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A credit risk analysis of the Norwegian bank bond market

Effects of MREL implementiation in the Norwegian bank bond market

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Abstract

If recovery and resolution directives are credible, investors owning bail-in debt will have an incentive to monitor the risk of a bank. In this thesis we have analyzed the effects of the new EU resolution framework, with a special focus on the minimum requirement for own funds and eligible liabilities (MREL). We have studied how the Norwegian bond market, mainly focused on Tier 2, senior and senior non-preferred (SNP) debt, have shifted the risks within the mentioned debt classes. The new debt class SNP is introduced as a consequence of the MREL regulation.

We have constructed our own credit model to price the credit risk inspired by the Merton model. The results from our model are then compared with market data collected from Nordic Bond Pricing (NBP). We find the pricing of these debt classes to be in line with their position in the credit hierarchy. The relative risks within our credit model are also comparable to the market data. However, within the SNP class we observe two securities where a call option seems to be mispriced. A SNP bond with an embedded call option traded at levels equal to an equivalent bond without the option, with equal credit risk, are most likely mispriced and thereby being an arbitrage opportunity. This breaks the premise that an option has a strictly positive value. As the implementation of the SNP class is an ongoing process, we believe the differences between credit risk from NBP data and our own estimates will settle over time.

As the MREL regulations are not fully implemented in Norway yet, there can be new changes concerning the volume of SNP expected to be issued by the market. The total volume of SNP issuances can change even without regulatory changes, because the requirement of each bank depends on how their assets are distributed. In our analysis we find the volume and pricing of SNP debt to be positively correlated with the MREL set for banks. A higher MREL requires more SNP debt to be issued.

Preface

The research presented in this thesis is a part of our master's degree in Economics and Business Administration with a major in Financial Economics at Norwegian School of Economics.

There are several persons we would like to thank for advice and support through working with this thesis. We would sincerely like to thank our supervisor, professor Svein-Arne Persson, for his timely feedback, good discussions and critical insights. Your guidance has helped to make this thesis educational.

We also express our gratitude to Torgeir Stensaker and Lars Andreas Løwe Løtvedt in Nordea Asset Management for sharing their insights, providing us with examples and helping us understand how the MREL framework will impact the Norwegian fixed income market. We also thank Pål Prestegård Jonassen for helping us organize and better understand the data provided to us by Nordic Bond Pricing. Finally, we would like to thank friends and family for their support.

Bergen, December 2021

Arne Kalland-Olsen & Jarand Reiersen

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List of abbreviations

BRRD - Bank recovery and resolution directive

Bps - Basis points

CBR - Combined buffer requirements

CCB - Counter cyclical buffer

Coco's - Contingent convertibles

CRD - Capital requirements directive

DGS - Deposit guarantee scheme

EEA - European economic area

EFTA - European free trade association

EIM – Early intervention measure

EU - European union

FRN - Floating rate note

FSAN - The financial supervisory authority of Norway

FSB - Financial stability board

IPS – Institutional protection scheme

MREL - Minimum requirement for own funds and eligible liabilities

NIBOR - Norwegian InterBank Offered Rate

NBP - Nordic bond pricing

NCWO - No creditor worse off

NOK - Norwegian kroner

Pillar 1 - Requirement for core common equity capital

Pillar 2 - Requires companies to carry out an internal assessment of capital requirements

RWA - Risk-weighted asset

SNP - Senior non-preferred

US - United States

1. Introduction

During the global financial crisis of 2007-2009 several major banks worldwide failed and were bailed out by their sovereign governments. In the wake of the crisis, regulators in the United States (US) and the European Union (EU) started a process to improve banking regulation that would help to ensure stability and improve lending conditions (European Council, 2012). In the US this has resulted in requiring national and foreign banks to sustain a Total loss-absorbing capacity (TLAC). In Europe, this has resulted in increased capital requirements. Our focus will be solely on European capital requirements and how these regulations have impacted the Norwegian bond market.

This paper investigates how the Norwegian bank bond market will be affected by the EU minimum requirement for own funds and eligible liabilities (MREL). Our objective is to provide analyses and insights for the following research question:

How will the implementation of senior non-preferred (SNP) bonds alter credit risk, and thus the price, within the market for bank bonds denominated in Norwegian kroner?

The Bank recovery and resolution directive (BRRD) was adopted in 2014 as a preventive measure against future crises. BRRD is a part of EU legislation, and it covers banks, credit institutions and investment firms. The directive is part of a broader review of EUs financial legislation aimed at reducing risk in the financial sector (Banking reform package) and making it more resilient (Finanstilsynet, 2019). The directive is concerned with equity- and debt holders bearing the losses in situations where the bank fails. One of the new additions of the BRRD framework will play a major role for banking debt instruments in the coming years. Specifically, it states minimum levels of the first debt layers after the equity layer. These first debt layers are called junior debt. The purpose of the BRRD is to harmonize the order of priority for creditors in the member states, meaning that junior debt financing has changed across the European union.

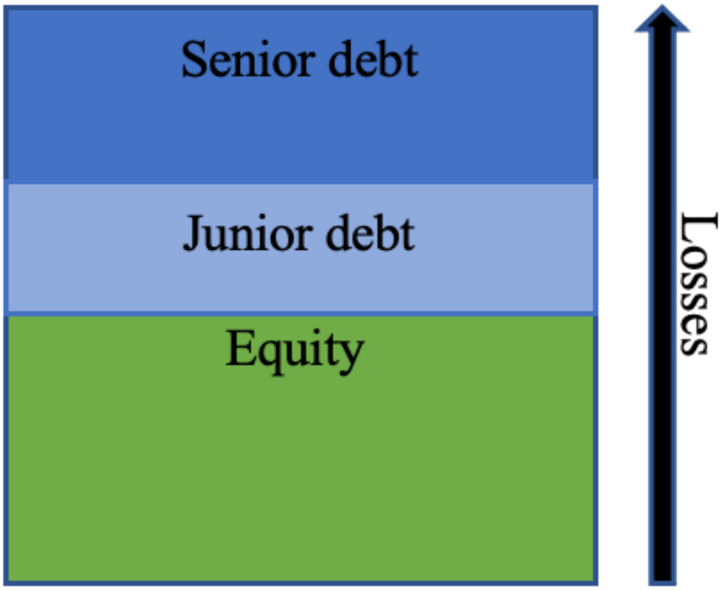


Figure 1: Financing side of a bank.
BRRD has set requirements for how banks are allowed to choose their junior debt. Losses are borne from the bottom and up, meaning the equity needs to be lost before junior debt suffers losses.

As well as decreasing regulatory differences across member states in the EU, BRRD also directly impacts the market for junior debt in two ways: it creates a clearer hierarchy of which asset classes take losses first in a bail-in situation. For investors, a clearer subordination makes it easier to understand the risk profile and therefore to price financial instruments accordingly. In case of a default, the subordinated debt will not be paid back until the debt that ranks higher is paid back in its entirety. Secondly, the directive states that banks could raise a new type of subordinated debt to fulfill the new MREL. The new debt class is the SNP.

We will study the effects of these regulations on the Norwegian bond market. The BRRD is aimed against EU credit institutions and systemically important investment firms. Norway is not a member of the EU, but through the membership of the European Economic Area (EEA) it is obligated to enact important directives and regulations (Sjøqvist et al., 2020). However, Norway (and the other EEA/EFTA-countries) are lagging behind in the implementation of EU financial legislation. As a result, an EEA-directive which correspond to BRRD was implemented into Norwegian law on January 1st, 2019. Some parts of the banking reform package are also implemented, specifically rules determining minimum levels of equity capital and a partial introduction of the MREL requirements.

The rest of our thesis is structured the following way: We start by explaining how the credit hierarchy of Norwegian banks changes as a result of the MREL regulation. Then we will create a credit model to simulate the spreads and yields for different types of bonds impacted by the MREL. Next, we compare the results from our simulation against actual data received from

Nordic Bond Pricing (NBP). A discussion of how and why our model can analyze credit risk follows. In addition, this paper will take a closer look at some interesting pricing patterns within the SNP class. Lastly, we will summarize our results.

Throughout this paper we will consequently refer to the capital classes as equity, Tier 2, SNP and senior, for the financing items in focus. What we refer to as “senior” is actually senior unsecured, since there also exists a debt class called senior secured. We have been able to follow the latest changes regarding the MREL implementation in Norway, as well as some analysis on exciting pricing oddities that were corrected in September.

1.1 Scope of thesis

At the time of writing, there are still changes regarding the regulations concerning MREL. Capital requirements regulation II (CRR2) and banking recovery and resolution directive II (BRRD2) have made the framework for setting MREL significantly more complicated. These regulations have been further specified during the period in which we have written our thesis but are not finally adopted into Norwegian national law. Based on this ongoing regulatory process, we do our analysis based on the best interpretation made by the Financial Supervisory Authority of Norway (FSAN), the opinions of leading Norwegian banks and our own interpretation of the information we have available as of November 2021.

Other research articles, such as Crespi et al. (2018), have pointed out that the phasing-in period of MREL, could have a temporary impact on the SNP prices. We try to clarify this in our analyzes, but it is also worth noting there may be a transitory effect on prices of the bonds during the first years of SNP trading.

In the ownership structure of Norwegian banks, there are “Kredittforetak” which are entities that issue debt with mortgages as collateral. Most, if not all of these collateralized securities are rated AAA, and they are viewed as one of the safest investments in Norway. Because the “Kredittforetak” are special entities, they are not directly a part of the banks’ balance sheet. We are mainly interested in the market for junior debt and not the market for the collateralized mortgage obligations. Since they are not on the balance sheet directly, we omit them from our analyses. We are more eager to investigate how credit risk is compensated, and because of the high ratings on mortgage obligations, we determined to focus on the riskier parts of banking activity.

2. Background for MREL

2.1 Creditor hierarchy

To obtain the most information from this thesis, we wish to familiarize you with the balance sheet of a typical business bank. Specifically, we focus on the financing side of the bank, as opposed to the asset's banks hold. The reason we do not cover the asset side closely is because SNP and other equity and debt instruments fall into the financing category. The financing side of a bank tells us how large the debt and equity of the bank is. Both the equity and debt can be further dissected into a credit hierarchy. The impact of regulating the composition of the capital structure plays directly into the relative risks shared within the credit hierarchy. This is what happened with the introduction of MREL, by introducing SNP bonds risk carried by different tranches of equity and debt have shifted slightly. The credit hierarchy has been affected by the introduction of SNP bonds, because it imposes restrictions on how large layers within the hierarchy have to be.

Which order the assets are in the hierarchy, determines the risk and return of the asset. When regulators decide the size of one element within the credit hierarchy, it also affects the surrounding elements. Before we explain how the surrounding elements are altered as a result of the SNP's introduction, we will present the hierarchy.

The SNP debt is placed where it bears losses after the equity and Tier 2 layers. As a consequence, the SNP bond is affected by credit risk, and owners of this asset wish to be compensated for this risk. Since SNP bonds suffer losses as the third layer, SNP debt is often referred to as Tier 3 capital. Meanwhile, the senior debt contains less credit risk as a result of the creation of the SNP class. The credit risk is reduced since the SNP layer effectively increases loss absorbing capital, thereby reducing the risk for owners of senior debt.

FINANCE SIDE HIERARCHY	FULL DESCRIPTIONS
GUARANTEED DEPOSITS	*Deposits guaranteed by the Deposit Guarantee Schemes (DGS)*
TAX LIABILITIES	*Transactional taxes or other liabilities owed to the government*
NON-GUARANTEED DEPOSITS	*Deposits by households not covered by DGS*
SECURITIES ISSUED, DEPOSITS LARGE CORPORATIONS	*Senior secured,* *Corporate deposits, senior debt*
SNP	*Senior non-preferred debt*
TIER 2	*Subordinated Debt (Tier 2)* • *Asset Revaluation* • *Undisclosed Reserves* • *General Provisions/loan-loss Reserves* • *Hybrid instruments (debt/equity) capital instruments (Coco's)*
Equity	*Equity* • *Additional Tier 1* • *Disclosed Reserves* • *Common Equity Tier 1 (CET1)*

Table 1: Creditor hierarchy.
Losses are borne first at the bottom of the hierarchy, with each subsequent layer upward being the next. Source: (Sairally et al, 2013).

With the introduction of MREL, there has been a further clarification of the credit hierarchy. Figure (2) on next side shows how the new regulation has impacted the hierarchy.

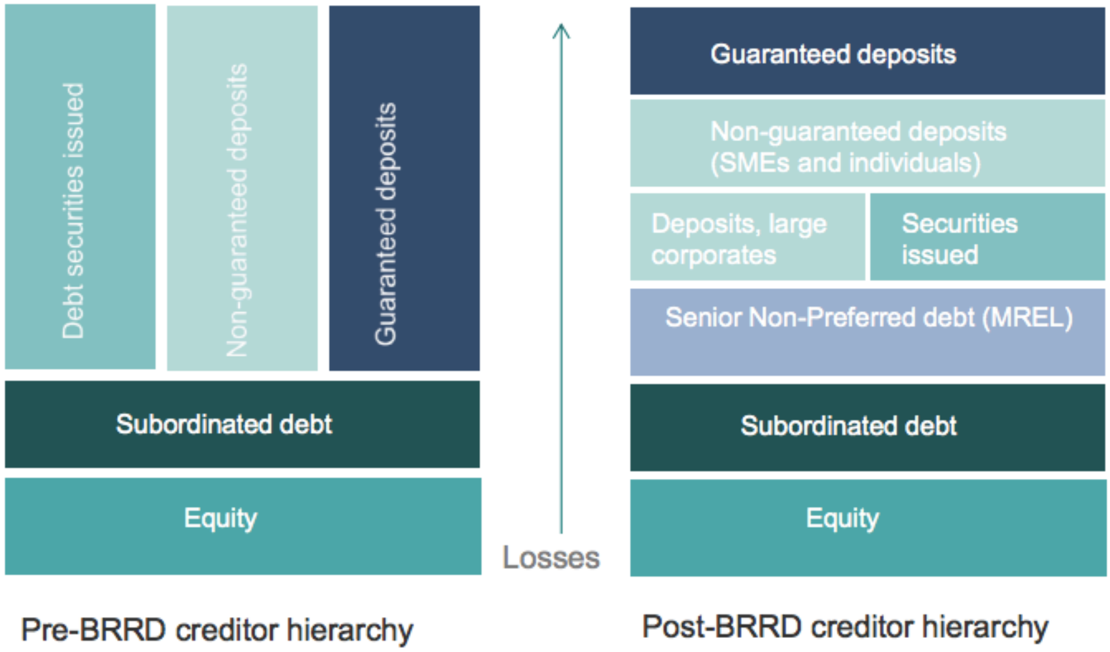


Figure 2: Effects from BRRD on creditor hierarchy.
We are now following the credit hierarchy on the right. Note the introduction of SNP in the figure on the right. This is the new class. Source: DNB, (2019).

To provide an example of a capital structure we have illustrated the financing side from DNB's annual report 2020 into a bar chart. Later in the thesis, we will take a closer look at the structure of Norwegian banks and how large the various capital classes are. The composition of equity is the least important part of the creditor hierarchy, since our main concern are the debt instruments above the equity. What can be noticed by figure (3) is that SNP is zero, as DNB issued their first bonds of this type during 2020.

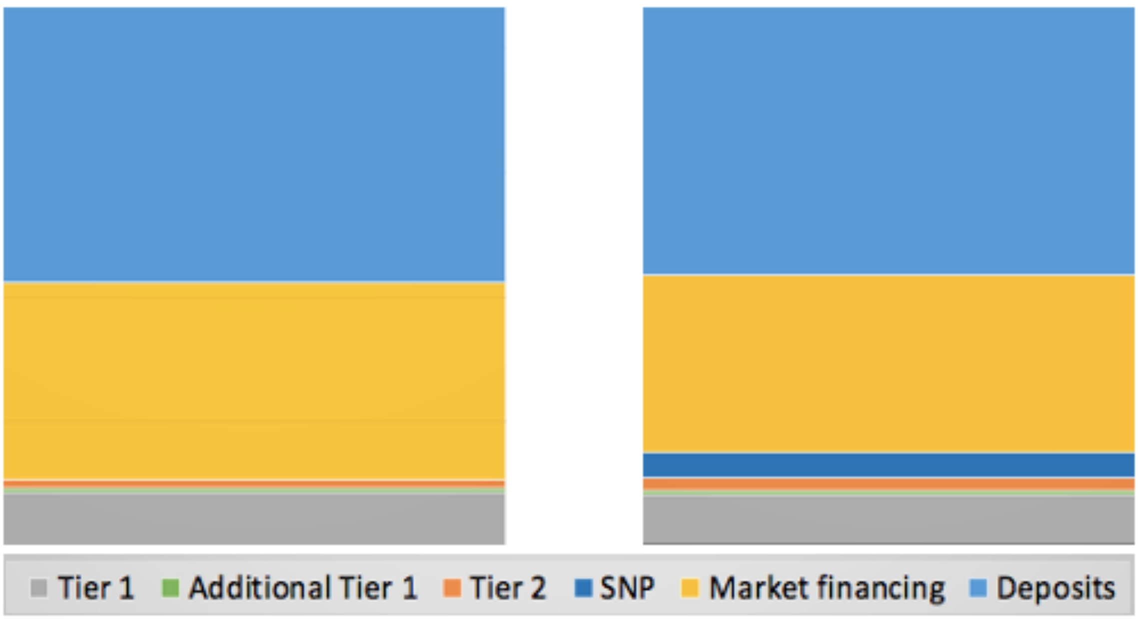


Figure 3: DNB financing side 2020 (left) and our expectation for DNB financing side 2024 (right).
The amounts in DNB's financing side illustrating the relative size of the capital layers. We have also created an estimate for when SNP debt is fully implemented. SNP is a thin layer, but nonetheless important.

