a whole. Several media recently reported a slight recovery of the housing market.[37] Also, there were signs of foreign mortgage lenders entering the Dutch market. The last development discussed here is a possible IPO for ABN AMRO.

Mortgage brokers sold more mortgages this year, than in the same period last year. This might indicate a slight recovery of the mortgage market. The new regulation by the Dutch government might have contributed to this, since most mortgages were sold to first-time homebuyers. It will probably take quite some years for the mortgage market to reach its pre-crisis level, if this level will be reached at all. Fact is, that the there is a housing shortage in the Netherlands, which is only increasing.[38] For now, the (slight) recovery of the housing market is a positive signal. Relocations

[36] http://www.rijksoverheid.nl/onderwerpen/koopwoning/nieuwe-regels-hypotheek
[37] http://www.rtlnieuws.nl/nieuws/binnenland/voorzichtig-herstel-huizenmarkt
[38] http://www.vastgoedactueel.nl/index.php?option=com_k2&view=item&id=993

(largest share of *liquiditeitstypische* prepayments) will increase, resulting in a shorter effective maturity.

There was quite some commotion when media reported that German mortgage lenders would enter the Dutch market. This commotion turned out to be a bit exaggerated afterwards. The capital available for the Dutch market was less than first thought, the maximum LTV was 70% and there were other pitfalls. Dutch mortgage lenders do not really need to fear these German competitors. However, as the Dutch interest rates remain among the highest in Europe, there is a realistic chance that one day foreign mortgage lenders will enter the Dutch market, with lower rates. This results in higher incentive rates, borrowers will refinance their loans (type of *rentetypische* prepayment) and the *liquiditeitstypische* prepayments will increase as well. The entry of a foreign party will thus shorten the effective maturity.

The last development discussed here is the possible IPO of ABN AMRO in the near future; several media reported 2014 might be the year. Investors will probably demand a higher return on equity than the Dutch state currently demands. The costs of equity will thus rise; future cash flows will need to be discounted by a higher weighted average cost of capital (WACC). This also goes for future mortgage (p)repayments. A second result of an IPO might be that ABN AMRO's credit rating will be adjusted. ABN AMRO will lose its support by the Dutch government which is considered to be a very creditworthy party. This should not have an effect on the credit rating of RMBSs sold, since this rating depends on the underlying mortgages in this security. There are no certainties in the current financial market though. A decreased credit rating results in higher funding costs which again will probably be passed through to the mortgage rates.

6.4 PARTIAL CONCLUSION AND DEVELOPMENTS

This chapter analysed the effects of current and upcoming regulation and developments; not only on the mortgage market as a whole, but where applicable, on the effective maturity. In short, the following relations were found. Basel III requires higher capital ratios and sufficient liquid assets, both result in a lower incentive rate causing the effective maturity to increase (or at least, not to decrease). One of Basel's requirements decreases the effective maturity, namely the maximum average LTV of mortgage pools, in case these want to be categorized as HQLA. As for IFRS 9, the main implication will be that provisions have to rise, financed by additional capital; this turns out to increase the effective maturity. Dutch regulation on the mortgage market will cause the effective maturity to decrease, as will a recovery of the housing market and the entry of a foreign mortgage lender. An IPO of the ABN AMRO is probably going to decrease prepayments.

The effective maturity is affected by the regulation and developments discussed; some cause an increase, others a decrease. Since it is impossible to accurately measure the impacts, it can only be concluded that the effective maturity will probably become an even more important concept and that additional research is required to understand the effect of macro-economic drivers on prepayments.

CHAPTER SEVEN – CURRENT PORTFOLIO

Chapters three and four analysed historical data and computed the contractual and effective maturity profiles based on that data. Chapter five subsequently tried to model prepayment rates using multiple linear regression. Using the knowledge gathered throughout these chapters, the current portfolio will be analysed in this chapter. This includes computing the contractual and effective maturity profile for the current portfolio. The main research question is actually answered in this chapter. The first section will be used as an introduction to the current portfolio. Section 7.2 discusses the three types of contractual maturities (7^{th} – 9^{th} from table 3), including a profile. The effective maturity at origination and a profile are in section 7.3. The last section of this chapter contains a partial conclusion.

7.1 INTRODUCING THE CURRENT PORTFOLIO

[CONFIDENTIAL]

CHARACTERISTIC	ABN AMRO	FLORIUS
ORIGINATION DATE	[CONFIDENTIAL]	
NUMBER OF UNIQUE LOANS		
NUMBER OF LOAN PARTS		

Table 15 – Characteristics current portfolio

[CONFIDENTIAL]

CHARACTERISTIC	ABN AMRO	FLORIUS
ORIGINAL PRINCIPAL[1]	[CONFIDENTIAL]	
GUARANTEED (NHG)		
FIXED RATE PERIOD[2]		
AMORTIZATION TYPE[3]		
INTEREST RATE		
Notes *(1) Averages are on loan part level* *(2) One and three month fixed rate periods are defined as variable* *(3) As a percentage of the total amount of principal*		

Table 16 – Main characteristics current portfolio

[CONFIDENTIAL]

7.2 CONTRACTUAL MATURITY PROFILE

Chapter three discussed the contractual maturity at origination (table 7) and the contractual maturity profile (figure 22) of the historical data, i.e. for the accounting period February 2007 till April 2013. This section will do the same, but now for the current profile.

7.2.1 CONTRACTUAL MATURITY AT ORIGINATION

First, the contractual maturity at origination will be computed. As said in section 3.2.2, the same operationalization can be applied here. The variable '*Looptijd*' denotes the total contractual amortization period of a mortgage as recorded in the contract, i.e. the contractual maturity at origination.

CONTRACTUAL MATURITY AT ORIGINATION (AVERAGE)	ABN AMRO	FLORIUS
CURRENT PROFILE INCL. AFLOSSINGSVRIJ	[CONFIDENTIAL]	
CURRENT PROFILE EXCL. AFLOSSINGSVRIJ		

Table 19 – Average contractual maturities

[CONFIDENTIAL]

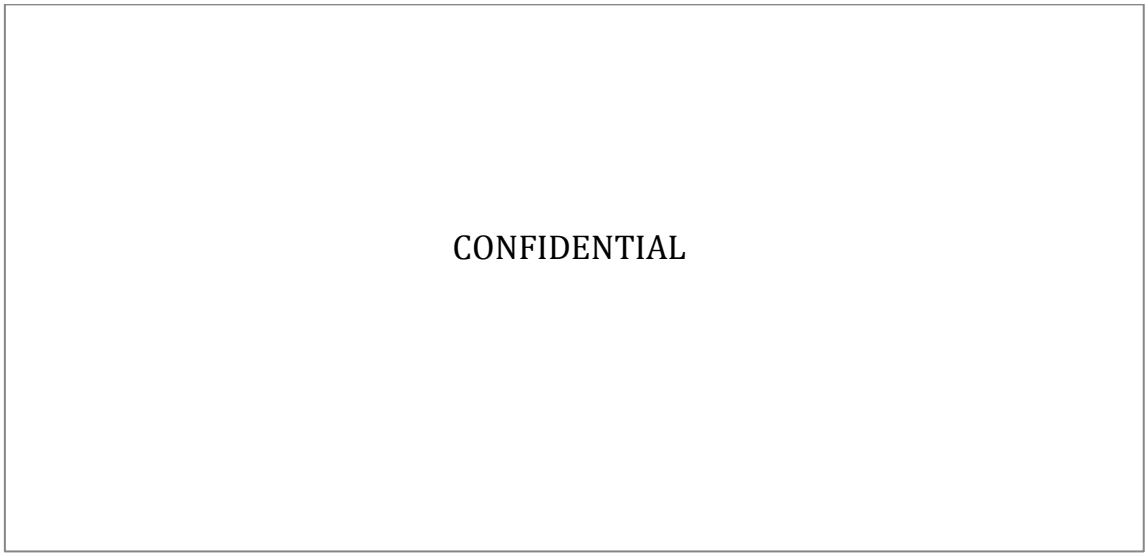


Figure 48 – Share contractual maturities

As in section 3.2.2 it is interesting to have a look at the weighted averages. The table below gives a summary of the most important statistical characteristics of the current portfolio.

SUMMARY STATISTICS		ABN AMRO	FLORIUS
CONTRACTUAL MATURITY AT ORIGINATION			
	AVERAGE	[CONFIDENTIAL]	
	WEIGHTED AVERAGE		
	STANDARD ERROR		
	MEDIAN		
	MODE		
	STANDARD DEVIATION		
	SAMPLE VARIANCE		
	KURTOSIS		
	SKEWNESS		
	RANGE		
	MINUMUM		
	MAXIMUM		
WEIGHTED AVERAGES PER MORTGAGE TYPE			
	AFLOSSINGSVRIJ	[CONFIDENTIAL]	
	ANNUÏTAIR		
	LINEAIR		

Table 20 – Summary statistics contractual maturity

[CONFIDENTIAL]

7.2.2 RESIDUAL CONTRACTUAL MATURITY

The residual contractual maturity was not computed for the historical data. Reviewing the definition of this concept, one understands why. It is the residual contractual amortization period of a mortgage expressed as the time between the contractual end date and the current date. It defines a period between two dates, since the historical data represents a range of dates it is illogical to compute the residual contractual maturity for the historical data.

[CONFIDENTIAL]

SUMMARY STATISTICS		ABN AMRO	FLORIUS
RESIDUAL CONTRACTUAL MATURITY			
	AVERAGE	[CONFIDENTIAL]	
	WEIGHTED AVERAGE		
	STANDARD ERROR		
	MEDIAN		
	MODE		
	STANDARD DEVIATION		
	SAMPLE VARIANCE		
	KURTOSIS		
	SKEWNESS		
	RANGE		
	MINUMUM		
	MAXIMUM		
WEIGHTED AVERAGES PER MORTGAGE TYPE			
	AFLOSSINGSVRIJ	[CONFIDENTIAL]	
	ANNUÏTAIR		
	LINEAIR		

Table 21 – Summary statistics residual contractual maturity

[CONFIDENTIAL]

The residual contractual maturity also denotes the remaining period for which contractual repayments are to be received for the current portfolio. Knowing this period is a first step towards computing the contractual maturity profile for the current portfolio which will be done next.

7.2.3 CONTRACTUAL MATURITY PROFILE

As said before, a contractual maturity profile for the current portfolio is the same as a residual contractual maturity profile with the current date as the start date. The residual contractual maturities are known (previous subsection), but the to-be received contractual cash inflows during these residual contractual maturities are unknown because of the future interest rates. Section 3.4 discussed this issue and the EIR method turned out to be the best option due to its broad application and simplicity. This method holds that the interest rate on which the contractual repayments depend is assumed to remain fixed during the contractual maturity; the interest rate is assumed to remain the same once the fixed rate period has come to an end.

The future contractual repayments are analysed per mortgage type. First, *aflossingsvrij* loan parts do not incorporate any interim contractual repayments. However, the original principal is to be repaid completely at maturity. The graphs below give the contractual repayments that arise because of these complete repayments at maturity.

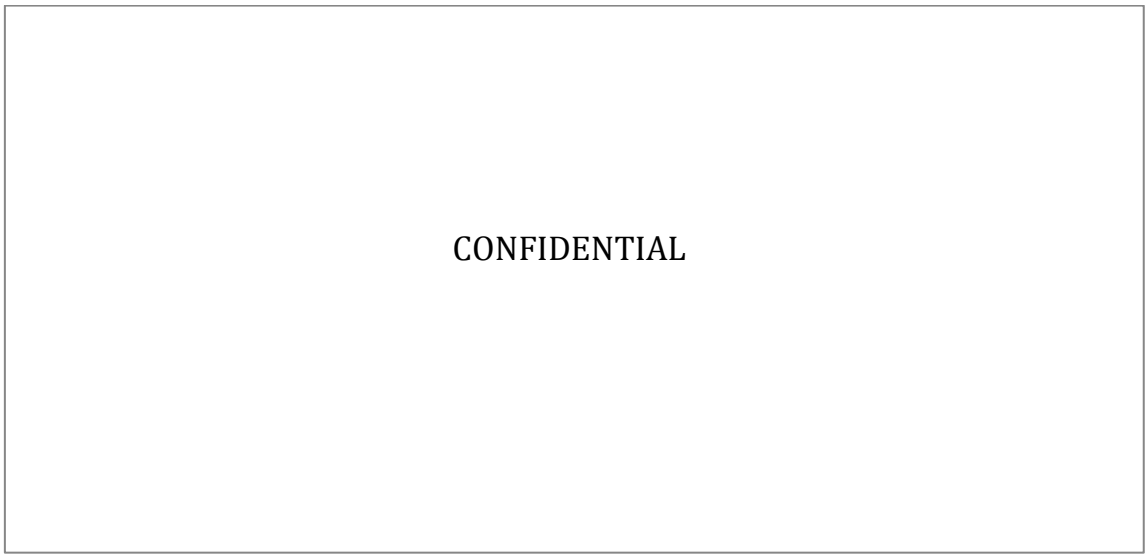


Figure 49 – Contractual repayments – *aflossingsvrij* (AAB)

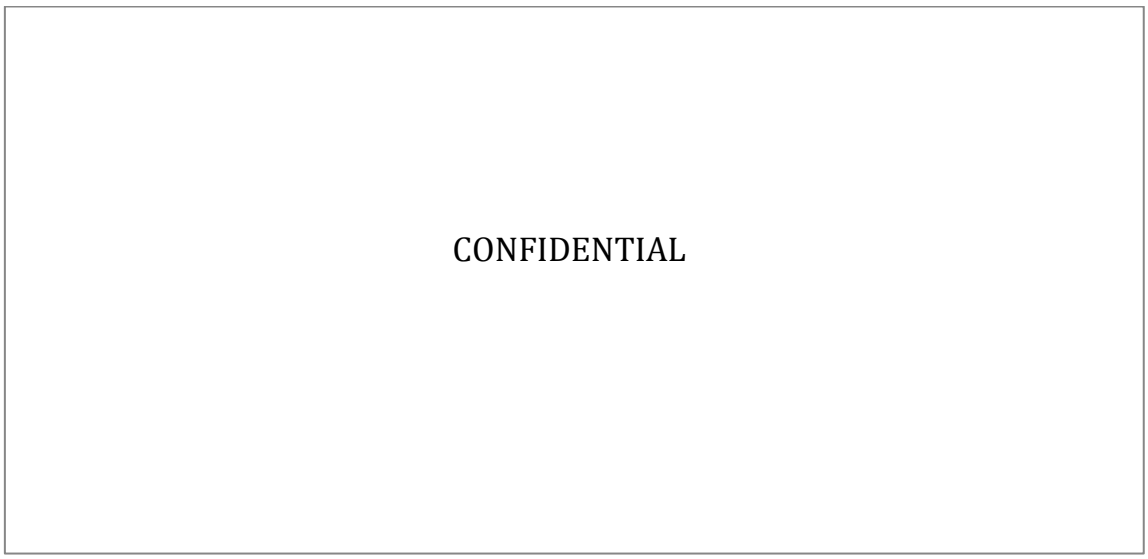


Figure 50 – Contractual repayments – *aflossingsvrij* (Florius)

[CONFIDENTIAL]

