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Risk Premium in Norwegian Covered Bonds

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Contents

List of Figures

List of Tables

Abstract

In this thesis we study the determinants of risk premium in Norwegian covered bonds. Due to differences in data quality and bond characteristics we study the market for EUR and NOK denominated bonds issued by Norwegian credit institutions in separate. In line with theory we find that most of the risk premium in the EUR sample is due to liquidity. As for the relationship between the two samples we see that their strong co-movement is explained by variation in the cross-currency basis swap. We conclude that the Norwegian market for covered bonds is sound and prices bonds in a correct manner.

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1 Introduction and research question

Covered bonds have quickly grown to become one of the most important funding sources for Norwegian mortgage banks (Finance Norway, 2018). Since the first issuance in 2007, the covered bond market has grown to comprise of more than 30% the Norwegian bond market (Heitmann & Stokstad, 2017). Academic research on the topic has, however, been very limited both in Norway and Europe.

In this thesis, we study the risk premium of Norwegian covered bonds traded in the secondary market. In particular, we examine how Norwegian cover bond spreads relate to various bond-specific and macroeconomic factors. Our research question is:

Which risk premium determinants are priced in Norwegian covered bonds?

Our thesis is structured as follows. First we present a summary of academic literature on covered bonds and related topics. Next, we give a brief introduction to the broad history of covered bonds and also provide an overview of the Norwegian market. We further introduce some theory on bonds relevant for this thesis before we present our data and research methodology followed by the main results. After some robustness checks and an analysis of the relationship between the samples we end with the final conclusions in addition to some criticism and suggestions for future research.

2 Literature review

The covered bond market is critical for European banks as they provide the most competitive source of market funding (Global Capital, 2017). However, it has not caught the degree of academic focus it deserves and even fewer studies focus on pricing and spreads. Most research has been conducted on the German *Pfandbrief* market which is by far the most established covered bond market in the world (Werner & Spangler, 2014).

In the literature concerning covered bonds, yield spreads are often interpreted as pure liquidity premia due to their high safety (Prokopczuk & Vonhoff, 2012; Kempf, Korn, & Uhrig-Homburg, 2012; Koziol & Sauerbier, 2007). Kempf et al. (2012) argue that German covered bonds are essentially risk-free with the spread only caused by liquidity. Some researchers argue however that credit risk can be an important factor in explaining spreads. To assess credit risk in fixed income securities and hence credit spreads there are two approaches with well grounding in theory. In the structural framework (Black & Scholes, 1973; Merton, 1974) we model the evolution of a company's value and assume that it defaults on its obligations when the value of the assets falls beneath a certain point. By integrating the term-structure of interest rates model by Vasicek (1977) with the work of Merton (1974), Shimko, Tejima, and Van Deventer (1993) extend the structural framework by assuming that interest rates behave stochastic. Further, they assume that interest rates follow a mean-reverting process with constant volatility. They find that the credit spread is an increasing function of the (risk-free) term structure volatility for reasonable parameter values. Similar results are also found by Leland and Toft (1996).

In the reduced form approach (R. Jarrow & Turnbull, 1992; R. A. Jarrow & Turnbull, 1995; Duffie & Singleton, 1999), credit risk is estimated assuming a probabilistic process for the probability of default and recovery rate. In a study of the two models' performance in the Nordic covered bond market, Sulku and Falkenbach (2011) find that the reduced form model prices covered bonds with satisfactory results. They argue that the structural model is not suitable for their study as the necessary information is not easily or publicly available to the investors.

Within the structural approach, Huang and Huang (2012) conclude that credit risk accounts to a high degree for yield spreads in junk bonds but only for a small fraction in investment grade bonds. Prokopczuk, Siewert, and Vonhoff (2013) find however that credit risk also is present in German covered bonds, especially under financial turmoil, by assessing the credit quality of the cover pools. This is in line with a broader study by Prokopczuk and Vonhoff (2012) who investigate covered bond spreads in Germany, France, Spain and the UK. They calculate yield spreads on a range of covered bonds and include several bond-specific variables such as coupon (to account for tax-effects since higher-paying bonds are more taxed throughout their life time) and bid-ask spreads (which proxies for tighter liquidity), both yielding statistical significance. Furthermore, they surprisingly find that real-estate returns as a proxy of the cover pool quality have no statistically significant impact on the spreads in normal circumstances but highly (negatively) significant in times of financial turmoil. The risk-free rate was included in order to account for the lower expected spreads due to higher risk-neutral drift (Longstaff & Schwartz, 1995; Campbell & Taksler, 2003). They find that equity returns (on each country's major equity index) reflecting the general business climate have a strong negative effect and that (implied) volatility affect spreads positively.

Hellmich, Kraft, and Siddiqui (2015) conduct a study on the financial crisis' impact on the relation between government and covered bond spreads in Germany, France, Italy and Spain as these should exhibit a tight co-movement. They find that this relation in Germany were only temporarily driven apart during 2007-2009 which they attribute to *flight to safety* suggesting that covered bonds carry additional risk other than pure liquidity. In France, Italy and Spain, the relation between government and covered bond spreads has not yet returned to normal.

3 Covered bonds

In this section we provide a brief introduction to the concept and historical developments of covered bonds

3.1 Definition of covered bonds

A covered bond is a debt security issued by a credit institution (often a bank or mortgage institution). In addition to providing unsecured recourse against the issuer (e.g. regular senior unsecured debt) in the case of default, the debt is collateralised against a pool of assets (cover pool) on which the investors have priority claims. The concept of double protection against both the issuer and collateral is known as *dual recourse* and differentiates covered bonds from both traditional asset-backed securities (ABSs) and traditional senior unsecured debt. The fact that covered bonds are secured by collateral pools in addition to the issuer's creditworthiness results in a higher rating than *plain vanilla* bank debt (Packer, Stever, & Upper, 2007). The cover pool is usually made up of high-grade mortgages and public sector loans and is dynamic in the sense that loans which have either matured, been redeemed early or lost quality can be replaced by the issuer. Strong legislative protection of bond holders coupled with the dual recourse make covered bonds attractive for many types of investors required to hold safe assets and is the reason that covered bonds issues normally receive AA+ ratings.

3.2 History of covered bonds

The history of covered bonds can be drawn back to the 18^{th} century when the first German Pfandbrief was issued following the Seven Years War. Covered bonds also played an important role in stabilizing the financial system after the turmoil seen at the turn of the 19^{th} century. Since the mid 20^{th} century, the interbank market grew its retail deposit base, hence reducing the need for the financing provided by covered bonds (Burmeister, Grossman, & Stocker, 2009).

The proliferation of covered bonds started when the first German Pfandbrief of benchmark size (Jumbo) was issued in 1995. European banks in need of new funding sources increased the issuance of liquid, high quality bonds to attract international investors. This demand for a more competitive capital market instrument was what reinvigorated the European covered bond system at the turn of the millennium.

In the following years the covered bonds market grew at a rapid pace. In the wake of the financial crisis of 2008-2009, the European Central Bank (ECB) announced its first Covered Bond Purchase Programme (CBPP) to improve liquidity. Over the next year, the ECB purchased EUR 60 billion nominal worth of covered bonds. This was one of several measures taken to stabilize financial markets following the crisis. The programme helped narrowing spreads and thereby eased banks' funding conditions and subsequently increased the willingness to issue credit (Beirne et al., 2011). The ECB has since conducted two similar purchasing programmes to help the European economy recover further. The second was initiated in 2012 and the third and last one in 2014. Over the last decade, there has also been increased interest for, and issues of, covered bonds in North-America and Asia (Schwarcz, 2010).

3.3 The impact of ECB intervention and the covered bond purchase programmes

As described, the ECB has, due the remarkably low inflation after the financial crisis of 2008, maintained sizable asset purchase programmes. The three Covered Bond Purchase Programmes (CBPP1-CBPP3) have played a significant part from the start where the ECB bought back covered bonds in 2009-2010 (CBPP1), through 2011-2012 (CBPP2) and finally in recent times 2014-2018 (CBPP3) (ECB, 2018). The effects from such a significant market participant is known to cause prices to rise as a function of lower supply and hence cause yield spreads to tighten and thus make credit more accessible to issuers. This in turn leads other participants to speculate on the degree of interaction from the ECB in the future which might in turn lead to even lower spreads (Thompson, 2014). These findings are consistent with the paper by Pinto and Correia (2017) who find that the first ECB programme lowered covered bond spreads.

3.4 Covered bonds vs asset-backed securities

The loans that make up the collateral on which the issuer issues covered bonds stays on the issuer's balance sheet. This forces issuers to follow a *originate-to-hold* model, rather than the *originate-to-distribute* model which has gotten much blame for playing a significant role in what caused the 2007-2008 financial crisis (Brunnermeier, 2008). The repackaging of loans, offloading of risk and related moral hazard issues that found place prior to the financial crisis are not possible under current covered bonds regulations. While covered bonds, as mentioned, have a dynamic cover pool, ABSs usually have a static cover pool combined with a *pass-through* structure where all payments from loans in the asset pool are transferred directly to the bond holder.