We continue explaining the intricate interactions that take place between these layers of capital. Also, we will describe and analyze if there are adaptations in the market that seem strange, and if so, what the motivations behind them are. But first, we will present the MREL timeline.

2.2 MREL overview

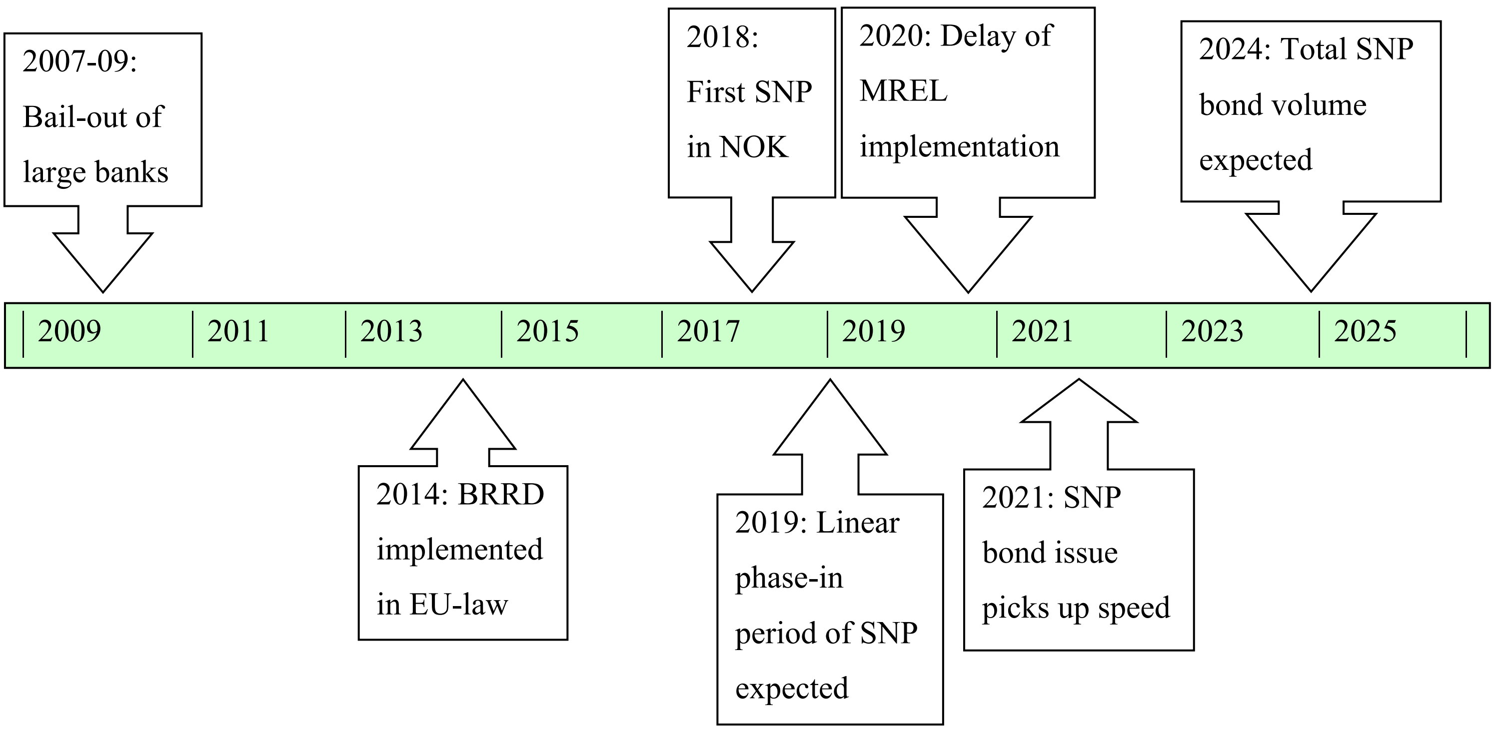


Figure 4: Timeline for MREL implementation.

The MREL requirements are new and, in some areas, still in change. The timeline gives an overview of why the MREL regulation was created and what will happen. Norwegian banks started preparing for the implementation of MREL in the period right after 2015. The Financial stability board (FSB) presented its first proposal for new principles for crisis resolution banks in 2011. The principles, in a somewhat adjusted version, form the basis for the EU crisis management directive (BRRD) which was adopted in 2014. To prepare for the coming capital regulations, banks operating in the Norwegian market started issuing SNP bonds.

The BRRD framework is based on three main pillars: (i) Recovery planning, (ii) Early intervention and (iii) Resolution (EBA, 2021). Recovery planning is about the banks building up capital reserves in good times, so they are equipped in times of crisis. Some scenarios of crises lead to larger bank losses than others. With an early intervention there is still the possibility of preventing major problems. Resolution is winding up the entire bank. Resolution is initiated if fears of contagion to other parts of the financial system prevents ordinary insolvency proceedings from being performed. Keeping core financial services is key to performing a successful resolution (SRB, 2021). As a result of these principles, a crisis situation must first be addressed by the institution itself, before supervisors start the intervention or resolution processes. This should be done as it stands in the BRRD:

"Article 32(1)(b) BRRD, one of the conditions for resolution is that 'having regard to timing and other relevant circumstances, there is no reasonable prospect that any alternative private sector measures, including measures by an institutional protection scheme (IPS), or supervisory action, including early intervention measures (EIM) or the write down or conversion of relevant capital instruments in accordance with Article 59(2) taken in respect of the institution, would prevent the failure of the institution within a reasonable timeframe".

Essentially all private sector initiatives must have failed or be likely to fail before national authorities can place a bank in the resolution phase. How regulators can determine if all options are exhausted or likely to be exhausted does not have a clear answer. Most likely they would outsource this question to a group of experts.

In the big picture it can be said that MREL works in two ways; (1) in resolution and (2) as a preventive regulation. As described earlier, MREL clarifies how to ensure a fair and effective resolution process. MREL is therefore contained within the BRRD, providing the means for the overall directive. Banks are obligated to keep plans for recovery based on a number of indicators, which they deliver to resolution authorities (Hoff, 2017, p. 7-10). If banks start breaching buffers, they will contemplate which of the steps described in the recovery plan to improve their indicators. If banks fail to meet their capital requirements, over time it will weaken the recapitalization capacity and loss absorbing abilities. This is why the recovery plan contains scenario plans for which banks are able to preserve, rebuild or issue additional stock, thereby improving capital ratios. At the core of these plans is the functioning of basic credit services, being able to issue loans and access deposits. Should the need arise for resolution, regulators will help speed up the process, since it is in the public interest to maintain a functioning banking industry.

The MREL regulations are structured so that it comes into play when entering a resolution process. MREL also has a preventive effect. The expectations embedded in the regulations reinforce sound capitalization of banks, which is represented by adding a new capital layer in the capital structure of the banks. However, while we are still in the initial phase of the MREL regulations, it is seen by many as a greater burden than its preventive potential in a situation where the bank is failing (Dec & Masiukiewicz, 2020). For banks that are already fairly well capitalized, it is easier to see the MREL regulation as representing increased regulatory cost and financing choice restrictions.

After all, MREL is possibly a more preventive measure and does not provide enough clarity of how resolution would be completed. In resolution, MREL is described as a solution that can quickly convert SNP debt into equity so that the bank can quickly re-emerge and continue normal operations. However, assessing the size of losses, determining which creditors are given which haircut is an ominous task. In real life, re-establishing a bank quick enough without triggering legal battles concerning if any creditors are left worse off this seems to be impossible. This is because altering the size of the estimated loss can be so profitable for investors, if they are able to avoid being wiped out. We will come back to the re-emergence of a bank following a resolution process in the section about bail-in capital.

2.3 European banking regulation

Within European banking regulation, there is a difference between hard capital requirements and softer requirements that trigger dividend restrictions. The pillar 1 and pillar 2 requirements constitute the absolute minimum requirements before a bank is deemed non-viable. Additionally, system buffers and countercyclical buffers together with pillar- 1 and 2 make up the combined buffer requirements (CBR). A breach of MREL and CBR does not necessarily mean the bank is going into resolution, but if the pillar 2 requirements are breached, this seems to us like a reasonable time to invoke crisis management. However, a breach of MREL and CBR should lead to dividend and bonus restrictions. Differences between requirements and buffers is nicely illustrated in Martino & Parchimowicz (2020) page 9.

While the amount of own funds is statutorily required through the CRR, MREL is custom-made to each institution. On the next side is an illustration of the capital requirements and MREL that are set for banks.

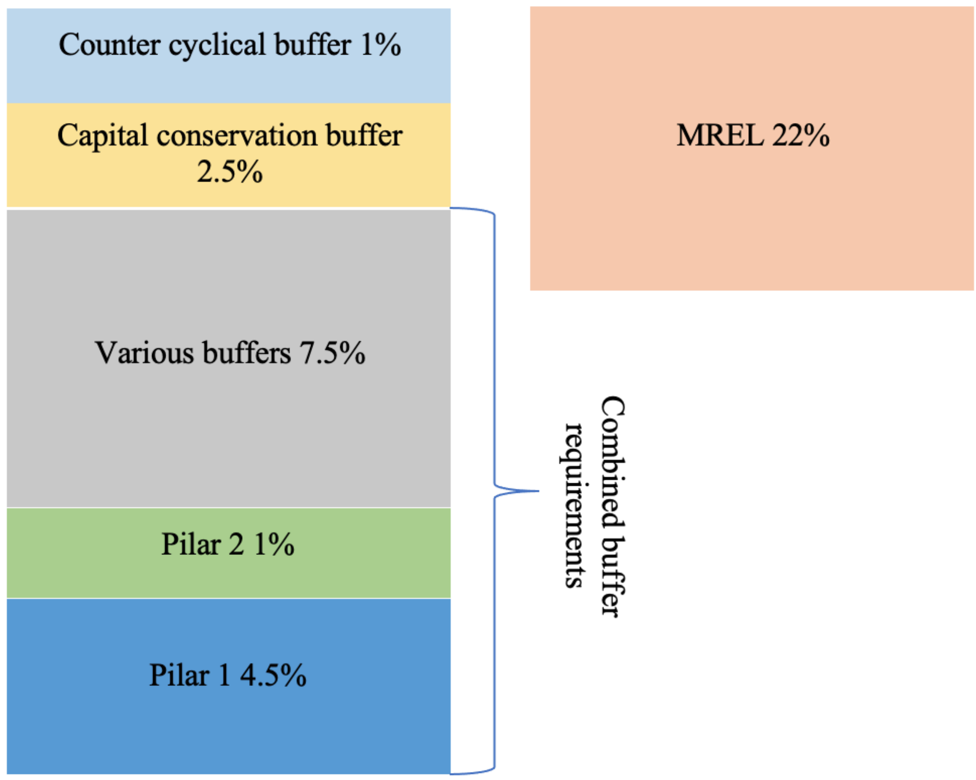


Figure 5: Structure of capital requirements.
Equity requirements and how MREL is related to the overall capital requirements of Norwegian banks. The MREL requirement is both a part of the capital requirement, while simultaneously sitting atop of the capital requirements. Stylized box sizes are not proportional to their value.

The MREL requirement concerns all the three lower capital layers within the credit hierarchy, shown in figure (1). While the new SNP debt in itself constitutes the third layer within the credit hierarchy, the MREL regulates the three lower levels of capital. As a result, the MREL requirement covers both equity and debt, which is why we in figure (5) place the MREL-level next to the capital requirements, while it actually sits both at the top and within the capital requirement. The total capital requirements will vary from bank to bank as not all buffers are required for all banks.

2.4 MREL regulations in Norway

MREL is as mentioned previously a part of the implementation of the EU bank recovery and resolution directive. BRRD is established to prepare recovery plans for banks to overcome financial distress (European Commission, 2020). The crisis management directive requires member states to establish specific crisis management regulations that ensure financial stability. Banks, other credit institutions and certain investment firms, as well as the authorities are provided with tools to prevent and deal with crises at an early stage. The BRRD was an additional regulation amending and expanding on previous banking regulation.

The directive states that the MREL requirement must be covered by subordinated capital or debt instruments with lower priority than senior debt (Finanstilsynet, 2019). As a result, a new type of convertible debt, the SNP bond was created. Banks do not have to issue SNP bonds, but there is a common view that it will be preferable to issue this type of debt. The alternative would be to fill the MREL requirement with Tier 2 capital, which will probably be more expensive and more difficult in a regulatory setting. Since Norwegian banks are already required to have high levels of equity compared to international banks (DNB, 2020), fulfilling the MREL requirement with SNP capital seems like the best choice. There is already enough capital ready to absorb losses and provide relief, should there be a need for it. All of the Norwegian banks that have been subject to an MREL requirement are therefore currently issuing SNP bonds.

The financial supervisory authority of Norway has set a MREL for 14 of the largest banks in Norway. Among others, banks that have received their MREL requirements include DNB, Sparebanken Sør, Sparebanken 1 SMN and Sparebanken Vest. The requirement is calculated on the basis of risk-weighted assets, where mortgages have a low risk-weight, while business loans will have higher risk weights because they are more likely to default. Cash and cash equivalents carry zero weight. We will describe this process in section 6.2.

MREL consists of a loss absorption amount and a recapitalization amount. The loss absorption amount is tied to current capital adequacy requirements, while the recapitalization amount is linked to the expected capital requirement after the crisis management is performed and the business continues to operate (The Norwegian Government, 2020). The starting point is the EU regulations, with adjustments for FSAN to maintain some discretion for maneuvering national crises. The Norwegian banks started the process of issuing eligible debt instruments in 2020. The banks have made plans, so the new SNP capital is gradually phased in as required by FSAN.

When presented, the banks had to fulfill the requirement within the phase-in period lasting until 31.12.2022. However, in early 2020 the pandemic Covid-19 affected the whole world. FSAN announced to the banks that received a claim on MREL in December 2019, that the deadline for fulfilling subordinated requirements was postponed to 1. January 2024

(Viljugrein, A. & Karslen, O. 2020). The aim was to help mitigate the economic effects of the pandemic, and let banks focus on core activities.

In 2018 Nordic Credit Rating calculated that Nordic banks will need to issue around €100bn of the SNP bonds (Cotton & Kristiansen, 2018). These numbers were based on the regulations and market prospects in 2018. The calculated numbers on the total amount of SNP bonds issued by Norwegian banks has varied over the years and with new clarifications on the regulations. Now, in September 2021, it is estimated Norwegian banks need to raise at least NOK 190 billion in additional SNP-funding, instead of the approximately NOK 300 billion previously anticipated in 2020.

Example of a MREL calculation:

	Loss absorption amount	**Recapitalization amount**
P1	4.5%	4.5%
P2	1%	1%
CCB	2.5%	
Various buffers	7.5%	
CCyB (only valid as a loss absorption amount)	1%	
SUM	**16.5%**	**15.5%**
MREL =	**2xP1 + 2xP2 + Buffers**	**= 22%**

Table 2: Example of the MREL calculation.

The example is close to the reality for most of the Norwegian coastal banks. In this example the bank has received a MREL of 22% based on the calculation: 2xP1 + 2xP2 + Buffers. The numbers in this table are the same as in figure (5).

Above we have created an example of how FSAN could have set an MREL level of 22%. What makes the requirement-level vary between banks is the size of the various buffer component. These buffers will be slightly lower in banks with low operational risks, and higher in banks with more operational risk. For example, this level could be 7% for one bank and 8% for another, resulting in a different MREL requirements.