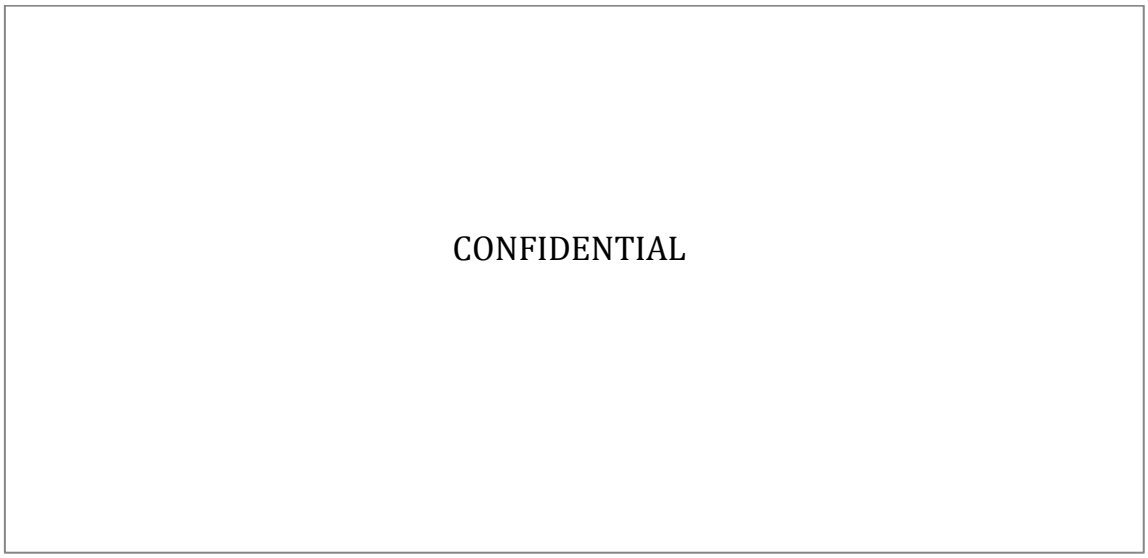


Figure 51 – Outstanding balance – *aflossingsvrij* (AAB)

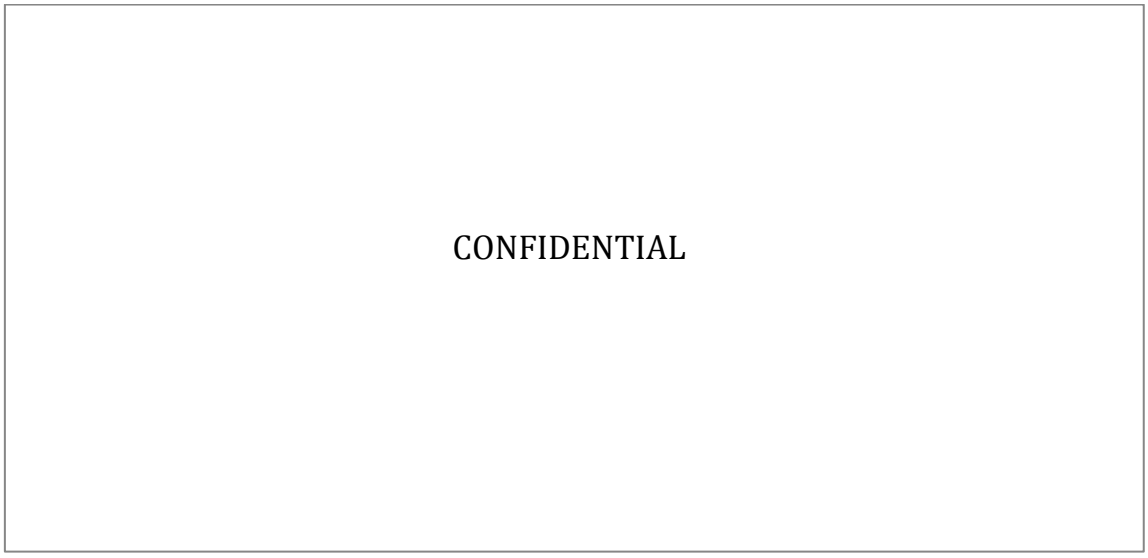


Figure 52 – Outstanding balance – *aflossingsvrij* (Florius)

[CONFIDENTIAL]

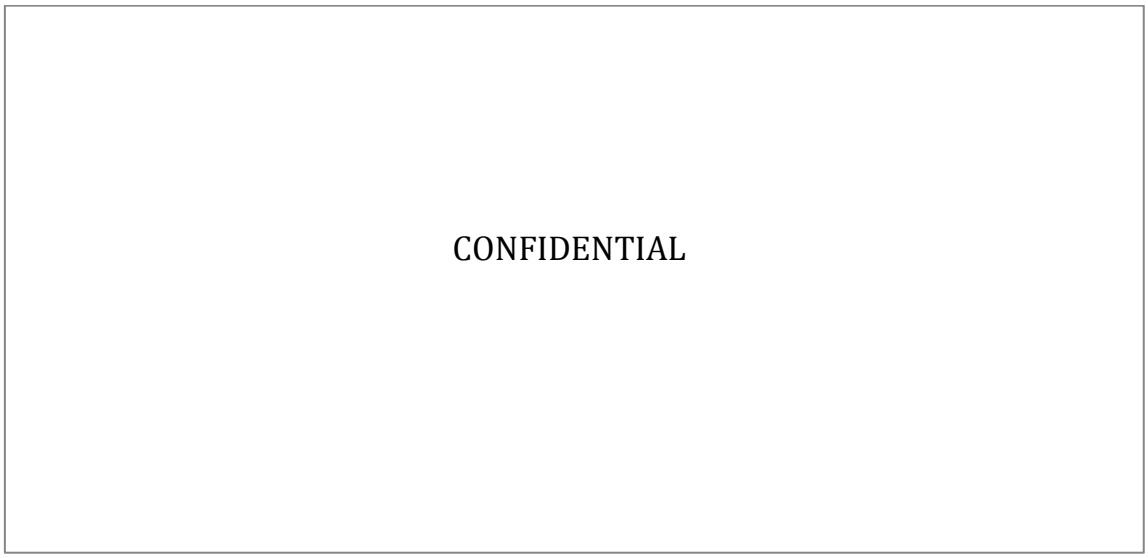


Figure 53 – Contractual repayments – *lineair* (AAB)

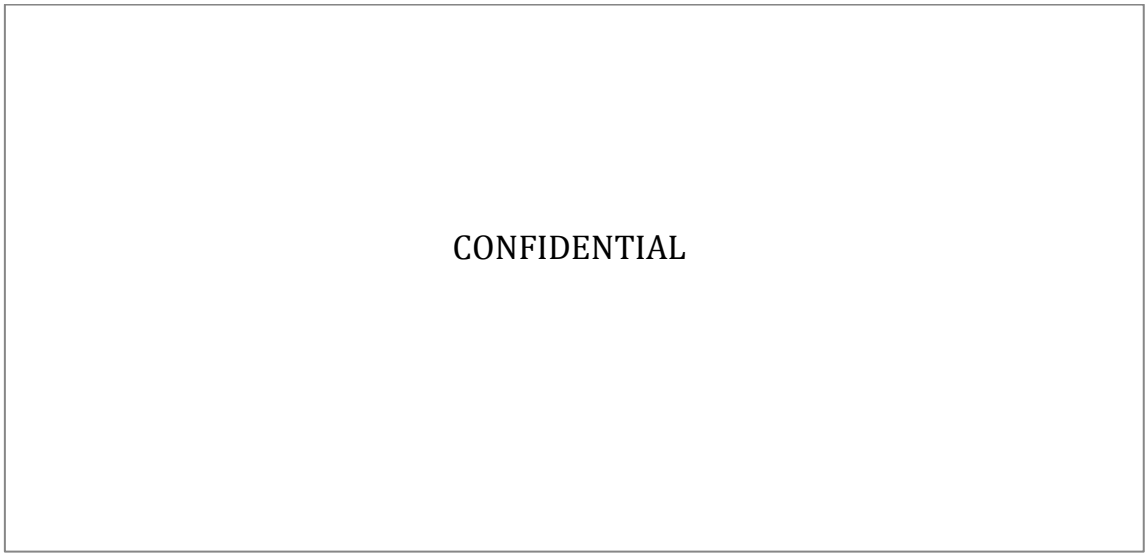


Figure 54 – Contractual repayments – *lineair* (Florius)

Both figures show a linear decrease in the contractual repayments over the upcoming thirty years, which is the largest residual contractual maturity. As can be seen in table 18 above, the share of *lineair* loan parts is less than XX per cent of the total principal for both labels. As a result, the outstanding balance is a fraction of the outstanding balance involved in *aflossingsvrij*. The graphs below give the outstanding balance for both labels over time.

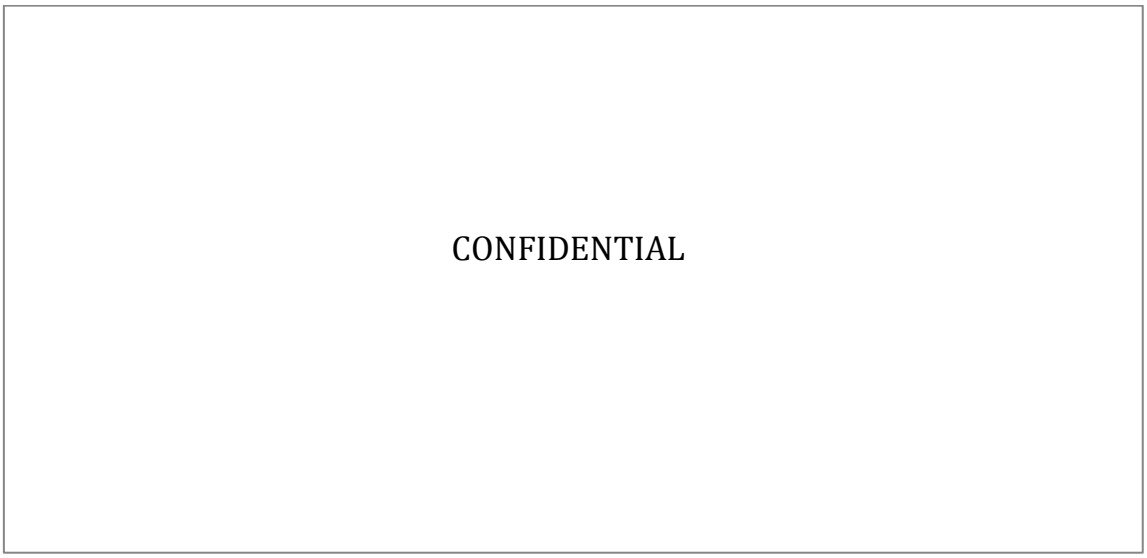


Figure 55 – Outstanding balance – *lineair* (AAB)

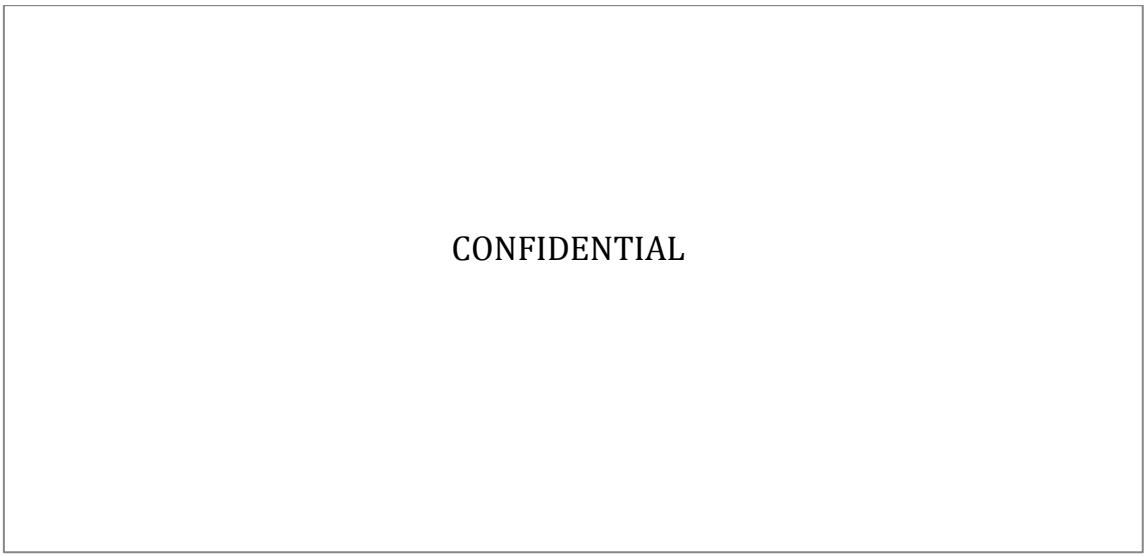


Figure 56 – Outstanding balance – *lineair* (Florius)

It becomes a little harder for the *annuïtair* loan parts. The gross monthly payments are stable, but the contractual repayments do not remain the same over the contractual maturity and interest rates now do play a role. As said before, it is assumed that the interest rate remains the same during the contractual maturity. Under that assumption, the gross monthly payment (interest + principal repayment) can be calculated using the formula $P = \frac{i}{1-(1+i)^{-n}} * T$ where T is the principal, n the total periods and i the interest rate per period (annual interest rate divided by 12 here). The first interest payment is i times the principal; the first principal repayment, by which the principal thus reduces, is P minus the interest payment. The payments in the following periods are calculated by multiplying the remaining outstanding debt by the monthly interest rate, the principal repayment equals the gross monthly payment P minus the interest payment. The table below includes an example.

CALCULATING AN ANNUITY				
PARAMETERS				
P	*Monthly annuity*		$P = \frac{i}{1-(1+i)^{-n}} * T$	
T	*Original principal*			
i	*Interest rate per period*			
n	*Total periods*			
EXAMPLE				
T	EUR 250,000		$P = \frac{0.004}{1-(1+0.004)^{-360}} * 250{,}000$ $P = 1312$	
i	4.80 percent / 12 = 0.004			
n	360			
PER MONTH				
	OUTSTANDING DEBT	*INTEREST*	*REPAYMENT*	*ANNUITY*
1	250,000	0.004 * 250,000 = 1000	1312 – 1,000 = 312	1312
2	250,000 – 312 = 249,688	0.004 * 249,688 = 999	1312 – 999 = 313	1312
3	249,688 – 313 = 249,375	0.004 * 249,375 = 998	1312 – 998 = 314	1312
n	OUTSTANDING DEBT N-1 MINUS REPAYMENT	0.004 * OUTSTANDING DEBT	ANNUITY MINUS INTEREST	1312

Table 22 – Calculating an annuity

[CONFIDENTIAL]

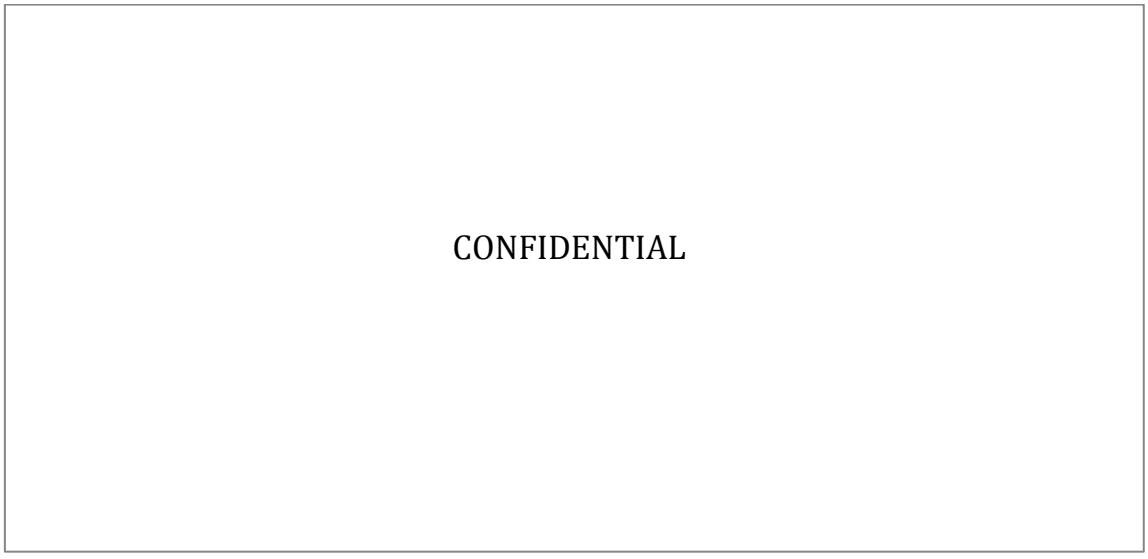


Figure 57 – Contractual repayments – *annuitair* (AAB)

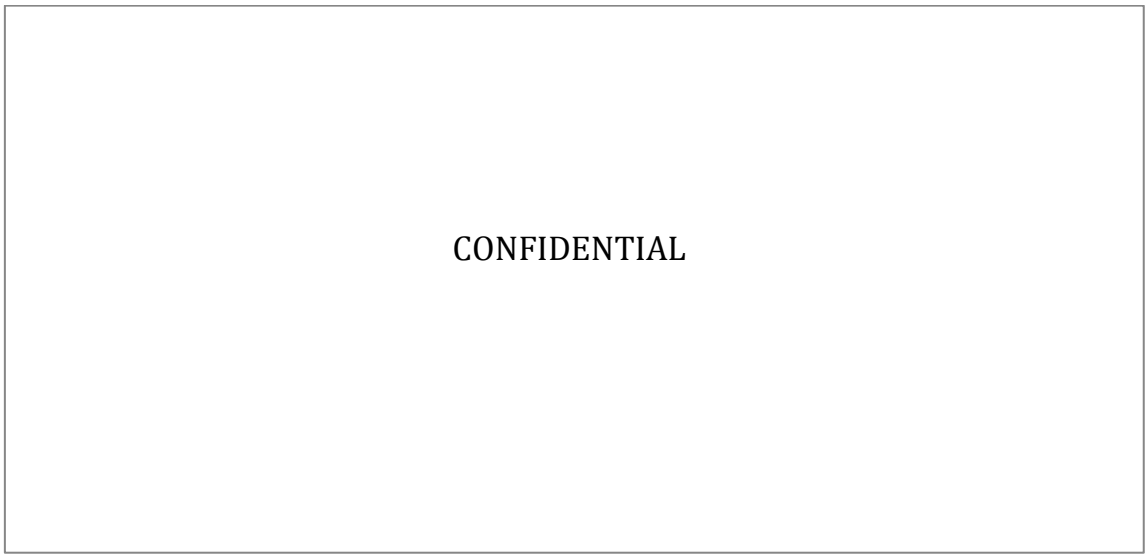


Figure 58 – Contractual repayments – *annuïtair* (Florius)

[CONFIDENTIAL]

The share of *annuïtair* loan parts is significantly larger than that of *lineair* loan parts; this is reflected in the outstanding balance which decreases rather linear.