Pinto and Correia (2017) have found credit spreads on public covered bonds to be significantly lower than those on other asset-backed securities. These results hold in both normal and crisis periods implying that covered bonds are considered safer than ABSs. However, when they consider bonds backed by mortgages only, they find that the results only hold in crisis periods.

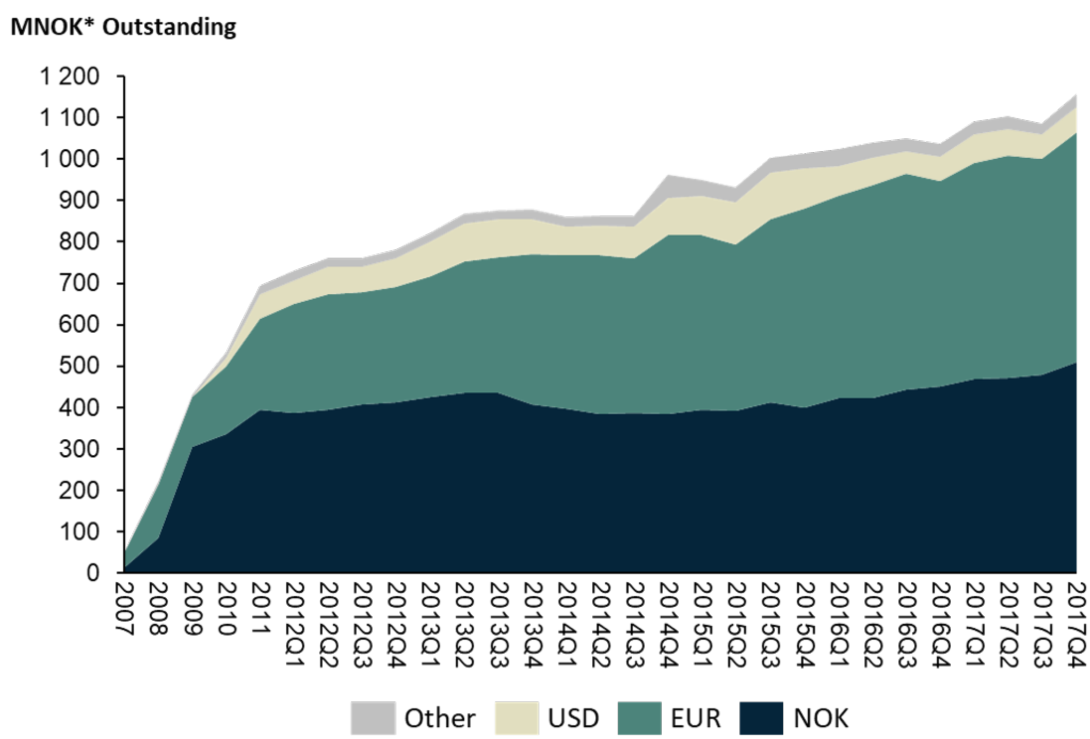
4 The Norwegian covered bond market

In this section we go through the history and structure of the Norwegian covered bonds market in more detail.

4.1 Overview of the Norwegian covered bond market

After the adoption of the Norwegian covered bonds legislation in June 2007 with the first issue following in the second half of 2007, the Norwegian covered bond market quickly became an integral part of the Norwegian financial system. The Norwegian covered bond market has also received much attention from investors abroad due to the absence of a large market for government bonds following Norway's privileged financial condition. As of March 2017, covered bonds accounted for more than 30% of the Norwegian bond market and it has become one of the main funding sources for Norwegian financial institutions (Heitmann & Stokstad, 2017). According to Norwegian regulation, covered bonds can be issued by special purpose vehicles only (Finance Norway, 2018). Most issuers are subsidiaries owned by individual parent banks, while some are owned by a group of banks. The Norwegian covered bond market is made up of 26[1] issuers with a total outstanding amount of more than NOK 1,100 billion (see Figure 1).

Figure 1: Norwegian covered bonds outstanding



Note: Foreign denominated issues converted to NOK. Other currencies are SEK, GBP, CHF, JPY and AUD.

Source: Finance Norway (2018)

As of December 31 2017, 44% of outstanding bonds are denominated in NOK, 48% in Euro, 5% in USD and 3% in other currencies. 80% of NOK bonds issued

[1]See appendix Table A.1 for a full list of the issuers

on Oslo Stock Exchange are floating rate notes (FRNs). The issues in foreign currency are mostly done with fixed coupons. The issues in NOK are all listed on Oslo Stock Exchange or Nordic ABM while foreign issues can be listed anywhere (Finance Norway, 2018). The most common marketplace for EUR denominated Norwegian covered bonds is Bourse de Luxembourg (See Appendix Table A.2).

Most Norwegian covered bonds are issued with a soft-bullet structure meaning that final the repayment of the loan can be delayed twelve months without triggering a default. This provide issuers an increased ability to avoid fire sale of cover pool assets in periods of distress.

4.2 Cost of funding through foreign currency markets

Substantial amounts of Norwegian mortgage companies' financing of NOK assets come from issuing covered bonds in foreign currency markets (Molland, 2014). Most of this type of issuance in the Norwegian market is done in EUR. Funding NOK assets in a foreign currency exposes the banking group to foreign exchange risk. The foreign currency needs to be converted to NOK for lending in the Norwegian market, but at the same time the banking group needs to ensure that it is able to pay its obligations in foreign currency. This risk needs to be hedged which can be done using foreign exchange derivatives. A cross-currency basis swap with the same maturity as the issued bond is a particularly popular instrument in this regard. The EURNOK cross-currency basis swap (see section 5.5) is a known measure of the relative cost of receiving funding in EUR versus NOK and should be a significant determinant for the spread difference between the EUR and NOK bond markets.

4.3 Regulations

High level of transparency and investor protection are important requirements in the covered bond market and is much of the reason for its attractiveness. All entities with outstanding covered bonds are required to release information on the quality of the cover pool on a quarterly basis. This information is reported according to the Harmonised Transparency Template (HTT) initiated by the European

Covered Bond Council (ECBC) in 2012.

There has historically been very low default rates on mortgages is Norway. This can in large part be ascribed to regulatory conditions of the mortgage market. The borrower is liable for the remaining outstanding amount if the relevant residence is sold without covering the full mortgage (dual recourse).

Practically all covered bonds issued in Norway are covered by a pool of residential mortgages. According to EU regulations, the loan-to-value (LTV)[2] ratio for residential mortgages can not exceed 75%. For commercial mortgages the LTV ratio can not exceed 60%. The median LTV of Norwegian cover pools as of the end of 2017 is around 50% (Heitmann & Stokstad, 2017).

Regulations imposed by the Norwegian Ministry of Finance set requirements for the size of the cover pool. As of March 29 2017, the value of the cover pool must exceed 102 percent of the nominal value of outstanding bonds covered by that pool, meaning that they require an overcollateralisation (OC) level of 2%. This limit is subject to individual adjustment based on the derivatives positions of each issuer. The OC values of Norwegian cover pools as of 31.12.2017 ranged from 6% to 8,600%[3] with a median of 17% (Heitmann & Stokstad, 2017).

4.4 Domestic currency bonds

As of December 2017, there are a total of 26 specialized credit institutions with a total of NOK 52 Bn outstanding (Table A.1) with license to issue covered bonds in Norway (Finance Norway, 2018). For the aggregate market of Norwegian covered bonds, the largest issuer is by far DNB Boligkreditt. It is followed by Sparebank 1 Boligkreditt, Eika Boligkreditt and Nordea Eiendomskreditt (Heitmann & Stokstad, 2017). All major issues in the Norwegian market are highly rated by rating agencies, reflecting the good health of Norwegian banks and the financial system in general.

The secondary market for Norwegian covered bonds market is considered to

[2]Measured as the percentage of the asset value (e.g. residential or commercial property) which is borrowed.

[3]The extraordinary OC of 8,600% is due to buybacks done by DNB Næringskreditt (DNB's commercial mortgage institution).

be liquid (even more liquid than the market for Norwegian government bonds). To further improve liquidity, measures were taken by OSE in 2014 to increase the market transparency by introducing the Norwegian Covered Bonds Benchmark list. The listed bonds are subject to continuous indicative pricing by Nordic Bond Pricing. This is beneficial as we are able to retrieve prices for our analysis as actual trades are not done often enough to provide reliable data.

4.5 Foreign denominated bonds

Of the 26 issuers in NOK bonds there are 9 that also issues in EUR where only 5 have a significant issue size (greater than NOK 10 Bn) (See Table A.1). From the table it can be seen that DNB (56%) and Sparebank 1 (24%) make up the larger part of the foreign market and have activities abroad to a much higher extent than home. Although there are less active issuers, the foreign market is larger than the domestic with a total of NOK 56 Bn as of December 31 2017. Norwegian bonds are considered very safe by foreign investors being perceived as one of the best in class of European covered bonds (Finance Norway, 2018). The foreign dominated bonds should exhibit a high degree of co-movement with the issues in NOK as they are backed by the same collateral and subject to many of the same risk factors. In theory the difference should largely be due to liquidity and currency exposure.