The directive can make a claim on subordinated debt to an upper limit of the highest of 8% of total assets and the formula: P1 x 2 + P2 x 2 + C, where C is the sum of buffers required. The formula is built up of a loss absorption amount and a recapitalization amount. The buffers will only be counted one time but are valid for both amounts. The difference between those two is the countercyclical buffer which only counts towards the loss absorption amount. Which buffers that should be counted in will vary from bank to bank. Some examples of such buffers are systemic risk buffer, institution-specific countercyclical capital buffer and buffers for systemically important banks. To regulate banks is an enormous task, so we will not go into detail on how all buffers are determined. Also, the equity components are not an integral part of our further analyses.

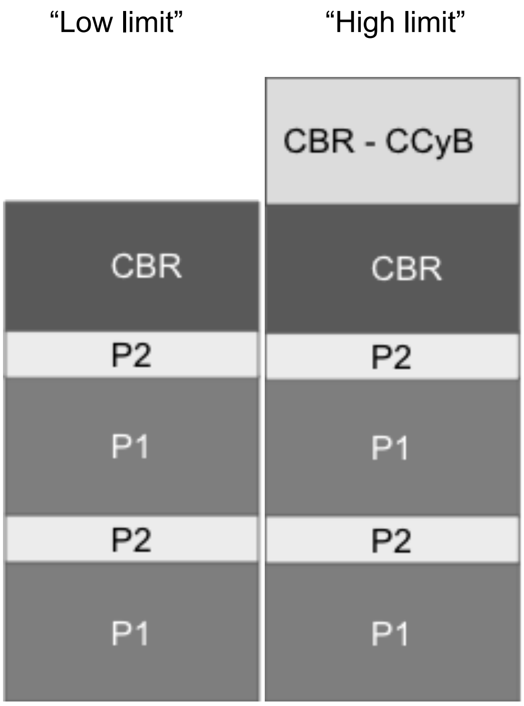


Figure 6: The impact from BRRD2 on MREL.
The rules have been unclear on how to implement the directive. In 2021 FSAN clarified the regulation which made the banks switch from "high limit" to "low limit". As a result, we use the low limit in our calculations.

Figure (6) illustrates the main alternatives that were considered when setting the MREL requirement. The figure on the right would almost double the CBR, essentially increasing the capital requirements for banks substantially.

FSAN has clarified that the equity used to fulfill CBR can also be used to fulfill the subordinated requirement according to the formula. This method is also referred to as "double counting" (Martino & Parchimowicz, 2020), since equity in excess of Pillar 2 counts towards both MREL and CBR. The Norwegian banking industry was prepared for the "high limit" case, where equity in excess would not count towards both CBR and MREL. As a result of the clarification from the Norwegian Financial Authorities they will now, as of September 2021, prepare for a “low limit”.

2.4.1 Changes in the crisis management regulations (BRRD2)

The FSAN initiated a public hearing October 2020 on their working on implementing CRR2 and BRRD2 to Norwegian law. EU directives and regulations have no immediate direct effect on Norway, but FSAN is responsible for implementing core EU financial regulations into Norwegian law. The consultation note points out that the new BRRD2 directive has to some extent already been operationalized in Norway, nevertheless the actual implementation of the directive will require more assessment parameters than in the early phase, as a result of more detailed requirements for determining MREL capital (The Norwegian government, 2020).

BRRD2 specifies the rules and levels for subordination of MREL instruments. After BRRD2 was adopted, however, there have been differing views on how the regulations should be understood. Especially in the question of how different capital requirements are stacked and prioritized was a cause for confusion. Different interpretations created divergent estimates for the needs of issuing new SNP bonds to satisfy the requirements.

As of September 16th, the latest correspondence between Norwegian banks and FSAN indicate that a low cap of MREL capital is going to be the configuration banks will need to implement. This means that Norwegian banks can issue fewer SNP bonds in 2021 than has been expected by the industry in the years leading up to the implementation. Because the overall need for MREL capital is lower, the required annual phase-in amount is lower. However, banks are still able to follow their initial plans for SNP debt, but market participants in the Norwegian bond market believe that banks will not issue more than required in 2021. What we observed from the market data after September, was that banks issued fewer SNP bonds in the last quarter of 2021.

With banks preparing for the “low limit” this can also impact the rating of debt securities issued by our banks of interest. E.g., in July 2021 Moody’s upgraded several senior debt instruments one notch based on there being a larger cushion of SNP debt instruments to decrease losses given default (Sparebanken Sør 2021, Moody). However, after the updates of September 16th, we expect some of the upgrades may be reversed. This is because banks are no longer obligated to increase the level of subordinated SNP capital to improve the protection for senior bonds. We can also imagine banks choosing to issue an amount of SNP debt in line with what was previously communicated, so that they can keep their improved rating on senior unsecured debt. How credit rating agencies react to the updates will most likely depend on which policy they see from each bank. Banks will most likely perform financial optimization, obtaining the lowest possible funding cost available. Even though some institutions may receive a lower credit rating, the lobby organization for the finance and insurance industry seemed satisfied with the clear communication from the FSAN.

The Director of Banking and Capital Markets at Finans Norge, Erik Johansen wrote on their website; "It is very gratifying that the authorities have concluded on this difficult issue and clearly communicated how the banks now have to deal with this. This is an important clarification that will give Norwegian banks the necessary predictability when adapting to the crisis management regulations and plan for fulfilling MREL" (Finans Norge, 2021).

2.5 Bail-in capital

SNP bonds are debt instruments that can be converted into equity, making the instrument a hybrid instrument. However, opposed to ordinary convertibles, which have a strike price, the SNP bonds do not have an explicitly stated conversion price. Additionally, it is not up to the owner of the SNP bonds to exercise the equity option embedded within the instrument. This can be confusing, since the instrument has some of the characteristics of an option and existing convertibles, but at the same time it is up to crisis authorities to decide at what point and at which terms the SNP bond is converted. Exactly how market participants should price this part of the SNP bond is still a conundrum. SNP bonds are debt, but in cases of large losses of equity and Tier 2 capital, it can be converted into equity. We will not go into detail of how this process can be completed. Sweeping changes have been made, at least in theory, to banking regulation with the introduction of bail-in. We need to thoroughly understand the bail-in principle, where bank creditors are increasingly held accountable for losses. The bail-in principle has quickly become the prevalent principle in bank regulation, and also a feature of SNP debt.

Regulators have imposed stricter capital- and liquidity requirements for banks after the financial crisis. The idea is that shareholders and unsecured bondholders should bear the risk and take losses in case of financial distress. This induces banks to reduce their risk, because equity- and debtholders are liable for all losses incurred. The bank can then recapitalize, and if losses are large enough, it can convert bonds to equity.

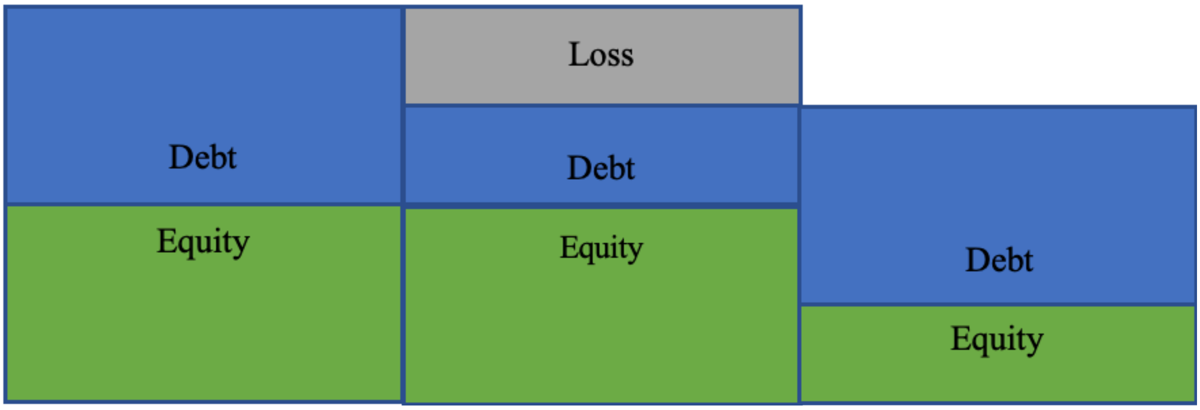


Figure 7. Before bail-in capital.
The bank has a certain portion equity and debt. The bank suffers a loss and is left with the same amount of debt, while the equity is reduced by the loss.

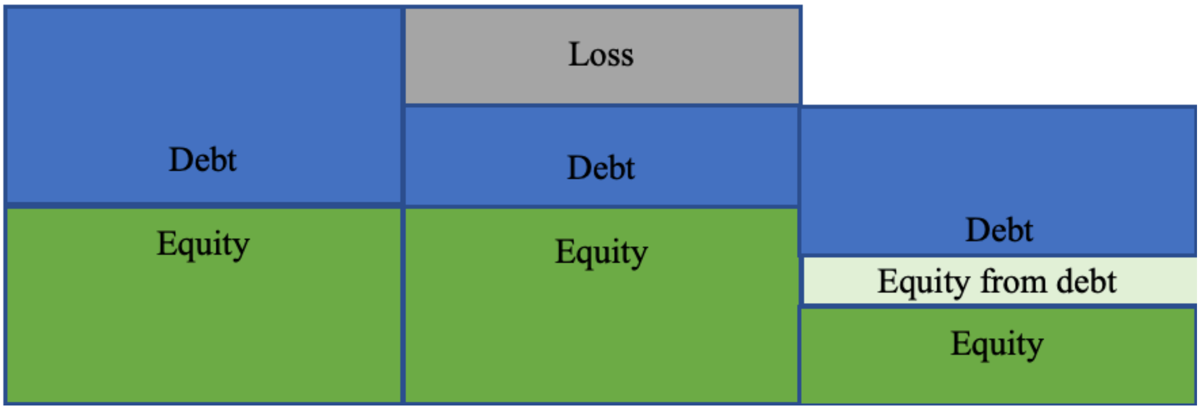


Figure 8. Post bail-in capital.
The bank has a certain portion equity and debt. The bank suffers a loss and is left with less debt and equity. However, a portion of the SNP debt is converted to equity.

The MREL requirements are meant to have a dual purpose (Martino & Parchimowicz, 2020). Firstly, to provide a countercyclical impulse to banks, by letting investors increase the funding costs of banks they see as taking excessive risks. Secondly, MREL is meant to be a tool to handle a bankruptcy if a bank is failing. Capital requirements are meant to make sure guaranteed deposits do not suffer losses (ECB, 2019). Since governments offer these guarantees, there is strict regulation within the industry so that deposits are safe and credit flow is not overly affected by variations in economic activity.

The SNP debt will be written down and possibly converted by crisis management if the bank is failing. If the SNP debt is not sufficient, the crisis authorities must write down or convert senior debt. Crisis authorities are legally required to make no creditor worse off, which means that they are not allowed to make creditors suffer larger losses by restructuring a bank, than they would suffer losses under public administration. The principle is called; no creditor worse off (NCWO). This is stated in the EU directive from 2014; “No creditor shall incur greater losses than would have been incurred under normal insolvency proceedings" (Directive

2014/59/EU (BRRD), article 34(g)). For example, would SNP equity owners after a successful bail-in have an unlimited upside such unconverted equity? This could have been an interesting research question as well, but we chose to keep it outside of our scope.

As far as we can tell there has not yet been any case of bail-in being used to rescue an ailing bank, with the exception of the banking crisis in Cyprus (Demetriades, 2018). In the Cypriote banking crisis, the losses were so large that even depositors received a haircut, which temporarily decreased the trust in the banking system. A large proportion of households suffered losses for deposits, while some also lost equity they had invested in national banks. The new shareholders after converting debt to equity were mostly Russian and Ukrainian oligarchs, who may not be the desired shareholders seen from the public's view.

There could be other adverse effects if equity owners are wiped out and replaced by debtholders. Firstly, debtholders can be less involved in the day-to-day activities of the banks, because they lack strong incentives to pay close attention (Hessami, 2013). Because of the higher security in their claims, this decreases the incentive to monitor the bank, since they can rely on equity owners to reign in the bank. Secondly, debtholders may not be interested in running a bank, for example if they wish to receive stable payments, which differs from the variable payoff equity owners can expect.

Another potential pitfall when assessing the bail-in principle is that not all debtholders are aware of the risks involved when investing in SNP assets. E.g., a pension fund that invests in assets perceived as safe may lose retirees money based on the choices of the asset managers. If bail-in capital then receives a haircut and gets converted into equity, losses are then borne directly by the retiree's which governments want to protect by applying the bail-in principle. What we wish to highlight is that even though bail-in capital is elegant in principle, applying it under uncertainty and time pressure can be a daunting task.

Lastly, there is a fundamental difference between a system-wide meltdown of financial institutions and having one bank that is on the verge of failing. In the event of a financial collapse, bail-in principles will be applied before the government has a possibility to step in. If all options for private sector initiatives fail, and the bank is deemed to be systemically important, it would probably be bailed out in some form. For a single bank in trouble, this is where the MREL regulatory framework can work its wonders.

2.6 Callable SNP bonds

SNP bonds in the Norwegian market mostly come in two forms. Those that are issued with an embedded call option and those issued without an option. What this option does is that the issuing bank can repurchase the face amount of the bond from investors, usually one year before maturity. When there is less than a year until maturity, SNP bonds with call options can typically be called once per quarter. The possibility to call bonds early is something the banks will wish to do due to regulatory efficiency (Torgeir Stensaker, 2021). Therefore, the distinction between callable and non-callable bonds are important both to investors who purchase these instruments and for the banks issuing them.

Since there is no prevailing method of rolling over SNP bonds, this can cause issues closer to the maturity date. Issuers of SNP will often wish to rollover existing SNP, since only debt with more than one year until maturity counts towards the MREL requirement. Callable SNP debt has proven to be popular among issuers because it gives them greater flexibility to retire the bond at par value one year before maturity, which is the date of MREL-ineligibility. Also, banks do not have to go through the hassle of negotiating with owners of non-callable SNP debt, if they wish to maximize regulatory efficiency. For the issuing bank, SNP debt that is not rolled over would be ineligible for MREL, and thus viewed as overly expensive. The MREL requirement is the main reason why SNPs are issued in the first place.

Simultaneously investors expect to be compensated according to their credit risk, which is still subordinated to senior debt. This mismatch between how investors expect to be compensated and how inefficient short-term SNP debt is viewed from the bank's viewpoint is a conflict that needs resolution. There are two ways in which a bank can achieve regulatory efficiency, and hopefully mitigate and compensate investor’s credit risk: It can either repurchase a bullet SNP bond before maturity, or it can call back a callable SNP bond. But the transaction cost and uncertainty will be much lower for the bank if they can call back the callable bond. Doing either of those two will hopefully alleviate the conflict between the issuing bank and the investor.

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
COUPON	-2	-2	-2	-2	0
ISSUE (REPURCHASE)	100				(100)

Table 3: Potential cash flows from a 5NC4.

A 5NC4 is a 5-year bond that can be called back after 4 years. We note that the bank receives a positive cash flow at the start of year 1 and is able to call back the bond at par at the start of year 5. If the bond is not called, it will pay another coupon in year 5 of 2.

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
COUPON	-2	-2	-2	-2	-0
ISSUE (REPURCHASE)	100				(100+x)

Table 4: Potential cash flows from a five-year bullet.

Here the issuer needs to negotiate a repurchase price of x relative to par. This imposes both a transaction cost and the uncertainty of what the issuer needs to pay over par. If it is repurchased, then this will happen in the start of year 5. If not, they would pay another coupon of 2 in year 5.

The value of the call possibility will depend on two aspects; the probability that the bond will be called back, and the steepness of the credit curve. As mentioned, the bond is issued to fulfill the FSANs requirement. The bonds are riskier and also more expensive than normal senior bonds. As a result, the probability that the bonds are called back is very high. The steepness of the credit curve will tell how costly it is to have the bond for another period. It is possible to make calculations to predict the cost. Pål Prestegård Jonassen from Nordic Bond Pricing stated that they add about 10 basis points (bps) to the yield of SNP bonds with built in call options, compared to those without. We will come back to the pricing of call and bullet SNP bonds later.

3. Related litrature

Although the regulations and the SNP bonds are fairly new, some research has already been conducted on the subject. This applies to literature from other countries and markets, where progress has been faster than in Norway. It is worth noting that different countries' financial supervisors could have adapted and interpreted the regulations somewhat differently than Norway. However, in the big picture most countries have a similar implementation of MREL.

Jensen & Skovsgaard (2017) investigate how capital markets are affected by the MREL requirement. Additionally, they perform a thorough spread-analysis based on the Merton model. We are interested in comparing our collected spreads with our own version of the theoretical credit spreads which they also recreated.

Crespi et al. (2018) was investigating how the pricing of senior bonds in the Italian market has changed with the issuance of bail-in bonds. The result from their research showed the spread was increasing and that issuing bonds became costlier after SNP entered the market.