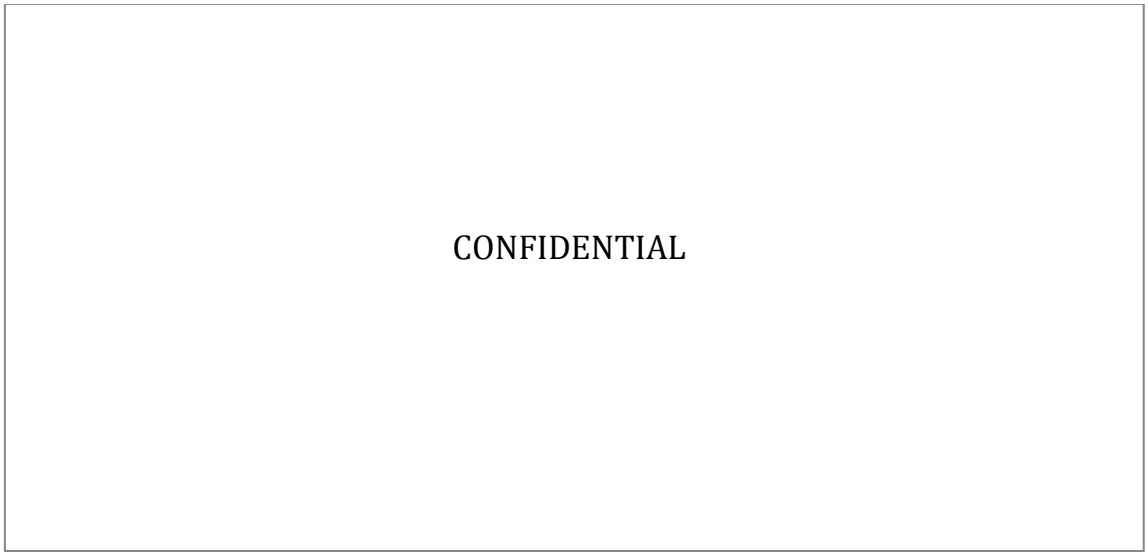


Figure 59 – Outstanding balance – *annuïtair* (AAB)

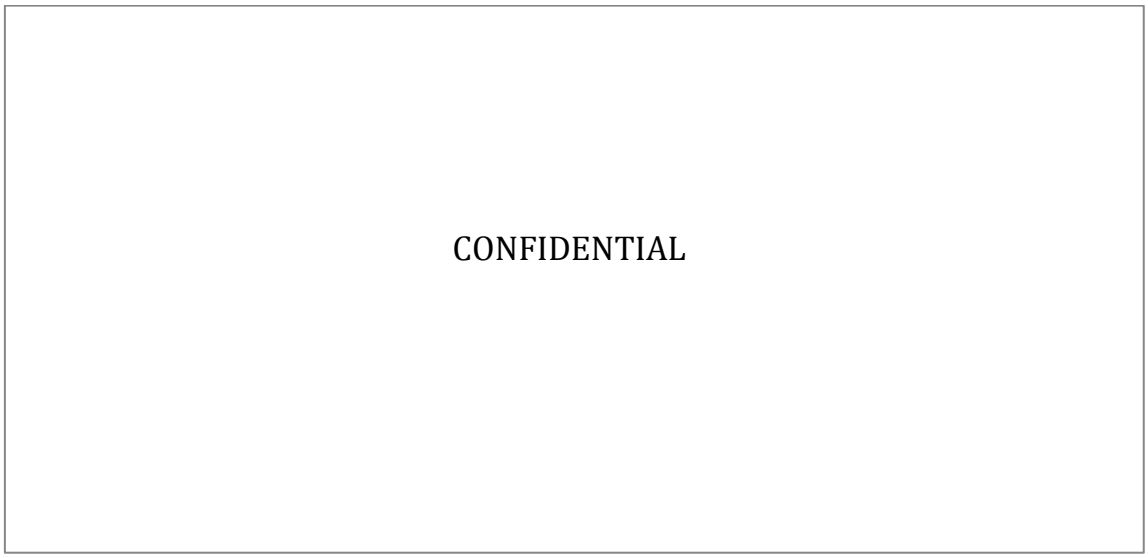


Figure 60 – Outstanding balance – *annuïtair* (Florius)

The previous section analysed the residual contractual maturity. The weighted average residual contractual maturity denotes the average period in months the principal is yet to remain in the portfolio. For the graphs above, the weighted average time till the contractual repayment is made can also be computed. This is done for the three amortization types and the complete labels in the table below.

		ABN AMRO	FLORIUS
WEIGHTED AVERAGE TIME TILL CONTRACTUAL REPAYMENT			
	AFLOSSINGSVRIJ	[CONFIDENTIAL]	
	ANNUÏTAIR		
	LINEAIR		
	COMPLETE LABEL		

Table 23 – Weighted average time till contractual repayment

[CONFIDENTIAL]

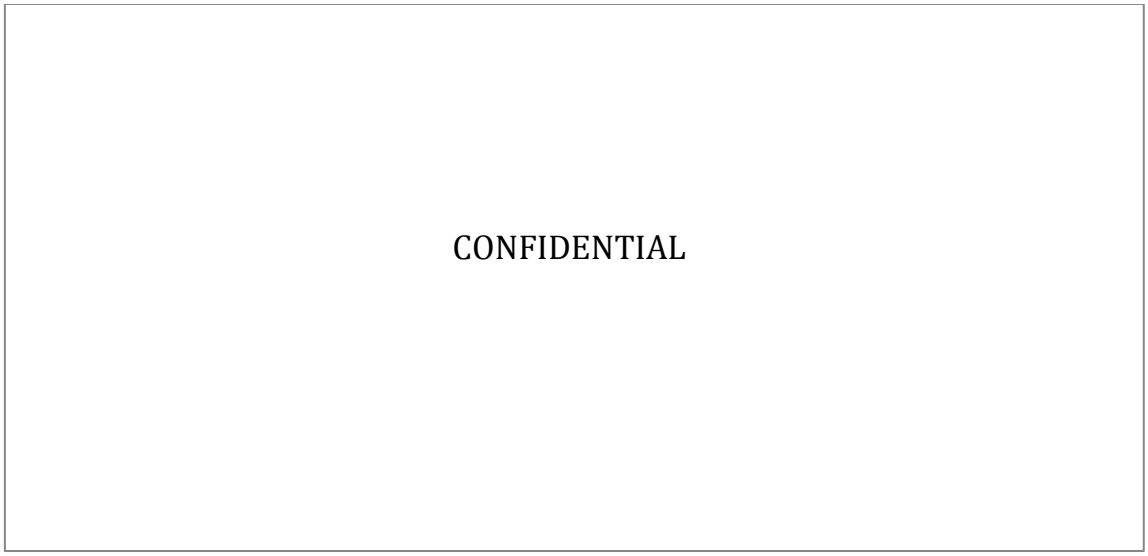


Figure 61 – Contractual maturity profile (per month)

[CONFIDENTIAL]

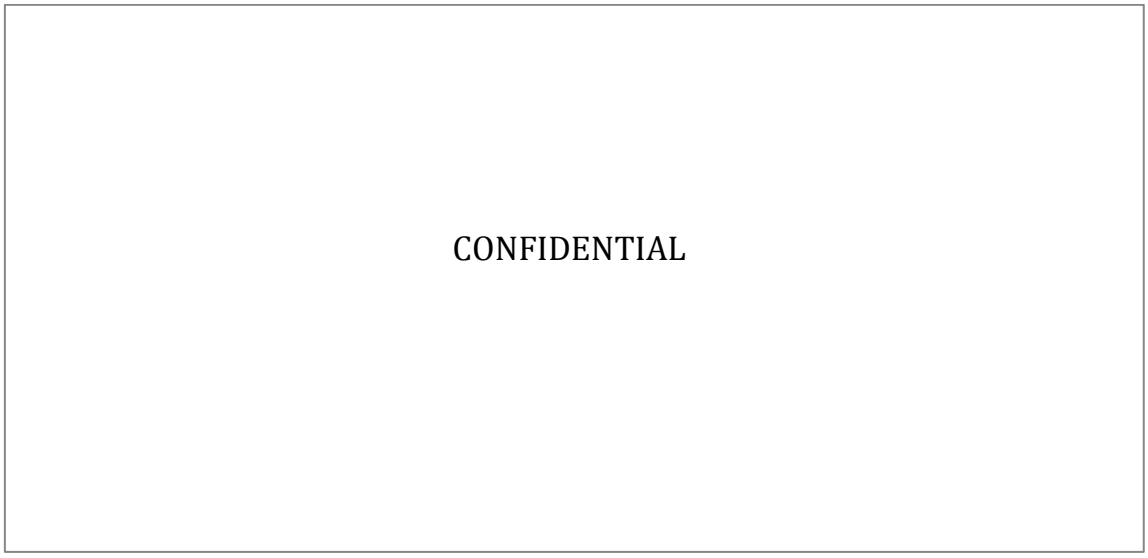


Figure 62 – Contractual maturity profile (excluding *aflossingsvrij* and *(bank)spaar*)

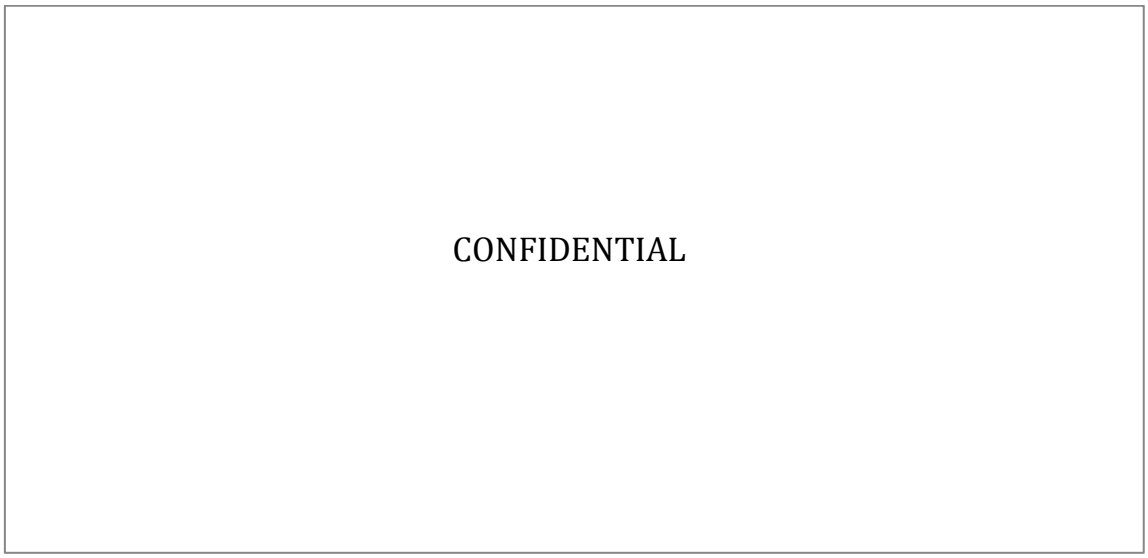


Figure 63 – Contractual repayment rate

[CONFIDENTIAL]

By combining all the data from the graphs in this section, the outstanding balance for the complete current portfolio can be given. The figure below is a stacked column chart. The first couple of years are mainly affected by *annuïtair* contractual repayments, but the *aflossingsvrij* contractual repayments take over when the current portfolio reaches the average residual contractual maturity.

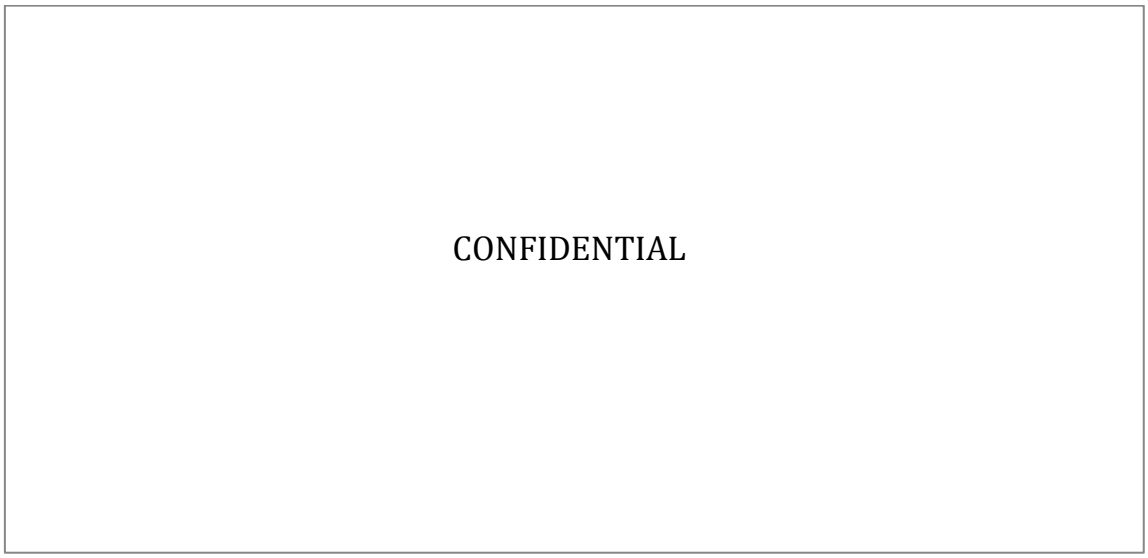


Figure 64 – Outstanding balance (current portfolio)

This section analysed the current portfolio and its (residual) contractual maturity profile. Figure 62 gives the contractual maturity profile for the current portfolio excluding *(bank)spaar* and *aflossingsvrij*; it turns out the future contractual repayments are higher than the contractual repayments received in the (analysed) past period; which is thus mainly due to the increased (decreased) share of *annuïtair* (*aflossingsvrij*) mortgages. The total outstanding balance for the current portfolio is in figure 64, which is mainly defined by the *aflossingsvrij* contractual repayments. The next section is about future non-contractual payments, i.e. prepayments.

7.3 EFFECTIVE MATURITY PROFILE

This section answers the main research question of this thesis by computing the effective maturity profile for the current portfolio. The effective maturity at origination is analysed first. The residual effective maturity will not be determined for the current portfolio.

