On the pricing of Credit-Linked Notes: Evidence from the Swedish market

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Abstract

Based on international evidence of overpricing, we study the newly established credit-linked note (CLN) market in Sweden during the period 2012 – 2013. We derive a theoretical pricing model based on a reduced form framework and value the outstanding CLNs in the Swedish market. Our results suggest significant and consistent overpricing, ranging from 0.6% to 6.4%. Furthermore, when accounting for the counterparty credit risk exposure in the issuer, the overpricing increases substantially to a maximum of 8.5%. Given this considerable overpricing, it is possible that the counterparty risk is not priced in the CLNs. Plausibly, investors perceive the issuer as "too big to fail", which is supported by previous findings of Arora et al. (2012). Lastly, our study indicates the existence of market frictions that influence the market pricing mechanism, obfuscating the relationship between observed prices and credit risk. Based on findings of Blanco et al. (2005), this could be a result of limited liquidity.

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Keywords: Structured products, interest certificates, credit-linked notes, reduced form models

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1 Introduction

In early 2012, Nordea, northern Europe's largest financial institution, launched a new investment product, Räntebevis (English translation: interest certificates), aimed at the individual investor market in Sweden. The product has the cash flow characteristics of a 5-year bond. It pays coupons on a quarterly basis until the product matures after five years and the investor receives the principal of 10.000 SEK, all cash flows being contingent on the absence of any credit event on the reference entity prior to any payoff date (Nordea, 2013). These characteristics might well lead individual investors to believe that they are investing in corporate debt, but this is a chimera; the interest certificate is in fact a structured product composed of a long position in a bond-like credit extension to Nordea and a short position in a credit default swap (CDS) on the reference entity. In marked contrast to a corporate bond, any credit event on Nordea is treated analogous to a credit event on the reference entity from a contractual point of view, also suspending all future cash flows. Thus, an investor that invests in an interest certificate is exposed to both credit risk and counterparty credit risk (Nordea, 2013). Despite this additional risk factor, interest certificates have proven hugely popular with the general public with sales totalling almost 5 billion SEK in 2012 (Bolander, 2013), representing 65% of the total increase in structured product sales in Sweden during the period (Hernhag, 2012; Taltavull, 2012). By lowering the investment threshold significantly, from roughly 500.000 SEK for a standard corporate bond to 10.000 SEK for an interest certificate, Nordea has been able to extend the market for fixed-income securities to include a far greater number of investors. The product is marketed as "higher interest than a savings account, safer than equity" likely because Swedish individual investors have traditionally been investing predominantly in equity (Broomé, 2012). It is plausible that part of the product's popularity might be driven by investor interest in finding fixed-income investments to diversify their portfolios, something that has increased posterior to the financial crisis.

Given the remarkable growth of the interest certificate market over the past year and the product's increased share of individual investors portfolios, it is relevant to study whether investors are being sufficiently compensated for the risk they take when investing in these products. International research is a further imperative as it has consistently identified significant overpricing in structured product markets (Stoimenov and Wilkens, 2005, 2007; Wilkens et al., 2003; Wallmeier and Diethelm, 2009; Rathgeber and Wang, 2011). Certainly, the topic of whether or not interest certificates are fairly priced has already attracted attention from business media in Sweden (Flores, 2012), but to date, no academic study has attempted to address the question. In this paper, we derive a theoretical fair price model for interest certificates based on a credit-linked note (CLN) valuation framework. We employ this model in estimating daily fair prices for the outstanding interest certificates and then gradually relax the underlying assumptions. First, we relax the ex-post recovery rate assumption to examine the effect that an altered recovery rate has on the valuation and discuss whether different expectation about the recovery rate could explain the mispricing. Finally, we extend our valuation to include the credit risk exposure in the issuer.

This study is, to the best of our knowledge, the first study of its kind on the Swedish market as well as the first study that value CLNs using a time-series approach rather than valuing the products at issuance. Since Nordea's interest certificates are market traded, a time-series approach increases the scope of the research to reach beyond primary market activity to include the secondary market. Studying only the primary market typically limits the scope to examining whether structured products are mispriced in favor of the issuing institution at issuance, as well as studying what factors that influence the mispricing. Extending the scope of the research to include the secondary market has several advantages. First of all, the extent to which theoretical and observed prices track one another in the time-series estimation gives a distinct indication of the valuation model's validity. In a simple valuation at issuance, it is much more difficult to ensure a robust model. Additionally, since a theoretical price model implicitly assumes a frictionless market, a time-series comparison between theoretical and observed prices is an indirect way of studying market frictions and their pattern over time.

Our results indicate significant mispricing of interest certificates throughout our sample time period, with an average overpricing that ranges from 0.6% to 6.43% depending on reference entity. We argue that observed price discrepancies cannot be explained by erroneous assumptions about the recovery rate, since the required rates are substantially higher than the long-term historical average for all interest certificates in the sample. Furthermore, when accounting for the counterparty credit risk exposure, the overpricing increases between 2.1% and 4.1%, to a maximum of 8.5%. Given this considerable overpricing, we find it plausible that investors do not value the counterparty risk, perceiving the issuer as "too big to fail", which is supported by previous findings of Arora et al. (2012). Lastly, our study indicates the existence of market frictions that obscures the relationship between the price and the perceived credit risk. Based on the findings of Blanco et al. (2005), this could be the result of limited liquidity.

We believe that the results of this study are relevant to individual investors with an interest in Nordea's interest certificates. Furthermore, by illustrating the impact that gradually altered assumptions about the recovery rate and counterparty risk has on the fair price of a CLN product, investors can develop a general understanding of the risks associated with structured product investments. Finally, the features and frictions of the interest certificate market should be interesting for both individual investors and academics, being both a novel market and one made up almost exclusively by individual investors.

1.1 Paper outline

The rest of this paper is organized as follows. In section 2, we give a background on interest certificates, on what information can be gathered from the investor prospectus and conclude that interest certificates are a form of credit-linked notes (CLNs). We also provide a background on CLNs, their historical usage and some controversy surrounding the instrument. In section 3, we discuss previous research on the pricing of structured products, this includes studies on both non-coupon paying and coupon paying structured products. The chief interest is to develop an understanding of what patterns of mispricing that have been identified in previous research as well as plausible drivers of mispricing. In section 4, we develop the theory on CLN valuation and derive the theoretical pricing model employed to price the interest certificates. This section also includes a discussion on recovery rates, the interest rate interpolation procedure and details on the copula function used to value the counterparty credit risk exposure. In section 5, the data is described. In section 6 our results are presented leading up to a discussion of our results in section 7 and our conclusion in section 8.

2 Background

2.1 Interest certificates

Interest certificates are more complex products than what it might appear at first glance. In the prospectus, Nordea refers to the product as a credit-linked note. Although Nordea recognise that the instrument is not the equivalent of a corporate bond, the return of the product is supposedly driven by the same underlying factor as a corporate bond; the credit risk of the reference entity. However, besides being exposed to the credit risk of the reference entity, the buyer of the product also has a credit risk exposure to Nordea. In return for taking on these credit risk exposures, the investor receives quarterly coupon payments, determined by the STIBOR and a fixed coupon depending on the reference entity. These coupons are paid on March 20th, June 20th, September 20th and December 20th, the IMM (International Monetary Market) dates commonly used for CDS contracts under the standard ISDA (International Swaps and Derivatives Association) contract clauses. The interest certificates are traded in notional values of 10.000 SEK and promises to repay this principal at maturity contingent that no credit event has occurred. Three forms of credit events are defined; insolvency, illiquidity ("failure to pay") and restructuring. This is equivalent to the convention on European standard CDS contracts. The subsequent section provides more details on CLNs, their usage, as well as some historical controversies surrounding the product.