Martino & Parchimowicz (2020) probe how the MREL requirements are supposed to be both a resolution mechanism, as well as being preventive of bank failure. Additionally, they find that so long as banks are in an expanding economy, MREL requirements only function as disciplinary for banks, since resolution is out of the question. Lastly, how MREL regulation functions in conjunction with other capital requirements is nicely illustrated, with a discussion on what restrictions are imposed with different breaches.

4. Methodology

4.1 Structure

Since the inception of the SNP bonds, we are interested if the SNP bonds are priced consistent with established bond pricing models. If the market for Norwegian SNP bonds does not fall in line with what we would expect from comparable debt markets, there would be money to be made correcting market inefficiencies. On the other hand, if the market functions reasonably well, we expect the SNP market to be similar to other debt markets. To check if the market for SNP bonds is priced accordingly, we want to investigate if the SNP bond, which is a debt asset, has characteristics in line with models used to price debt assets. The characteristic we are mostly interested in concerns credit risk, which uses the spread as a measure. Additionally, we will recreate yields in our credit model.

For our credit model, we looked at existing models that model both equity and debt. The model developed by Merton in 1974 contained many of our desired properties. Another advantage is that we can recreate spreads using the Merton model if we calculate the yield and subtract the theoretical risk-free rate. Therefore, we wish to compare our collected data from Nordic Bond Pricing (NBP) with a Merton model. The Merton model will also contain a lower limit, which we use to determine losses for the different creditors in the model.

First what we want to do is present our collected dataset. The dataset contains SNP bonds, but also has yields and spreads of Tier 2 capital as well as senior bonds. By having these different tranches within the credit hierarchy, we can do different kinds of analyses. For example, we will find relative spreads, meaning how SNP spreads are as a multiple of the other spreads.

Specifically, we are interested in how the relative spreads between debt classes compare. Subsequently, we will compare both quantitatively and qualitatively what separates our theoretical spreads from our collected spreads. Also, we can gain an understanding on how credit risk is altered under different market conditions. We hope this can give a better sense of how the introduction of SNP bonds affects the Norwegian bank bond market.

We make initial data analyses and explore how our model performs compared to market prices. Later, we evaluate if the callability of bonds is priced with the previously mentioned 10 basis points premia. In each step, we will do our best to clearly explain how we select our data, and why we believe it is relevant to do so. The results will be discussed during the analysis, as well as being summarized by the end of this section.

5. Data collection

5.1 Data categories

To best investigate how the introduction of the SNP bonds affect the overall banking bond market, we have chosen to analyze debt instruments issued by banks. Having received data from NBP of subsequent layers within the credit hierarchy, this gives us a unique opportunity to find the credit risk for each security. This is especially true when we thoroughly control for factors that might confound our findings. With these considerations in mind, the data we have received from NBP are from the following categories.

SNP	Senior non-preferred bonds issued by banks in category Bank 1 and Bank 2
Bank 1	Senior debt from large Norwegian banks: DNB
Bank 2	Senior debt from large regional banks and coastal banks: Sparebank 1 SR-Bank, Spb Vest, Spb 1 SMN
Subordinated debt 1	Tier 2 bonds from Bank 1
Subordinated debt 2	Tier 2 bonds from Bank 2

Table 5: Description of what our dataset received by NBP contains.

Especially for the banks, there is a larger difference between the two categories, than there exists within each one bank category. The banks in “Bank 1” have better access to market funding than banks in “Bank 2”. Also, since the regional- and coastal banks are smaller, they are oftentimes not the biggest lenders to risky businesses. Business risk and risk-weighted assets are typically lower for a regional bank than it is for DNB, while the business risk between any two regional banks is often very similar.

5.2 Data handling by NBP

Our empirical analysis focuses on the time-series of Nordic banks for the period 2015Q1 up until 2021Q4. The data is retrieved from Nordic Bond Pricing, a dataset containing data on Tier 2-, SNP- and senior bonds issued in Norwegian kroner (NOK) in this period. The data contains information on price, spread, yield, duration and maturity for all bonds.

We note that the data from NBP is not actual pricing but calculated based on a basis of data reported from all leading banks and brokerage houses combined with other observations from the market, such as traded prices (Nordic Bond Pricing, 2021). Therefore, during periods of few transactions and large market turbulence it is hard to determine if quoted prices are legitimate. Most of the time, bond traders we have talked to say that NBP prices are fairly accurate and close to the price where they can make trades (Torgeir Stensaker, 2021). For this reason, we choose to trust the reported prices.

In the data we received from NBP there are for each bond, several data points that are closely related. These points are the credit duration, the price, the yield and importantly, the spread. NBP uses the 3M Norwegian InterBank Offered Rate (NIBOR) to build a yield curve. This yield curve is the markets best guess at future interest rates. The yield for each asset is then compared to the yield curve based on NIBOR, before a bootstrap method is used to calculate the Z-spread. We will describe this process in detail in section 6.6.

5.3 Data overview

Description	Year	2015	2016	2017	2018	2019	2020	nov.21
	Senior	237	227	222	244	246	204	193
Bond overview	SNP	0	0	0	2	11	26	57
	Tier 2	19	27	39	57	51	47	51
	Total bonds	256	254	261	303	308	277	301
	Credit duration in years							
	5.5 -					3	3	13
	4.5-5.5				2	8	12	18
SNP	3.5-4.5					6	15	23
	2.5-3.5					1	9	14
	1.5-2.5					1	3	8
	0-1.5						1	1
SNP	Callable	0	0	0	0	0	17	38
Norwegian banks	Non-callable				2	6	2	2
FRN	Senior	102	101	103	116	118	93	87
Norwegian banks	SNP				2	5	18	35
Fixed	Senior	125	119	115	126	126	109	96
Norwegian banks	SNP					4	4	7

Table 6: Information about our dataset.
Every year we provide the number of individual bonds we have data for at that time, as well as the composition. For example, we start in 2015 by having prices for senior and Tier 2 bonds. The composition of bonds changes over time.

Table (6) shows what our obtained dataset contains. We illustrate the bonds we have prices for in any given year. Also, we show the composition divided by the three debt classes, as well as if the senior and SNP pay a floating or fixed rate. The most noteworthy information from this figure is the information about SNP bonds. Those are the numbers we will study most in detail during this thesis. We observe that the number of SNP bonds in the market was low prior to 2020 and has since increased. We expect this number to climb further until the MREL requirement is fully implemented in 2024. An additional detail is that most SNPs are issued with a call, which we will provide a numerical example of in section 9.

As mentioned earlier, the Norwegian banks started issuing SNP bonds in NOK in 2020. The issues of SNP bonds in the Norwegian market before this were made by foreign banks such as Nordea and Danske Bank.

6. Model framework

6.1 Building our credit model

Merton's credit model (1974) seems like a natural place to start when we want to investigate what drives the credit risk in the Norwegian bank bond market. By creating a credit model where we can control the input parameters, we can build in the MREL regulation to compare how changes in individual parameters could affect credit risk. We then draw parallels from the model we create to the market data.

The model works under the risk-neutral probability measure. Changes in the asset values are described by the formula where W_t is a Wiener process. We have a constant drift of rf and a volatility σ. The constants rf and σ are given initially.

$$dV_t = rfV_t dt + \sigma V_t dW_t \tag{1}$$

The solution to formula (1) is:

$$V_t = V_0 exp((rf - 0.5 \times \sigma^2) \times dt + \sigma W_t) \tag{2}$$

A thorough calculation and description of the two formulas can be found in the paper to Jensen & Skovsgaard (2017). We will use formula (2) to find our asset values in a Monte Carlo simulation.

Assessing losses

The Merton model has two asset classes: equity and debt. The business, which is modelled, is controlled by the equity holders. In our case, we will call this business a bank. The owners of equity will continue paying bondholders as long as it is in their best interest to do so. There is only one bond outstanding, with face value K and maturity at T. As long as the asset value (V_T) is greater than the debt (D), the latter will be fully paid back, equivalent to $V_T > D$.

At time zero we have equity and debt. The total asset value at time zero is a given constant. B_T is the payoff of the debt, while S_T is the payoff of equity.

$$B_T = min(D, V_T) = D - max(D - V_T,\ 0) \tag{3}$$

$$S_T = max(V_T - D,\ 0) \tag{4}$$

Simplified, we can say that the equity holders run the firm. They pay D to retain their ownership to be worth more than D. If the total amount of assets is less than debt, the equity holders will not pay back D, as seen in (4). In this case debt holders receive the amount remaining of V_T as a recovery instead of the promised D, shown in formula (3).

In an extension of the Merton model, Black and Cox (1976) made a model where default can appear prior to maturity of the bond. In a model like this, the losses occur if assets hit a lower boundary. This can be looked at as a covenant to the bond (Lando, 2004). We use the covenant property in our model, since we will evaluate the asset values at a number of discrete periods.

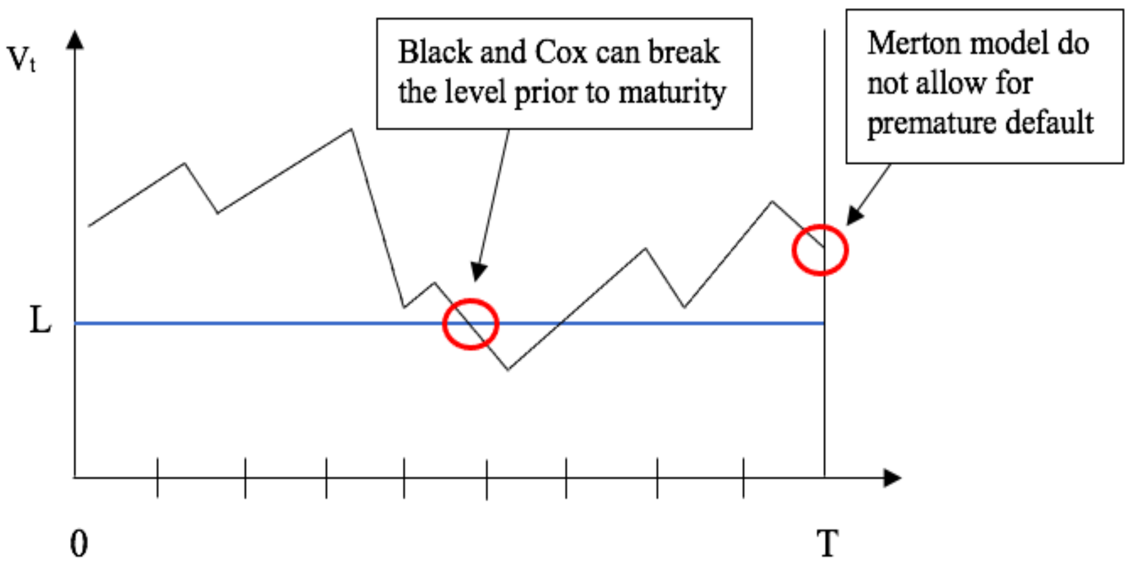


Figure 9: Illustration of difference between Black and Cox model and Merton model. *When evaluating the asset values against a lower boundary L, the Merton model evaluates at the end of the finite period T. While Black-Cox is evaluated in continuous time against the boundary and stops evaluating asset values at the time of default (when L is breached). We use the MREL and estimates of the bank's future balances to set our boundaries for the different asset classes.*

Conceptually, what we are doing is evaluating if V_T breaches a lower boundary at any one of the finite periods where we decide to check the asset value. This is what Black and Cox wrote in their 1976 paper. We therefore change our perception of debt, from formula (3) to (5).

The new payoff function at maturity is:

$$B(V_T, T) = min(V_T, D)1\{\tau > T\} \tag{5}$$

In most cases the bondholders will be repaid at maturity (T). However, if the assets hit the boundary level, and then default, on a time before maturity, τ, then payoff will be:

$$B(V_\tau, T) = C_1(\tau)\, 1\{\tau < T\} \tag{6}$$

The payoff is at the default time τ. In this setting the equity of the firm is a down-and-out call option. $C_1(\tau)$ are by Lando defined as a function of coupons paid in connection to the bond. The Black and Cox model finds that such a default barrier will increase the bond price and lower the spreads even though the risk is also increasing. It is a result of the bondholder taking over the rest of assets of the firm at default time, while in Merton's model a strictly positive equity amount, which is given, is owned by the shareholders.

Summary

The most important takeaway from our credit model is illustrated in figure (9). By creating asset values based on the Merton model we can assess credit risk for the debt classes that are most affected by the new MREL regulations. We introduce limits as seen from Black and Cox, which we check at each interval for which we compute an asset value. The limits are determined by the size of debt classes, and when these classes start suffering losses. A detailed description of how we set these limits appear in section 7.2. We have now explained the origins of our credit model. In the next sections we will describe other core concepts, parameters and methods we use to make the credit risk model. Our analysis will revolve around us changing parameters of interest, before we interpret the output and discuss how this relates to our data.

6.2 Risk-weighted asset

The bank's assets consist in broad terms of cash, issued loans, financial securities and more. The total value of those assets is as previously explained given by V_t in our model. This book value of the assets is essentially when defining the risk-weighted asset (RWA). RWA is the assets of a bank or off-balance-sheet weighted for risk. The measure links the capital amount a bank needs to the risk profile of their lending activity (APRA, 2020). The more risk connected to the bank's activity; the more capital is needed.

The level of RWA_t can be described as the book value of the assets multiplied with a constant. This gives the result that a certain percentage of the book value gives the RWA.

$$RWA_t = V_t \times w \quad (7)$$

This number is important because it is actively used to set the MREL targets. The bank levels of RWA can vary over time depending on the assets. However, based on DNBs report about risk and capital management the RWA has been on a stable level since 2014 (DNB, 2019). Then over the five-year period for our simulated bonds we assume the variable to be a constant in this thesis, w.

A short and simplified example follows of how to find the risk weighted assets for a bank with total assets of NOK 100. Different balance sheet elements are multiplied with an exposure amount to the level of risk connected to the assets. The calculation is repeated for all the different exposure amounts. As the table shows, cash has a risk weight of 0%, while business loans exposure to risk is 100%. We use RWA from the banks themselves later in this thesis.

ASSETS	*AMOUNT (NOK)*	*RISK (%) APPROX*	*RWA (NOK)*
CASH	15	0%	0
SECURITIES	10	0%	0
HOUSING LOANS	40	25%	10
SMALL / MEDIUM BUSINESS LOANS	10	70%	7
BUSINESS LOANS	25	100%	25
TOTAL AMOUNT	**100**	**43%**	**43**

Table 7: Illustrated RWA for a hypothetical bank.

6.3 Creditor hierachy and assessing losses

In some cases, we will end up in situations where the value of assets is not enough to repay everyone who has a claim on it. In situations like this the previous defined creditor hierarchy will be followed. Furthermore, a simplified example follows:

Vt = Value of assets Ds = Debt senior SNP = SNP E = Equity

	Vt < Ds	**Ds < Vt < (SNP + E)**	**Ds + SNP < Vt**
Senior	Vt	Ds	Ds
SNP (T3)	0	Vt - Ds	SNP
Equity	0	0	Vt - (Ds+SNP)

Table 8: Creditor hierarchy.
What creditors are left with in different scenarios. The bank is simplified and has only three asset classes.

As seen, equity only receives something back in the cases where the different debt holders are paid back first. This is a simplified overview over equity and debt, which we thoroughly described in section 2.1.

Loss given default (LGD) is a risk parameter used in many academic papers. One of the most used variants is the approach presented by Moody's in 2006. It is described by Moody's that the expected loss for a security is the product of the probability of a loss and the loss given a default (Moody's, 2006). The formula for LGD is given in formula 8:

$$LGD_{k,t} = \sum_{s=k}^{t}((IS_s + LP_s)/((1 + c_s)^{s-k+1}))\,/B_k \quad (8)$$

Explained shortly, the formula defines the LGD as a discounted present value of an interest shortfall and the loss from the principal value by a default. The coupon rate, c, is used as the discount rate for period s. Small t is time, while k is a reference date. IS and LP is the two losses, interest shortfall and loss of principal value. B is the outstanding principal value. In the formula the reference date (k) can appear as three dates, origination date, at default and a cohort formation date.

The output from our model will give an expression for loss given default, something that will be used further to find spreads and yields for our bonds of interest.

6.4 Monte Carlo simulation

Monte Carlo simulation, also known as multiple probability simulation, is a mathematical technique that is used to estimate the outcome of an uncertain event (IBM, 2020). We will present the basic principles behind Monte Carlo simulations. The method uses the law of large numbers to approximate the expected value of an uncertain event. The law of large numbers states that the mean of a sequence of independents and random variables will converge to the expected value $E[X]$.

$$\bar{X} = \frac{1}{n}(X_1 + X_2 + \ldots + X_n) \tag{9}$$

Where $\bar{X} \rightarrow \mu \; as \; n \rightarrow \infty$

The forecasting model tries to predict the outcome based on a set of estimated values and some fixed inputs. A Monte Carlo model uses one or more probability distributions, for instance a uniform or a normal distribution, and runs the simulation over and over. The precision of the expected value increases as the number of simulations run into the thousands. We reduce the bias by running the simulation as many times as possible, since there is a possibility of obtaining skewed results.