7.3.1 EFFECTIVE MATURITY AT ORIGINATION

Section 4.3 analysed the effective maturity for the historical data. The effective maturity depends on prepayments which are non-contractual and behavioural. At origination, it is not known if, when and how much a borrower will prepay. The effective maturity was defined as the period between the first cash-out flow, as seen from AAHG, and the last cash-in flow after which AAHG has no further contractual obligations towards the client/after which no further cash flows take place. The start of the effective maturity at origination is known, but the 'end date' not which implies some assumptions need to be made. The effective maturity at origination is calculated in two ways, the first is based on a rather simple weighted average method; the second uses a more sophisticated Excel macro in order to determine the effective maturity on a single loan part level.

Concerning the first method, the weighted average effective maturity per mortgage type was also computed in section 4.3. If these weighted averages are multiplied with the shares of each mortgage type in the historical data set, the outcome is very close to the overall weighted average. It is assumed the historical weighted averages for the three mortgage types are an appropriate

estimation for the current portfolio. The current overall weighted average effective maturity can then be determined using the formula below.

$$Weighted\ average\ effective\ maturity\ (current\ portfolio) = [current\ share\ aflossingsvrij * historical\ weighted\ average\ aflossingsvrij] + [current\ share\ annuïtair * historical\ weighted\ average\ annuïtair] + [current\ share\ lineair * historical\ weighted\ average\ lineair]$$

For ABN AMRO the formula above results in a weighted average effective maturity of XX months.

[CONFIDENTIAL]

For Florius the result is XX months (X years). For both labels these values are higher than the weighted averages for the historical data (table 11). This is due to an increase in the share of *annuïtair* mortgages. As *annuïtair* mortgages were most popular during the 1980s they will have a higher average effective maturity than the other two mortgage types. As the effective maturity is affected by the *liquiditeitstypische* prepayments '*verhuizing*', '*algehele aflossing*' and '*gedeeltelijke aflossing*' an increase is no surprise. There are less complete prepayments since the financial crisis and relocations have reached an all-time low. As the calculations above are based on historical weighted averages, this effect is not taken into account but based on logical thinking the effective maturity will be higher for the current portfolio.

In theory, the residual effective maturity can now be determined by calculating the period between the elapsed maturity of a loan part and the weighted average effective maturity from above. However, this will not be done since there are loan parts in the current portfolio with a loan age larger than the weighted average effective maturity. The method used above is rather simple and assumes the historical weighted averages of the various mortgage types can be applied to the current portfolio. Because of these shortcomings the computed averages are merely an indication rather than a precise estimate. In order to overcome this, the effective maturity at origination was also determined on a single loan part level.

The available computational power did not seem to be sufficient at first; however, using an Excel macro that stores the hard values per loan part instead of the complete formulas made it possible. For both labels, the current portfolio was split into the three distinct mortgage types. The snapshot below represents an example of the available data per loan part; which is sufficient to determine the contractual repayments, the non-contractual prepayments, the outstanding debt over time and the effective maturity at origination. The effective maturity profile that is discussed in the next subsection can thus also be determined using the same macro.

EXAMPLE									
Loan ID	Loan part ID	CM	Principal	Outstanding debt	Residual CM	Elapsed Maturity	Interest	Monthly interest	Annuity
700178688	107	276	60.000,00	53.536,58	257	19	4,45%	0,37%	€ 347,66

Figure 65 – Example of available data per loan part

Starting with the contractual repayments, for *aflossingsvrij* mortgages these consist of the complete repayments of the total original principal at maturity. For *annuïtair* mortgages there is an Excel formula called PPMT that calculates the monthly contractual repayment using the monthly interest

rate, the period to be calculated, the total number of payments, the principal and the future value. The monthly contractual repayments for *lineair* mortgages are simply computed by dividing the original principal by the contractual maturity in months. The prepayments are calculated using the same method for all mortgage types. The prepayment rate is based on the historical prepayment rates over the elapsed maturity of the loan parts. For example, the loan part from figure 65 above has an elapsed maturity of 19 months. In August 2013 the elapsed maturity is 20 months; using a lookup function, Excel analyses what prepayment rate (SMM) belongs to a loan part with an elapsed maturity of 20 months. The outstanding debt is then multiplied by this prepayment rate resulting in the prepayment made in that month. The outstanding debt per month is than calculated by subtracting the contractual repayments and prepayments made from the outstanding debt in the previous month. The figure below does this for the loan part example above for the first 5 months.

Residual Maturity	1	2	3	4	5	...	n
SMM	0,04%	0,59%	0,44%	0,35%	0,32%	...	X,XX%
Month	8	9	10	11	12	...	Month
	€ 134,28	€ 134,78	€ 135,28	€ 135,78	€ 136,29	...	Contractual repayment
	€ 159,10	€ 178,64	€ 166,41	€ 191,90	€ 201,17	...	Prepayment
	€ 53.243,19	€ 52.929,77	€ 52.628,08	€ 52.300,39	€ 51.962,93	...	Outstanding debt

Figure 66 – Snapshot of Excel file

The formulas for one loan part are copied to the next loan part after which the values for the first loan part are pasted as hard values. The macro stops automatically as the last loan part has been done. The macro is given below and can be applied to all mortgage types.

EXCEL MACRO

```
Sub Macro()
'Copies formulas and pastes hard values.
   Application.ScreenUpdating = False
   Dim finish As Integer
   Dim index As Integer
   finish = 0
   index = 0
   While finish = 0
      Range("M4:M6").Offset(index*3,0).Select
      Range(Selection, Selection.End(xlToRight)).Select
      Selection.Copy
      Range("M7").Offset(index*3).Select
      ActiveSheet.Paste
      If index > 0 Then
         Range("M4").Offset(index*3).Select
         Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _ :=False, Transpose:=False
      End If
```

EXCEL MACRO CONTINUED

```
    If Range("A7").Offset((index + 1)*3).Value = "" Then
      finish = 1
    End If
    index = index + 1
  Wend
 Application.ScreenUpdating = True
End Sub
```

Figure 67 – Excel macro

Using this method, the future prepayments are based on the historical seasoning SMM rates. Within the computational limitations, this is believed to be the best predictor. The effective maturity at origination can now be determined by finding the month by which the outstanding debt has reached 0 and add the already elapsed maturity to that. The results are in the table below.

RESULTS MACRO		ABN AMRO	FLORIUS
AVERAGE EFFECTIVE MATURITY AT ORIGINATION			
	AFLOSSINGSVRIJ	[CONFIDENTIAL]	
	ANNUÏTAIR		
	LINEAIR		

Table 24 – Average effective maturity at origination

There are two limitations in the macro which are reflected in the values above. First, the residual maturity is limited to 360 months, as are the historical prepayment rates. No prepayment rates are available for loan parts with an elapsed maturity of > 360 months; the macro assumes a prepayment rate of zero for those maturities which results in a higher effective maturity at origination. The next time the macro is ran,[39] an average prepayment rate can be assumed for loan parts with an elapsed maturity of > 360 months or it can be assumed the loan part is completely prepaid at an elapsed maturity of 360 months. Secondly, the prepayment rate is the percentage of the outstanding debt that is prepaid in a specific month. By working with percentages, zero cannot be reached. Together with the contractual repayments, the outstanding debt can in fact reach zero before the loan part has reached its maturity, but it is definitely a limitation worth mentioning. In practice, not every borrower is prepaying e.g. 0.59% per month; some borrowers make a curtailment, other loan parts are completely prepaid due to a relocation. In case of the latter, the loan part terminates and the effective maturity is shorter. This 'issue' can be partly solved by calculating the weighted average effective maturity.

RESULTS MACRO		ABN AMRO	FLORIUS
WEIGHTED AVERAGE EFFECTIVE MATURITY AT ORIGINATION			
	AFLOSSINGSVRIJ	[CONFIDENTIAL]	
	ANNUÏTAIR		
	LINEAIR		

Table 25 – Weighted average effective maturity at origination

[39] Running the macro for all mortgage types and labels took about 3 full days on a high-end laptop and resulted in Excel files > 4 gigabyte; as the PCs at AAHG were not able to run this macro, the two assumptions could unfortunately not be tested within the time and resources available.

The weighted averages are lower than the simple averages, the values are also closer to the historical values from table 12. Because the limitation mentioned above is partly overcome by calculating the weighted averages, the values above are a better estimate. The second limitation is also the main reason why the values above are considerably higher than the estimated effective maturity using the first method. The macro used can also be applied to find the effective maturity profile which is of greater interest; this is done in the next subsection.

7.3.2 EFFECTIVE MATURITY PROFILE

The future contractual repayments for the current portfolio have been determined in section 7.2.3. In order to compose an effective maturity profile, the future non-contractual payments, i.e. prepayments need to be determined as well. Section 4.4 looked into the prepayments received in the analysed accounting period; this data is used as a basis for this section. The prepayment rates were analysed for various characteristics. As said above, the historical seasoning SMM rates from figure 40 are used to estimate the future prepayments. The enclosed Excel file includes the contractual repayments calculated using the macro as well, these are similar to the graphs in section 7.2.3. The prepayments are determined for the three mortgage types for the two labels separately. Not all the six figures are given in the main text here; the figure below is one of the six and gives the prepayments for ABN AMRO's *aflossingsvrij* loan parts, the other five show a comparable pattern. As the outstanding debt reduces over time, the prepayments will also decrease. Also, figure 40 showed that prepayment rates decrease with further seasoning.

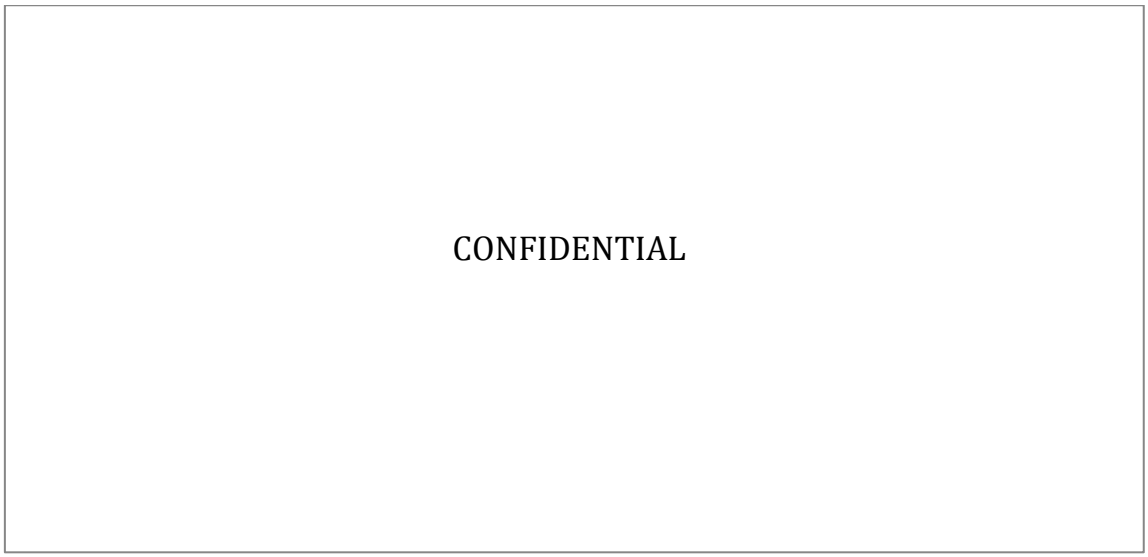


Figure 68 – Prepayments – *aflossingsvrij* (AAB)

Now that both the contractual repayments as the prepayments are known, the outstanding balance over time can be computed. For example, the outstanding balance for ABN AMRO's *aflossingsvrij* loan parts is given below.

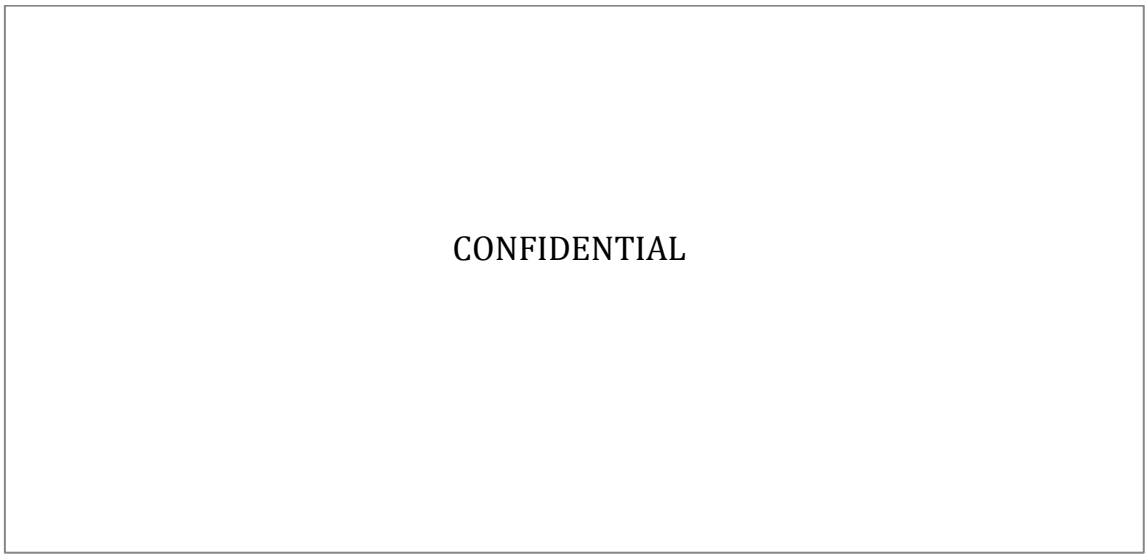


Figure 69 – Outstanding balance – *aflossingsvrij* (AAB)

The outstanding balance for ABN AMRO's *aflossingsvrij* loan parts shown in figure 51 only took the contractual repayments into account. It can be seen that in case the prepayments are included as well, the outstanding balance decreases faster. The same is done for the complete current portfolio. The figure below is a stacked column chart.

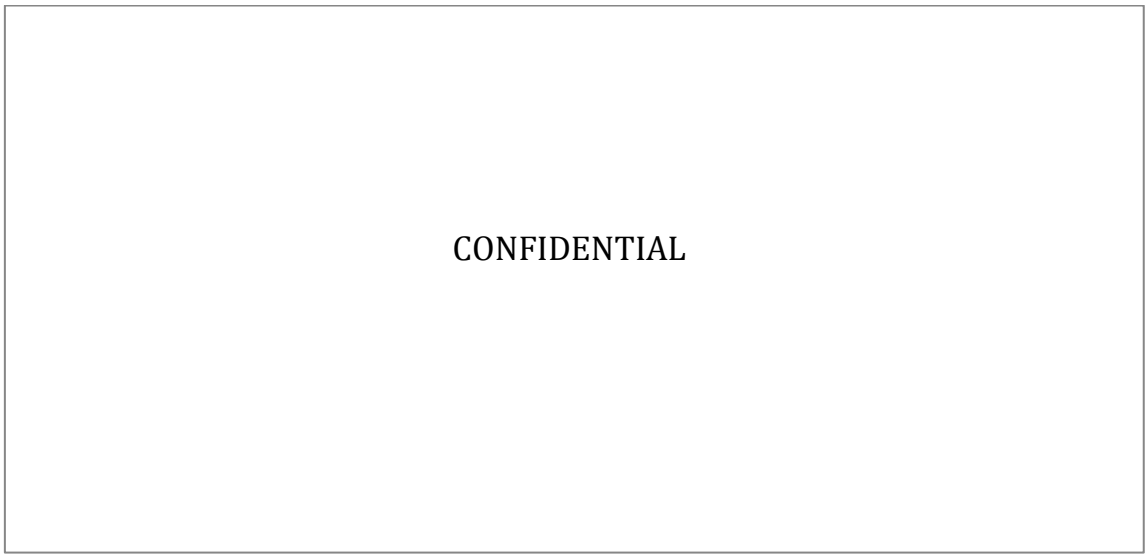


Figure 70 – Outstanding balance (current portfolio) including prepayments

Again, due to the prepayments, the outstanding balance decreases faster. The graph below gives the combined total payments for both labels. The total payments are decreasing for the first couple of years. The increase after 2025 is caused by the contractual repayments from the *aflossingsvrij* loan parts, see figures 49 and 50.