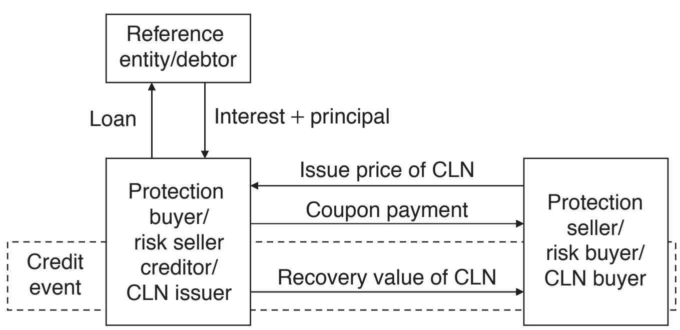
2.2 Credit-linked notes

A credit-linked note (CLN) is a funded credit derivative with an embedded CDS and is used to transfer credit risk from the issuer to third-party investors. Thus, the investor in the note functions as the protection seller and makes an upfront payment to the issuer of the note, the protection buyer, when purchasing the note. In the absence of any credit event the investor will be repaid the par value of the note at the maturity of the contract. However, if a credit event occurs, the investor will receive a reduced amount contingent on the market value of a reference asset, typically a bond, to which the CLN is linked. This credit risk is transferred by the use of a CDS. For taking on this risk, the investor is compensated with regular coupon payments. There is one additional risk factor, however; if the issuing counterparty would default prior to the maturity of the product, the investor also loses part or all of her investment. This risk is transferred through the use of some debt obligation from the issuer to the investor. The investor therefore has a dual credit risk exposure to both the reference entity and the financial counterparty. Depending on the specific financing set-up, the counterparty can be either the issuing bank or an off-balance sheet entity. Prior to the financial crisis, American investment banks, notably Lehman Brothers, issued CLNs through off-balance sheet structured investment vehicles (SIVs) backed by collateral, commonly US Treasuries or collateralized debt obligations (CDOs). In a collateral pool of treasuries, this reduced the counterparty risk significantly. CDOs, on the other hand, turned out to be rather opaque and difficult for investors, or even credit institutes, to value accurately (Fabozzi et al., 2007).

Nordea's CLNs are issued by Nordea Finland Oy and retains the collateral for sold CLNs on their balance sheet. To assess the counterparty risk of Nordea's CLNs, investors need to have a good understanding of Nordea's credit position.

A typical CLN construction is illustrated in Figure 1.

Figure 1 – CLN construction



source: Rathgeber and Wang (2011)

2.2.1 Regulatory capital requirements and CLNs

Historically, CLNs have been an attractive way for banks to reduce regulatory capital requirements, mainly by selling off the credit risk of their loan portfolio to third party investors. By doing so, the bank can reduce or eliminate its need for the core capital buffer stipulated by financial regulation, e.g. Basel II/Basel III. This can lower the bank's funding cost significantly. As an example, take a bank that gives out a loan of $100 million to a corporate client. In accordance with financial regulation, the bank has to maintain a core capital buffer to cover eventual credit losses from the loan. The size of the required capital buffer depends on risk of the loan; this example will assume a core capital requirement of 10%. Thus, the bank needs to raise $10 million in core capital. By issuing a CLN that is sold to third-party investors, the credit risk of the loan can be transferred away from the bank's balance sheet. The bank retains the proceeds from the note sale as collateral, either in the form of cash, treasuries or similar low risk securities, while the holder of the note receives periodic coupon payments originating from the loan as compensation. If the entire $100 million is transferred, the bank has a net loan volume of $0 and need not raise any core capital but can likely charge some intermediary rent to manage the credit risk transfer. Third party investors are interested in this arrangement if it opens a new investment possibility for them that have a more attractive yield than alternative investments (Fabozzi et al., 2007).

Due to the on-going regulatory changes related to the Basel III implementation with increased core capital requirements, the issue of regulatory capital is of paramount importance in contemporary bank financing. Banks are increasingly trying to identify business opportunities that are "capital-light", meaning that they will not require banks to burden their balance sheets with credit or market risks that will require core capital buffers. The use of CLNs as vehicles of credit risk transfer could be one such financial product. By acting as a broker of credit risk, a bank can charge intermediary rents without taking on risk itself.

2.2.2 Controversy surrounding CLNs

There has been some historical controversy surrounding the use of CLNs in the late 90's and beginning of the 21st century. Enron relied heavily on CLNs for funding through SIVs. The banks that issued these CLNs eliminated the credit risk of Enron from their balance sheets and transferred it to third party investors. When Enron declared bankruptcy, all coupon payments were suspended and investors received near worthless Enron bonds through the physical settlement process specified for these CLNs. The banks, on the other hand, claimed the secure collateral that the SIVs had been investing in. Posterior to the bankruptcy of Enron, investors sued the banks that had issued the CLNs, claiming that they had had inside knowledge of Enron's credit position that had incentivized them to off-load their credit risk to investors (Fabozzi et al., 2007).

More recently and similar to the Nordea case, individual investors in Hong Kong and Singapore invested substantial capital in CLN based products labelled "minibonds", whose chief issuing institution was Lehman Brothers. These products had credit risk exposures to Lehman Brothers, resulting in massive losses for individual investors when Lehman Brothers proclaimed bankruptcy. In Hong Kong, 43 000 individuals had bought minibonds issued by Lehman Brothers to a value of 1.8 billion US dollars. Eventually, investors did redeem a significant amount in the settlement process, mainly by the sale of the CDO collateral that backed most of these instruments. Nevertheless, the minibond tale highlights the importance of including counterparty credit risk exposure in the valuation of structured products (Yiu, 2012) (Swedberg, 2010).

3 Literature review

There exists a literature, albeit a relatively limited one, devoted to studying of the pricing and mispricing of structured products. The research is aimed at identifying whether or not structured products are mispriced relative to their theoretical prices as well as what factors that tend to amplify the mispricing.

Burth et al. (2001) study the pricing of structured products on the primary market in Switzerland, using a sample consisting of all outstanding products on the Swiss market as of August 1st, 1999. The authors compare the offer prices from the issuing institutions with the theoretical prices of buying the replicating portfolio, calculated using EUREX data of derivate prices. In 84% of the issuances, the issuing price deviates from the theoretical value of the replicating portfolio in favor of the issuing institution. However, since individual investors are typically unable to construct the equivalent position themselves, the authors argue that some premium is reasonable. Furthermore, by analysing the two sub-categories of coupon and non-coupon paying structured products, the authors find that the mispricing of coupon-paying instruments is higher relative to non-coupon paying instruments. They hypothesize that this pattern could be explained by the relative novelty of coupon-paying structured products on the Swiss market at the time. Finally, they find that when private banks act as a co-lead manager for a structured product issue, the issuance price is closer to the fair price of the position on average.

Stoimenov and Wilkens (2005) perform a study of the market for equity linked structured product in Germany. Similar to Burth et al. (2001), they find a consistent pattern of overpricing relative to the price of the equivalent positions constructed from EUREX derivatives data. Furthermore, they find that the overpricing is higher for more complex products that incorporates exotic options relative to more "plain vanilla" type structured products. The authors explain this as being related to the issuers hedging cost. Another important finding is that single stock structured products are, on average, sold at a higher premium relative to their theoretical prices than structured products based on the DAX-index. A consistent pattern of decreasing divergence between observed and theoretical prices as the products approach maturity is also identified. Stoimenov and Wilkens (2005) believe that this pattern could be explained by the market maker role of the issuing institution. As the products approach maturity, the issuer has an incentive to lower its prices in order to sell off the remaining inventory.

Wallmeier and Diethelm (2009) perform a similar study on multi-asset reverse convertibles with knock-in barriers in Switzerland and find significant overpricing averaging 3.4%. Furthermore, they find that products with higher coupon rates are more significantly overpriced on average, leading the authors to conclude that individual investors have a behavioural bias for high coupons over the risk profile of the investment.