5 Bond pricing and key concepts

In this section we provide a brief overview of relevant bond pricing theory and relevant concepts.

5.1 Yield and the pricing of bonds

All fixed income securities can be priced by discounting their future cash flows to present values using appropriate discount factors (Veronesi, 2010). For an observed price P there must be a yield y that sets the present value of cash flows equal to the bond price. This yield (more specifically yield to maturity) is the expected annualized return if the bond is held to maturity. At time t, the price P of a standard coupon bond maturing at time T with yield to maturity y (using continuous compounding), paying a fixed coupon c each period in addition to the principal M at maturity is given by:

$$P(t,T) = \sum_{t=1}^{T} c \times e^{-y\times t} + M \times e^{-y\times T} \tag{1}$$

5.2 Risk measures

Bond investors are exposed to several risk factors. The most important are outlined below.

Interest rate risk

The interest rate in the market is an important component in the discount factor. Bond prices will fluctuate with changes in the interest rate. Duration is a common interest rate risk measure for bonds. It can be mathematically expressed as a first-order approximation of the price sensitivity with respect to changes in the interest rate.

$$D = -\frac{1}{P}\frac{dP}{dr} \tag{2}$$

A favorable trait of bonds is their convex relationship between yield and the bond price. The convexity of a bond is a second-order approximation of the bond price sensitivity with respect to interest rate changes.

$$C = \frac{1}{P}\frac{d^2P}{dr^2} \tag{3}$$

Credit risk

Another component of the discount rate is the credit risk. Credit risk is the risk of a bond issuer defaulting on its obligation. The larger the probability of default, the larger the discount rate investors will apply when pricing a bond. This risk contains the issuer specific risk that an investor is exposed to by investing in a bond.

Liquidity risk

If there are few active buyers and sellers in the market for one or several bonds, an investor wanting to liquidate a position might have to deviate from the last market price to sell a bond. In times of financial turmoil one might see a large number of sellers having problems with finding potential buyers, leading to a drop in bond prices and hence higher spreads.

Embedded options in bonds

Some bonds are callable. This means that the issuer has an option to call back the bond and pay the par value to the bondholder at any time (American) or at prespecified dates (European). This option has a cost to the bondholder as it would only be exercised when it is optimal for the issuer (and hence suboptimal for the bondholder) and will reduce the price as the bondholder in effect has a long position in a non-callable bond and short position in a call option on the same bond.

5.3 Yield curve

Interest rates can vary greatly over time and across different maturities. The annualized interest rates for different maturities at a point in time (the term structure of interest rates) can be represented graphically in a yield curve. There is vast academic research on the shape of the term structure of interest rates, the most known being the expectations hypothesis and the liquidity preference theory. The common belief is that the shape depends on a combination of market expectations of short-term interest rates in the future and risk premia required by investors to hold longer maturity bonds (Russell, 1992). The implication is that the yield curve is normally upward sloping, however it might also have periods with different shapes. Plotting a yield curve from observed bond yields in the market directly will often give an uneven curve as one will almost never have bonds with regular maturity intervals. The Nelson-Siegel method (Nelson & Siegel, 1987) can be used to estimate a smoothed yield curve given input from yields observed in the market. It is important to specify which yield curve that is being referenced as there are several yield curves. The most commonly used are those for government bonds or interbank lending (IBOR) in different markets.

5.4 Spreads

Yield curves are often used as benchmarks for bonds. The difference in a bond's yield to maturity and that of corresponding maturity on the reference yield curve is commonly referred to as the (yield) spread. It incorporates characteristics (e.g. coupon size and frequency, maturity and embedded options) and different risk factors (e.g. liquidity and credit risk) that is inherent in bonds and for which investors require compensation over the benchmark yield. A bond's spread is thus a measure of the risk premium required by investors to hold that bond and therefore the reason why we study bond spreads rather than yields.

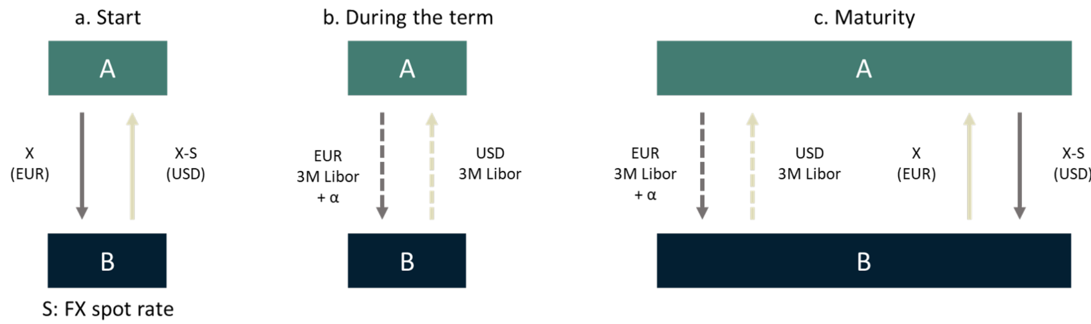
Discount margin and zero-volatility spread

The discount margin is the average expected return in addition to the reference rate for a floating rate note (FRN). It is a constant margin that would make the bond trade at par when added to the reference rate. The zero-volatility spread (z-spread) is the constant spread that when added to the benchmark yield curve sets the present value of cash flows equal to the market price of the bond.

5.5 Cross-currency basis swap

Cross-currency basis swaps (CCBS) can be used to fund investments in foreign currency or convert funding in foreign currency to domestic currency. A cross-currency basis swap is a contract where two parties agree to exchange two currencies at current spot rates today and the reverse transaction at an agreed forward rate in the future. What differentiates it from a plain FX swap is that for the duration of the contract, the parties also exchange floating rates plus a spread (α in Figure 2) for one of the parties. This spread is what is commonly referred to as the basis swap spread.

Figure 2: Cross-currency basis swap example



Note: This figure illustrates the dynamics of a cross-currency basis swap involving EUR and USD.

Source: Baba, Packer, and Nagano (2008)

The parties involved in a cross-currency basis swap are often financial institutions acting on behalf of themselves or their clients. They are also used as a tool for converting currencies of bonds (liabilities) denominated in foreign currency. Most cross-currency basis swaps are long-term as they are often agreed on the same tenor as that of the bond transaction they are intended to fund (Baba et al., 2008). The level of the cross-currency basis swap is determined by supply and demand factors in the currency markets.

6 Data

As mentioned in section 4, the NOK issues are primarily done with floating coupons whilst fixed issues are dominating the EUR issues. The latter is also true for European issues as a whole and as a consequence, most studies on covered bond spreads have been on fixed coupon issues. The different structures of floating and fixed rate bonds make them very hard to compare as the prices of FRNs reset to par on each coupon payment. Another distinguishing factor between EUR and NOK bonds is the presence of Quantitative Easing (QE) by the ECB in the Eurozone which should affect EUR and NOK bonds differently. Due to these facts, we need to study each market separately.

Our final sample consists of N=31 fixed rate EUR denominated bonds bonds with weekly data entries from 1/1/2012 to 25/4/2018 (329 periods) and N=19 floating rate NOK denominated bonds from 1/7/2014[4] to 25/4/2018 (196 periods). See Table A.2 and A.3 for information on the bonds. Throughout this thesis we will refer to covered bonds issued by Norwegian credit institutions in Norwegian kroner as NOK bonds, while the Euro denominated bonds issued by the same institutions are referred to as EUR bonds.

6.1 Dependent variable (bond spreads)

In this section we will go through the calculation of both risk premium (spread) measures in detail.

6.1.1 EUR spreads

The most correct way of calculating the spreads for a coupon paying bond would be strip the coupons into zero coupons and compare the yield to maturity with government bonds of the same maturity. As this is practically impossible due to the mismatch in maturities the next best approach is to calculate the spreads as the difference between the bond's yield to maturity and the corresponding point at the linearly interpolated Euro interest rate swap curve[5]. Therefore we construct at each point in time the linearly interpolated swap curve and deduct the relevant swap spread for each bond.

6.1.2 NOK spreads

As mentioned in section 4, the large majority of NOK denominated bonds are FRNs. As FRNs are priced differently than fixed coupon bonds we cannot use the same measure as the EUR sample. A relevant proxy for the risk premium

[4] As there is poor pricing data before the beginning of the OSE benchmark practice.

[5] More precisely we retrieved the Euro interest rate swap curves for each tenor up to 10 year maturity. The interpolated swap yield on e.g. a 7.4 maturity would then be $r_7 + d \times (r_8 - r_7)$ where r_t is the swap rate at time t and $d = 0.4$ is the fraction that is included of the difference to the next tenor.

measures for these bonds is the discount margin. We use bid discount margins retrieved from Bloomberg.

6.2 Independent variables

In this section we will present the independent variables used in the study. Although we use two different markets for the spread variables we are still going to use Norwegian macro factors as this is the relevant source of risk also for the EUR bonds. Most of the variables are common in both studies as we will indicate further on.