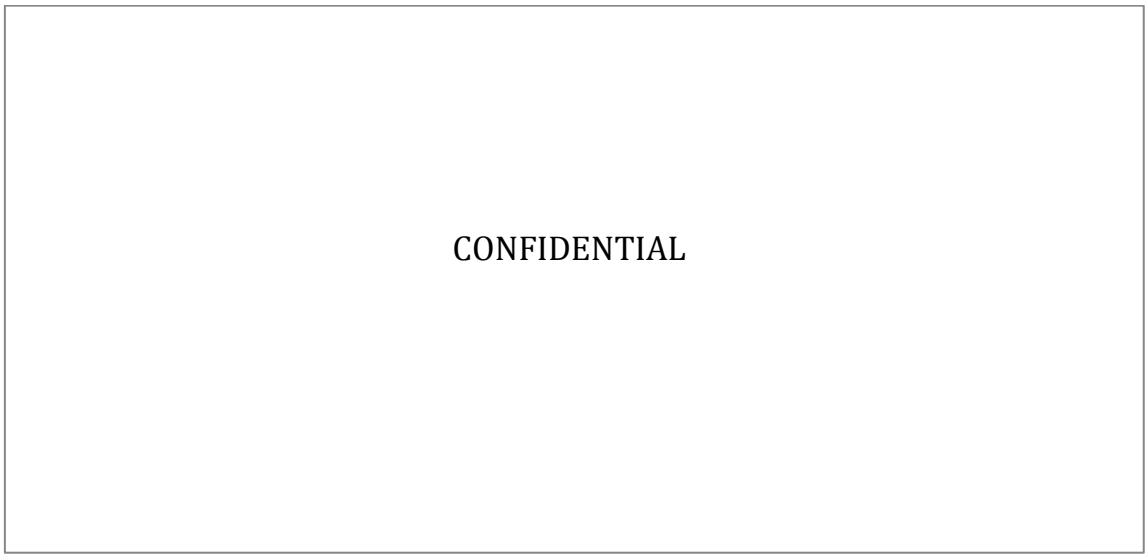


Figure 71 – Total payments per month

Using the formula below, figure 72 represents the total payment rate per label per year, i.e. contractual repayments plus *liquiditeitstypische* prepayments divided by the outstanding balance.

$$Total\ payment\ rate = 1 - (1 - SMM^{total\ payments})^{\wedge 12}$$
$$where\ SMM^{total\ payments} = SMM^{liquiditeitstypische\ prepayments} + SMM^{repayments}$$

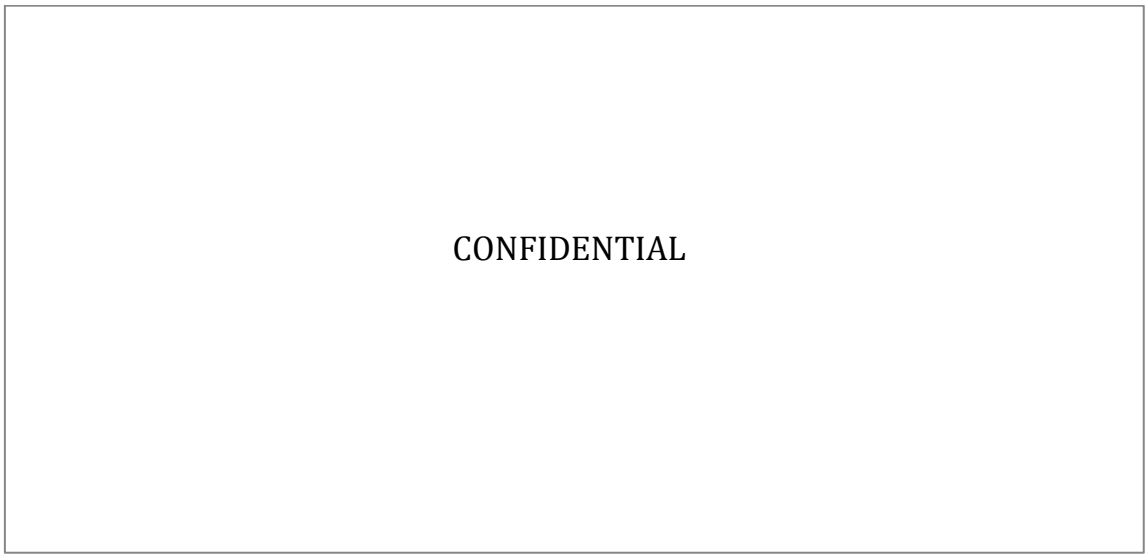


Figure 72 – Effective maturity profile (current portfolio)

It can be seen that the decreasing trend observed for the historical data in figure 43 continues for both labels. After 2020, the total payment rate is stabilizing and increasing afterwards. The last couple of years are not included in the graph, which is because the payment rate is going to 100% as the outstanding balance decreases over time (under the assumption of no production) and many *aflossingsvrij* mortgages are completely repaid as they reach their contractual maturity.

7.4 PRACTICAL APPLICATION

The previous sections analysed the different types of maturities for the current portfolio. This section combines the knowledge gathered throughout the chapters in a practical sense.

Starting with the basics, there are three types of mortgages being *aflossingsvrij*, *annuïtair* and *lineair*. These types have all got three distinct maturities, namely the contractual maturity, the effective maturity (*liquiditeitstypische looptijd*) and the interest rate period (*rentetypische looptijd*). How do these compare to one another? An Excel sheet was created to improve the understandability of the relationship between the types of maturity. There are six parameters as input, which are the original principal, the contractual maturity, the interest rate, the fixed rate period, the CPR and the tax rate. Using these parameters the sheet calculates the monthly outstanding debt, interest payable, contractual repayment, gross/net payment, *liquiditeitstypische* and *rentetypische* prepayment and the (weighted) effective maturity in months. In the sheet and in the examples below, the red line represents the outstanding debt at time t; the blue line represents the *liquiditeitstypische* prepayments which are on the right y-axis. The contractual repayments are not graphically displayed in the figures, but it may be clear that the outstanding debt is each month reduced by the contractual repayments plus the *liquiditeitstypische* prepayments. The green arrowed line represents the *rentetypische* prepayments which occur at the end of a fixed rate period. From an interest-rate-risk point of view, the outstanding balance is prepaid at the end of a fixed rate period.

An *aflossingsvrij* mortgage does not incorporate any interim contractual repayments. The graph below is based on a fictitious loan part with an original principal of EUR 250,000 and a contractual maturity of 360 months. Other assumptions are an interest rate of 6.0 per cent, a fixed rate period of 60 months, a tax rate of 42 per cent and no *liquiditeitstypische* prepayments, i.e. a CPR of zero.

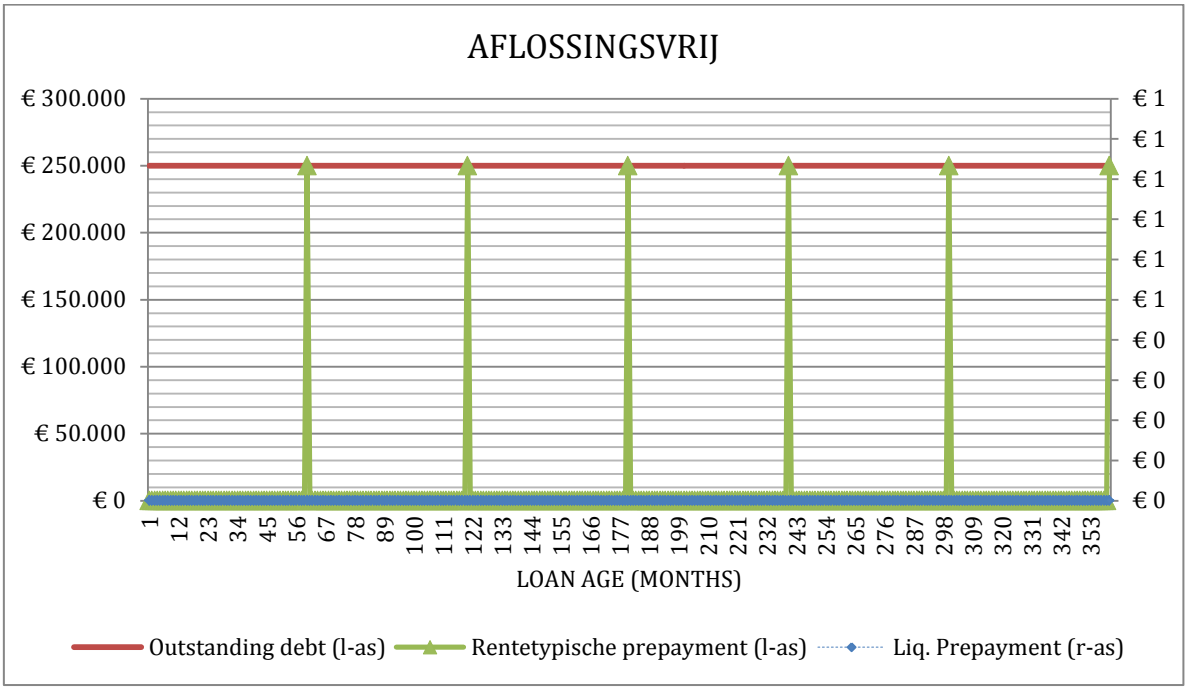


Figure 73 – Example *aflossingsvrij* loan part (CPR 0%)

As there are no contractual repayments and no *liquiditeitstypische* prepayments (blue line), the outstanding debt (red line) remains constant during the lifetime of the loan part. The fixed rate period is set at 60 months; from an interest-rate-risk point of view, there is a *rentetypische* prepayment every 60 months (green line). After this prepayment, a new loan part originates with the same outstanding debt and fixed rate period which is again completely prepaid (*rentetypisch*) as 60 months (120 months in total) have passed. In this example, the contractual maturity is thus 360

months, the effective maturity is also 360 months, as is the weighted effective maturity, the interest rate period is 60 months. The situation changes as there are contractual repayments involved, which is the case for *annuïtair* mortgages.

The assumptions made above are also applied here; the only adjustment is that the CPR (SMM) is now set to 2.0 per cent (0.17 per cent). This implies 0.17 per cent of the outstanding debt is prepaid every month. The result is in the figure below.

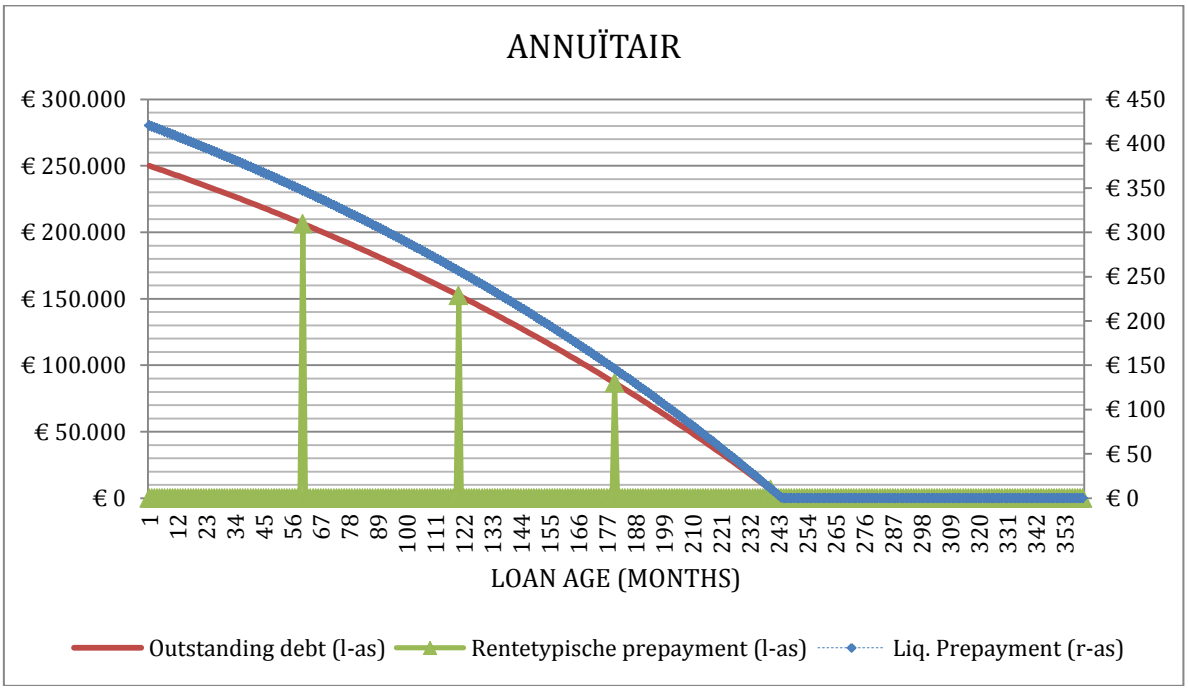


Figure 74 – Example *annuïtair* loan part (CPR 2%)

The outstanding debt is now reduced every month by the contractual repayments and the *liquiditeitstypische* prepayments. The contractual maturity and the interest rate period are unchanged. But as the loan part is completely (p)repaid prior to its contractual maturity, the effective maturity is lower now. As can be seen in the graph, the outstanding debt is zero after 244 months; no cash flows take place after that implying the effective maturity is 244 months or 20⅓ years. The weighted effective maturity is 139 months or 11½ years. This value represents the weighted average of time until the cash flows (here: *liquiditeitstypische* prepayments plus the contractual repayments) are received. This value approaches the duration of a mortgage but is not exactly the same as interest payments are not taken into account here.

The last example is a *lineair* mortgage with an original principal of EUR 250,000, the contractual maturity is 240 months and the fixed rate period 120 months. The interest and tax rate are unchanged, the CPR rate is set to 4.0 per cent (SMM is 0.34 per cent).

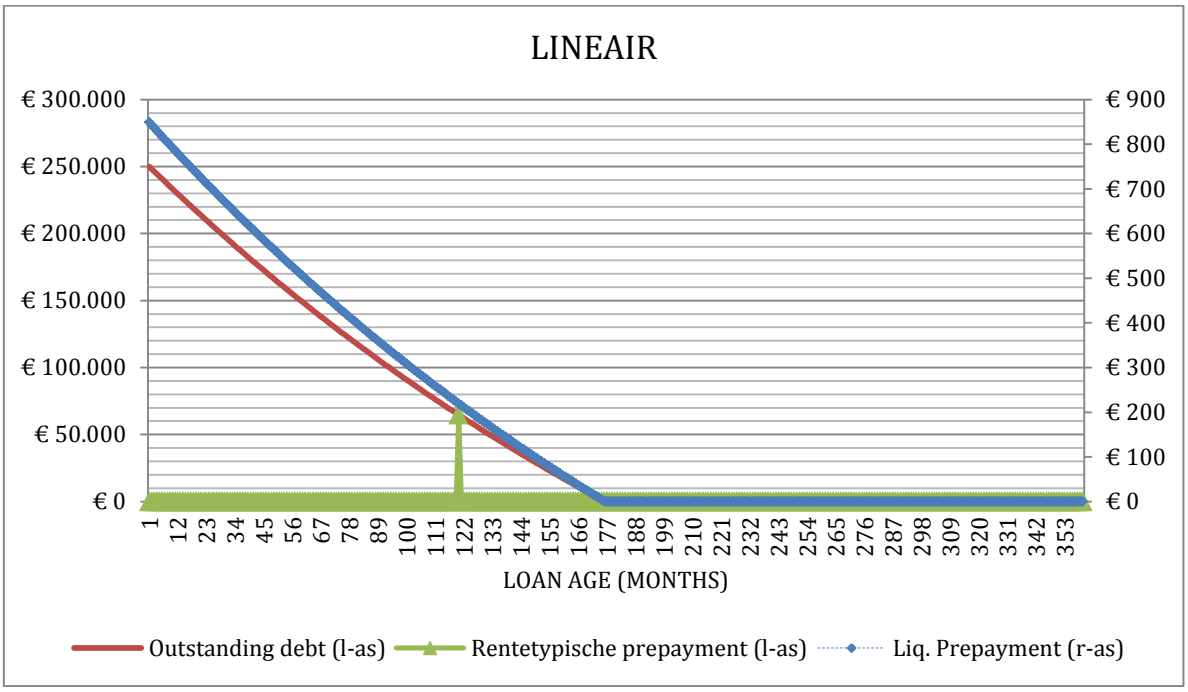


Figure 75 – Example *lineair* loan part (CPR 4%)

For a *lineair* mortgage, the contractual repayments are equal each month. If there are no prepayments, the outstanding debt would thus decrease linearly. In the example above, the CPR rate is set higher than in the *annuïtair* example, the loan part is thus (p)repaid faster. The contractual maturity is 240 months, but the effective maturity is 176 months or 14⅔ years; the weighted effective maturity is 80 months or 6⅔ years.