Think of a fair six-sided dice where we record each roll. If we record only ten rolls, there is a chance we do not obtain all the possible outcomes of the dice, and we can be certain that we did not obtain the same number of all the possible outcomes. To avoid this problem, if we simulate a large number of dice throws, we will approximate the uniform distribution. In our case, running a large number of simulations will be especially important for the most secure type of debt we include in our banking model. Because this debt class suffers losses rarely, a low number of simulations will most likely provide zero defaults, which would underestimate the expected default rate.

Number of simulations	Mean Default rate %	Standard deviation in % of mean	Number of runs
10 000	0.3074	8.85	10
50 000	0.307	3.51	10
100 000	0.31404	1.98	10

Table 9: Impact of a higher number of simulations.

As we observe, the mean does not change that much when we evaluate the probability of default. However, the standard deviation as a % of the mean falls sharply. This entails that we are a lot more certain about the range for which the mean default varies when we increase the number of simulations.

We will set up our own Monte Carlo simulation to simulate the bank's liabilities to find what the expected spreads and yields of SNP bonds should be.

The simulation technique has three main steps:

(i) Set up the predictive model

(ii) Specify the distribution and values for the input parameters

(iii) Run the simulation. It is crucial to have a large number of runs to gain a credible result.

Once we have found how the value of the asset develops using Monte Carlo simulation, these results will be used to find coupon payouts on different bonds. Using the theory of risk neutral pricing we will iterate the function over time and try to find the value of the coupon for different types of bonds.

6.5 Bond pricing

Since our goal is to find the level of yields so the risk-adjusted return equals the risk-free rate, we will briefly describe the most important theory of bond pricing. Basic pricing theory tells us that the value of a bond is the expected present value of all its cash flows. The price could be found discounting all the future cash flows with a discount rate. The next step is to evaluate the cash flows. Typically, the coupons are paid out semi-annually, and we will use this in our model. In addition to the coupons the bonds will be paid the principal at maturity.

$$\text{Bond Price} = \frac{C}{(1+r)} + \frac{C}{(1+r)^2} + \ldots + \frac{C}{(1+r)^n} + \frac{M}{(1+r)^n} \tag{10}$$

Formula (10) can be shortened to:

$$\text{Bond Price} = \sum_{t=1}^{T} \frac{C_T}{(1+r)^T} + \frac{Par\ Value}{(1+r)^T} \tag{11}$$

- C = Coupon payment,
- n = Number of payments
- r = Interest rate/discount rate
- M = Value at maturity/Face Value
- T = Number of periods to maturity

6.6 Z-spread

The Zero volatility spread (Z-spread) is a constant spread that makes the present value of the cash flows of a security equal to its price (Chen, 2020). This is true when you add it to a treasury rate curve or its equivalent. The Z-spread is found by using a bootstrap method of trial and error. First, you use the interest rate found from short term treasury bonds to determine discount rates for the period you are interested in. Subsequently, if you have the price of the security, and wish to find the Z-spread, you add basis points when discounting each cash flow so that the present value of the cash flows equals your initial price.

A critique of Z-spread is that there is typically more credit risk the longer until maturity, while this metric does not fully indicate the differences here. Therefore, we have to be aware of how the Z-spread is calculated so we do not make any mistakes by applying it.

We make an example to illustrate how to find a Z-spread for a bond. First, we find the effective rate, given one coupon per year:

Year	Swap rate	Discount factor	Effective rate
1	2.30%	0.9775	2.30%
2	2.60%	0.9500	2.60%
3	*3.00%*	0.9151	*3.00%*

Table 10: Effective rate.
We can extrapolate the implicit interest rates using zero-coupon bonds. In our dataset, 3-month NIBOR is used to calculate the yield curve. If we have semi-annual coupon payments, this will increase the effective rate.

Z-SPREAD

Year	CF	Z-spread	Effective rate	Present value
1	5	0.94%	2.30%	4.84
2	5	0.94%	2.60%	4.66
3	105	0.94%	3.00%	93.49
Sum		*0.94%*		*103.00*

Table 11. Equal Z-spread.
The present value of the cash flows above the treasury curve equals the price of the security. The static spread, or Z-spread is added for each period and discounted. It is found using goal-seek.

$$\text{Bond Price} = \frac{C}{(1+(r_1+Z))} + \frac{C}{(1+(r_2+Z))^2} + \dots + \frac{C}{(1+(r_n+Z))^n} + \frac{M}{(1+(r_n+Z))^n} \tag{12}$$

$r_i = Treasury\ rate\ at\ time\ i$

$C\ = Coupon\ payment$

$Z\ = Z\text{-}spread$

$M\ =\ Face\ value\ of\ the\ bond$

The short example illustrates how Z-spread bootstrapping works in practice. We have a bond which pays an annual coupon of 5% and has the price of 103. We then find the present value of the cash flows based on the term interest rates plus the Z-spread measure that is equal for all three years. By performing a bootstrap where we try and fail until we find a Z-spread so that the sum of present values equals the price of the bond.

Also, we note that the Z-spread value is equal, no matter how many years there are left until maturity. In reality, we will have substantially different values for a Z-spread measure depending on the remaining maturity of the bond. A bond with two years until maturity will typically have a lower spread than a bond with 5 years to maturity.

7. Design of our banking model

7.1 Asset parameters and generation of the model

We were inspired by Lando (2004) to design our stylized balance sheet and run simulations to determine what spread levels we should expect from a Merton model. Because of this, we have created our own credit model which we use to calculate spreads for our debt instruments. Our model uses the Merton model as a starting point and then takes the Black and Cox model as inspiration to allow for default prior to maturity. The model can hopefully provide some insights into which factors that drive the spread differentials, and most importantly how different levels of MREL impacts the bonds.

We have produced a five-year banking model where we check at each discrete period whether the assets are in default. As long as the value of assets is above the predefined threshold for each instrument, it is not in default. If there is a default, we find the proportion of assets that are lost for each debt class. We run a large number of simulations so that the mean approaches the expected value of defaults per asset class. The resulting expectation is what we use to calculate which level of yields and spreads, above the risk-free rate, debt owners should demand.

Formula (13) is equal to the formula (2). Here we present how each value moves with a drift from the previous value.

$$V_t = V_{t-1} exp((\mathrm{rf} - 0.5 \times \sigma^2) \times dt + \sigma \times W_t^Q)) \tag{13}$$

$V_t = Value\ of\ bank\ assets\ at\ time\ t$

$rf = Risk\ free\ rate$

$\sigma^2 = Variance$

$dt = Number\ of\ periods\ per\ year$

$\sigma = Standard\ deviation$

$W_t^Q = Wiener\ process, under\ the\ risk\ neutral\ measure\ Q$

We use formula 13 to model our asset values. We did this by creating a function that contains the arguments listed below. These are our benchmark values. We will later analyze the results we get from changing some of these values.

Parameters	Abbreviation	Value
Risk free rate (yearly)	rf	0.5%
Standard deviation (yearly)	σ	3.5%
Cost of resolution	Z	2%
Number of simulations	n	100,000
T (function argument)	T	5
t (sequence of numbers)	dt	1/4
PONV (equity ratio)		10%
MREL		22%
Value time zero	V_0	100

Table 12: Benchmark parameters in our model.

In the appendix you find a more thorough description of how we make the model and run the simulations.

7.2 Pricing the bonds

After the simulations are done, we want to use the output to price our bonds. The price of a bond at time zero is the sum of the coupon payments and principal value. The value of the coupon payments is given by the formula:

$$\sum_i^T B_i \times e^{-rt} \tag{14}$$

The subscript i denotes to the liability (T2, SNP, senior). In the same way we have a formula for discounted our principal value. The principal value also takes into account whether the bond has been taken in the resolution process.

$$\sum_i^T B_i \left(e^{-rt} \times 1\{\tau > T\} + R_i \times e^{-rt} \times 1\{\tau < T\}\right) \tag{15}$$

Combining the two formulas we have an expression for the value of a bond of liability class i at time zero:

$$B_{i,0} = \sum_i^T c_i \times B_i \times e^{-rt} + B_i\left(e^{-rt} \times 1\{\tau > T\} + R_i \times e^{-rt} \times 1\{\tau < T\}\right) \tag{16}$$

For each simulation we do, we will find a value for the bond. Then by using the law of large numbers we calibrate the bond value.

At the end the coupon rate c_i will be found when $B_{i,0}$ equals B_i. Then our calibrated coupon rate is c_i^*. Having found c_i^*, the spread is calculated by the formula: $s = c - rf$. The calibrated spread is then given by:

$$s^* = c^* - rf \tag{17}$$

This spread is not the same as the Z-spread from our collected data. This is closest to a nominal spread, since we do not have fluctuating prices for our bonds in the model we built. However, the default rates and losses increase the required coupon c* so that the difference between the coupon rate and risk-free rate gives us a model nominal spread.

Figure 3 in section 2.1 showed a graph over the financing side of DNB. We replicate the numbers from DNB here and at the same time make a prediction of an average Norwegian bank. We have used DNB and some of the other biggest Norwegian banks to find a good prediction for numbers we will use in our model. These numbers will be used to determine when the different liability classes take losses.

	Liabilities *(DNB 2020)*	*Liabilities* *(Expected for an average bank when SNP is fully implemented)*
Deposits	51.3%	50%
Senior Bonds	36.3%	35%
SNP	0%	3%
Tier 2	1.5%	2%
Additional T1	0.9%	1%
Equity	10%	9%

Table 13: Liabilities before and after MREL.

The percentage distribution between different liabilities classes in DNB for 2020 at left. At right it is how an average bank will look like after SNP is fully implemented based on our calculations. Senior Bonds includes all senior securities, see section 2.1.

Determining the size and limits of our debt classes

We used book values from DNB to determine the equity level, set at 10%. Subsequently the Tier 2 size is set to 2% and SNP is decided on the basis of the MREL requirement. We calculate the SNP threshold using three pieces of information: FSAN and the published MREL requirements (Finanstilsynet, 2020), from a presentation with the banking industry's own estimates (Torgeir Stensaker, 2021) and by assuming a minimum level of Tier 2 capital.

MREL level	SNP size of total assets
10%	1.4%
22%	3.0%
30%	4.2%
40%	5.6%

Table 14: Our best estimates of SNP volume based on for different MREL levels.

At all times the banks should be holding a MREL ratio above specific minimum requirement, this ratio will differ from bank to bank. We assume this ratio to be 22% in our model. The calculation behind this number is shown in section 2.4.

The first expectations for MREL were presented by FSAN in 2019. At that time, the Norwegian banks were expected to have an MREL of around 33% on average. After the clarification of the regulations, the level of expected issuances is lower.

7.3 Reasoning behind benchmark parameters

Several of the parameters from table (12) have been well described. However, we believe a couple of the parameters need a little more explanation. Before we present the results from the model, we will describe why the combination of parameters have been chosen as they have:

Risk free rate. The risk-free rate chosen needs to stay constant throughout the simulation period, given our model design. Since we both have a growth expectation of 0.5% annually for our assets, and subsequently discount asset value based on the period it is in, the growth rate has only a minimal impact on our overall model.

Volatility measure. The volatility measure in short describes how much assets can vary from one period to another. When we determine a value for sigma, this represents the annual variation in the development of the bank's assets. Volatility is the most important measure which alters our calibrated rates the most. A larger sigma will increase the risk that certain runs of our simulated bank's end up in ruin. This is because the range of possible outcomes increases as sigma is increased. We have in our analysis set the base case sigma to 3.5%. This is based both on estimates of global stock market volatility being between 15-20%. Banks assets are a lot more stable compared to the stock market. We therefore set a substantially lower sigma than the market volatility. Since the volatility can be difficult to determine, we make a thorough analysis of how our model will change for different volatility values.

Point of Non-Viability (PONV). If a bank loses assets at a gradual pace, it will eventually reach a point where it needs to increase its equity, or in this simulation, enter resolution proceedings. What the PONV will be in our simulation is equity, some levels of Tier 2 capital and SNP capital suffering losses. We will need to stop taking losses as the equity level when reaching PONV, and then to allocate the bankruptcy costs, if any, on the first levels of debts.

Cost of resolution. We include a parameter Z to take into account the process and cost of a resolution process. We define this as a constant with a value of 2%. In case the model goes into resolution the value of the asset will drop to the value at point t: $(1 - Z)V_t$.

7.4 Limitations of the model

Regulatory authorities have several tools at their disposal in a situation where banks suffer losses, which are far too complex to build into our model. Because there are authorities that are determined to prevent a banking crisis, our Monte Carlo simulation is inherently flawed. It is too complicated to build in all tool's regulators have at hand, but the simulation will still provide insights. Concrete intervention tools regulators have newly used are:

Reductions in countercyclical buffers, which reduced the CBR temporarily. There was also indirect state aid to the banks since the bank's creditors received monetary transfers. Default rates therefore went down compared to previous years, since weak businesses were able to stay afloat (Nilsen, 2021). Banks were also not forbidden, but strongly encouraged by FSAN and other government agencies to restrict dividends and preserve equity in case of larger losses. Another government intervention was the extraordinary liquidity measures provided by Norges Bank.

Both the Merton model and Black-Cox model are very simplified models. The balance sheet of a real bank is a lot more complicated than what presented in this theoretical case, even when we do take into account different seniority of debt classes. In our analyses we make some alterations so that our model contains the MREL requirement. However, our model will still contain assumptions and simplifications, but we believe the model can be a useful tool because of the possibility to shift parameters.

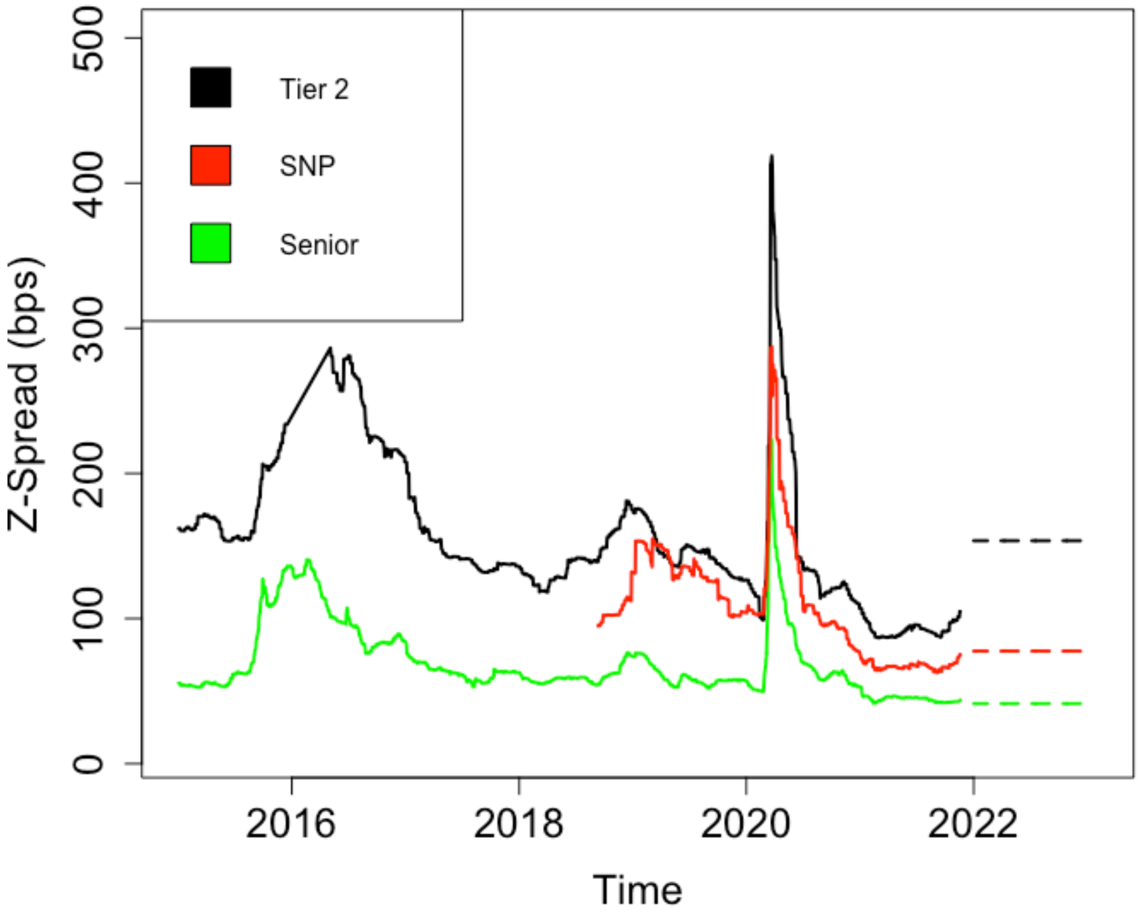
8. Results and discussion

We will in this section start using our model, and change input parameters so we can better understand the market data. We discuss how model output relates to our collected data from the market, thereby investigating the bond market with the rise of SNP bonds. We choose carefully how we compare the two types of data and will perform comparisons from metrics computed within each method. An example is that we will compare the relative levels of spreads within each method, before we compare the results. Next, we will describe and show how our analysis provide insight into what drives credit risk, often expressed in the terms of spreads. When talking about our results and the subsequent discussion, we will be as clear as possible whether the description is about the collected data, our designed model or if there is a comparison between the two of them.