Data is for the most part retrieved from Bloomberg. Bid-ask yield spreads are based on the Bloomberg Generic prices (BGN) methodology. They are single-security composites derived from dealer contribution. Indicative and executable prices are considered and weighed according to prespecified criteria. These prices are indicative of available consensus-forming prices (Bloomberg, 2016). We believe that this combination of executable and reliable indicative prices provides the best picture of market prices for the bonds under study.

In the following we present both macroeconomic and bond-specific variables with their expected effect on spreads in both samples.

6.2.1 Macroeconomic factors

Risk-free interest rate

As mentioned in Section 2, according to Longstaff and Schwartz (1995) bond spreads should react negatively to increased risk-free interest rates due to the lower risk-neutral probability of default. Furthermore, since interest rates are proven to be non-stationary in low-interest rate environments we difference the proxies for the short-term risk-free interest rates, i.e. 3-month Euribor and 3-month Nibor and expect the spreads to react negatively in both samples.

Term spread

We include the term spread (slope of the term structure) calculated as the difference between the 10-year and the 3-month Nibor rate. This has been shown to be an important indicator of the economy, especially a predictor of economic recessions (Prokopczuk & Vonhoff, 2012; Bernard & Gerlach, 1998). As an increased slope (steeper term structure) normally corresponds with a more healthy economic outlook (and hence lower uncertainty for bond investors) we would expect a negative relation between spreads and the slope factor in both samples.

Equity returns

The return on a country's major stock index is associated with the general health of the economy and the business climate which should be negatively related to spreads (Prokopczuk & Vonhoff, 2012). Hence we include the returns on the Oslo Stock Exchange (OSE) benchmark index. We use the 4 weeks rolling returns to reduce the impact of noise and expect a negative relation between spreads and equity returns in both samples due to the increased positivity in the market.

Implied volatility

In line with the previous, we would also expect that increased (expected) volatility in the equity factor to be relevant, however with the opposite sign as greater uncertainty should translate into a higher compensation to holding risky assets. We use the 30-day OSE implied volatility index[6] and expect a positive relation between spreads and implied volatility in both samples.

Real estate returns

Recalling that all Norwegian covered bonds are backed by cover pools which largely constitute Norwegian housing mortgages we include real estate returns to

[6] Because put and call options on the issuers are non-existent it is not possible to back out implied volatility for issuers using the Black-Scholes option pricing formula. Instead we use the 30-day implied volatility on Oslo Stock Exchange to get a forward looking estimate of market volatility.

proxy for the average cover pool quality. We expect a negative relation between real estate returns and covered bond spreads in both samples as lower returns reduce the flexibility of cover pools and hence lower the collateral. We note that Norwegian housing statistics are only quoted on a monthly basis which cause this variable to change slower than the rest of the dataset.

Cross-currency basis swap

As cross-currency basis swaps are commonly used to hedge conversion of foreign funding back to domestic currency, the CCBS is an important factor in the relative funding costs between domestic and foreign currency. This should in theory equal the difference in yields on else equal bonds denominated in EUR and NOK. Increases in the cross-currency basis swap should increase the observed spreads as EUR issues become relatively cheaper for both issuers and potential bond investors. We include the 5-year EURNOK cross-currency basis swap.

6.2.2 Bond-specific factors

In addition to the macroeconomic factors that are equal for all the bonds in our samples we include bond-specific factors justified in theory.

Taxes

In their study, Prokopczuk and Vonhoff (2012) include the coupon rate to account for tax-effects as bonds that pay higher during the early part of the lifetime are more taxed and hence should reward additional spreads. As this effect is negligible for FRNs due to the continuous resetting we include only the coupon payments for the EUR sample and expect a positive relation.

Liquidity

In line with most previous studies (Prokopczuk & Vonhoff, 2012; Kempf et al., 2012; Koziol & Sauerbier, 2007) etc. that largely point out liquidity as the most important factor we expect that it should also be important in our sample. In the EUR sample we use the relative bid-ask yield spread and expect that larger bid-ask spreads should translate to lower liquidity and hence wider bond spreads. As the Norwegian sample suffers from less frequent trading (often with close-to-constant or erroneous bid-ask spreads) we use the number of trades reported from OSE on a monthly basis as our proxy for liquidity and expect that a higher number of trades corresponds with reduced bond spreads (Houweling, Mentink, & Vorst, 2005). We note that this variable is updated less frequently than others like in the case with real estate returns.

Issuer-specific effects

Although the regulations and requirements around covered bonds are strong we expect issuer-specific effects to be relevant. We hypothesize that DNB, Norway's largest mortgage bank and the bank with most international exposure[7] should trade at slightly lower spreads in both samples. This might e.g. be due to the larger cover pool, reporting standards and general solidity. We therefore include issuer-specific dummies and measure their impact on spreads relative to DNB.

Time to maturity

At last we include the bond's time to maturity (measured in years until maturity) to control for the fact that bonds with higher time to maturity are less liquid, more risky (longer duration) and generally trade at higher spreads.

6.3 Data description

As described, our dataset comprise of weekly observations on 19 NOK denominated bonds from 1/7/2014 to 1/5/2018 and 31 EUR denominated bonds from 1/1/2012 to 1/5/2018 with various frequencies as not all bonds are active throughout the whole period. We drop bonds with either an issue size of less than NOK 500 (EUR 50) million or time to maturity of less than one year. This is due to poor data quality on smaller issues and the extraordinary behavior of bonds close to maturity, respectively. We also drop bonds with data entries less than half of the sample period and remove observations that show a change in spreads above

[7] Recalling that Nordea only issues domestic bonds.

30 bps in a week. Weekly data was chosen over daily data to avoid strong auto-correlation and reduce noise levels in the data set. We have an *unbalanced panel data* type of structure as not all bonds are active throughout the whole period (T ranges from 18 to 329 with $\overline{\mathrm{T}} = 222.5$).

Summary statistics of the most relevant variables can be found in Table 1 followed by correlation matrices in Table 2 and Table 3 for the EUR and NOK sample, respectively.

Table 1: Summary statistics

	Mean	St. dev.	Min.	p25	Median	p75	Max
EUR Spread*	8.34	16.07	-15.67	-2.67	3.81	14.19	77.83
NOK Spread+	29.57	15.20	0.16	18.5	26.04	37.99	79.50
Euribor 3m*	9.37	30.77	-33.20	-13.60	17.00	22.80	131.90
Nibor 3m+	117.75	26.13	75	75	110	136	176
Bid-Ask (yield)*	5.98	2.06	2.30	4.50	5.60	7.00	21.60
No. of trades+	8.65	8.37	0	3	6	12	55
Impl. volatility	15.07	5.69	6.85	11.00	13.44	17.31	38.34
CCBS	16.59	10.67	-2.75	7.80	16.00	22.75	44.50
Equity returns	0.12	0.45	-1.73	-0.15	0.16	0.41	1.20
Slope	0.94	0.37	0.29	0.64	0.88	1.25	1.72
RE returns	4.90	3.63	-4.08	2.22	5.62	7.43	12.62
Time to maturity	4.17	2.16	1.00	2.45	3.80	5.41	9.97
EUR observations	6 904						
NOK observations	3 140						

Note: * only in EUR sample, + only in NOK sample

Table 2: EUR sample: Correlation matrix

	Spr.	Eur.	B/A	Vol.	CCBS	Eq.	Slope	RE	TTM
EUR Spread	1.00								
Euribor 3m	0.73	1.00							
Bid-Ask (yield)	0.48	0.36	1.00						
Impl. volatility	0.22	0.01	0.27	1.00					
CCBS	-0.05	-0.54	0.25	0.45	1.00				
Equity returns	0.05	0.07	0.02	-0.11	-0.07	1.00			
Slope	-0.26	-0.06	-0.32	-0.54	-0.40	0.07	1.00		
RE returns	0.05	-0.16	0.21	0.28	0.46	-0.03	-0.66	1.00	
Time to maturity	0.54	0.29	-0.28	-0.02	-0.15	0.03	-0.07	0.01	1.00

Table 3: NOK sample: Correlation matrix

	Spr.	Nbr.	Liq.	Vol.	CCBS	Eq.	Slope	RE	TTM
NOK Spread	1.00								
Nibor 3m	-0.13	1.00							
Liquidity	-0.20	-0.20	1.00						
Impl. volatility	0.47	0.11	-0.16	1.00					
CCBS	0.60	-0.65	0.08	0.30	1.00				
Equity returns	-0.04	-0.14	0.08	-0.06	0.12	1.00			
Slope	-0.25	-0.31	0.21	-0.51	-0.16	-0.01	1.00		
RE returns	0.12	0.06	0.08	-0.00	0.28	0.10	-0.35	1.00	
Time to maturity	0.39	0.61	-0.25	0.18	-0.37	-0.10	-0.30	0.00	1.00

Table 4: Theory predictions

		Expected signs	
Variable	Description	EUR	NOK
ΔXIBOR 3m	Risk of default	−	−
Term slope	Uncertainty	−	−
Impl. volatility	General (forward-looking) uncertainty	+	+
Basis swap	Relative funding cost	+	0
Equity returns	Business climate	+/−	+/−
Real estate return	Collateral risk	−	−
Bid-ask spread	Liquidity	+	n.a.
Number of trades	Liquidity	n.a	−
Coupon	Tax effects	+	n.a.
Term-to-maturity	Liquidity control	+	+

7 Methodology

7.1 Ensuring stationarity of variables

As shown by Granger and Newbold (1974), variables should be characterized by stationary processes for OLS to provide meaningful results. If this is not the case, then two unrelated variables drifting away from their initial values (even without following a predetermined trend) could be suggested to have a close connection by an OLS model. We run the augmented Dickey-Fuller test on the average spread time series to investigate this. The test results imply that the null hypothesis of spreads being non-stationary can be rejected at all conventional confidence levels. This result is fairly robust across different specifications and number of lags[8]. In addition Longstaff and Schwartz (1995) provide a study where spreads are treated as stationary processes. Based on this, we continue our analysis on the levels of spreads. The infinite variance characteristic of random walks also provides little economic intuition for credit spreads and they are also treated as stationary processes in most theoretical frameworks.