The above can also be applied to the current portfolio. The averages from table 18 could be used as input parameters. The pattern can then be compared to the pattern visible in figure 70. Another option is to apply the model from section 5.3 to the current portfolio. However, because of the very low goodness of fit of the model, it was chosen not to do so.

7.5 PARTIAL CONCLUSION AND DEVELOPMENTS

The first section of this chapter introduced the current portfolio that is analysed in section 7.2 and 7.3. The ABN AMRO label holds about XXX,XXX loan parts, Florius just over XXX,XXX and the total principal analysed is over EUR 90 billion. It turned out there were some small characteristical differences between the historical loan parts and the current. The most obvious difference is in the share of the different mortgage types; *annuïtair* increased whereas the share of *aflossingsvrij* decreased.

The (weighted) average contractual maturity only slightly decreased compared to the historical data. The residual contractual maturity was determined in subsection 7.2.2. Assuming no production, on average the current loan parts will remain XXX respectively XXX months in the portfolio for the ABN AMRO and Florius label before they reach their contractual end date. Next, figures 61 and 62 represent the contractual maturity profile for the current portfolio (in- or excluding *(bank)spaar*). If *(bank)spaar* mortgages are excluded, the current contractual maturity profile is comparable to the

profile based on historical data. About X.X basis points of the total AAB principal is contractually repaid every month, circa X.X basis points for Florius; again excluding *(bank)spaar* repayments.

[CONFIDENTIAL]

As for the developments, insight in the effective maturity (profile) is becoming more important. This was in fact one of the reasons to perform this study. There is only little literature and research available on the effective maturity of a mortgage portfolio. Other developments include additional research into this topic as investors and financial regulators like BIS require the effective maturity to be known.

CHAPTER EIGHT – CONCLUSIONS AND FURTHER RESEARCH

The objective of this thesis was set in chapter one and is as follows.

Determining the effective maturity of a mortgage over its complete economic life time by taking into account all contractual repayments and non-contractual (i.e. behavioural) prepayments.

This final chapter combines the answers of the subquestions in order to answer the main research question and to achieve the objective. The partial conclusions at the end of the previous chapters will help in doing so. A discussion of the results and suggestions for further research is also included in this chapter.

8.1 CONCLUSIONS

Achieving the research objective requires an understanding of the contractual repayments and the non-contractual prepayments. This understanding has been obtained by analysing an historical data set which holds data on the (p)repayments made in the last six years. By analysing this data set and reviewing relevant literature, the effective maturity turned out to be affected by prepayments. These prepayments can be split into *liquiditeitstypische* and *rentetypische* prepayments; the first are relevant for this study.

[CONFIDENTIAL]

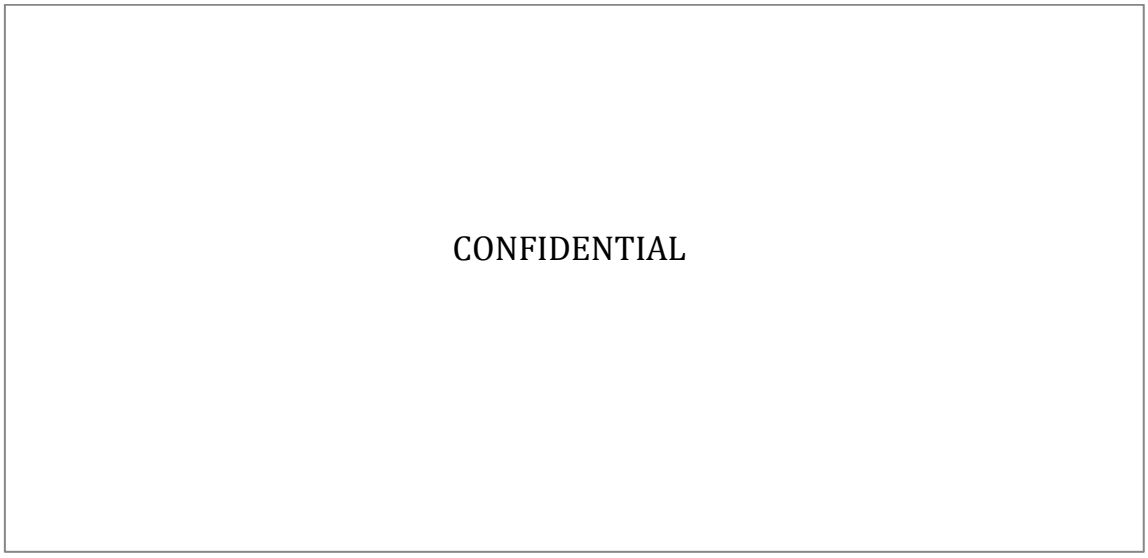


Figure 76 – Contractual maturity profile (per month)

[CONFIDENTIAL]

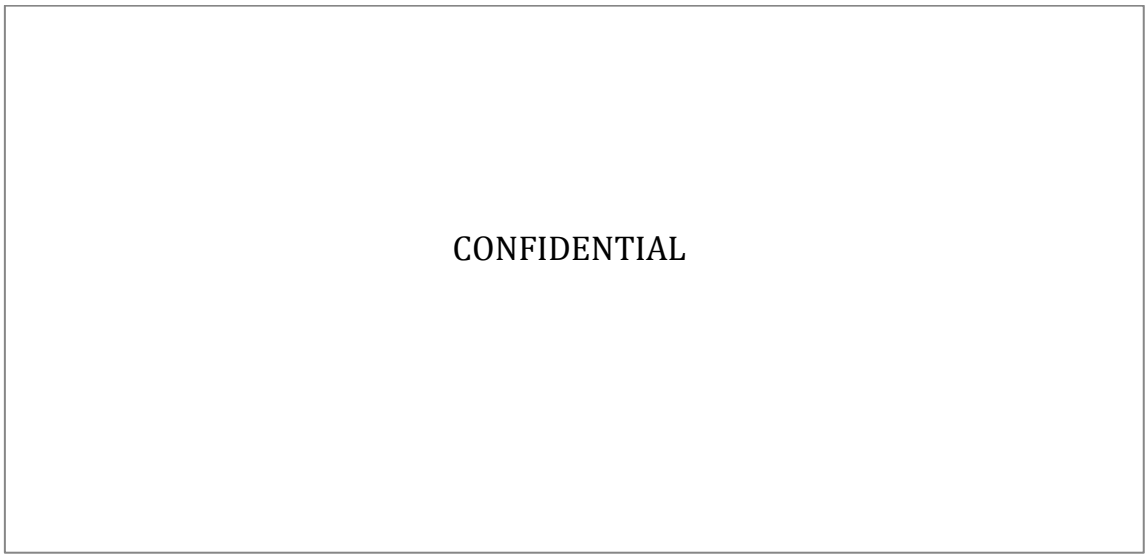


Figure 77 – Outstanding balance (current portfolio)

Based on a literature review and discussion with several colleagues (appendix F) it was found that prepayments affect the contractual maturity. More specifically, it is the *liquiditeitstypische* prepayments that matter, which can be divided into relocations (*verhuizing*), complete prepayments (*algehele aflossing*) and curtailments (*gedeeltelijke aflossing*).

Whereas ALM's current prepayment model only incorporates three explanatory variables of prepayments, tens have been discussed and found significant in the literature and other empirical studies. One of ALM's action points is therefore to identify additional variables that significantly impact prepayment rates. Several variables have been suggested, but by means of a multiple linear regression model it could not be concluded that any of these are significant for the analysed data set. Despite the transformation of some variables, the model's goodness of fit implies prepayment rates cannot be accurately modelled using linear regression.

Instead, an Excel macro was developed in order to achieve this thesis' research objective. The available data is sufficient to determine the contractual repayments, the non-contractual *liquiditeitstypische* prepayments, the outstanding debt over time and the effective maturity at origination; all on a single loan part level. The future total monthly payments, i.e. the contractual repayments and the *liquiditeitstypische* prepayments, for the current portfolio are in the figure below.

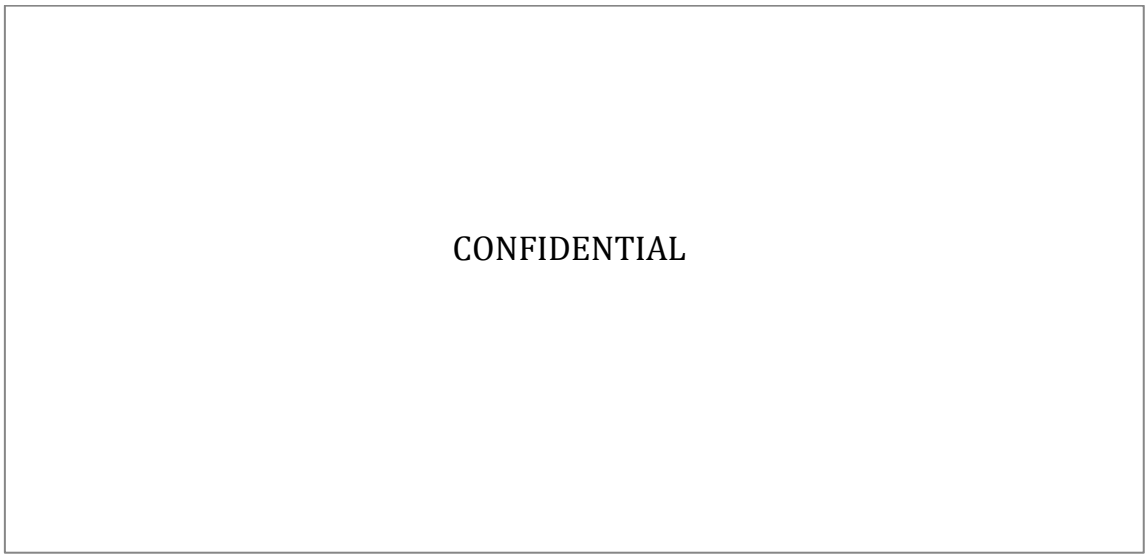


Figure 78 – Total payments per month

These total payments can be converted into a total payment rate per label per year, i.e. contractual repayments plus *liquiditeitstypische* prepayments divided by the outstanding balance. It can be seen that the decreasing trend observed for the historical data in figure 43 continues for both labels. After 2020, the total payment rate is stabilizing and increasing afterwards. The last couple of years are not included in the graph, which is because the payment rate is going to 100% as the outstanding balance decreases over time (under the assumption of no production) and many *aflossingsvrij* mortgages are completely repaid as they reach their contractual maturity.

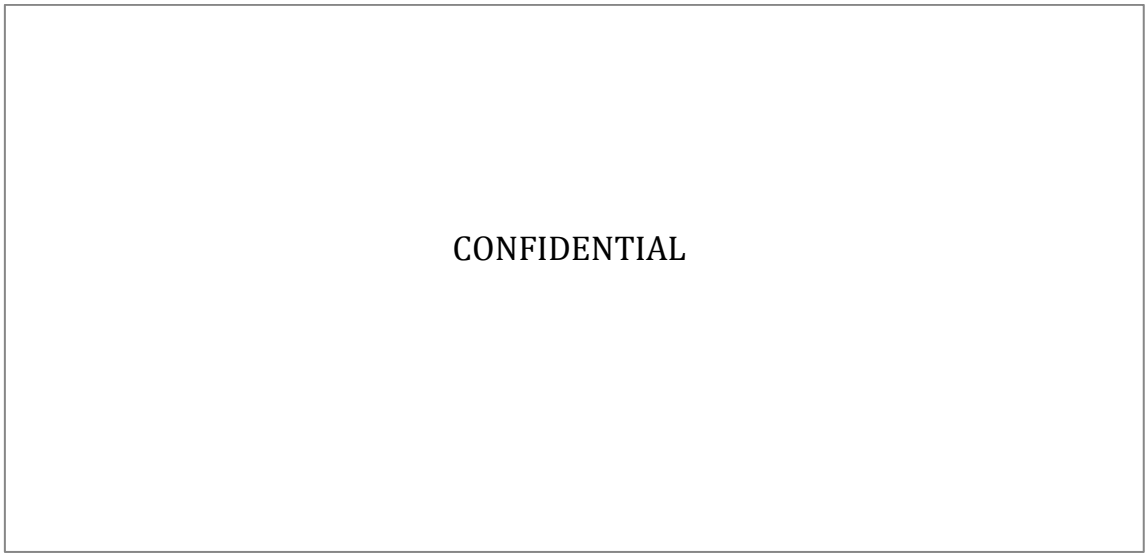


Figure 79 – Effective maturity profile (current portfolio)

Given the prepayments, the weighted average effective maturity at origination is XXX respectively XXX months for the ABN AMRO and Florius label. These values are considerably lower than the weighted average contractual maturities at origination, which are XXX and XXX months for ABN AMRO and Florius. These differences indicate the impact prepayments have on the effective maturity of a mortgage. By including prepayments, the outstanding balance decreases faster as is shown in the figure below.

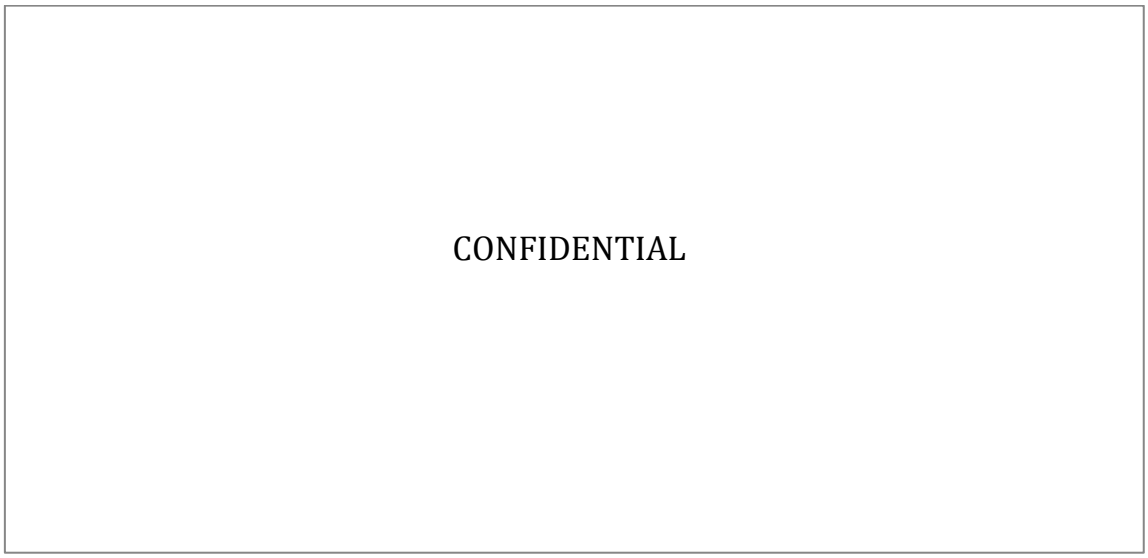


Figure 80 – Outstanding balance (current portfolio) including prepayments

This developed macro allows determining the effective maturity of a single mortgage (or the complete portfolio) over its complete economic life time by taking into account all contractual repayments and non-contractual (i.e. behavioural) prepayments. This thesis' research objective has been achieved therewith.