There is a major difference between the approach of the aforementioned studies and the approach of this paper. The previous studies have been performed on structured products that can be perfectly replicated using options and underlying financial instruments. These structured products allow for a relatively straightforward no-arbitrage pricing using equity, equity indices, stock options, index options etc. Valuing credit derivatives is somewhat more complicated since the market is more opaque, being an OTC market. Nevertheless, there exist CDS par spreads on benchmark contracts that can be obtained from Bloomberg, Thomson Reuters and FactSet that can be used to value structured products with credit risk exposures. Although the literature on the mispricing of such products is very limited, Rathgeber and Wang (2011) perform a study of 136 CLNs on the German market. By bootstrapping implied default probabilities from CDS spreads, they are able to assess the fair price of the outstanding CLNs. They find that the CLNs on the primary market are generally significantly overpriced in favor of the issuing institutions. Several factors tend to amplify the magnitude of the mispricing, notably the number of underlying reference entities and the size of the coupon payments. The authors argue that the complexity of the product is strictly increasing in the number of credit risk exposures, since multiple exposures require more sophisticated valuation models. Such methods are not generally available to individual investors, which might help explain why they are more overpriced on average. Rathgeber och Wang conclude that the issuing institutions exploit this information asymmetry by charging higher premiums, increasing the magnitude of the mispricing.

While most of the aforementioned articles value structured products under the assumption of a risk-free counterparty, this paper extends the scope of the analysis by estimating theoretical fair prices when the risk-free counterparty assumption is relaxed. In order to make this extension, we need to incorporate a framework for estimating the default correlation between the issuer and the reference entities, since the assumption of non-correlated defaults is too simplistic and leads to underestimated theoretical prices. This is done by using the copula function approach proposed by Li (2000).

4 Theory and methodology

4.1 CLN Valuation

In this paper, we analyze CLNs with four quarterly coupon payments and a principal repayment at maturity. Under the assumption of a risk-free issuing counterparty, the valuation model is equivalent to that of a coupon-paying bond with a non-zero recovery rate. Thus, the value today is the sum of the present discounted value of the coupon and principal payments, where the weights are given by the risk-neutral survival probabilities $Q(t,T)$ (Bomfim, 2005):

$$V^{CLN} = \left[\sum_{i=1}^{N} Z(t,T_i)Q(t,T_i)C + Z(t,T_N)Q(t,T_N)\right]F + \sum_{i=1}^{N} Z(t,T_i)\left[Q(t,T_{i-1}) - Q(t,T_i)\right]R \quad (1)$$

Where R is the recovery rate, F is the notional value and Z is the riskless discount factor.

While Formula 1 assumes a fixed coupon rate, C, the actual coupons of many CLNs are floating. Nordea's, for instance, is specified as STIBOR plus a fixed coupon depending on the reference entity. The floating coupon can be accounted for by calculating a forward rate from observed spot rates. We take the Nordea CLN with quarterly coupons consisting of the STIBOR plus b basis points. The forward rate for payment between term t_1 and t_2 is denoted $f_{t1,t2}$ and is given by (Fabozzi and Mann, 2005):

$$f_{t1,t2} = \left(\frac{(1+r_2)^{t_2-t_0}}{(1+r_1)^{t_1-t_0}}\right)^{\frac{1}{t_2-t_1}} - 1 \quad (2)$$

Since the spread b is known today and fixed for all future payments, we simply add the spread to the forward rate to get the coupon payment.

In order to estimate the fair value of this contract (Formula 1), we need to estimate the two unknown parameters, the recovery rate and the cumulative probability of survival. Recovery rates are admittedly tricky since the underlying reference entities are giant corporations of the type that rarely default and hence leave very little historical data. However, historical estimates puts the long-run recovery rate at approximately 40% (Altman and Kishore, 1996; Moody's, 2011). For a more in-depth discussion, see Section 4.3

There exist two principal methods of deriving default probabilities: Structural models and reduced form models. These models have radically different approaches. Structural models are typically based on the Merton model proposed by Merton in 1974, which assumes that equity, $E(t)$, can be viewed as a call option on firm value. The idea is that the firm has a set of assets that constitute the firm value, $V(t)$, as well as debt, $\overline{DD}$, in the form of a zero-coupon bond maturing at T. If the value of the assets exceeds the face value of debt at maturity ($V(T) > \overline{DD_T}$), equity holders will be entitled to the residual value. If not, they are assumed to be protected by limited liability, hence the call option like payoff structure. Conversely, this model can also be used to value the outstanding debt of a company. The elegant structure of the Merton model also provides an endogenous definition of the recovery rate. The basic assumption of the model is that the firm value $V(t)$ can be modeled. Merton's original approach was to model it as a Geometric Brownian motion, an assumption that has subsequently received some critique, resulting in alternative definitions, notably including a jump-diffusion process to account for the sudden nature of default. Under the basic assumption that the firm value follows a Geometric Brownian motion, it has the dynamics (Bomfim, 2005):

$$dV(t) = \mu V(t) + \sigma V(t) dW_t \tag{3}$$

Employing these dynamics in repeated Monte Carlo simulations, we can estimate default probabilities for different time windows. A structural model has several benefits. It provides an endogenous analytical solutions to the recovery rate and other key variables and thus allows us to study interrelated changes in the parameters. Furthermore, structural models are partly built on balance sheet data and therefore explicitly link the probability of default of a given firm to its economic and financial condition. On the other hand, balance sheet data is usually only available on a quarterly basis, or even on an annual basis for non-listed firms, leading to a rigid model with infrequently updated parameters such as outstanding debt. Since a structural model estimates the default risk based on financial fundamentals rather than market data, it is also ill-suited for estimating daily default probabilities. Market activity and information influencing the default risk result in significant short-term variations in the perceived credit risk that cannot be captured by quarterly or annual fundamentals. Structural models are therefore better suited for long-run rather than short-run estimations. Additionally, the structural model relies on a number of crucial assumptions about the firm value dynamics, firm value volatility and drift (Bomfim, 2005). These assumptions have a tremendous impact on the simulated default probabilities. Using a structural model therefore requires an accurate model specification and finely tuned parameters. Estimating a parameter such as firm value volatility is complicated since the firm value is not the price of a traded asset. Thus, some approximation would have to be made, such as assuming that the firm value volatility is equal to the stock price volatility. Obviously, this is an imperfect assumption that might bias the results. Moreover, for a non-listed firm, it would not be possible to make an equity-based volatility estimation.

Reduced form models take a different approach than structural models, inferring the default risk based on market data rather than by simulating default probabilities based on financial fundamentals. This results in a model that has a more flexible parametric estimation of observed credit spreads in the market. The most commonly used reduced form method is the Jarrow and Turnbull (1995) model, which assumes the default probability at time τ follows a Poisson process (O'Kane and Turnbull, 2003):

$$P[\tau < t + dt | \tau \geq t] = \lambda(t) dt \tag{4}$$

The probability of default occurring within the time interval $[t, t+dt)$, conditional on surviving to time t, is proportional to a time dependent function $\lambda(t)$, commonly referred to as the hazard rate. Modelling this in a simple one-period binomial tree setting yields a survival rate of $1 - \lambda(t)dt$, or default with probability $\lambda(t)dt$. The n-period default and survival rates are $\lambda(t + (N-1)dt)dt$ and $1 - \lambda(t + (N-1)dt)dt$, respectively. For simplicity, the hazard rate is assumed to be deterministic and independent of recovery rates and interest rates. In continuous time, the multi-period survival probability model in the limit $dt \to 0$ is given by (O'Kane and Turnbull, 2003):

$$Q(t_V, T) = exp\left(-\int_{t_V}^{T} \lambda(s)ds\right) \tag{5}$$

For the purpose of our study, we find a reduced form model approach to be the most suitable way of estimating default probabilities. This is due to the fact that we want to estimate CLN prices on a daily basis and require an approach that allows us to account for daily variations in credit risk. The two main financial instruments with direct exposures to credit risk are corporate bonds and CDS contracts. Although default probabilities can be inferred from both bond prices and CDS spreads, the superior liquidity of the CDS market makes probabilities inferred from CDS spreads a more direct measure of credit risk. Default probabilities inferred from bonds typically include some liquidity premiums that can result in overestimated default risk (Blanco et al., 2005). In the subsequent section, the method used to extract risk probabilities from CDS spreads are discussed in detail.