We run Dickey-Fuller tests for the explanatory variables and find no statistically significant deviations from stationarity. However, several economic time series are shown to behave like random walks (i.e. show characteristics of non-stationarity) within bounded intervals. As there is a common understanding that nominal interest rates are (lower) bounded (Goodfriend, 2000) and that Cavaliere and Xu (2014) find conventional unit root tests unreliable under these conditions[9] we use a differenced version of the Euribor and Nibor 3-month rates.

[8]Results are slightly less in favor of stationarity when including a time trend in the test. However, the null hypothesis of the time series being a unit root process can still be rejected at the 5% level.

[9]They prove that nominal interest rates are in fact integrated of order one as also suggested by the slowly decaying autocorrelation in general interest rates. As a remedy they suggest an alternative approach utilizing simulations instead.

7.2 Choosing between Fixed Effects, Random Effects and Pooled OLS

As the number of periods (329/196) is much larger than the number of bonds (19/31) we have *long panel data*. The two most prominent ways of handling such data is by either *Fixed effects* or *Random effects* models. The major distinction between the two is in the assumption on whether the unobserved individual effects are correlated with the regressors in the model. For a fixed effects model, the correlation between an entity's error term and the predictor variables is assumed to be non-zero implying that some factor(s) within the entity might bias the variable under study and this must be controlled for. Stock and Watson (2003, p. 289-290) emphasized that for fixed effects, "the key insight is that if the unobserved variable does not change over time, then any changes in the dependent variable must be due to influences other than these fixed characteristics". Contrary to fixed effects models, random effects models assume that variation across entities is random and uncorrelated with the regressors in the model. A basic unobserved effects model can be written as

$$y_{i,t} = \mathbf{x}_{i,t}\boldsymbol{\beta} + c_i + u_{i,t}, \qquad t = 1,\, 2,\, \ldots,\, T \tag{4}$$

for a randomly drawn cross section observation i. $\mathbf{x}_{i,t}$ is $1 \times K$ and can contain variables that change across i and t. Fixed effects models treat c_i as a parameter that can be estimated while random effects models treat it as random (Wooldridge, 2010).

In order to choose the proper specification we run the Hausman test which has the null hypothesis that the series show a better fit with random effects than fixed effects. The test clearly goes in favor of a fixed effects model which also is the most widely used method in the field as the random effects assumption is often seen as a strong one (Clarke, Crawford, Steele, & Vignoles, 2010).

A major drawback with fixed effects is, however, that it relies heavily on variation in the independent variables, granting no explanatory power to constant (dummies) or slow-moving variables. As we want to investigate whether the issuers come with different risk premiums and if bond-specific factors such as issue size and fixed coupons matter, a fixed effects model cannot be used.

Random effects use Generalized Least Squares (GLS) instead of Ordinary Least Squares (OLS) which is known to provide some additional challenges and demand stricter assumptions. Our remedy is to use pooled OLS with robust standard errors adjusted for clusters which ensures that that we control for likely correlated errors over time within a given entity. This approach is preferred by several researchers because of its simplicity and established popularity (Angrist & Pischke, 2008; Cameron & Miller, 2015). This method produces consistent standard errors if the residuals are correlated within, but uncorrelated between entities (Hoechle et al., 2007). Failure to control for this could potentially cause misleadingly small standard errors, which again could lead to incorrect inference.

In turn we specify a pooled OLS regression on the form of

$$y_{i,t} = \alpha + \sum_{j=1}^{k} \beta_j X_{i,t} + \sum_{j=k+1}^{K} \beta_j D_i \tag{5}$$

where $y_{i,t}$ is the spread variable, K is the total number of independent variables, β_j captures the effect of the independent variables, $X_{i,t}$ are time-varying variables and D_i are dummy variables.

8 Empirical results

In this section, we present and discuss our empirical findings for EUR sample and NOK sample separately.

8.1 EUR sample

8.1.1 Main results

We run a series of regression specifications which are presented in Table 5.

Regressions (1-3) isolate the bond-specific effects whilst (4-5) investigate macroeconomic factors. Regression (6) includes the full specification. The coupon size effect is significant with the expected sign in (1) and (2) but remains insignificant with the opposite sign when we include time to maturity. An important

Table 5: EUR sample: Regression results

	(1)	(2)	(3)	(4)	(5)	(6)
Coupon	2.78**	3.17***	-1.47			-1.41
	(0.92)	(0.81)	(1.00)			(0.92)
Bid-Ask (yield)	3.56***	3.52***	5.22***			4.84***
	(0.49)	(0.51)	(0.39)			(0.46)
SP1BOL		2.01	-0.16			0.06
		(1.64)	(1.73)			(1.59)
Eika		5.48**	4.21**			4.28**
		(1.70)	(1.44)			(1.29)
SPVest		0.19	2.72			2.80
		(2.09)	(1.69)			(1.59)
Time to maturity			7.24***		3.64***	6.85***
			(0.38)		(0.42)	(0.39)
ΔEuribor 3m				-4.07***	-3.70***	-1.29***
				(0.29)	(0.22)	(0.19)
Impl. volatility				0.27***	0.30***	0.23***
				(0.06)	(0.04)	(0.03)
CCBS				-0.21***	-0.06	-0.03
				(0.06)	(0.05)	(0.04)
RE returns				-0.59***	-0.60***	-0.52***
				(0.11)	(0.07)	(0.04)
Slope				-10.90***	-7.93***	-0.07
				(1.30)	(1.16)	(0.88)
Equity returns				-0.34	-0.43	-0.24
				(0.29)	(0.27)	(0.22)
Constant	-20.14***	-22.33***	-46.90***	18.75***	-1.81	-44.65***
	(3.49)	(3.23)	(2.38)	(2.12)	(3.30)	(3.47)
Adjusted R^2	0.254	0.268	0.787	0.236	0.471	0.817
Observations	5703	5703	5703	6856	6856	5664

Note: Robust standard errors are in parentheses. Significance levels: *10%, **5%, ***1%.

learning is the marginal effect on adjusted R^2 of including time to maturity as it improves from 0.268 to 0.787. The bid-ask yield spread is highly significant in all specifications with the expected sign which is consistent with theory as tighter liquidity should be compensated with larger spreads.

When we isolate the macroeconomic effects, we see that the results are less sensitive to the inclusion of time to maturity. The change in the 3-month Euribor interest rate is significant in all specifications with the expected sign. This is also true for the performance of the real estate market which proxies for the quality of the cover pool. The volatility and equity returns show the expected sign in all specifications. Implied volatility is however the only significant one. This insensitivity to equity performance due to the high protection that investors get from the cover pools and priority of claims on the issuers. Volatility could be severe to both of these factors at once and should better pick up the tail risks.

An important learning lies in what happens to the slope factor that is highly significant with the expected sign in (4) and (5) but insignificant when we run the full specification. This suggests that the slope factor does well in capturing general credit risk (as higher slopes are associated with sounder market conditions). However, when the bond-specific credit factors are included the marginal effect is negligible.

The signs on the issuer specific coefficients are in line with our expectations. As we hypothesized, there is evidence of the other issuers being traded at higher spreads than DNB even after controls. Only the coefficient for Eika is statistically significant (at 5%) in the full specification. All three dummies have however the expected sign. We emphasize that the sample for Eika and SPVest is not sufficiently high enough to conclude anything. We note however that Eika bonds in the sample trade at a spread 7.07 bps higher on average than those issued by DNB.

Lastly, we note that the cross-currency basis swap is insignificant in line with expectations as this should only be present in the NOK sample.

8.1.2 Economic significance

Statistical significance does not necessarily imply economic significance, i.e. that a variable has a substantive effect on the dependent variable. To determine the economic significance of the coefficients we run a standardized regression. This means that all explanatory variables are standardized such that the beta coefficient can be interpreted as the change in the standard deviation of spreads as a result of a one standard deviation change in the explanatory variable. Standardized coefficients adjust for the fact that some variables will have larger standard deviations than others (Miller & Rodgers, 2008). In this way we can determine which variables carry the most economic value. The results are tabulated in Table 6.