The methods applied can easily be reapplied in the future. Say, ABN AMRO wants to perform the same analysis in a year from now. There are three relatively simple steps that need to be performed: (1) run the 'current loan parts' query from appendix E in Microsoft SQL Server Management Studio®, (2) paste the results in the standard Excel layout that is in the enclosed Excel file and (3) run the macro. For single loan part analysis, the second enclosed Excel file can be used.

8.2 FURTHER RESEARCH

Each of the previous chapters contained a brief discussion on the current developments on the specific subject discussed in that chapter. These developments might serve as ideas for further research. As said before, insight in the effective maturity (profile) is becoming more important. As there is only little literature and research available on this topic one suggestion is further research on effective maturity in general. What is meant by it exactly? Is it possible to set up standardized definitions? Next, research is required on the context of effective maturity, i.e. how does it relate to other (financial) characteristics and topics? What are the advantages of understanding the effective maturity? Additional research might be performed on the explanatory variables that affect the effective maturity (and prepayments). These suggestions are all rather general simply because there is little literature and research available on the subject; effective maturity is a relatively new, immature aspect of the broad research area on 'maturities'.

This thesis contributed to a better general understanding of the effective maturity (profile). More specifically, further research is required on how prepayments can be modelled best. As the multiple linear regression model failed to accurately predict future prepayment rates, other models need to be tested. The ALM department is constantly working on improving ABN AMRO's prepayment models. As said before, in case the forecasted rates are structurally incorrect, capital will be funded for a period too long or too short. There is a potential risk in case funding is too long (short) and the

interest rates decrease (increase). As a mortgage lender, it is thus crucial to have an adequate prepayment model.

In predicting the future contractual repayments the EIR method was applied which holds the interest rate on which the contractual repayments depend is assumed to remain fixed during the contractual maturity. A suggestion for further research is to find out what other methods could be applied to predict the future interest rates and how this affects the contractual repayments. It is also interesting to analyse the discounted contractual repayments and prepayments. ING for example, uses the interest rate on deposits with a similar maturity as discount rate. One of the most interesting characteristics that could not be analysed is the LTV of a loan part and how prepayments differ for the various LTV classes. It is assumed prepayment rates are higher for low LTV loan parts. As housing prices have decreased significantly since the financial crisis, the LTV of most loan parts has increased. Because the attention paid to LTV ratios by e.g. investors and regulation (Basel III) is only increasing, further research on this topic is valuable.

Another suggestion for additional research is how the effective maturity relates to duration, which includes interest payments. It is interesting to know if, and to what extend the effective maturity can be used as a measure of interest rate sensitivity. A last suggestion for further research relates to chapter six. It is interesting to investigate the effect of upcoming regulation and developments on prepayments. Basel III and Dutch regulation are particularly interesting. During last week's Budget Day (*Dutch: Prinsjesdag*) new plans were introduced on NHG and the mortgage interest deduction.

8.3 DISCUSSION

The theoretical sections from this thesis introduced the mortgage market and improved the understanding of the role the different types of maturities play in this market. By providing insight in the different types of *rentetypische* and *liquiditeitstypische* prepayments this thesis is already of great worth to ABN AMRO. Until recently all focus was on the fixed interest rate period and on the prepayments made within that period. This thesis looks beyond that period and analyses mortgages over their complete economic lifetime (see figure 45). Unfortunately there were some limitations in performing this analysis. First, the historical database only distinguishes three different types of mortgages; the current database classifies multiple subtypes. Future analyses will thus be more detailed. Next, the modelling in chapter five is rather limited. A trade-off had to be made between paying more attention to model prepayments or to develop the macro that computes the effective maturity (profile). As the latter is the main research objective of this thesis, it was chosen to focus on the macro. Testing other models has been suggested for further research. Also, within the time available, it would not have been possible to create a better model than ALM's current prepayment model. Speaking of ALM, the cooperation with them was rather limited which was mainly due to other obligations and lack of time. Altogether, as many of the limitations encountered during this thesis were taken away, be it by means of learning the SQL basics or by borrowing a high-end laptop.

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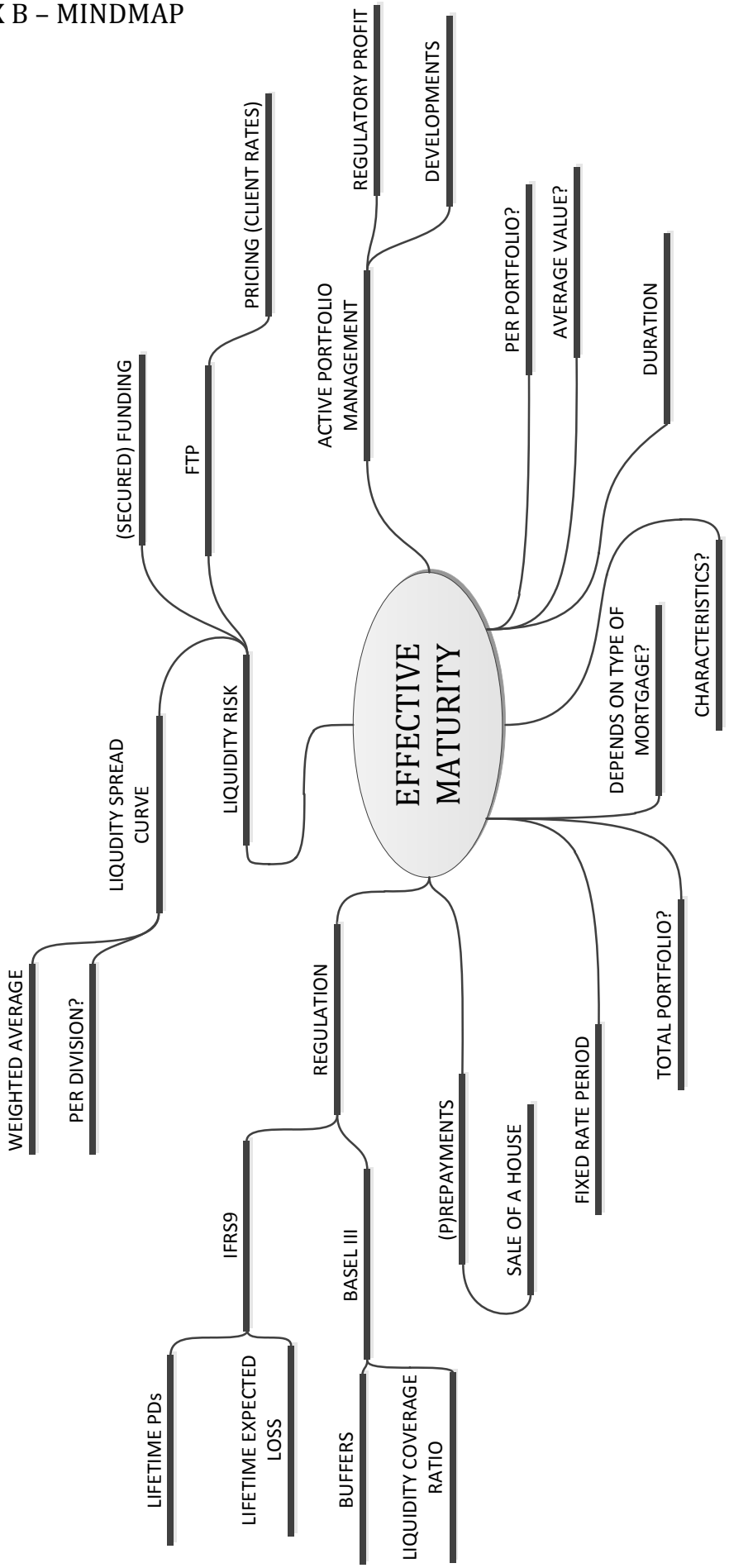
APPENDICES

APPENDIX A – TIMETABLE

WEEKS	ACTIVITIES	RESULTS
1 & 2	• Introduction • Acquire basic knowledge • Interview various colleagues • Determine focus of thesis	• Basic knowledge • Mindmap • Delineation/focus of thesis
3 & 4	• Study literature • Meeting mr. De Bakker (UT)	• Literature review • Research approach
5 & 6	• Operationalization • Collect data	• Set collectable data • Data collected
7 & 8	• Analyse data • Sensitivity analysis	• Data analysis • Sensitivity analysis
9 & 10	• Determine relation underlying variables • Discuss progress with supervisors UT	• Causal relationship characteristics mortgage • Update thesis based on insights supervisors
11 & 12	• Discuss prepayments • Analyse prepayment behavior clients AAHG	• Memo • Insight in historical prepayment rates
13 - 15	• Model prepayments [in co-op with ALM]	• Simple model • SQL queries
16 & 17	• Discuss current developments & regulation • Analyse their impact	• Understanding of how regulation will affect the effective maturity
18 & 19	• Analyse current portfolio	• Excel template/macro
20	• Concept report	• Improved report
21 & 22	• Improve concept report	• Final report
September	• Final report • Colloquium	• Diploma

APPENDIX B – MINDMAP



APPENDIX C – CHARACTERISTICS DATA SET

[CONFIDENTIAL]

APPENDIX D – APPLIED FILTERS

It is important that one uses the same data sources for each of the calculations and conclusions made. Several queries, filters and not all the data being available reduced the population (number of records) of the measurements. In this thesis, in case the population altered, it was mentioned. But for those who like an overview, the table below summarizes the filters that were applied.

ABN AMRO				
# RECORDS	FILTER	REASON	# RECORDS LEFT	# LOAN PARTS
XX	BUSINESS UNIT = ABN VALID FROM < JUNE 1st 2013	Scope of this thesis	XX	XX
	↓			
XX	ORIGINATION DATE ACCOUNTING PERIOD	Origination date available and < March 2013 January '07 < Accounting period < May '13	XX	XX
	↓			
XX	EMPLOYER ID	ABN AMRO/FLORIUS employees out of scope	XX	XX
	↓			
XX	MATURITY ≤ 900 MONTHS FIXED RATE PERIOD > 0 ELAPSED FRP ≤ 900 MONTHS REMAINING FRP > 0 MONTHS ORIGINAL PRINCIPAL > 0	Excluding invalid values	XX	XX
	↓			
XX	NO ARREAR PAYMENT ELAPSED MATURITY AVAILABLE	Additional restrictions in order to determine the contractual repayments	XX	XX

Table 31

FLORIUS				
# RECORDS	FILTER	REASON	# RECORDS LEFT	# LOAN PARTS
XX	BUSINESS UNIT = FLORIUS VALID FROM < JUNE 1st 2013	Scope of this thesis	XX	XX
XX	ORIGINATION DATE ACCOUNTING PERIOD	Origination date available and < March 2013 January '07 < Accounting period < May '13	XX	XX
XX	EMPLOYER ID	ABN AMRO/FLORIUS employees out of scope	XX	XX
XX	MATURITY ≤ 900 MONTHS FIXED RATE PERIOD > 0 ELAPSED FRP ≤ 900 MONTHS REMAINING FRP > 0 MONTHS ORIGINAL PRINCIPAL > 0	Excluding invalid values	XX	XX
XX	NO ARREAR PAYMENT ELAPSED MATURITY AVAILABLE	Additional restrictions in order to determine the contractual repayments	XX	XX

Table 32

APPENDIX E – SQL QUERIES

The queries used in Microsoft SQL Server Management Studio® are in the table below.

DimLeningDeel	
DESCRIPTION	Query below selects all the available columns from the table 'DimLeningDeel' from the 'DatamartPrepaymentBacktest' database, results in XX records
QUERY	SELECT * FROM DatamartPrepaymentBacktest..DimLeningdeelPrepaymentBacktest
Feiten	
DESCRIPTION	Query below selects all the available columns from the table 'Feiten' from the 'DatamartPrepaymentBacktest' database, results in XX records
QUERY	SELECT * FROM DatamartPrepaymentBacktest..FeitenPrepaymentBacktest
Leningdeel	
DESCRIPTION	Query below selects all the available columns from the table 'Leningdeel' from the 'InformationHub' database, results in XX records
QUERY	SELECT * FROM InformationHub..Leningdeel
Join	
DESCRIPTION	Query below joins the columns from the three tables mentioned above, differerent columns/variables can be selected. The filters from appendix D are also applied. If no filters are applied, the query results in XX records.
QUERY	SELECT a.Variable, a.Variable, b.Variable, c.Variable FROM DatamartPrepaymentBacktest.dbo.DimLeningdeelPrepaymentBacktest a INNER JOIN InformationHub.dbo.Leningdeel b ON a.LeningdeelID=b.LeningdeelID INNER JOIN DatamartPrepaymentBacktest.dbo.FeitenPrepaymentBacktest c ON a.DimLeningdeelPrepaymentBacktestVersieKey=c.DimLeningdeelPrepaym entBacktestVersieKey WHERE a.CodeBusinessUnit = XX and a.GeldigVanaf < '2013-01-06 00:00:00' and c.Boekperiode < '2013-01-05 00:00:00' and c.Boekperiode > '2007-01-01 00:00:00' and b.IngangsdatumLooptijd IS NOT NULL and b.IngangsdatumLooptijd < '2013-01-03 00:00:00' and a.WerkgeverID = 0 and a.IndicatiePersoneelsregeling = 'N' and a.Looptijd <= 900 and a.Rentevastheidsperiode > 0 and c.RentevastheidsperiodeVerstreken <= 900 and c.RentevastheidsperiodeResterendeDuur > 0 and b.Hoofdsom > 0 and c.CodeTypeAflossingPrepaymentBacktest != 4 and c.LooptijdVerstreken IS NOT NULL

Contractual repayments (without linking refinanced/reconsidered loan parts)	
DESCRIPTION	Query below counts the number of loan parts per contractual maturity (in months) and sums the amount of contractual repayments made at that specific contractual maturity. If c.Looptijdverstreken is changed into c.Boekperiode, the contractual repayments per accounting period can be computed.
QUERY	SELECT DISTINCT c.LooptijdVerstreken, COUNT(a.LeningdeelID) as '# Contr. aflossingen', SUM(c.ContractueleAflossingPrepaymentBacktest) as '€ Contr. aflossingen' FROM DatamartPrepaymentBacktest.dbo.DimLeningdeelPrepaymentBacktest a INNER JOIN InformationHub.dbo.Leningdeel b ON a.LeningdeelID=b.LeningdeelID INNER JOIN DatamartPrepaymentBacktest.dbo.FeitenPrepaymentBacktest c ON a.DimLeningdeelPrepaymentBacktestVersieKey=c.DimLeningdeelPrepaymentBacktestVersieKey WHERE c.ContractueleAflossingPrepaymentBacktest > 0 and a.CodeBusinessUnit = XX and a.GeldigVanaf < '2013-01-06 00:00:00' and c.Boekperiode < '2013-01-05 00:00:00' and c.Boekperiode > '2007-01-01 00:00:00' and b.IngangsdatumLooptijd IS NOT NULL and b.IngangsdatumLooptijd < '2013-01-03 00:00:00' and a.WerkgeverID = 0 and a.IndicatiePersoneelsregeling = 'N' and a.Looptijd <= 900 and a.Rentevastheidsperiode > 0 and c.RentevastheidsperiodeVerstreken <= 900 and c.RentevastheidsperiodeResterendeDuur > 0 and b.Hoofdsom > 0 and c.CodeTypeAflossingPrepaymentBacktest != 4 and c.LooptijdVerstreken IS NOT NULL GROUP BY c.LooptijdVerstreken ORDER BY c.LooptijdVerstreken ASC
Contractual repayments (with linking refinanced/reconsidered loan parts)	
DESCRIPTION	Query below links the refinanced/reconsidered loan parts; the amount of contractual repayments made at the specific contractual maturity is to be calculated thereafter, e.g. using Excel.
QUERY	SELECT DISTINCT a.LeningdeelID, a.LeningID, b.LeningdeelIDOmgezet, b.Ingangsdatum, b.IngangsdatumLooptijd, b.Aflosdatum, c.Boekperiode, a.Looptijd, CASE WHEN b.LeningdeelIDOmgezet IS NOT NULL THEN DATEDIFF(month,b_omgezet.IngangsdatumLooptijd, c.Boekperiode) ELSE c.LooptijdVerstreken END AS LooptijdVerstreken, b.Hoofdsom, c.Schuldrest, c.Spaarwaarde, c.Balanswaarde, c.Aflossing, c.ContractueleAflossingPrepaymentBacktest, c.VervroegdeAflossingPrepaymentBacktest, a.CodeTypeTechnischeAfloswijze, c.CodeTypeAflossingPrepaymentBacktest, c.CodeTypeVervroegdeAflossingPrepaymentBacktest, c.CodeTypeRedenEind, c.CodeTypeRedenVervroegdeAflossingPrepaymentBacktest, b_omgezet.LeningdeelID FROM DatamartPrepaymentBacktest.dbo.DimLeningdeelPrepaymentBacktest a INNER JOIN InformationHub.dbo.Leningdeel b ON a.LeningdeelID=b.LeningdeelID LEFT OUTER JOIN Informationhub..Leningdeel b_omgezet ON b.LeningdeelIDOmgezet = b_omgezet.LeningdeelID INNER JOIN DatamartPrepaymentBacktest.dbo.FeitenPrepaymentBacktest c ON a.DimLeningdeelPrepaymentBacktestVersieKey=c.DimLeningdeelPrepaymentBacktestVersieKey WHERE c.ContractueleAflossingPrepaymentBacktest > 0 and a.CodeBusinessUnit = XX and a.GeldigVanaf < '2013-01-06 00:00:00' and c.Boekperiode < '2013-01-05 00:00:00' and c.Boekperiode >