4.2 Deriving default probabilities from CDS spreads

Understanding the method used to infer default probabilities from CDS spreads requires some prior knowledge of CDS contracts. An introduction for readers unfamiliar with CDS contracts can be found in Appendix B.

4.2.1 CDS valuation and implied default probabilities

The value of a CDS contract is theoretically determined as the sum of expected future cash flows. From the perspective of the issuer, CDS pricing is done in order to match the expected future cash-flow stream against the expected credit losses with the convention being to set a spread that makes the value of the contract zero at inception. The protection seller will receive an insurance premium equal to the CDS spread up-until the eventual default (credit event) of the reference entity when she will have to pay the default payment minus any accrued premium. Thus, the value of the contract depends on the expected credit losses, which determines the CDS spread (Hull, 2009; O'Kane and Turnbull, 2003).

Valuing the premium leg

The valuation of a CDS is comprised of two parts; valuing the premium leg and valuing the protection leg. The premium leg is the series of premium payments made until maturity or the time of a credit event, whichever occurs first. In the event of default, the premium also typically includes accrued premiums up to the date of the credit event. Ignoring accrued premiums until later, the present value of the premium leg can be written as (O'Kane and Turnbull, 2003):

$$Premium\ Leg\ PV(t_V, t_N) = S(t_0, t_n) \sum_{n=1}^{N} \Delta(t_{n-1}, t_n, B) Z(t_V, t_n) Q(t_V, t_n) \tag{6}$$

Where:

$S(t_0, t_n)$ is the contractural default swap spread

$\Delta(t_{n-1}, t_n, B)$ is the day count fraction between premium dates t_{n-1} and t_n in the appropriate convention noted by B

$Q(t_V, t_n)$ is the survival probability of the reference entity from valuation date t_V to time of premium payment t_n

$Z(t_V, t_n)$ is the discount factor from from valuation date t_V to time of premium payment t_n

As previously mentioned, the above model ignores the effect of accrued premiums. If the reference entity defaults between two premium dates, the protection buyer normally has to pay accrued interest for the period between the last premium installment and the date of default. To account for the effect of accrued premiums, one has to consider the possibility of default occurring at any given time in-between two premium dates and calculate a probability weighted accrued premium payment. This is done by determining the cumulative survival probability for each successive time period as well as the conditional probability of default, the hazard rate, in the next small time step, given by $Q(t_V, s)\lambda(s)ds$. Since the accrued premium will simply be the CDS spread times the time lapse between the last premium payment and the time of default, the full model including discounting is given by (O'Kane and Turnbull, 2003):

$$S(t_0, t_N) \sum_{n=1}^{N} \int_{t_{n-1}}^{t_n} \Delta(t_{n-1}, s, B) Z(t_V, s) Q(t_V, s) \lambda(s) ds \tag{7}$$

However, this integral is complicated to compute in practice. O'Kane and Turnbull (2003) show that the expression can be approximated with:

$$\frac{S(t_0, t_N)}{2} \sum_{n=1}^{N} \Delta(t_{n-1}, t_{,n}, B) Z(t_V, t_n)(Q(t_V, t_{n-1}) - Q(t_V, t_n)) \tag{8}$$

Assuming that, on average, default occurs exactly between two premium dates, the accrued premium is half of the premium of the premium paid at the end of the premium period.

Using the above approximation, the full expression of the premium leg is given by:

$$S(t_0, t_N)\sum_{n=1}^{N}\Delta(t_{n-1}, t_{,n}, B)Z(t_V, t_n)\left[(Q(t_V, t_n) + \frac{1}{2}(Q(t_V, t_{n-1}) - Q(t_V, t_n))\right] \tag{9}$$

Valuing the protection leg

Valuing the protection leg is equivalent to valuing the risk-weighted default payment ($N - \mathit{Recovery\,value}$) that is paid from the protection seller to the protection buyer subsequent to a credit event. Although the exact time lapse between a credit event and the default payment can vary in practice, mostly because the time required to determining the realized recovery rate varies, it is conventional to assume that any default payment is paid immediately after the credit event. To account for the risk of default in each time period, the cumulative survival probability, Q_t, and conditional probability of default, $\lambda(t)$ are computed for each time period t. Using these estimates, the risk of default in all time periods can be calculated at time t_0 and a risk-weighted estimation of the default payment can be calculated. The present value of the default payment is (O'Kane and Turnbull, 2003):

$$(1 - R)\int_{t_V}^{t_N} Z(t_V, s)Q(t_V, s)\lambda(s)ds \tag{10}$$

Assuming that a credit event can only occur at a finite number of M discrete points in time per year, we get:

$$(1 - R)\sum_{n=1}^{Mxt_N} Z(t_V, t_m)(Q(t_V, t_{m-1}) - Q(t_V, t_m)) \tag{11}$$

The above approximation reduces the estimation accuracy with $r/2M$ relative to calculating the integral, where r is the risk-free interest rate. In our case of quarterly intervals ($M = 4$) and assuming $r = 2\%$, the approximation will result in a percentage error of 0.25% or 1.25 bp on a 500 bp spread assuming a flat hazard rate term structure; a rather limited effect that will not implicate the overall results (O'Kane and Turnbull, 2003).

Breakeven spread and the hazard rate term structure

The issuing institution sets the CDS spread so that the cost of entering into the contract, equivalently the value of the contract, is zero at inception. This implies that:

$$PV(Premium\ Leg) = PV(Protection\ Leg) \tag{12}$$

Given this equality the CDS spread can be expressed as:

$$S(t_V, t_N) = \frac{(1-R)\sum_{m=1}^{M \times t_N} Z(t_V, t_m)\left[Q(t_V, t_{m-1}) - Q(t_V, t_m)\right]}{\sum_{n=1}^{N} \Delta(t_{n-1}, t_n, B) Z(t_V, t_n)\left[Q(t_V, t_n) + \frac{1}{2}\left(Q(t_V, t_{,n-1}) - Q(t_V, t_n)\right)\right]} \tag{13}$$

Given a constant recovery rate and a known yield curve, the only unknown factors in this equation are the survival probabilities (Q_t), which, assuming quarterly payments and monthly discretization, sum up to a number of sixteen. Obviously, without further assumptions, the survival probabilities cannot be inferred from this equation. In order to solve for the survival probabilities, we assume that the hazard curve is a piecewise flat function of maturity T (see Figure 2 for an illustration; the left picture illustrates the piecewise flat term structure). This assumption is necessary since it is not possible to extract multiple hazard rates from only one data point without further assumptions. Using quoted CDS spreads with maturities of $1\text{Y}, 3\text{Y}, 5\text{Y}, 7\text{Y}$ and 10Y, the piecewise flat hazard term structure would comprise of $\lambda_{0,1}, \lambda_{1,3}, \lambda_{3,5}, \lambda_{5,7}$ and $\lambda_{7,10}$ (O'Kane and Turnbull, 2003).