Table 6: EUR sample: Economic significance results

	(1)	(3)	(4)	(5)	(6)
Coupon	0.15	-0.08			-0.08
Bid-Ask (yield)	0.47	0.69			0.65
Time to maturity		0.80		0.50	0.77
ΔEuribor 3m			-0.36	-0.33	-0.12
Impl. volatility			0.10	0.11	0.09
CCBS			-0.14	-0.04	-0.02
RE returns			-0.14	-0.14	-0.12
Slope			-0.25	-0.18	-0.00
Equity returns			-0.01	-0.01	-0.01

Note: Number in the parenthesises corresponding with the regression results in Table 5. The high economic significance of Time to maturity is due to the fact that bonds in general trade at lower spreads as they move towards maturity and become less sensitive to interest rate changes which should not be interpreted as a determinant per se.

Recalling that one standard deviation in the spread is 16.07 basis points we can for example read that a standard deviation change in implied volatility only changes the spread by approximately 1.4 basis points. We also see that although real estate returns and implied volatility are highly statistically significant there is little economic significance. The issuer dummies carry much more economic significance information as we saw in Table 5. These findings suggests that Norwegian covered bonds in the EUR market are well protected against the general market environment. When we in rather look at the liquidity factor proxied by the bid-ask yield we see that a standard deviation change corresponds to a highly economically significant 10.3 basis points change in the spreads. The notion that liquidity is the only significant priced determinant is well in line with the existing theory.

8.2 NOK sample

8.2.1 Main results

We run the same specifications for the NOK sample which is tabulated in Table 7. Liquidity as proxied by the number of trades in the bond per month is negative in all specifications and statistically significant at the 10%-level in the full specification. The reason why it might not be as significant as in the EUR sample is expectedly due to the quality of the proxy as we cannot use bid-ask spreads and that the number of trades is generally low.

The issuer dummies are mostly insignificant however with the expected signs (with the exception of SP1BOL) meaning that they should trade higher than the benchmark which is DNB.

We see that the slope factor is large and significant in the unexpected direction both ran with and without the other credit factors. This is contrary to the EUR sample and quite puzzling. As in the EUR sample, changes in the risk-free interest rate are negatively associated with spreads as expected.

Equity returns, volatility and real estate returns are statistically significant with the expected sign in all three specifications except real estate returns when not controlling for time to maturity.

As expected we see a very large and significant positive coefficient for the cross-currency basis swap and re-emphasize that this should be the main difference between EUR and NOK spreads with the same collateral. The fact that this effect is only present in the NOK sample is perfectly in line with expectations as this picks up the relevant cost difference for Norwegian issuers facing a foreign market and not the contrary.

Table 7: NOK sample: Main results

	(1)	(2)	(3)	(4)	(5)	(6)
Liquidity	-0.36**	-0.27*	-0.09			-0.10*
	(0.12)	(0.10)	(0.09)			(0.04)
STAB		-1.77	-0.01			0.62
		(2.73)	(0.97)			(0.60)
SP1BOL		3.00	1.44			-0.31
		(3.25)	(1.12)			(0.80)
EIKA		6.62	4.49*			1.55
		(4.39)	(1.63)			(0.85)
MORE		1.95	6.51***			5.14***
		(3.17)	(1.55)			(0.84)
Time to maturity			4.88***		9.33***	9.21***
			(0.46)		(0.39)	(0.30)
ΔNibor 3m				-8.34***	-6.64***	-6.73***
				(1.25)	(0.54)	(0.54)
Impl. volatility				0.66***	0.35***	0.34***
				(0.06)	(0.02)	(0.02)
CCBS				0.80***	1.28***	1.27***
				(0.07)	(0.07)	(0.07)
RE returns				-0.13	-0.29***	-0.21***
				(0.21)	(0.06)	(0.05)
Slope				-2.95	7.80***	7.90***
				(1.58)	(0.67)	(0.79)
Equity returns				-2.63***	-1.70***	-1.48***
				(0.22)	(0.08)	(0.11)
Constant	32.32***	29.77***	13.45***	3.31	-39.55***	-39.66***
	(1.98)	(2.36)	(2.05)	(2.21)	(2.49)	(3.00)
Adjusted R^2	0.041	0.071	0.203	0.469	0.836	0.858
Observations	2929	2929	2929	3089	3089	2887

Note: Robust standard errors are in parentheses. Significance levels: *10%, **5%, ***1%.

8.2.2 Economic significance

The results from the beta regressions are tabulated in Table 8.

Table 8: NOK sample: Economic significance results

	(1)	(3)	(4)	(5)	(6)
Liquidity	-0.20	-0.05			-0.05
Time to maturity		0.40		0.72	0.74
ΔNibor 3m			-0.02	-0.02	-0.02
Impl. volatility			0.27	0.14	0.14
CCBS			0.54	0.86	0.85
RE returns			-0.03	-0.07	-0.05
Slope			-0.06	0.15	0.15
Equity returns			-0.08	-0.05	-0.05

Note: Number in the parenthesises corresponding with the regression results in Table 7. The high economic significance of Time to maturity is due to the fact that bonds in general trade at lower spreads as they move towards maturity and become less sensitive to interest rate changes which should not be interpreted as a determinant per se.

Similarly to the EUR sample we see that the implied volatility carries higher economic significance than equity returns. Another important result is the fact that in addition to the expected importance of time to maturity, the cross-currency basis swap is the most important determinant for the NOK bonds. This result is in line with our earlier discussion.

9 Robustness checks

As mentioned under the methodology section there is a wide array of available panel data models in the field. In Tables 9 and 10 we present the regression coefficients and standard errors under Fixed effects, Random effects and POLS modeling for both the EUR and NOK sample. All statistically significant results in the POLS share the same sign with the fixed and random effects. We conclude that our analysis is not sensitive to the choice of regression specification.

As described in the data section, we removed outliers and bonds with few observations. In Tables A.4 and A.5 we report the unconstrained regressions. For the EUR sample the results are very similar for the bond-specific factors but rather suspicious for the macroeconomic determinants since real estate returns, slope and equity returns are significant but in the opposite direction than expected. In the NOK sample all significant results are in the same direction, however we see that even though the sample size is almost doubled, the R^2 is dramatically reduced and standard errors increase substantially.

Table 9: EUR sample: Comparison of regression specifications

	Fixed effects	Random effects	POLS
ΔEuribor 3m	-1.11***	-1.15***	-1.29***
	(0.09)	(0.11)	(0.19)
Impl. volatility	0.19***	0.20***	0.23***
	(0.02)	(0.02)	(0.03)
CCBS	0.21***	0.19***	-0.03
	(0.04)	(0.04)	(0.04)
Equity returns	-0.08	-0.09	-0.24
	(0.19)	(0.19)	(0.22)
Bid-Ask (yield)	4.23***	4.24***	4.84***
	(0.27)	(0.32)	(0.46)
Slope	3.15***	2.82***	-0.07
	(0.66)	(0.64)	(0.88)
RE returns	-0.52***	-0.52***	-0.52***
	(0.04)	(0.04)	(0.04)
Time to maturity	8.58***	8.44***	6.85***
	(0.31)	(0.32)	(0.39)
SP1BOL		-0.34	0.06
		(2.51)	(1.59)
Eika		6.13**	4.28**
		(2.24)	(1.29)
SPVest		5.66*	2.80
		(2.53)	(1.59)
Coupon		-0.98	-1.41
		(1.66)	(0.92)
Constant	-55.62***	-53.61***	-44.65***
	(2.34)	(3.64)	(3.47)

Table 10: NOK sample: Comparison of regression specifications

	Fixed effects	Random effects	POLS
ΔNibor 3m	-6.23***	-6.63***	-6.73***
	(0.54)	(0.54)	(0.54)
Slope	10.62***	8.58***	7.90***
	(0.61)	(0.76)	(0.79)
Impl. volatility	0.25***	0.32***	0.34***
	(0.01)	(0.02)	(0.02)
CCBS	1.37***	1.29***	1.27***
	(0.07)	(0.07)	(0.07)
Equity returns	-1.16***	-1.40***	-1.48***
	(0.10)	(0.11)	(0.11)
RE returns	-0.31***	-0.23***	-0.21***
	(0.06)	(0.05)	(0.05)
Liquidity	-0.08	-0.10*	-0.10*
	(0.06)	(0.04)	(0.04)
Time to maturity	11.01***	9.62***	9.21***
	(0.41)	(0.34)	(0.30)
STAB		0.52	0.62
		(0.72)	(0.60)
SP1BOL		-0.67	-0.31
		(1.01)	(0.80)
EIKA		1.08	1.55
		(1.09)	(0.85)
MORE		4.91***	5.14***
		(0.89)	(0.84)
Constant	-47.11***	-41.31***	-39.66***
	(2.12)	(2.99)	(3.00)

Recalling that the two sample series have different starting dates due to poor quality in the Norwegian prices we conduct the EUR analysis with the same time horizon as the NOK series and observe that the results do not change much and that the main results hold, however it seems as the results become more statistically significant (see Table A.6).