8.1 Z-spread overview of NBP data

We start by subsetting the data received from NBP which contains debt instruments and prices for banks that have issued Tier 2, SNP and senior debt instruments. For the SNP data, our dataset would shrink disproportionately so we are unable to distinguish between subcategories within this debt class. We tested the differences within the SNP classes and found two main groups that had comparable spreads. What we mean by this is that three/four callable SNP bonds had comparable spreads and three/four other categories of SNP debt had similar spreads. We believe this difference can be driven by a few factors: First, different business risk associated with the different SNP groups. And secondly, the difference can be driven by differences in the SNP bonds themselves. As we will show later on, there are differences between callable and noncallable bonds. We ended up sacrificing category distinction to be able to present the SNP spreads with one graph.

Secondly, we pulled only observations that had a remaining maturity between 4 and 5 years, so that the differences in Z-spreads represent the inherent risk of each debt instrument. We then calculated daily averages for each group so that if we had 40 senior bonds for Jan 24th, 2016, those spreads would become the average of those observations. The mean spread is calculated in the same manner for the Tier 2 capital. For the SNP bonds, this is a bit of a challenge in the beginning, since our dataset was sparse at the start. But as time progresses, meaning from 2020, there are more observations that enter into the aggregate for SNPs.



Graph 1: The Z-spreads for Tier 2-, SNP- and senior debt.

The data is controlled for duration. All bonds have a duration between 4 and 5 years. Estimates from our model are represented by the dashed lines.

8.1.1 Sub Discussion on Spread

We interpret these results as being consistent with economic theory. The introduction of SNP bonds in 2018 and their risk-premium, represented with the Z-spread measure, places the new security in between the previously traded Tier 2 and senior securities. As the market matures, we believe the spreads will continue to fluctuate.

However, if we had not adjusted for the duration, we would be comparing Z-spreads that could be substantially lower as we move towards the left on the yield curve. Since the spreads are calculated above the same area of the spot rate NIBOR curve, we can aggregate these without confounding the data.

What we find is that the spreads stay consistent with what we expect from a credit hierarchy standpoint. The most subordinated debt, the Tier 2, has a systematically higher Z-spread than the other two debt instruments. We believe that the Z-spreads for Tier 2 should increase, as seen in graph (1). Also, the SNP bond, from when trading commences in 2018, moves in between the more secure senior bond and the less secure Tier 2 bond. We can therefore interpret the results from graph (1) to be highly consistent with what our model outputs in the stapled lines in same graph.

What do we learn from this? We learn that Z-spreads can be quite unpredictable at any given time. Several factors can affect these spreads. The underlying interest rate, in our case the NIBOR can change, which alters the Z-spread. Or there could be increases in default rates, or general risk in the economy which could push yield data upwards, while interest rates could be pushed downwards. The yield development is also very similar to the spread-development.

A small deviation occurs in 2019 when the SNP has a higher spread than Tier 2. This was caused by only being two bonds with the appropriate duration within the SNP category. The low number of bonds caused large price movements, but we believe this short period was just an anomaly and not systematic mispricing of risk.

Potentially it is the upside of convertibility within SNP bonds that cause a reduction in spread compared to Tier 2 capital. The second factor driving the spread differentials between the two classes is their placement within the credit hierarchy. We have projected a substantial cushion of SNP capital, which not only decreases loss given default, but the fact that the Tier 2 class needs to be wiped out first, increases the threshold for when losses first occur. Since senior debt suffers losses after SNPs, we believe it is mainly the placement within the credit hierarchy that causes their Z-spreads to be different. Additionally, market participants gained experience in pricing SNP bonds, which increases our belief that yields, and therefore spreads seem reasonable in the period.

8.2 Model generated spreads

Here we present the results from our benchmark model. We perform 10 runs of our model to gain a sense of how much it varies, the number was chosen because of the required computation time. Each of the ten runs contains 100,000 simulations for how the asset values of our bank develop over time, which we use to determine how our three different bonds perform given the benchmark parameters.

N = 100,000	*Nominal Spread (bps)*			*Yield (%)*		
Number	**Tier 2**	**SNP**	**Senior**	**Tier 2**	**SNP**	**Senior**
1	152.56	77.87	41.92	2.03%	1.28%	0.92%
2	153.81	78.08	42.20	2.04%	1.28 %	0.92 %
3	152.35	75.98	40.54	2.02 %	1.26 %	0.91 %
4	156.34	78.35	41.98	2.06 %	1.28 %	0.92%
5	154.28	78.98	42.56	2.04 %	1.29 %	0.93 %
6	151.77	75.76	39.68	2.02 %	1.26 %	0.90 %
7	155.39	78.46	42.06	2.05 %	1.28 %	0.92 %
8	151.62	76.19	40.82	2.02 %	1.26 %	0.91 %
9	154.02	78.03	40.76	2.04 %	1.28 %	0.91 %
10	153.99	77.94	41.30	2.04 %	1.28 %	0.91 %
Average	**153.61**	**77.56**	**41.38**	**2.04 %**	**1.28 %**	**0.91 %**

Table 15: 10 simulations given our benchmark parameters

Here we do 10 simulations to show how accurate our model is. We find some variation from simulation to simulation, but the typical differences are small.

By doing 10 runs where each run contains 100,000 simulations, we believe our average results of those ten runs gives a reliable result. In section 6.5 we did a robustness test for how the results could change in respect to how many simulations we do.

In 2019 and 2020 we saw small differences in actual spreads between Tier 2 and SNP see graph (1). This is because both capital layers were extremely slim, which means that if all equity is lost, which is highly unlikely, it would ultimately wipe out both debt classes.

8.2.1 Discussion of benchmark parameters and model output

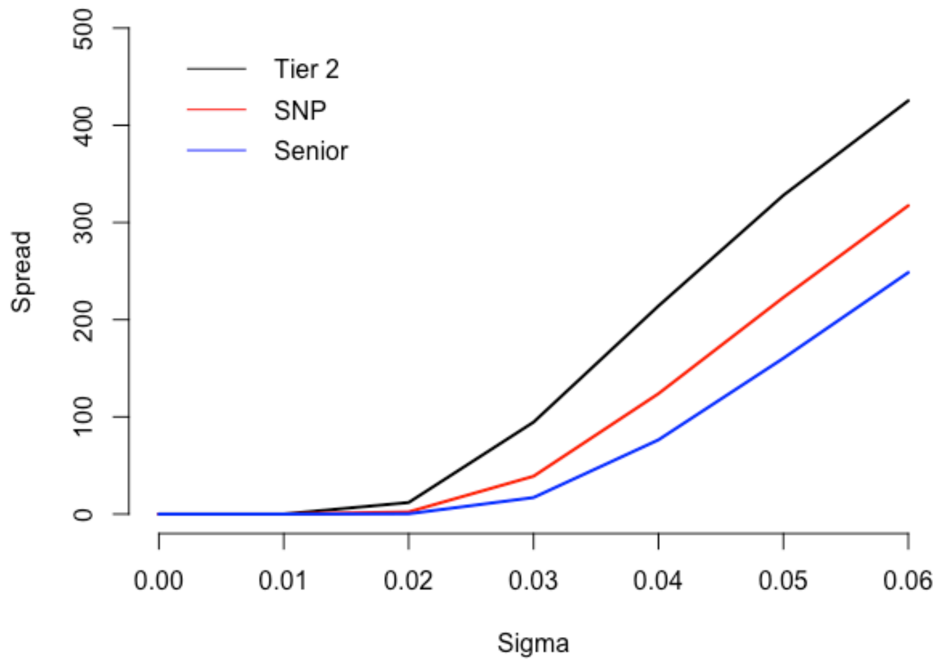
Our model provides nominal spreads that are comparable, but not equal to the Z-spreads we have observed in the market. Because of this, we believe we can alter input parameters in our model to evaluate how changes in capital requirements could impact Z-spreads.

Banks have from 2020, progressively built up a bigger amount of SNP bonds in their capital structure. Estimates and regulation requirements indicate they will continue the SNP increase until 2024 according to phase-in plans made for the Norwegian banks (Finans Norge, 2021). By including this information when setting our benchmark parameters, we believe that the results above to a certain degree can be looked at as a prediction of future spreads. The closer we get to 2024, we expect the difference in Z-spreads between SNP and senior to stay close to today's level. In addition, we expect the spread level between Tier 2 and SNP to widen.

When we consider what the spread differentials are between SNP and senior debt in our theoretical model, we believe it will not be that different from our collected spread differentials. This is because the two asset classes, both in theory and in practice have very low rates of default. Therefore, we expect that the spreads will not be particularly high and the relative difference between them could not be too high. Senior bonds are the one of the three classes where we believe our model results are most uncertain. The uncertainty is due to the likelihood of taking large enough losses to start losing senior capital is low. So even when we do 100,000 simulations, there will still be uncertainty in the model.

8.3 Effects of a change in sigma

When we change the sigma in the credit model from our base case scenario, we are interested in how the default rate change, and therefore what yields and spreads the debt owners should be compensated with. Our starting point is the base case is an annualized sigma value of 3.5%. When we choose to vary the sigma between 0% and 6%, we obtain the development in the spreads seen in graph (2). As we can see, the spreads increase rapidly when the sigma is set higher than 2%. When the sigma value is low the spread values for the different liability classes are more or less the same. Since we use Norwegian bank's equity levels, a low sigma will result in very low probabilities of default for all debt classes.



Graph 2: Spreads reaction to different sigma values

N = 100,000

	Spread (bps)			*Yield (%)*		
Sigma	**Tier 2**	**SNP**	**Senior**	**Tier 2**	**SNP**	**Senior**
0 %	0.00	0.00	0.00	0.50 %	0.50 %	0.50 %
1 %	0.00	0.00	0.00	0.50 %	0.50 %	0.50 %
2 %	11.88	2.22	0.30	0.62 %	0.52 %	0.50 %
3 %	94.59	38.94	17.02	1.45 %	0.89 %	0.67 %
4 %	214.11	123.90	76.36	2.64 %	1.74 %	1.26 %
5 %	327.96	222.84	160.28	3.78 %	2.73 %	2.10 %
6 %	425.28	317.32	248.54	4.75 %	3.67 %	2.98 %

Table 16: Spreads and yield for different sigma values.

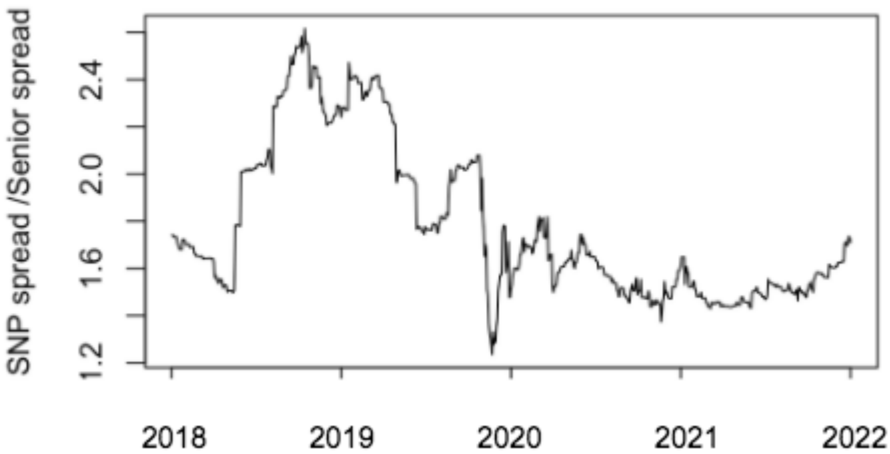
We note the strong increase in spread which starts somewhere between 2-3% for sigma. This is because the variance of our asset values increases both with time and with the volatility constant for each period.

8.3.1 Discussion on sigma

The result we get is as expected. Sigma represents the volatility for how our assets evolve, and a low sigma means the risk of default is low. This knowledge is relevant in financial markets, since low volatility decreases the range of possible outcomes, and especially outcomes that hurt us financially. As we increased our modeled volatility the spread levels moved exponentially upwards, but at different sigma levels based on how much cushioning capital there is to protect the specific debt class. If we compare these results to graph (1), we can compare risk in the market with what we find in our results. The Z-spread from the real bonds rose substantially in March 2020, due to the sudden appearance of the Covid-19 pandemic. In such a special case market participants price in large uncertainty, or sigma, and thereby increase the Z-spreads.

8.4 Relationship between SNP- and senior bonds

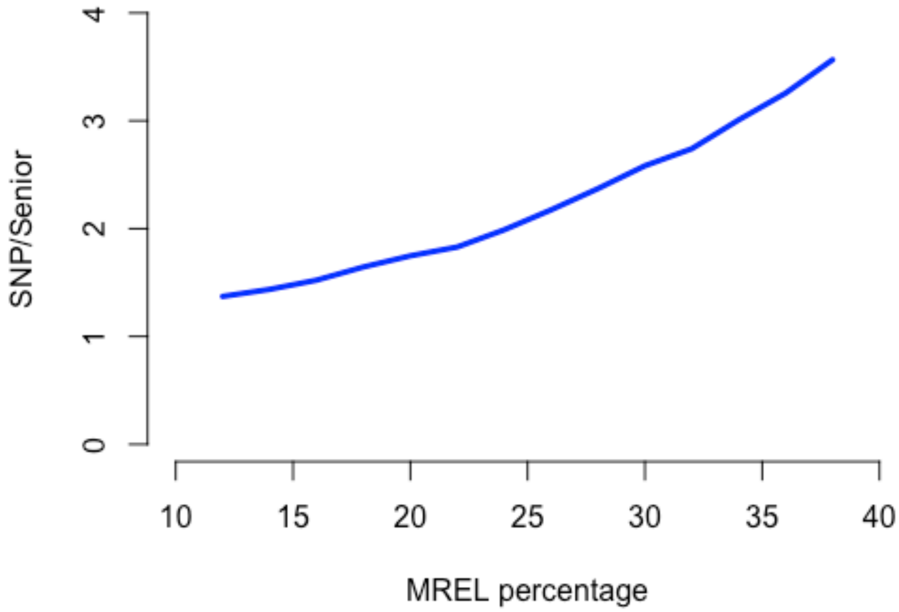
In our model we expect the total SNP volume to be fully implemented. In 2020 the SNP asset class was very small compared to what is expected in 2024. When more SNP bonds are issued, and the senior class is expected to decrease in volume this will impact the distribution of risk. We think the spreads on senior and SNP debt will stay the same as today. These thoughts are subject to the overall risk in the market being the equal and there are no new clarifications on the regulations from FSAN. As the SNP volume increases, the instances where senior debt suffer losses is reduced. As previously mentioned, rating agencies have opted to upgrade several Norwegian senior bonds because the SNP volumes are rising.



Graph 3: SNP/senior from our collected data with duration between 4-5 years.

It is hard to say what should be the correct level of this ratio. As illustrated in our model, and we can see from the real data, the ratio will change as the relationship between the volumes of SNP and senior outstanding changes and for the overall risk felt by the market. However, as an easy rule we believe the ratio should be between 1.5 and 2.5 according to the data from the market, graph (3).

Later in the discussion part we will present an analysis on how the spreads will react to different volumes of SNP in the market. Our analysis shows that the SNP amount increases when the MREL target set by FSAN increases. We then can compare the SNP spread to senior spread in our model with the dataset from NBP.