In order to solve for the unknown parameters, using monthly discretization, we use a bootstrapping procedure:

$$S(t_v, t_v + 1Y) = \frac{(1-R)\sum_{m=1}^{12} Z(t_V, t_m) e^{-\lambda_{0,1}\tau_{m-1}} - e^{-\lambda_{0,1}\tau_m}}{\sum_{n=3,6,9,12} \Delta(t_{n-3}, t_{,n}, B) Z(t_V, t_n) e^{-\lambda_{0,1}\tau_n}} \tag{14}$$

This is solved recursively, starting with the period $0 < \tau \leq 1$. With the periodic hazard rates and defining $\tau = T - t_V$ we get the survival rates:

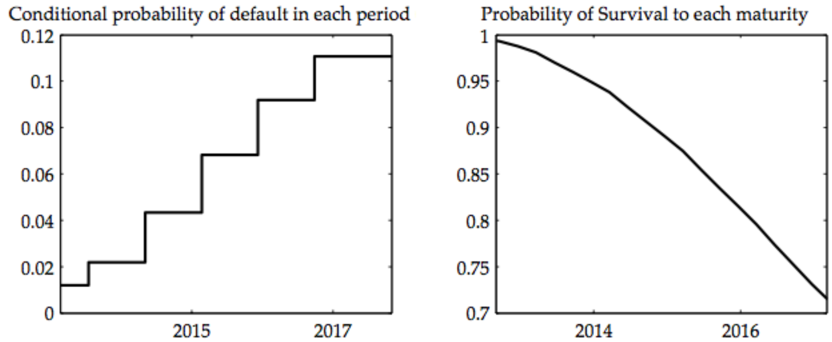
$$Q(t_V, T) = \begin{cases} e^{-\lambda_{0,1}\tau} & 0 < \tau \leq 1 \\ e^{-\lambda_{0,1} - \lambda_{1,3}(\tau - 1)} & 1 < \tau \leq 3 \\ e^{-\lambda_{0,1} - 2\lambda_{1,3} - \lambda_{3,5}(\tau - 3)} & 3 < \tau \leq 5 \\ e^{-\lambda_{0,1} - 2\lambda_{1,3} - 2\lambda_{3,5} - \lambda_{5,7}(\tau - 5)} & 5 < \tau \leq 7 \\ e^{-\lambda_{0,1} - 2\lambda_{1,3} - 2\lambda_{3,5} - 2\lambda_{5,7} - \lambda_{7,10}(\tau - 7)} & \tau > 7 \end{cases} \tag{15}$$

For a constant hazard rate it can be shown that (Beinstein et al., 2006):

$$Q(t_v, t_n) = (1 - \lambda)^n \tag{16}$$

for $i = n$

Figure 2 – Hazard rates and cumulative survival probability



Hazard rates and cumulative survival probability of Stora Enso, 5th of March 2012

A flat term structure implies a constant hazard rate, meaning that if the per period hazard rate is constant, then the spread should be constant and the curve should be flat. An upward sloping term structure implies that the market believes that the hazard rates are increasing over time. This means that the probability of default in any period, conditional on not having defaulted, is increasing for each successive time period. One plausible explanation of such a pattern could be found by looking at transition matrices of historical default probabilities; highly rated companies show higher default rates in the long run than in the short run. Although a company might have an excellent credit position in the short run, the risk of an event that might worsen that position is typically increasing over time. Conversely, a downward sloping credit curve implies that the market believes that the per period conditional default probability is decreasing over time. This pattern is prevalent in lowly rated companies, the intuition being that if such a company would survive the initial few years, its credit position is likely to have improved (Hull, 2009).

4.3 Estimating the recovery rate

CDS recovery rates are determined ex-post by two different methods. The first method is to observe the prices of traded bonds on a defaulted entity subsequent to a credit event to determine the recovery rate. The second method is to determine the recovery rate in an auction arranged by ISDA, where investment banks submit bids for which they would be willing to buy the debt of the defaulted entity (Helwege et al., 2009).

Several factors influence the recovery rate. The value of a defaulted credit obligation on a company should naturally depend on the markets expectation either on the company's ability to revitalize their operations despite the credit event, or on the perceived value of its assets if sold. Several studies have shown that recovery rates are negatively correlated with default rates, meaning that as the number of defaults increase, typically in periods of financial turmoil, recovery rates tend to go down, furthering investor losses (Altman et al., 2005). This is likely a result of both altered liquidity premiums and decreased asset demand during these periods of crisis. The claimable assets of any company should reasonably be harder to sell during a period of crisis, both since they are harder to put into productive use for another firm due to the macroeconomic climate and because of amplified liquidity and financing constraints. Similarly, the chance of a company making a financial turnaround so that it can generate sufficient cash flows to cover its debt liabilities is also reduced in periods of macroeconomic distress (Altman et al., 2004; Acharya et al., 2007).

The key problem in estimating a reasonable recovery rate is the scarcity of historical data. Since the companies that function as reference entities for Nordea's CLNs are all large corporation of the kind that rarely defaults, reasonable recovery rates of comparable firms are difficult to find. Although some historical realized recovery rates exist, they are typically available on levels of aggregation that complicates the analysis. Notably, the availability of reliable industry recovery rate estimates is severely limited. Different industries can reasonably be assumed to have different recovery rates, the intuition being that the amount of claimable assets should differ significantly between industries. Some studies have compiled industry level recovery rate estimates, one of the most comprehensive being Altman and Kishore (1996) who study bond defaults during the period 1971-95. They find that the highest average bond recovery rate for any industry is found to be roughly 70% for public utilities and the industries with the lowest recovery rates hovering around 30% or slightly lower numbers. Altman and Kishore (1996) provide some of the best available long-term estimates of defaulted bond recovery rates. However, the industry categories are rather broad and often include several types of firms with different lines of business. As an example, financial services is considered one industry although the recovery rates for the different types of financial services firms that constitutes the industry are widely different. During 1971 - 1995, mortgage institutions had an average recovery rate of 67.6% while saving institutions had a corresponding rate of only 9.25%. Also, for certain industries of interest for our study, notably telecommunications and shipping, no figures are provided. Another issue is that these estimates are non-contemporary; in the wave of bankruptcies related to the financial crises, the ex-post recovery rates were significantly lower than these historical numbers in certain cases of default. During 2008 – 2009, some recovery rates were as low as 10%, although it should be noted that these numbers were biased towards financial institutions holding toxic financial assets such as subprime CDO tranches. Nevertheless, based on the data from the 2000's, a 10% recovery rate can serve as a worst-case scenario in valuing the CLN products (Rathgeber and Wang, 2011).

4.4 Interpolating the yield curve

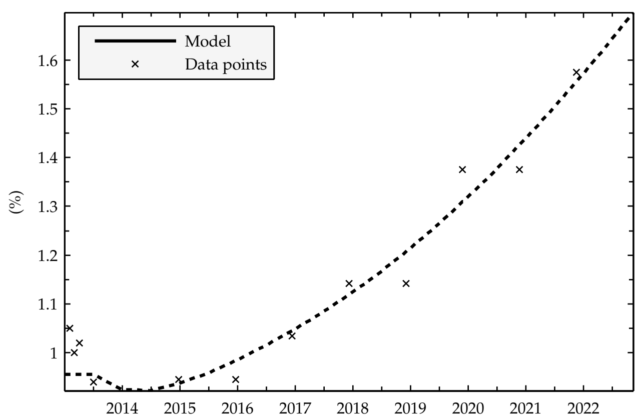
When valuing a CLN, the cash flows need to be discounted using an appropriate discount rate. The common practice amongst derivative traders is to use the LIBOR swap zero curve rather than the Treasury yield, because the latter is believed to be artificially low. For a discussion see Hull et al. (2004) and Longstaff et al. (2005).