10 The relationship between NOK and EUR spreads

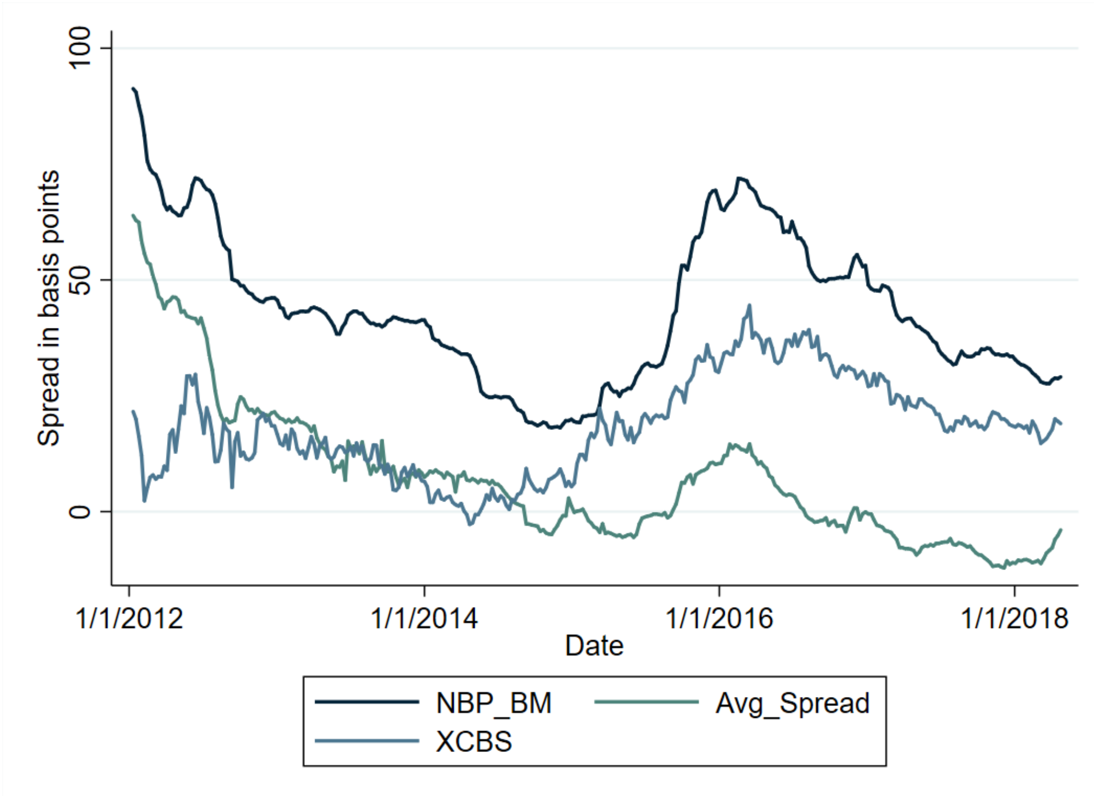
Before we can proceed to our conclusions we need to investigate the relationship between the two samples. According to Heitmann and Stokstad (2017), the difference between the NOK and EUR spreads should mostly be due to the cross-currency basis swap. In Figure 3 we show the average EUR spread calculated from our sample with the 5-year Nordic Bond Pricing's benchmark curve (due to the convenience in that the average time to maturity is close to 5 years in the EUR sample) and the 5 year cross-currency basis swap. As can be seen, there is a clear relationship between the three variables. In Table 11 we show the correlations between the three variables and a fourth variable consisting of the cross-currency basis swap added to the EUR spread. With a correlation of 0.92 we can establish that there is a tight link between the variables. In order to conclude which variable that affects the other, we run a Granger causality test with the NOK benchmark spreads and the combined EUR and cross-currency basis swap spreads and retrieve the following output from the test in Table 11. As expected, we see that the NBP benchmark is highly affected by the lags of the combined variable whilst the same does not hold in the opposite direction[10].

Table 11: Correlations

	Avg Spread	NBP BM	CCBS	EUR CCBS
Avg Spread	1.00			
NBP BM	0.69	1.00		
CCBS	-0.12	0.54	1.00	
EUR CCBS	0.81	0.92	0.49	1.00

[10] We also ran a slightly different specification with the combined variable as the cross-currency basis swap subtracted from the NOK spread and got similar results.

Figure 3: EURNOK basis swap and difference in risk premia



Note: Average spread measured as the arithmetic mean of the active bonds at each given period. The Benchmark curve is supplied by Nordic Bond Pricing and comprises the indicative spreads on 5 year NOK FRNs. We choose this time series as it is the closest to the average time to maturity in our series.

Source: Nordic Bond Pricing

11 Conclusions

From the EUR sample we can conclude that the Norwegian market for covered bond is sound and yield results in line with theory. Similar to Prokopczuk and Vonhoff (2012); Kempf et al. (2012); Koziol and Sauerbier (2007) we find that the yield spreads are mostly due to liquidity risk and only to a small degree credit risk. Looking at the NOK sample we see that liquidity and credit factors only provide minor economic influence on the spreads, however statistically significant with the expected signs. We suspect that the low magnitude in the NOK findings can be

Table 12: Granger causality test results

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
EURNOK CCBS						
EURNOK CCBS						
L1.	.9179	.0570	16.09	0.000	.8061	1.029
L2.	.0407	.0579	0.70	0.482	−.0728	.1542
NBP BM						
L1.	.1059	.1315	0.81	0.420	−.1518	.3638
L2.	−.0915	.1258	−0.73	0.467	−.3381	.1551
Constant	.2215	.6426	0.34	0.730	−1.037	1.481
NBP BM						
EURNOK CCBS						
L1.	.0929	.0206	4.50	0.000	.0525	.1334
L2.	−.0694	.0209	−3.31	0.001	−.1105	−.0283
NBP BM						
L1.	1.451	.04760	30.49	0.000	1.357	1.544
L2.	−.484	.0455	−10.64	0.000	−.5738	−.3953
Constant	.769	.2325	3.31	0.001	.3133	1.2249

driven by the low trading volume, high degree of quote based pricing in addition to a potentially poor liquidity proxy. In our broad assessment of Norwegian covered bonds we therefore choose to give the EUR sample a larger credit due to the superior data quality. As mentioned the NOK sample suffers from relatively low activity in the secondary market which might lead to sticky prices in the sense that quotes are not updated too often and lack relevant benchmark trades. This is a problem that is hard to get around other than what we did by including the foreign issues in EUR.

Different market environments between Norway and the Eurozone is of importance as we know that the European Central Bank has been very active in these bonds to support quantitative easing. ECB and the covered bond purchasing programmes have been present in our entire sample period which made us unable to differentiate the effects when these have not been present. The ECB owned around 30% of all outstanding covered bonds in the Eurozone as of mid 2017. They do not buy covered bonds issued by Norwegian banks, but this will likely have an effect on the whole market for covered bonds in Europe. Further research should be made to investigate the effects on covered bonds without the presence of interventions. Another difference between the markets is the different coupon structures (floating vs fixed). As these have very important determinants for pricing it is hard to compute a risk premium that is comparable. We recognize that our calculations are only simple approximations for the spreads. Future papers can try to integrate a more advanced approach. We also point out the period under investigation has been fairly stable for the Norwegian economy and the financial system in whole. The Norwegian covered bond market will not ultimately show its strength until it is tested against financial turmoil.

12 Appendix

Table A.1: NOK and EUR issues per issuer

Issuer	MNOK	EUR*
DNB (Boligkreditt)	83 670	312 425
Nordea	69 337	984
SpareBank1	61 868	134 408
Eika	43 752	40 837
Sparebanken Vest	32 850	30 564
Sbanken	25 500	-
Stadshypotek AB (Sweden)	23 000	-
KLP	17 046	-
Gjensidige Bank	16 991	-
Sparebanken Sør	16 563	9 840
Møre	15 550	3 001
Bustadkreditt Sogn og Fjordane	13 075	-
Storebrand	11 375	-
SR-Bank	11 060	23 568
Obos	11 000	-
Sparebanken Øst	9 381	-
SpareBank1 (Næringskreditt)	8 450	1 020
Verd	7 308	-
Fana Sparebank	6 337	-
Sandnes Sparebank	5 995	-
Helgeland	5 470	-
KLP	4 300	-
Eiendomskreditt	3 436	-
Landkreditt	3 105	-
Totens Sparebank	1 750	-
DNB (Næringskreditt)	257	-
Total	519 298	557 783

Note: *EUR amounts converted to NOK.