	'2007-01-01 00:00:00' and b.IngangsdatumLooptijd IS NOT NULL and b.IngangsdatumLooptijd < '2013-01-03 00:00:00' and a.WerkgeverID = 0 and a.IndicatiePersoneelsregeling = 'N' and a.Looptijd <= 900 and a.Rentevastheidsperiode > 0 and c.RentevastheidsperiodeVerstreken <= 900 and c.RentevastheidsperiodeResterendeDuur > 0 and b.Hoofdsom > 0 and c.CodeTypeAflossingPrepaymentBacktest != 4 and c.LooptijdVerstreken IS NOT NULL
Effective maturity (with linking refinanced/reconsidered loan parts)	
DESCRIPTION	Query below returns the elapsed maturity at which the loan part has been terminated, i.e. the query determines the effective maturities.
QUERY	SELECT DISTINCT a.LeningdeelID, b.IngangsdatumLooptijd, b.Aflosdatum, CASE WHEN b.LeningdeelIDOmgezet IS NOT NULL THEN DATEDIFF(month,b_omgezet.IngangsdatumLooptijd, c.Boekperiode) ELSE c.LooptijdVerstreken END AS LooptijdVerstreken, CodeTypeTechnischeAfloswijze, b.Hoofdsom FROM DatamartPrepaymentBacktest.dbo.DimLeningdeelPrepaymentBacktest a INNER JOIN InformationHub.dbo.Leningdeel b ON a.LeningdeelID=b.LeningdeelID LEFT OUTER JOIN Informationhub..Leningdeel b_omgezet ON b.LeningdeelIDOmgezet = b_omgezet.LeningdeelID INNER JOIN DatamartPrepaymentBacktest.dbo.FeitenPrepaymentBacktest c ON a.DimLeningdeelPrepaymentBacktestVersieKey=c.DimLeningdeelPrepaymentBacktestVersieKey WHERE c.CodeTypeRedenVervroegdeAflossingPrepaymentBacktest in (2,4,7) and b.Aflosdatum IS NOT NULL and a.CodeBusinessUnit = XX and a.GeldigVanaf < '2013-01-06 00:00:00' and c.Boekperiode < '2013-01-05 00:00:00' and c.Boekperiode > '2007-01-01 00:00:00'and b.IngangsdatumLooptijd IS NOT NULL and b.IngangsdatumLooptijd < '2013-01-03 00:00:00' and a.WerkgeverID = 0 and a.IndicatiePersoneelsregeling = 'N' and a.Looptijd <= 900 and a.Rentevastheidsperiode > 0 and c.RentevastheidsperiodeVerstreken <= 900 and c.RentevastheidsperiodeResterendeDuur > 0 and b.Hoofdsom > 0 and c.CodeTypeAflossingPrepaymentBacktest != 4 and c.LooptijdVerstreken IS NOT NULL
Liquiditeitstypische prepayments	
DESCRIPTION	Query below calculates the liquiditeitstypische prepayments made per elapsed maturity (which is linked for refinanced/reconsidered loan parts).
QUERY	SELECT DISTINCT a.LeningdeelID, CASE WHEN b.LeningdeelIDOmgezet IS NOT NULL THEN DATEDIFF(month,b_omgezet.IngangsdatumLooptijd, c.Boekperiode) ELSE c.LooptijdVerstreken END AS LooptijdVerstreken, c.VervroegdeAflossingPrepaymentBacktest FROM DatamartPrepaymentBacktest.dbo.DimLeningdeelPrepaymentBacktest a INNER JOIN InformationHub.dbo.Leningdeel b ON a.LeningdeelID=b.LeningdeelID LEFT OUTER JOIN Informationhub..Leningdeel b_omgezet ON b.LeningdeelIDOmgezet = b_omgezet.LeningdeelID INNER JOIN DatamartPrepaymentBacktest.dbo.FeitenPrepaymentBacktest c ON a.DimLeningdeelPrepaymentBacktestVersieKey=c.DimLeningdeelPrepaymentBacktestVersieKey WHERE c.CodeTypeRedenVervroegdeAflossingPrepaymentBacktest in (2,4,7) and c.VervroegdeAflossingPrepaymentBacktest > 0 and a.CodeBusinessUnit = XX and a.GeldigVanaf < '2013-01-06 00:00:00' and c.Boekperiode < '2013-01-05 00:00:00' and c.Boekperiode > '2007-01-01 00:00:00' and b.IngangsdatumLooptijd IS NOT NULL and b.IngangsdatumLooptijd < '2013-01-03 00:00:00' and a.WerkgeverID

	`= 0 and a.IndicatiePersoneelsregeling = 'N' and a.Looptijd <= 900 and a.Rentevastheidsperiode > 0 and c.RentevastheidsperiodeVerstreken <= 900 and c.RentevastheidsperiodeResterendeDuur > 0 and b.Hoofdsom > 0 and c.CodeTypeAflossingPrepaymentBacktest != 4 and c.LooptijdVerstreken IS NOT NULL and c.CodeTypeRedenEind != 4 and c.CodeTypeRedenEind != 3`
Current loan parts	
DESCRIPTION	`Query below selects characteristics from the loan parts in the current portfolio that are required to run the Excel macro.`
QUERY	`SELECT [nr_lnng] ,[nr_lnngdl] ,[dtm_ing_afls_lnngdl] ,[dtm_eind_lnngdl] ,[kd_aflswze] ,[lptd_lnngdl] ,[bedr_hfdsm_lnngdl] ,[sldo_schldrst] ,DATEDIFF(month,GETDATE(),[dtm_eind_lnngdl]) as 'Residual Maturity' ,DATEDIFF(month,[dtm_ing_afls_lnngdl],GETDATE()) as 'Elapsed Maturity' ,[perc_akternte] FROM [StagingISHYS].[dbo].[r_leningdeel] WHERE [per_bkng] = '01-jul-2013' AND kd_lnngdl_stat_aktl = 'B' GO`

APPENDIX F – MEMO CLASSIFICATION PREPAYMENTS

The memo below was discussed with several colleagues, including ALM modellers; it is in the original form and mostly in Dutch. Additional discussion on this memo is in section 4.3.1.

[CONFIDENTIAL]

APPENDIX G – LIQUIDITEITSTYPISCHE PREPAYMENTS

The figures below give additional insight in the *liquiditeitstypische* prepayments. These prepayments were split out in type of mortgage, in marital status, NHG and fixed rate period. The continuous variables discussed are the age of the borrower, the mortgage rate, seasonality and seasoning. A discussion on the visible patterns was given in section 4.4.2.

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Figure 82

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Figure 83

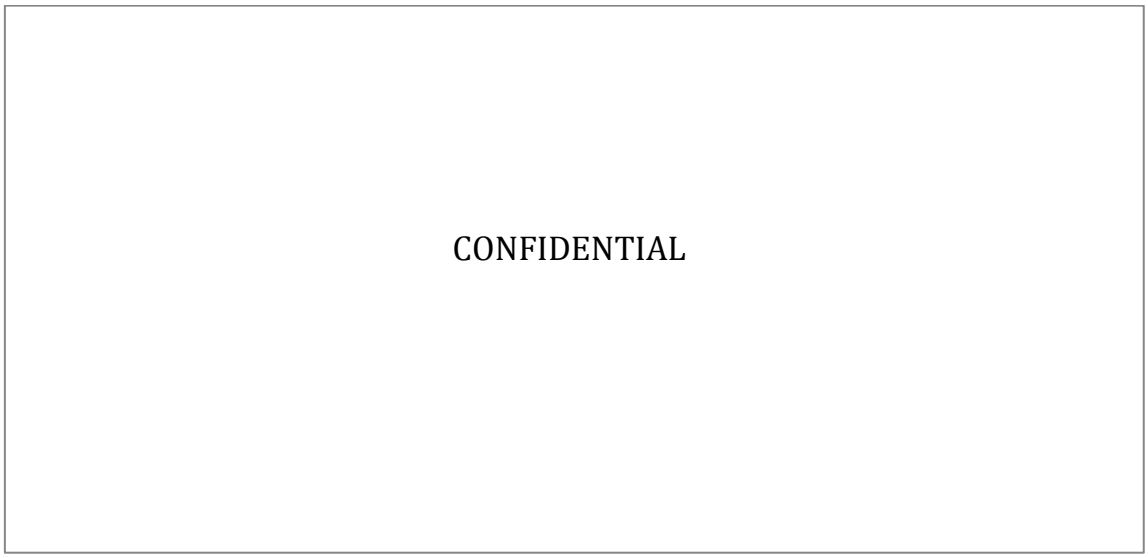

Figure 84

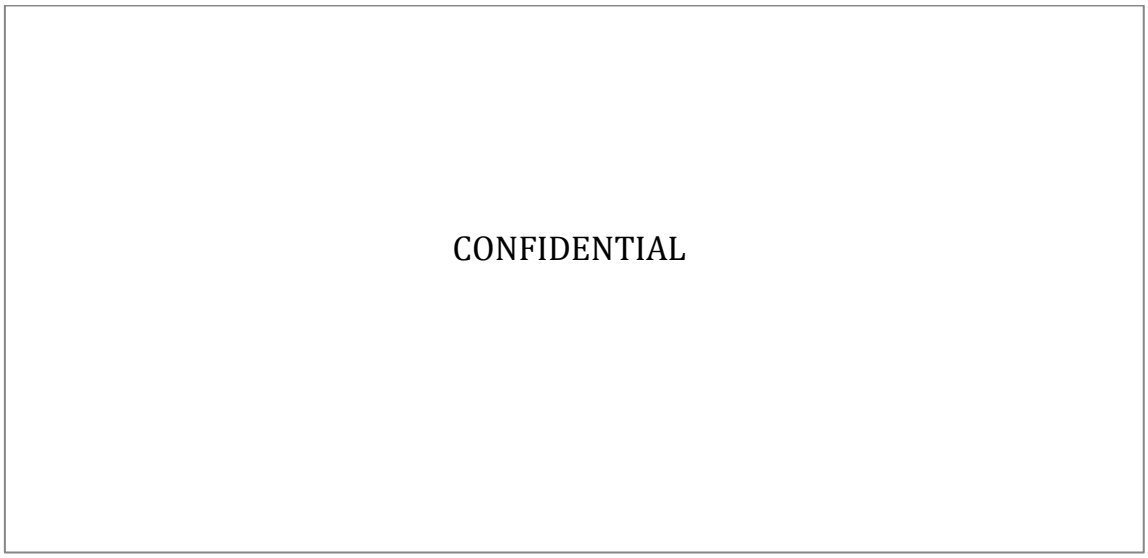

Figure 85

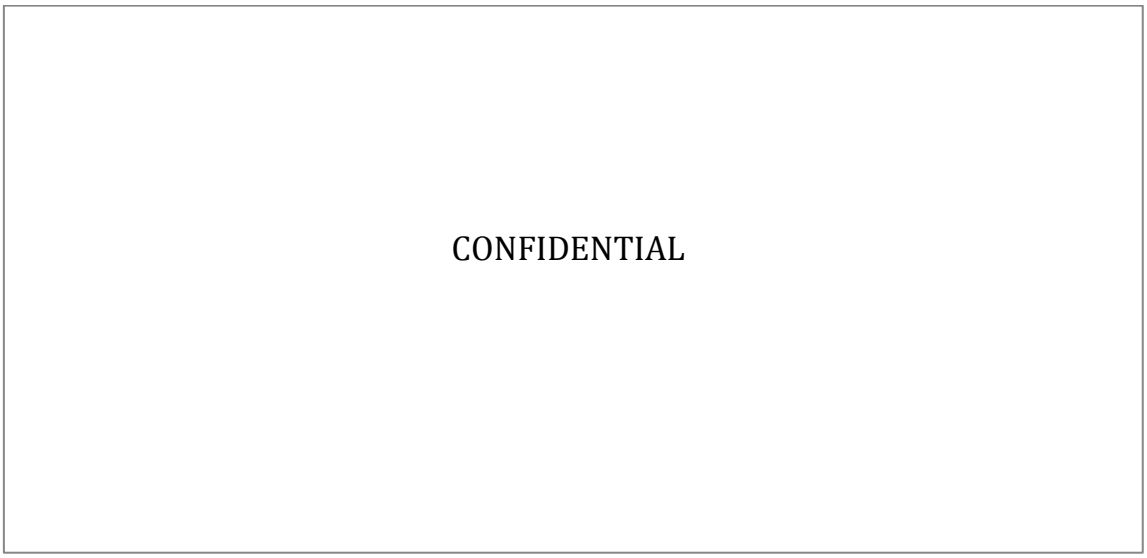

Figure 86

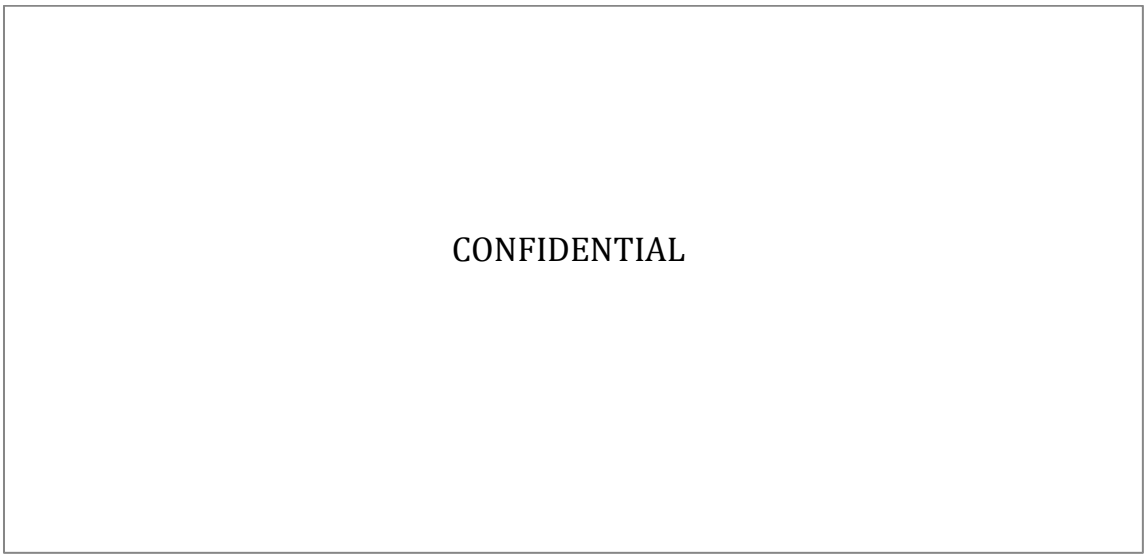

Figure 87

APPENDIX H – OUTPUT REGRESSION ANALYSIS

ABN AMRO LABEL

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FLORIUS LABEL

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