STIBOR is the LIBOR equivalent on the Swedish market, the local intra-bank risk-free benchmark. Since STIBOR has a maximum tenure of 6 months, discount rates for dates after 6 months are bootstrapped from quoted swap contracts with durations of 1-6 years. The Nelson-Siegel Svensson (Svensson, 1995) model, used by the Swedish Riksbank as well as other central bank authorities, is employed in the interpolation procedure. It is specified as:

$$y(\tau) = \beta_1 + \beta_2 \left(\frac{1 - e^{-\lambda_{1\tau}}}{\lambda_{1\tau}} \right) + \beta_3 \left(\frac{1 - e^{-\lambda_{1\tau}}}{\lambda_{1\tau}} - e^{-\lambda_{1\tau}} \right) + \beta_4 \left(\frac{1 - e^{-\lambda_{2\tau}}}{\lambda_{2\tau}} - e^{-\lambda_{1\tau}} \right) \tag{17}$$

where: $y(\tau)$ is the zero-coupon yield with τ to maturity, and β_1, β_2, β_3, β_4 and λ are model parameters. The model's estimation of the daily yield is portrayed below.

Figure 3 – Interpolated yield curve



4.5 Copula functions and counterparty credit risk

Valuing a single instrument with a univariate distribution is fairly easy relative to the task of valuing instruments with multiple exposures such as CDOs or CMOs, which have multivariate distributions. Assuming independence between different credit risk exposures in these sorts of instruments is not realistic and would result in inaccurately estimated spreads. In the case of a CLN, which has both a credit risk exposure to a reference entity and a counterparty credit risk exposure to the issuer, a copula model can be employed to model the default correlation between the reference entity and the counterparty. Copula functions provide a convenient method for linking univariate marginal distributions to their full multivariate distribution (Li, 2000).

In this paper, we are interested in deriving the joint probability function $C(x; y)$ in order to get a more accurate understanding of the default risk of a CLN when considering default correlation. Such a function must satisfy a number of general requirements. First, the set of values the function can assume, is restricted to the unit interval, i.e. $C(x; y) = [0, 1]$, as the output must represent probabilities. Furthermore, if one of the credit events has a zero probability at a certain point in time, then the joint probability of credit events occurring simultaneously on both the reference entity and counterparty in that time period must also be zero. Conversely, if one credit event has a probability of 1, then the joint probability that both event occurs equals the probability of the second event, i.e., if one of the arguments is equal to 1, then the output must be the other argument. The final requirement is intuitive; if the probabilities of both credit events increase, then the joint probability should also increase (Cherubini et al., 2004).

For two uniform random variables U_1 and U_2, the copula function C is defined as the joint distribution function of the two variables (Li, 2000):

$$C(u_1, u_2, \rho) = P\left[U_1 \leq u_1, U_2 \leq u_2\right] \tag{18}$$

Copula functions can be used to link marginal distributions to a joint distribution. For defined univariate marginal distribution functions $F_1(x_2)$ and $F_2(x_2)$ the function:

$$C\left(F_1(x_1), F_2(x_2)\right) = F(x_1, x_2) \tag{19}$$

results in a bivariate distribution function with univariate marginal distributions:

$$F_1(x_1)\ and\ F_2(x_2) \tag{20}$$

The copula function can be extended to m marginal distribution functions, a computational feature that contributed greatly to its popularity in finance.

4.5.1 Variation of copula functions and model specification

There exist several different specifications on copula functions that belong to two principal categories, Elliptical and Archimedean copula functions. The main difference between these two categories is the symmetry of the distributions employed. While Elliptical functions have symmetric bivariate probability distributions, Archimedean functions have asymmetric features such as differences in upside and downside tail dependency. This study will employ the standard Elliptical copula function - the Gaussian copula function - which assumes a normal bivariate distribution (Cherubini et al., 2004). The Archimedean Clayton copula function, which exhibits greater dependency in the negative tail, could have been employed in the study in order to control for the effects of macroeconomic stress scenarios, but given the short sample time period, this is not a relevant extension.

The (bivariate) Gaussian copula function is given by (Cherubini et al., 2004):

$$C_\rho(u_1, u_2) = \Phi_\Sigma(\Phi^{-1}(u_1), \Phi^{-1}(u_2)) \tag{21}$$

With:

$$\Sigma = \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix} \tag{22}$$

The Gaussian copula function preserves the underlying distribution of the individual random variables but models the joint distribution as a bivariate Gaussian.

4.5.2 Application to credit linked products

As mentioned, this study applies the copula function to CLNs in order to assess their fair price when both reference entity credit risk and counterparty credit risk are considered. There exist various methods to estimate the joint default probability. For a portfolio with multiple assets, it is common to use Monte Carlo simulations to generate correlated default times, from which joint default probabilities can be estimated. The benefit of the simulation method is that it can easily be extended to m entities and that the approach is fairly straightforward (see Li (2000)). Given that our model would have to estimate daily prices for 11 CLNs, some of which have been on the market for approximately a year, we require a model that is more computationally tractable.

Bomfim (2005) suggests an alternative approach. He starts by deriving the joint probabilities of default and survival scenarios, including both a reference entity (r) and an issuing counterparty (p). Denoting the joint survival probability Q_{rp}, the probability that both parties survive until time T_1 is:

$$Q_{rp}(\tau, T_1) = 1 - [\lambda_r(\tau, T_1) + \lambda_p(\tau, T_1) - \lambda_{rp}(\tau, T_1)] \tag{23}$$

The first two terms in the brackets represent the conditional default probabilities of default at time T_1 for the reference entity and the issuing counterparty. The last term represents the joint conditional probability that both parties default at time T_1, this can be illustrated as the intersection of a Venn diagram.

The simple one period case can easily be extended for $Q_{rp}(\tau, T_j)$ $j \geq 1$ into a generalized formula:

$$Q_{rp}(\tau, T_j) = \prod_{i=1}^{j} \{1 - [\lambda_r(\tau, T_i) + \lambda_p(\tau, T_i) - \lambda_{rp}(\tau, T_i)]\} \tag{24}$$

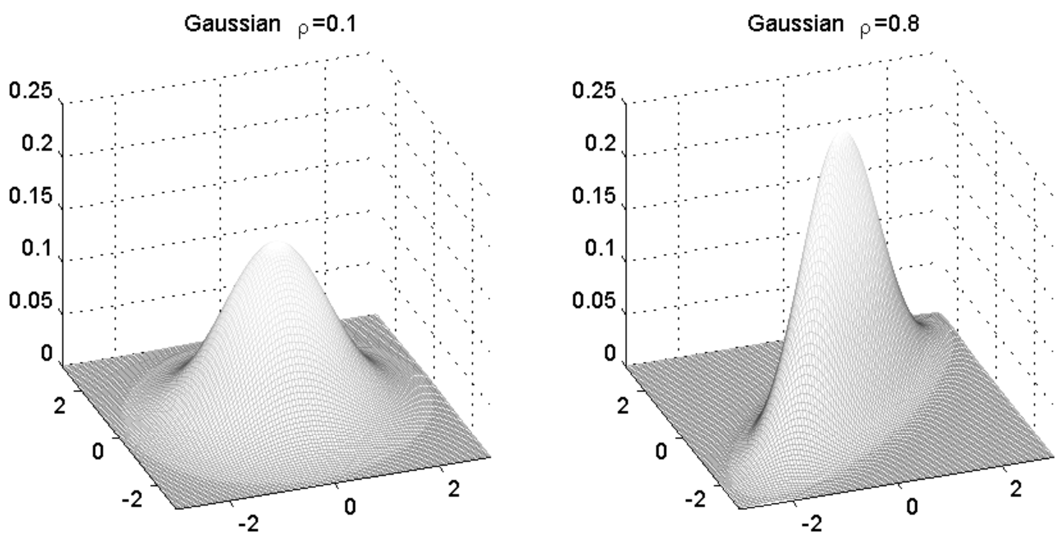
The probability of survival with counterparty risk is maximized when the value in the brackets is minimized. Since $\lambda_{rp}(\tau, T_i) \leq \lambda_p(\tau, T_i)$ and $\lambda_{rp}(\tau, T_i) \leq \lambda_r(\tau, T_i)$, the survival probability reaches its highest value when the intersection reaches its highest value for a given set of hazard rates. In this sense, the behaviour is equivalent to the lowest tranche of a CDO, i.e. the increased dependence increases the value for the lowest tranche while the upper tranches bear the costs.