Source: Finans Norge

Table A.2: EUR bonds in sample

Issuer	ISIN	Issue date	Maturity	Issue size	Exch.
DNB	XS0478979551	20.01.2010	20.01.2017	1 500	BDL
DNB	XS0502969388	20.04.2010	20.04.2015	2 000	BDL
DNB	XS0527362692	20.07.2010	20.07.2015	400	BDL
DNB	XS0537686288	31.08.2010	31.08.2017	1 500	BDL
DNB	XS0576372691	11.01.2011	11.01.2016	2 000	BDL
DNB	XS0637846725	16.06.2011	16.06.2021	1 500	BDL
DNB	XS0691355282	18.10.2011	18.10.2016	2 000	BDL
DNB	XS0728790402	11.01.2012	11.04.2017	2 000	BDL
DNB	XS0759310930	21.03.2012	21.03.2022	2 000	BDL
DNB	XS0794233865	18.06.2012	18.06.2019	1 500	BDL
DNB	XS0856976682	21.11.2012	21.11.2022	1 000	BDL
DNB	XS0877571884	22.01.2013	22.01.2018	1 500	BDL
DNB	XS0992304369	12.11.2013	12.11.2018	1 500	BDL
Eika	XS0537088899	31.08.2010	31.08.2015	500	LSE
Eika	XS0736417642	25.01.2012	25.01.2017	500	LSE
Eika	XS0794570944	19.06.2012	19.06.2019	650	LSE
Eika	XS0851683473	06.11.2012	06.11.2017	1000	LSE
Eika	XS0881369770	30.01.2013	30.01.2023	1000	LSE
Sparebank1	XS0495145657	17.03.2010	17.03.2017	1 250	LSE
Sparebank1	XS0519708613	23.06.2010	23.06.2015	1 000	BDL
Sparebank1	XS0587952085	03.02.2011	03.02.2021	1 000	BDL
Sparebank1	XS0674396782	07.09.2011	07.09.2021	1 000	BDL
Sparebank1	XS0707700919	22.11.2011	22.11.2016	1 250	BDL
Sparebank1	XS0738895373	01.02.2012	01.02.2019	1 250	BDL
Sparebank1	XS0820929437	28.08.2012	28.02.2018	1 000	BDL
Sparebank1	XS0942804351	12.06.2013	12.06.2020	1 000	BDL
Sparebank1	XS0995022661	19.11.2013	20.01.2020	1 000	BDL
Sparebanken Vest	XS0515762093	09.06.2010	09.06.2015	500	BDL
Sparebanken Vest	XS0589450211	08.02.2011	08.02.2016	500	BDL
Sparebanken Vest	XS0742398547	07.02.2012	07.04.2017	500	BDL
Sparebanken Vest	XS0969571065	11.09.2013	11.09.2018	500	BDL

Note: LSE = London Stock Exchange, BDL = Luxembourg Stock Exchange

Source: Bloomberg, Stamdata

Table A.3: NOK bonds in sample

Issuer	ISIN	Issue date	Maturity	Issue size
DNB	NO0010503931	30.03.2009	29.09.2017	8 800
DNB	NO0010622087	12.07.2011	12.07.2018	7 000
DNB	NO0010664394	22.11.2012	22.11.2019	11 000
DNB	NO0010669864	15.01.2013	15.01.2018	3 500
DNB	NO0010672405	26.02.2013	26.05.2020	4 000
Eika	NO0010612039	08.06.2011	08.06.2018	3 500
Eika	NO0010663727	03.12.2012	03.12.2019	5 500
Eika	NO0010685480	14.08.2013	16.12.2020	5 000
Møre	NO0010657232	06.09.2012	06.09.2018	1 500
Møre	NO0010676018	10.05.2013	10.05.2019	1 250
Møre	NO0010696990	06.12.2013	16.01.2020	800
Nordea	NO0010636574	21.02.2012	21.06.2017	10 000
Nordea	NO0010647241	29.05.2012	19.06.2019	7 500
Nordea	NO0010674971	19.04.2013	20.06.2018	7 800
Sparebank1	NO0010623234	16.08.2011	16.08.2018	5 750
Sparebank1	NO0010657596	10.09.2012	10.09.2019	5 700
Sparebank1	NO0010670508	22.01.2013	17.06.2020	4 500
Stadshypotek	NO0010646847	16.05.2012	16.05.2019	4 500
Stadshypotek	NO0010673155	12.03.2013	12.03.2018	4 000

Source: Bloomberg, Stamdata

Table A.4: EUR sample: with outliers and omitted bonds

	(1)	(2)	(3)	(4)	(5)	(6)
Coupon	4.45***	4.44***	-0.18			-0.57
	(0.52)	(0.50)	(1.10)			(0.98)
Bid-Ask (yield)	4.13***	4.15***	5.93***			5.54***
	(0.43)	(0.44)	(0.39)			(0.43)
SP1BOL		0.53	0.08			0.38
		(1.34)	(2.21)			(1.79)
Eika		3.23*	2.91			3.11*
		(1.26)	(1.77)			(1.52)
SPVest		-1.11	1.04			0.92
		(1.56)	(1.36)			(1.20)
Time to maturity			8.01***		3.59***	7.38***
			(0.35)		(0.42)	(0.33)
ΔEuribor 3m				-1.50***	-1.42***	-0.17
				(0.32)	(0.24)	(0.13)
Impl. volatility				1.36***	1.28***	0.62***
				(0.11)	(0.10)	(0.06)
CCBS				-0.56***	-0.46***	-0.16**
				(0.05)	(0.07)	(0.05)
RE returns				0.94***	0.82***	0.12
				(0.18)	(0.16)	(0.11)
Slope				2.89	3.44*	6.73***
				(2.11)	(1.54)	(1.18)
Equity returns				0.92**	0.68**	-0.04
				(0.27)	(0.25)	(0.17)
Constant	-23.71***	-24.25***	-55.63***	-10.28**	-26.35***	-64.66***
	(2.46)	(2.28)	(1.92)	(3.84)	(3.07)	(2.68)
Adjusted R^2	0.336	0.340	0.801	0.316	0.474	0.842
Observations	7966	7966	7966	10418	10418	7823

Source: Bloomberg, Stamdata

Table A.5: NOK sample: with outliers and omitted bonds

	(1)	(2)	(3)	(4)	(5)	(6)
Liquidity	0.05	0.20	0.35*			0.30
	(0.14)	(0.15)	(0.15)			(0.18)
STAB		7.66	10.54*			9.63*
		(5.58)	(4.22)			(4.41)
SP1BOL		8.41	7.90*			8.24*
		(4.95)	(3.90)			(4.01)
EIKA		11.53	11.98*			12.53*
		(5.94)	(4.76)			(5.03)
MORE		10.58*	16.54***			15.17**
		(5.17)	(3.87)			(4.71)
Time to maturity			6.13***		5.59**	6.09***
			(1.32)		(1.67)	(1.33)
ΔNibor 3m				-7.18***	-6.19***	-3.61
				(1.59)	(1.04)	(1.91)
Impl. volatility				0.45***	0.38***	0.44***
				(0.08)	(0.05)	(0.05)
CCBS				1.03***	1.11***	1.03***
				(0.10)	(0.11)	(0.12)
RE returns				0.07	-0.02	-0.04
				(0.13)	(0.07)	(0.07)
Slope				1.57	5.40**	1.76
				(1.63)	(1.58)	(2.77)
Equity returns				-1.86***	-1.41***	-1.74***
				(0.35)	(0.21)	(0.35)
Constant	30.09***	23.68***	-0.51	-2.04	-26.05**	-32.27***
	(2.97)	(4.89)	(3.46)	(2.10)	(7.55)	(5.13)
Adjusted R^2	0.001	0.060	0.266	0.338	0.508	0.588
Observations	5556	5556	5556	5824	5824	5449

Source: Bloomberg, Stamdata

Table A.6: EUR sample: with comparable time horizon

	(1)	(2)	(3)	(4)	(5)	(6)
Coupon	0.18	0.33	-1.08*			-0.76
	(0.39)	(0.35)	(0.48)			(0.41)
Bid-Ask (yield)	1.10***	1.04***	4.10***			2.59***
	(0.26)	(0.26)	(0.32)			(0.33)
SP1BOL		0.74	-1.00			-0.56
		(0.69)	(0.89)			(0.73)
Eika		3.16***	2.57*			3.04***
		(0.72)	(0.95)			(0.68)
SPVest		0.28	0.29			0.85
		(0.53)	(0.84)			(0.79)
Time to maturity			4.59***		1.53***	3.53***
			(0.44)		(0.25)	(0.32)
ΔEuribor 3m				-1.90***	-1.72***	-1.32***
				(0.23)	(0.16)	(0.14)
Impl. volatility				0.48***	0.46***	0.34***
				(0.04)	(0.03)	(0.03)
CCBS				0.19***	0.22***	0.11***
				(0.02)	(0.02)	(0.03)
RE returns				-0.18*	-0.22**	-0.38***
				(0.08)	(0.07)	(0.07)
Slope				-1.40**	-0.86	-0.76
				(0.48)	(0.54)	(0.55)
Equity returns				-1.52***	-1.47***	-0.89***
				(0.10)	(0.11)	(0.12)
Constant	-7.55***	-8.32***	-34.46***	-10.55***	-16.84***	-29.68***
	(1.71)	(1.62)	(2.64)	(0.79)	(1.93)	(3.01)
Adjusted R^2	0.053	0.075	0.456	0.389	0.537	0.643
Observations	2889	2889	2889	3689	3689	2889

Source: Bloomberg, Stamdata

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