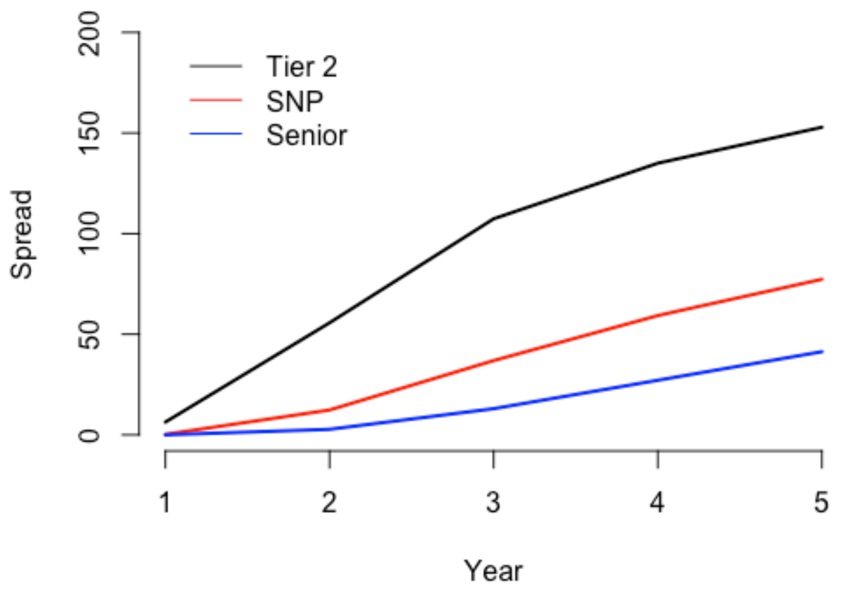


Graph 4: SNP/Senior spread ratio for different MREL requirements

What we can see is that the relative ratio between SNP and senior spreads stays in the interval of 1.5 and 3 for the most of time. Based on the information given from the market we believe the MREL for most banks will be around 22%, which gives a ratio of about 2. Nevertheless, some banks with a higher risk weight, such as DNB, will probably be somewhat higher than what can be assumed to be the average. It is still important to keep in mind that the two graphs presented above illustrate different times and different volumes of SNP, something that makes the analysis inaccurate. In addition, the spreads change every day as a reaction to new information. Using all the information gathered we would say that the SNP bonds should have a spread around the double of what the senior spread is. As times goes, we also believe the difference between SNP and senior spreads to increase, which gives an increased SNP-senior ratio from today's level. We can see the ratio rising in graph (3).

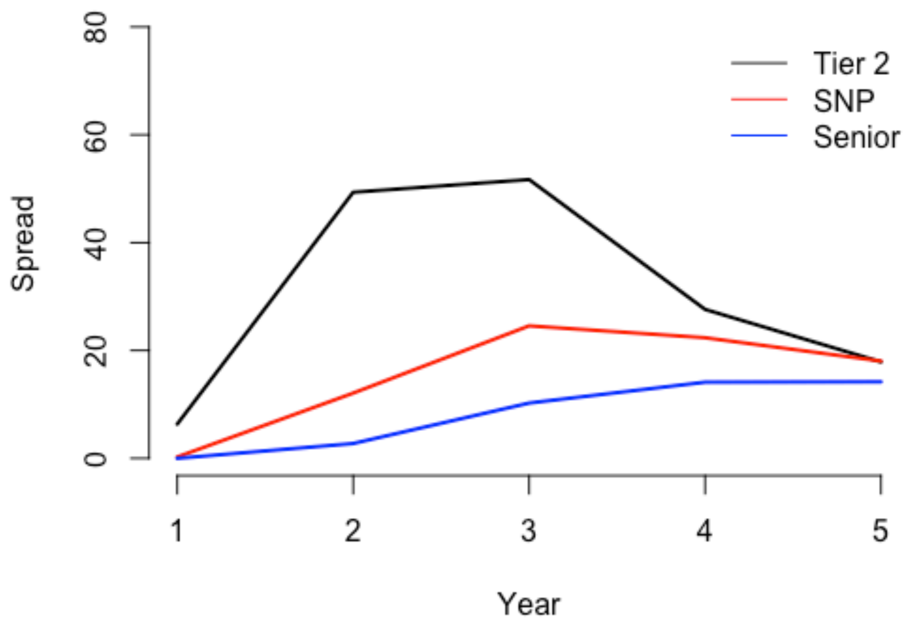
8.5 Effect of time on spreads

Graph (5) shows the effect of the remaining time to maturity on spreads. In addition, we can analyze the marginal effect of an extra year until maturity in graph (6).



Graph 5: How spreads develops as a function of time

Graph (5) shows how the spreads are increasing the longer time until maturity. We find this for all our three bond classes. This is caused by the time effect. The longer the time until the bond reaches maturity, the more likely it is that unexpected events will occur in the market. This is evident through the credit spread. We see the same connections between spreads and time in our model as we find in our dataset over actual values given from NBP.



Graph 6: Marginal change of spreads for every year

As we can see from the graph (6) of our model there are some differences on how the spreads react on the remaining time to maturity. The Tier 2 curve varies more, with much higher marginal change in year 2, 3 and 4 until maturity, compared to 1- and 5 years to maturity. The average marginal change provides 31 bps higher spread for each year in the Tier 2 class.

The SNP bonds are more stable. On average another year away from maturity should give 15 more bps to be compensated for the increased risk. This is not far away from what our regression of spreads on duration, from the NBP data. As presented in the next regression, which yielded a difference of 11 bps for each additional year to maturity.

The senior has the lowest marginal increase in spreads, with an increase of 8bps. We note that the higher the seniority of debt class, the lower the average marginal increase in spreads.

Regression

	Dependent variable:
	Spread (bps)
Credit Duration	**10.717*****
	(0.144)
Constant	**40.794*****
	(0.603)
Observations	**19,173**
R^2	**0.225**
Adjusted R^2	**0.225**
Residual Std. Error	**32.956 (df = 19171)**
F Statistic	**5,558.533*** (df = 1; 19171)**
Note:	***p<0.1; **p<0.05; ***p<0.01**

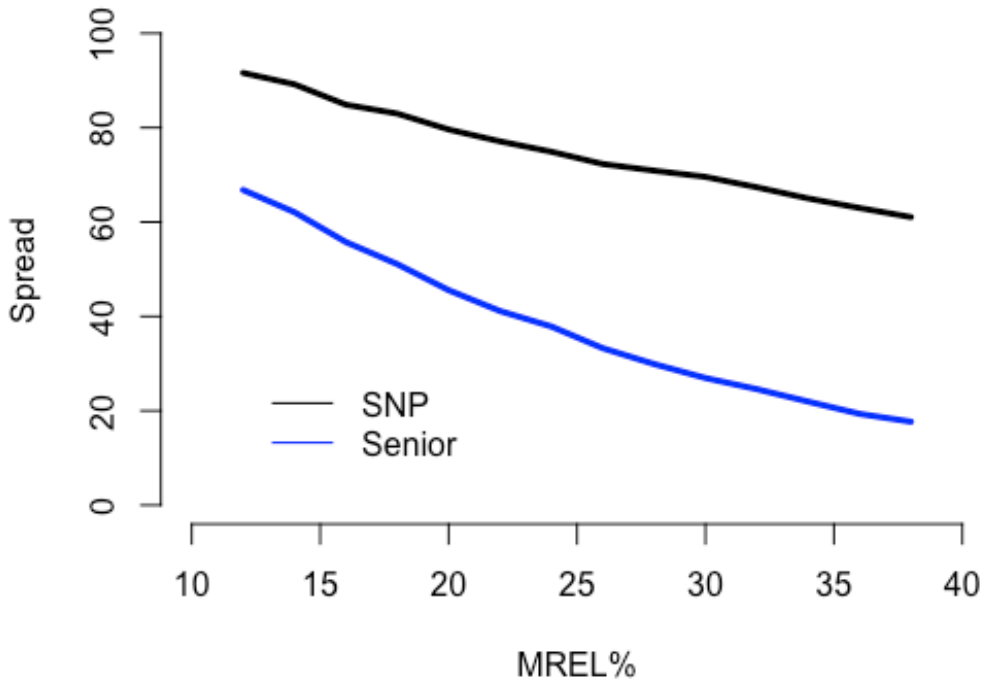
Regression 1: Regression over SNP bonds and how spreads develop as credit duration increases.

To test if this principle of time until maturity holds up, we decided to test it with a regression. We grouped our data for the SNP category, and ran regressions where we try to explain what drives the spread differentials within the group. Not surprisingly, we found that increased credit duration yielded higher levels of spread. For one extra year away from maturity, when credit duration increases by 1 year, the spread increases by 10.7 bps. We find the results to be significant at a 5% level.

The regression is for the entire period for which we have data on SNP bonds, and it has no other explanatory variables. We also believe we can draw a parallel from the regression above, to the other debt classes. Other debt classes should also experience a positive relationship between duration and credit risk. According to economic theory, credit risk stems mainly from the time dimension.

8.6 Impact of changes in MREL

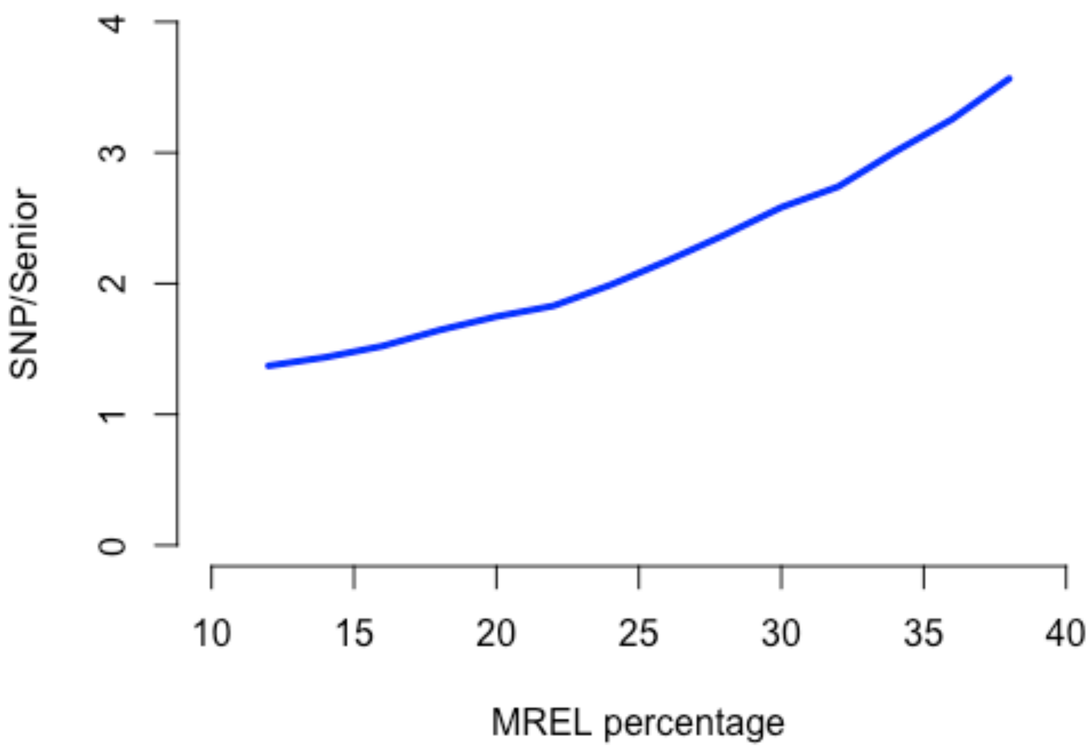
FSAN sets the MREL for the 14 biggest banks in Norway. We have implemented a variable for the MREL and will see how a change in this parameter will require more or less SNP bonds, as shown in table (14). We measure how these changes in the SNP size affects the credit risk for the SNP and senior class. The Tier 2 class is assumed unaffected by changes in MREL percentage.



Graph 7: How spreads react to different MREL requirements.

A higher MREL percentage set for the banks will force them to issue more SNP bonds according to our model. In reality, there may be deviations from this. This is because the MREL rate will change as the RWA for the banks changes. It is possible that this rate can change from year to year. Issuing or getting rid of SNP bonds can be time-consuming, which means that transitioning of the capital structure will happen gradually. We expect a positive correlation between the level of SNP and MREL percentage.

From the market we find evidence that none of the Norwegian banks are issuing a higher volume than they are forced to with the MREL requirements. As long as this is true, we will expect a pricing path to follow the results presented in graph (7). The reasoning for the downward slope of the spreads is that a higher volume of SNP capital will need a bigger loss in asset value before the whole capital layer is lost. Then the risk is lower, which also makes the spread to decrease.

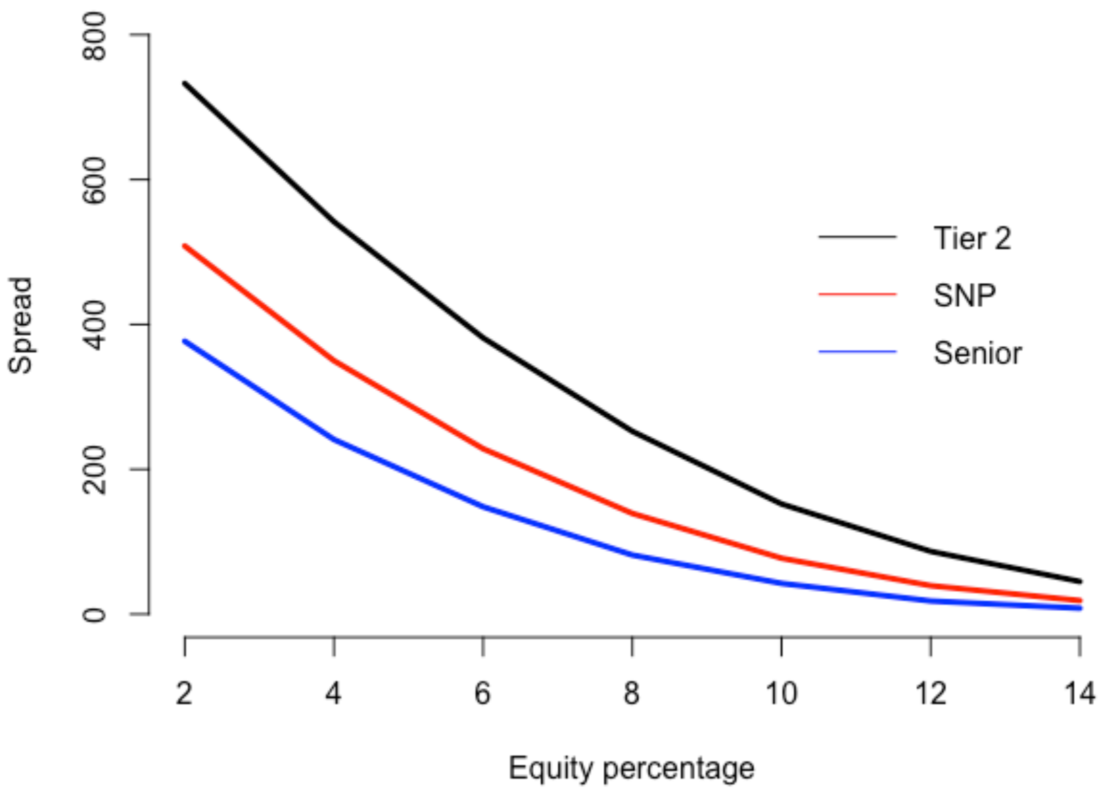


Graph 8: Show how the relative spread of Tier 3 and SNP will react to different MREL percentages.

In graph (8) we find the difference in spread between SNP and senior to grow for higher MREL values. The result is as expected. The SNP layer will still start taking losses at the same time however of the size of the MREL requirement. When Tier 2 capital is lost, SNP capital starts taking the losses. Then senior capital takes losses at a later point when the SNP capital layer is bigger. Out of this we will see that the senior spreads will decrease faster than the SNP spreads, which again make the SNP/Senior line increasing when MREL increases. In graph (7), we can see the same effect where the slope for seniors is steeper than the SNP slope.

8.7 Equity and spreads

We can also look at the relationship between spreads and equity. As we can see from the graph, a higher equity ratio will lead to lower spreads for our bond. This is due to the risk of our Tier 2, SNP and senior capital decrease when more equity is raised. The probability that all equity is lost decreases the higher volume outstanding.



Graph 9: Show how the spread of Tier 2, SNP and senior will react to different equity levels.

The banks' solvency has strengthened over the past ten years. Equity in relation to the risk-weighted calculation basis has more than doubled in the period 2009-2019 (Staavi, 2019). The effects we see from this are that all else being equal, spreads and yields will be at a significantly lower level today compared to ten years ago. Much of this strengthening in capitalization is due to stricter regulations that we have seen as an effect of the financial crisis.