While the method of Bomfim (2005) utilizes conditional default probabilities to obtain joint survival probabilities, Cherubini et al. (2004) estimate the unconditional joint default probability directly from the copula function:

$$Q_{rp}^{C} = C_{rp}(Q_r(\tau,T), Q_p(\tau,T))) = \phi\left[\phi^{-1}(e^{-\lambda_p(T-\tau)}), \phi^{-1}(e^{-\lambda_r(T-\tau)}); \rho\right] \tag{25}$$

Where $\phi^{-1}(Q_i(T))$, $i = 1,2$ denote the inverse of the marginal survival probabilities and ρ is the correlation between the assets. A simple estimation shows that the two methods yield very similar result. In a numerical exercise with $\lambda = [0.05\ 0.08]$ and $\rho = 0.2$, the latter model will overestimate the survival probability with [0.1 26 57 89] basis points at a time horizon of [1 2 3 4] years. This shows that the impact of using unconditional default probabilities rather than conditional default probabilities is rather limited and only has the implication of a slight overestimation of the survival probability. Since the implied default probabilities derived in section 4.2.1 are unconditional, we chose to use unconditional probabilities in the copula estimation to preserve the consistency of the model.

Figure 4 – Gaussian bivariate pdf



4.5.3 Estimating default correlation

According to Hull and White (2004), it is common to assume that the copula default correlation between two companies is the same as the correlation between their equity returns. This method is used by Rathgeber and Wang (2011) to estimate default correlation in CLNs with multiple credit risk exposures. However, in our sample, we face two problems with using an equity-based estimation. First, Stena, one of the reference entities, is not a listed company. Secondly, the reference entities of the interest certificates are international firms listed on a variety of different stock markets. Consequently, their stocks are denominated in different currencies. To circumvent both of these problems, we assume that the default correlation is equal to the correlation between the quoted 5-year CDS contracts on each reference entity and the issuing counterparty, Nordea. In contrast to listed stock, all of the CDS contracts used are denominated in EUR, which eliminates any FX-effects. Bloomberg 5-year CDS spreads on Nordea and the reference entities are used in the estmation.

Using the 5-year CDS spreads, we estimate the default correlations provided in Table I

Table I – Default correlations

Correlation Table	ρ
ArcelorMittal	0.26
Carlsberg	0.13
Ericsson	0.18
Metso	0.22
Nokia	0.14
Stena	0.22
StoraEnso	0.18
Telefonica	0.20
UPM-Kymmene	0.21
Volkswagen	0.23
Volvo	0.20

5 Data

Our data set consists of eleven CLNs issued by Nordea. As of the beginning of April 2013, Nordea offers a total of 18 CLNs, seven of which are not included in our sample due to their recent issuance dates.

To compute daily theoretical CLN prices, we require data on (1) issuance and maturity dates, (2) coupon payment dates and (3) coupon rates for all reference entities. This data is presented in Table II.

Table II – CLN overview

CLN	Issue date	Coupon	S&P/Moodys	Maturity	Industry
ArcelorMittal	2012-09-11	3M STIBOR + 5.05 %	BB+/Ba1	2017-10-20	Steel
Carlsberg	2012-03-09	3M STIBOR + 2.10 %	NR/Baa2	2017-04-20	Brewery
Ericsson	2012-03-08	3M STIBOR + 2.25 %	BBB+/A3	2017-04-20	Telecom
Metso	2012-06-07	3M STIBOR + 2.05 %	BBB/Baa2	2017-07-20	Industrial Machinery
Nokia	2012-03-07	3M STIBOR + 3.35 %	BB-/Ba3	2017-04-20	Telecom
Stena	2012-03-05	3M STIBOR + 5.45 %	BB/Ba3	2017-04-20	Shipping
StoraEnso	2012-03-05	3M STIBOR + 3.60 %	BB/Ba2	2017-04-20	Pulp & Paper
Telefonica	2012-09-11	3M STIBOR + 4.05 %	BBB/Baa2	2017-10-20	Telecom
UPM-Kymmene	2012-06-07	3M STIBOR + 3.55 %	BB/Ba1	2017-07-20	Pulp & Paper
Volkswagen	2012-06-07	3M STIBOR + 2.15 %	A-/A3	2017-07-20	Automotive
Volvo	2012-03-07	3M STIBOR + 2.35 %	BBB/Baa2	2017-04-20	Automotive

CLN data retrieved from Nordea.se, May 10th 2013

To calculate the implied default probabilities used in our theoretical pricing model, senior unsecured CDS par spreads are retrieved from Bloomberg, Thomson Reuters and FactSet. The rationale behind using data from several sources is that CDS contracts are OTC-instruments, whose quoted par spreads may differ between different issuers. To ensure a price that is robust to reasonable variation in CDS spreads, daily minimum, maximum and average spreads are computed for each reference entity, functioning as a confidence interval for the price estimation. In the graphs of the result, this confidence interval is shown as a shaded grey area surrounding the model price.

This study revolves around a comparison of theoretical prices and market prices and to make that comparison we require daily closing prices for each CLN in the sample. These prices are retrieved from NASDAQ OMX Nordics webpage by using the ISIN code for each instrument. The ISIN codes are published in the interest certificate prospectuses on Nordea's webpage.

6 Results

The main purpose of this paper is to develop a theoretical fair price model for the interest certificates in order to estimate any potential mispricing by comparing observed prices to theoretical prices. Since Nordea's interest certificates have the properties of CLNs, the instruments are valued according to a CLN valuation framework. This comprises of discounting expected future cash flows under a risk-neutral probability measure using an appropriate risk-free discount rate. Given how the contracts are specified, the cash flows in the case of no default are known in advance, while the cash flow in the case of default relies on an assumption about the recovery rate. Standard senior unsecured CDS contracts use a recovery rate of 40% to calculate their CDS spreads, which serves as the baseline recovery rate assumption of this paper.

To adjust for the default risk in each period, the cash flows are weighted by risk-neutral probabilities. These are inferred from observed CDS spreads in the market following the methodology of O'Kane and Turnbull (2003) outlined in the theory and methodology section. Finally, the risk-adjusted cash flows are discounted using an interpolated STIBOR curve.

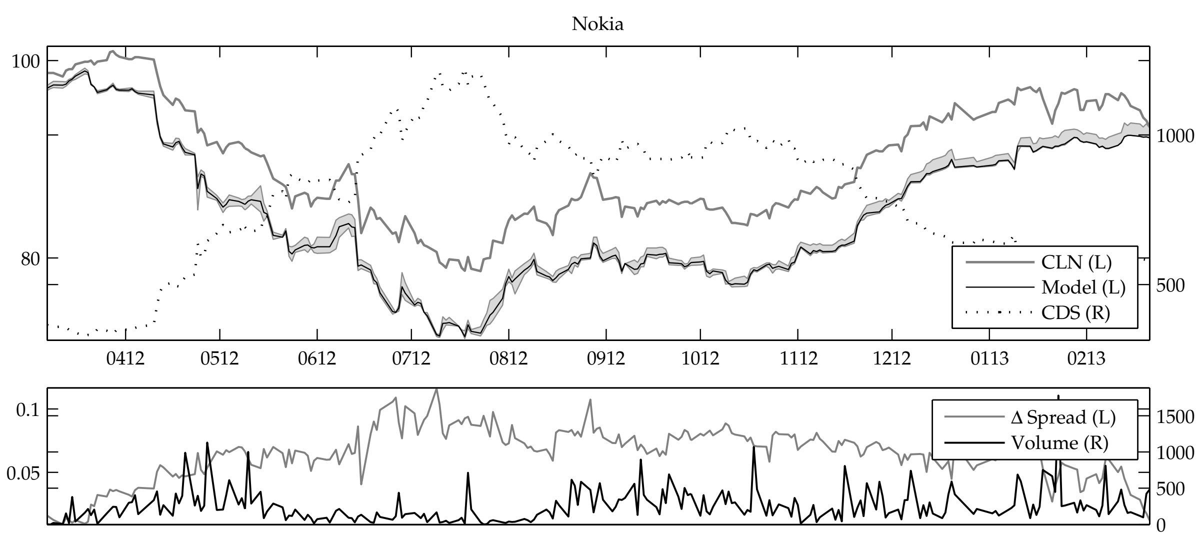
The initial valuation is performed assuming a 40% recovery rate and a riskless issuing counterparty. It results in a time series of daily theoretical prices from issuance to 21st of February 2013 for each reference entity. Later in the results section, we gradually relax these assumptions and perform valuations when varying the ex-post recovery rate as well as when accounting for counterparty credit risk.