9. SNP pricing analysis

9.1 Call and bullet bonds

Pål from NBP made a claim that callable SNP bonds usually have 10 bps higher spread compared to bonds without the call. SNP bonds only qualify for MREL when it is longer than 12 months until maturity. This creates an asymmetric risk profile for the issuer and investor. The debt will be MREL ineligible for the issuing bank when there is less than one year to maturity. Therefore, new SNP debt has to be issued one year prior to the expiration of existing SNP debt to still satisfy the MREL. For the investor, the SNP bond has the same risk profile as previously, even if it is ineligible for MREL. As a result, there is a great value to the banks to issue a callable bond, so long as the spreads are at reasonable levels. We have made careful calculations and collected data to see how the pricing between callable and non-callable SNP bonds have been so far.

We have also briefly looked at how the SNP bonds are built up structurally. Floating rate notes (FRN) are more common than fixed interest rates. This means that they are more exposed to credit risk than interest rate risk, which has been our focus. In addition, the bonds are issued with a call or a bullet structure. A bullet structure entails that the issuer needs to repay everything at maturity, without the possibility of earlier repayment. In 2021, as of November 2021, there are only two SNP bonds with a bullet structure issued by a Norwegian bank in the Norwegian market, while the rest are issued with a call. As previously discussed in 2.6, issuers tend to choose callable bonds to reduce transaction costs and increase regulatory efficiency.

The last two years we have seen that almost all SNP bonds issued in Norwegian kroner have a call. This differs from issues in other currencies, where there are more SNPs issued with a bullet structure. The market is still building upwards towards a steady state and there are still uncertainties connected to the new type of bonds. We have illustrated a small example of how we believe a bullet- and a callable bond may have been priced incorrectly which has given an arbitrage opportunity.

This example is based on a conversation with Lars Løtvedt in Nordea Asset Management. A 5-year bullet bond and a 5NC4 bond on the same bank should have the same total funding cost, because of the possibility of repurchasing a bullet bond. 5NC4 means it is a 5-year bond, but possible to call back after 4 years. After four years, 5NC4 can be recalled at no extra cost, while with a 5Y bullet, a premium will be required to repurchase the bond. If both bonds pay the same coupon, you will then have a difference in total funding cost, if the Z-spreads are equal. Therefore, we would expect the Z-spread to be higher for the 5NC4.

If there are to be no arbitrage opportunities, the total funding cost needs to be equal. The example below relies on the assumption of a relatively low redemption premium for the bullet bond. If the premium increases, this would also increase the difference between the required Z-spread from approximately 10 bps to a somewhat higher level. A figure of the differences in Z-spread between a callable and bullet SNP bond is seen in Graph (10).
To calculate the spreads, we used credit spread curves for a given date obtained from NBP.

Funding Cost	Spread (bps)	Type of bond
		5Y bullet repurchased year 4
Year 1	45	
Year 2	45	
Year 3	45	
Year 4	45	
Repurchase price year 4	38	
Total funding cost	**218**	

Table 17: Cash flow 5-year bullet SNP bond

A 5-year bullet SNP bond, being repurchased at the end of year 4. What we observed in the market at a given date. The Z-spreads change from day to day, as does the estimates for the repurchase price

Funding cost	Spread (bps)	Type of bond
		5Y call, called at par year 4
Year 1	45	
Year 2	45	
Year 3	45	
Year 4	45	
Repurchase price year 4	0	
Total funding cost	**180**	

Table 18: Cash flow 5-year callable SNP bond

A 5NC4 bond called at year 4. Repurchase price is 0 as this is predetermined as a part of the callable bond.

Funding cost	Spread (bps)	Type of bond
		5Y call, called at par year 4.
Year 1	54,5	
Year 2	54,5	
Year 3	54,5	
Year 4	54,5	
Repurchase price year 4	0	
Total funding cost	**218**	

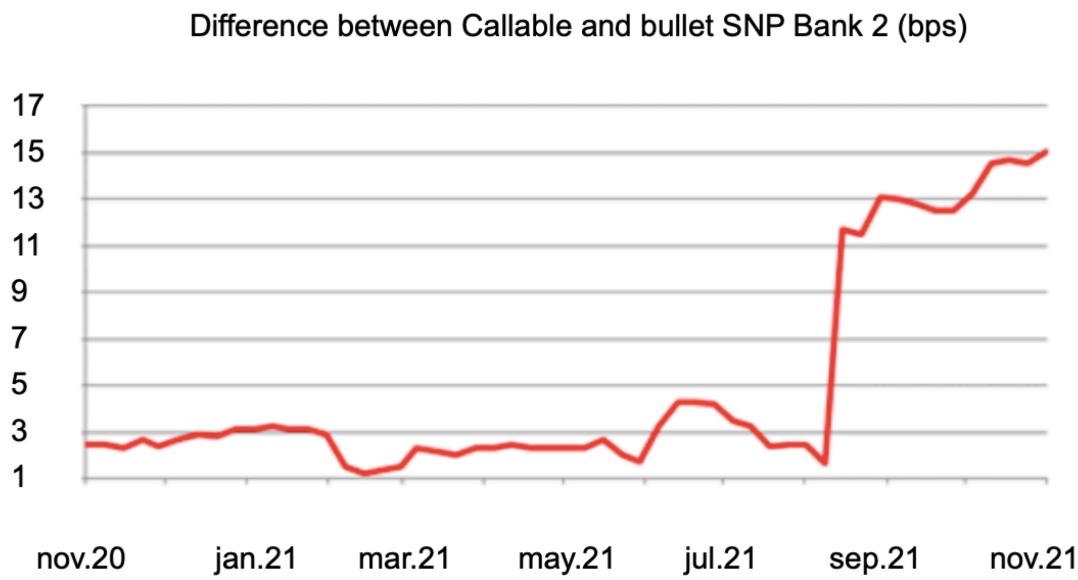
Table 19: Level of Z-spread so the call equals the bullet SNP.

If the total funding cost is equal, investors should demand a Z-spread that is about 10 bps higher than for an equivalent 5-year bullet bond. Now the funding cost is equal to the funding cost in table 17.

To sum up: Given the credit risk as in table (17), the funding cost for an equivalent bond with a call would be lower than for the bullet SNP. In this example the investors in table (18) receive less compensation for a callable bond than they would for an equivalent bullet bond. This implies that the issuer gets paid for issuing the option, as opposed to having to pay investors for the inconvenience imposed on them. Table (19) shows the Z-spread investors should demand, given the recall premium of an equivalent bullet bond (38bps).

What has been observed in the Norwegian market is that the differences between call and bullet bonds have been very small. Now this only applies to a very few bonds as mentioned. What seems like mispricing, may have occurred because of the low number of bullet SNP's in the market. A lack of active traders performing price discovery led to mispricing, before it got corrected.

A real example of what could be mispricing is to compare SNP bonds of Spb1 Nord-Norge (NONG) and Spb1 SR-Bank (SRBANK). The callable from NONG and the bullet SRBANK are issued with 23 days between. We make an assumption that the risk profile for the two banks is comparable and that the 23 days between issues do not impact the credit spread curves. It is also a possibility to adjust for the three-week difference. However, according to our data material the effect of the time difference will be minimal. In addition, both the bonds have FRN rates, so they are possible to compare. The credit spread of those two bonds is the same, but as the NONG has a call we could argue that the value of the call is not taken into account like our presented example.



Graph 10: Difference between SNP call and bullet spreads.
Graph received from Nordea shows how the spread difference has developed over the last year.

Through our work on this thesis, we have seen the difference in spread between bullet and callable SNP bonds to increase. Nordea has issued bullet SNP bonds this autumn at a low level which has increased the difference between bullet and call bonds. In our eyes it may seem like the mispricing was corrected with the development in September as can be seen in graph (10) from Nordea. Through communication with people in the market, it has been expressed that, as a rule of thumb, a 10 bps higher spread is often added for callable SNP bonds. The last months shows that the market now have started to price in the value of a call option. When the call is priced into the bonds, as represented by the Z-spread, issuers should observe market prices when considering whether they should issue callable- or bullet SNPs.

The mispricing would have been interesting to analyze in greater detail, but since the selection of bullet bonds in the Norwegian bank bond market is so limited, we believe it is insufficient to perform further analysis.

10. Conclusion

This paper investigates how relative credit risk changes in the Norwegian bond market with the rise of senior non-preferred bonds. We have had a special focus on the SNP capital class, in addition to the adjacent classes within the creditor hierarchy. We present our main findings in the two tables below:

Analysis	**Findings model**	**Findings empirical**	**Results:**
Spreads for Tier 2, SNP and senior bonds	Spreads for: T2 > SNP > Senior	Spreads for: T2 > SNP > Senior	The level of spreads changes every day. However, the model and empirical findings show how they are priced correct relative to each other given what theory tells us.
SNP/ Senior spread	Range [1.5 - 3.5] Depends on the total volume of SNP and senior in the market. Given our finding the gap between T2 and SNP will increase with a higher volume of SNP.	[1.2 - 2.5] Trending upwards against a ratio of 2.	SNP spreads are systematically higher than senior and seem to be within a reasonable “window”. We expect that the ratio will change as the volume of SNP increases. Given today’s regulation we have estimated the ratio to be around 2.
MREL	A higher MREL requirement will result in more SNP bonds being issued. This will again give lower spreads for both SNP and Senior bonds.	The collected data might be too small for a good analysis. On the contrary, we note that Z-spreads for SNPs decrease, along with the Tier 2 class as higher volumes have been issued.	A higher MREL set for banks will give more SNP issued and also impact the spreads. As more SNP issued, we find the spreads to decrease.

Table 20: Collection of our results (I).

We believe that the spread of SNP bonds will continue to be the same as today's level if everything else in the market stays equal. Further, we have an expectation that senior bonds will have a slightly lower spread as the SNP bonds increase in volume.

Overall, we believe that the implementation of SNP bonds has been correctly priced in relation to their location in the credit hierarchy. We find that Tier 2 bonds contain higher credit risk and is priced lower than SNP bonds, which again has higher spreads than senior bonds.

We find that the Norwegian banks issue SNP bonds to meet their MREL requirement. If their requirements increase, we will also see that the volume of SNP bonds increases. A result of increased volume will be changes in the spread levels. Higher volumes give lower spreads specially for senior bonds, but also to some extent on SNP bonds.

Analysis	**Findings model**	**Findings empirical**	**Results:**
Equity	More equity reduces the risk for all underlying capital classes.	Not possible to measure with our data. Data on equity ratios could have been collected. Other effects also in play.	If the volume of equity rises (falls) the spreads for SNP decreases (increases).
Changes in σ	Spreads across capital layers increase (decrease) with increased (decreased) σ.	Unobservable, but implied volatility indicates periods where sigma was higher yielding higher spreads. E.g., during March 2020.	Consistent view that periods with lower asset volatility provides convergent spreads, while higher volatility widens spread differentials.
Call vs. Bullet structure	Made calculations outside our model. There should be a higher spread for a call. It gives the issuer a right to call back the bond before maturity at a pre-specified price.	Find something that could look like an arbitrage opportunity, but mispricing seems to disappear during the time of our work.	Opportunity to call back will cost extra. But finds that call and bullet SNP bonds are priced almost equally before September 2021. Note, applies only to two bonds.

Table 21: Collection of our results (II).

The Tier 2 class will in principle not react to the level of SNP capital increasing, as long as equity requirements are unaltered. If equity requirements are altered, Tier 2, SNP and senior capital will all be affected by the change. This applies to both an increase and a decrease in equity.

When the volume of SNP bonds increases relative to senior bonds and Tier 2 bonds, it will affect the risk of all three capital classes. During periods of higher (perceived) volatility, we expect spreads across the asset classes to increase markedly.

For the call and bullet structure, we perform a separate analysis. However, we find that the optionality in SNP's issued with a call option may not be priced correctly. We have to say may, since there are only two equivalent SNP's we can match based on their duration. This provides us with few findings to definitely say that the call option is mispriced in SNP's. There have been adjustments in prices from August 2021, which makes the obvious mispricing disappear.

In section 6.4 we ran a robustness test for our Monte Carlo simulation. We saw that the standard deviation shrunk significantly when using 100,000 simulations instead of 10,000. Therefore, we believe that the results that our model gives are credible given the prerequisites that must be taken to be able to create such a model.

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11. Appendix

11.1 Step by step setup of the model

Step 1

What we do first is create a sequence t with a range from [0-5] with an increment of 0.25. This creates our 20 period, 5-year time horizon for our simulations. According to the Merton model, the value of the debt is a decreasing function of the time to maturity (Merton, 1974). Longer time to maturity gives higher yields, which again will result in lower value of the debt outstanding. Other values for t can be passed into our function, creating a total of $(t \times 4)$. We use the length of the sequence t to create the number of rows in our matrix. We call the number of rows m. The number of simulations, n, is combined with our m rows, thereby creating our $(m \times n)$ matrix. We will use this matrix to store our simulated asset values.

	Empty value matrix	
[1,1]	…	n (columns)
…	…	[..., n]
m (rows)	…	[m, n]

Table 22: Matrix for input from our simulations

Step 2

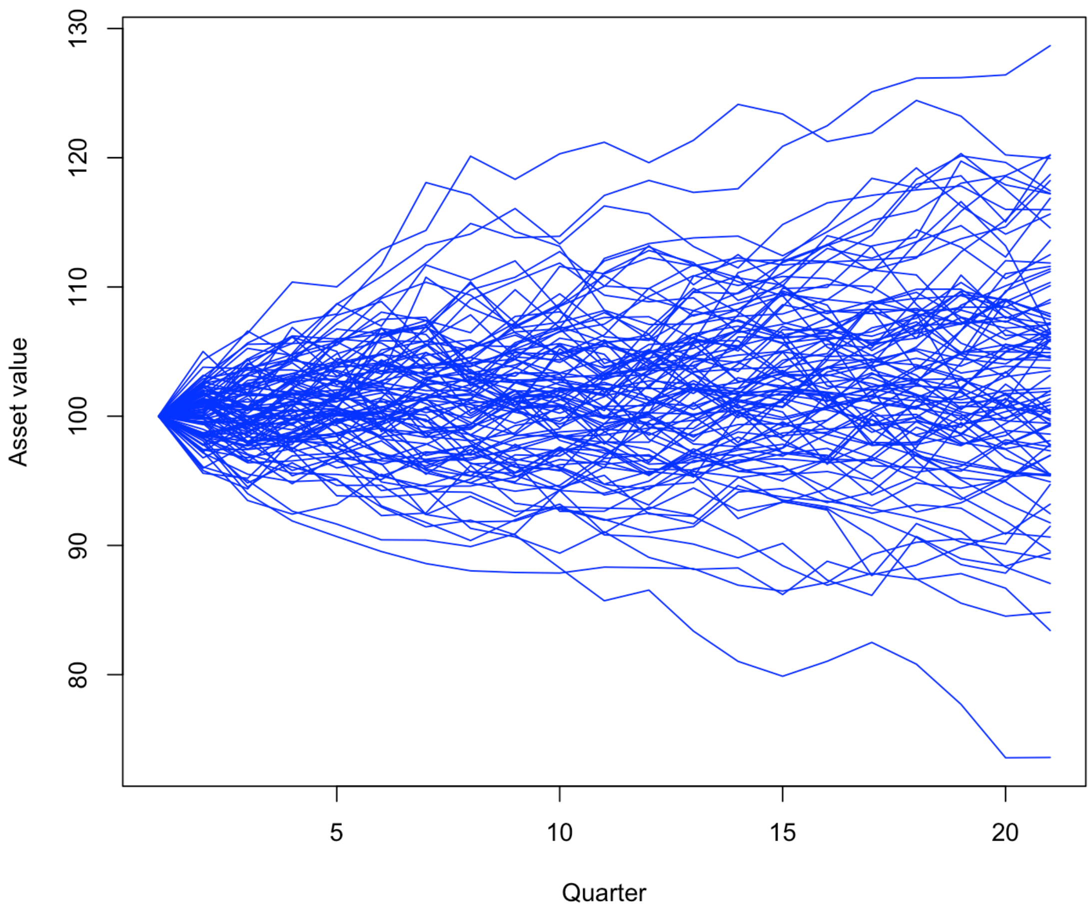
We continue by creating an equal sized $(m \times n)$ matrix to store our drift parameters, which we get from formula (18).

$$V_t = V_0 \exp\left((rf - 0.5 \times \sigma^2) \times t + \sigma W_t\right) \quad (18)$$

This gives us the growth factors for our asset values. We will multiply each growth rate with the initial value V_0. The development value of [1,1] and [2,1] gives us the growth rate for the first and second period.

Step 3

Lastly, we multiply these 20 rows and number of simulations by the growth factor. This creates the basis for our asset values. All start values are 100, and we have 20 subsequent values corresponding to each quarter for five years. This concludes our asset values. We use these values to find the coupons of the bonds, which again is used to price our bonds.



Graph 11: An example of how a Monte Carlo simulation could look like.

Here we have 100 different paths with our benchmark parameters used. The asset value starts at V_0 *and progresses along with the expectation which is the risk-free rate and follows a Wiener process.*