6.1 Estimating mispricing from the model

Before analyzing the results of our first theoretical price estimation, we must restate one crucial assumption about the model; the recovery rate is assumed to be 40%. It is important to briefly elaborate on the validity of this assumption. First, 40% is the historical long-term average recovery rate of senior unsecured bonds identified in previous studies of Altman and Kishore (1996) and ratified by a long series of Moody's reports (2004; 2009; 2011). This is also reflected in the market practice. ISDA's standard contract specification of senior unsecured CDS contracts uses a 40% recovery rate to calculate CDS spreads. The widespread use of this market standard is also supported by information from Nordea Norway. In Norway, structured products are required by law to include a simulated return figure in the prospectus, disclosing all crucial assumptions, including the recovery rate. In Nordea's simulations for their Norwegian interest certificates, that rate is set to 40%.

Our model produces daily theoretical prices that are adjusted for fees. Consequently, the estimated mispricing spread represents the difference between the price paid for a contract and the theoretical value of holding the position for an individual investor. The mispricing spread can therefore be seen either as a premium that the individual investor is prepared to pay for the contract, the result of an inaccurate credit risk estimation, or a combination of the two.

Figure 5 – Nokia observed and theoretical CLN prices



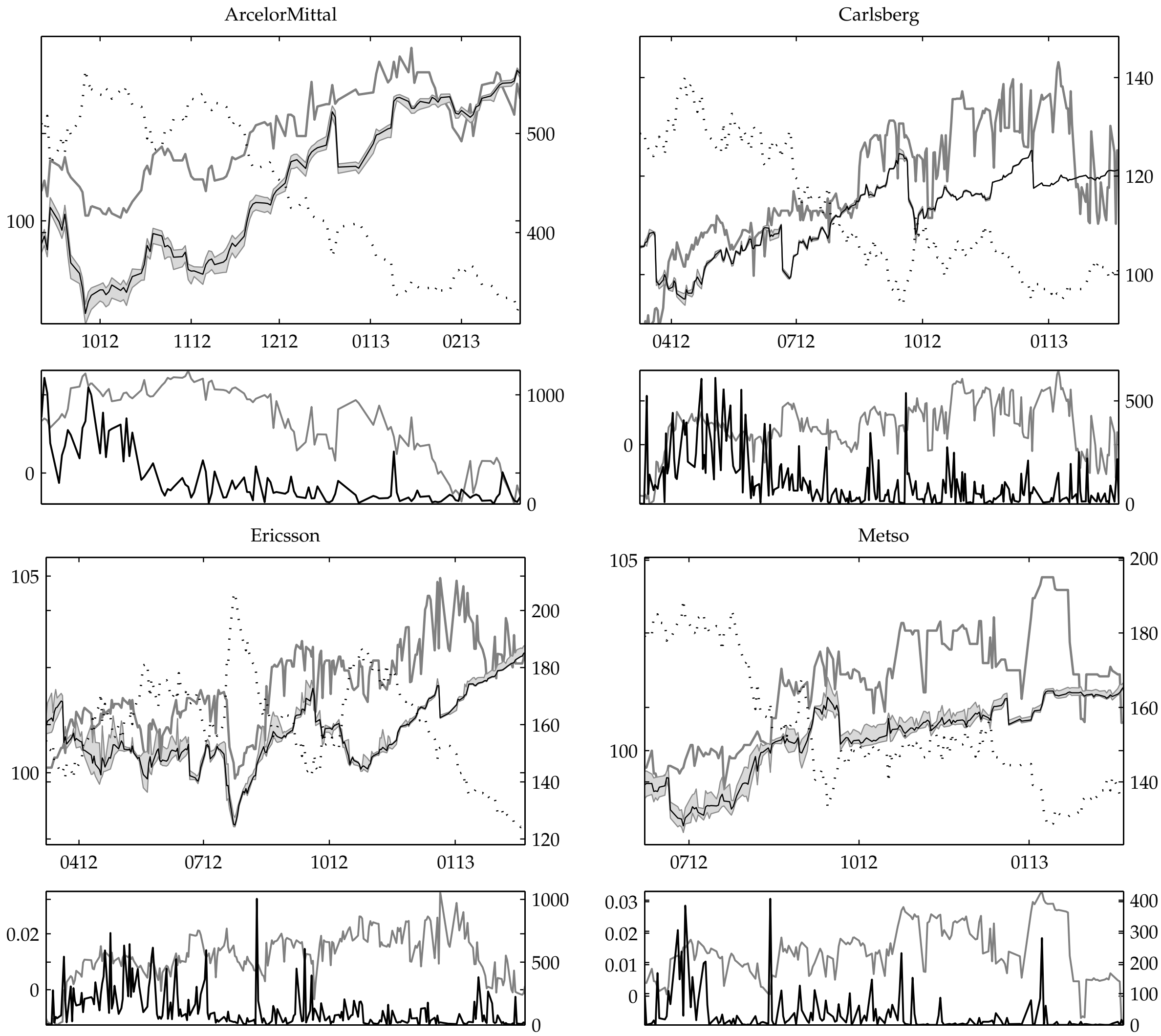
The upper chart depicts the CLN price (gray) and model price (black) on the left axis with the 5-year CDS (dashed) on the right axis. The lower chart shows the price spread on the left axis (gray) and volume on the right axis (black).

The above results for Nokia (figure 5) show that the theoretical prices track the variation in observed prices well but that there is a pattern of consistent overpricing throughout the sample time period. More importantly, the theoretical price mirrors the 5-year CDS spread on the reference entity almost perfectly. This is an important result. The interest certificates are constructed so that cash flows are essentially known in advance since changes in the floating part of the coupon will always be netted out by a corresponding change in the discount factor. Theoretically, the only risk exposures of the interest certificate are toward credit risk and interest rate risk. Therefore, any change in the price of the interest certificate should be explained by changes in the perceived credit risk or interest rate, as captured by the 5-year CDS spread and the discount rate. Since investors are repaid the principal after 5 years, the main risk is concentrated in the fifth year of the contract, which is also confirmed by the CLN durations (see Table VII on page 45). Thus, the 5-year CDS spread should function as a good overall proxy of the CLN credit risk. The strong dependence between theoretical prices and the 5-year CDS spreads therefore provides ample evidence that the model is accurately specified.

The pattern of overpricing is consistent even after robustness testing by using CDS spreads from different sources (Bloomberg, ThomsonReuters, FactSet) to value the implicit default risk. Overall, the use of different CDS spreads appears to have a limited effect on the results, and variation in the CDS spreads cannot explain the observed price discrepancies. For some of the reference entities, notably Telefonica, the CDS spreads varies significantly depending on the data source, but not sufficiently to close the mispricing spread. This result is important since the CDS spread used by Nordea in their internal valuation could have been a factor influencing their pricing. However, since the effect on the valuation appears limited regardless of the specific CDS spreads employed, the theoretical price can be considered to be relatively robust to reasonable variation in CDS spreads.

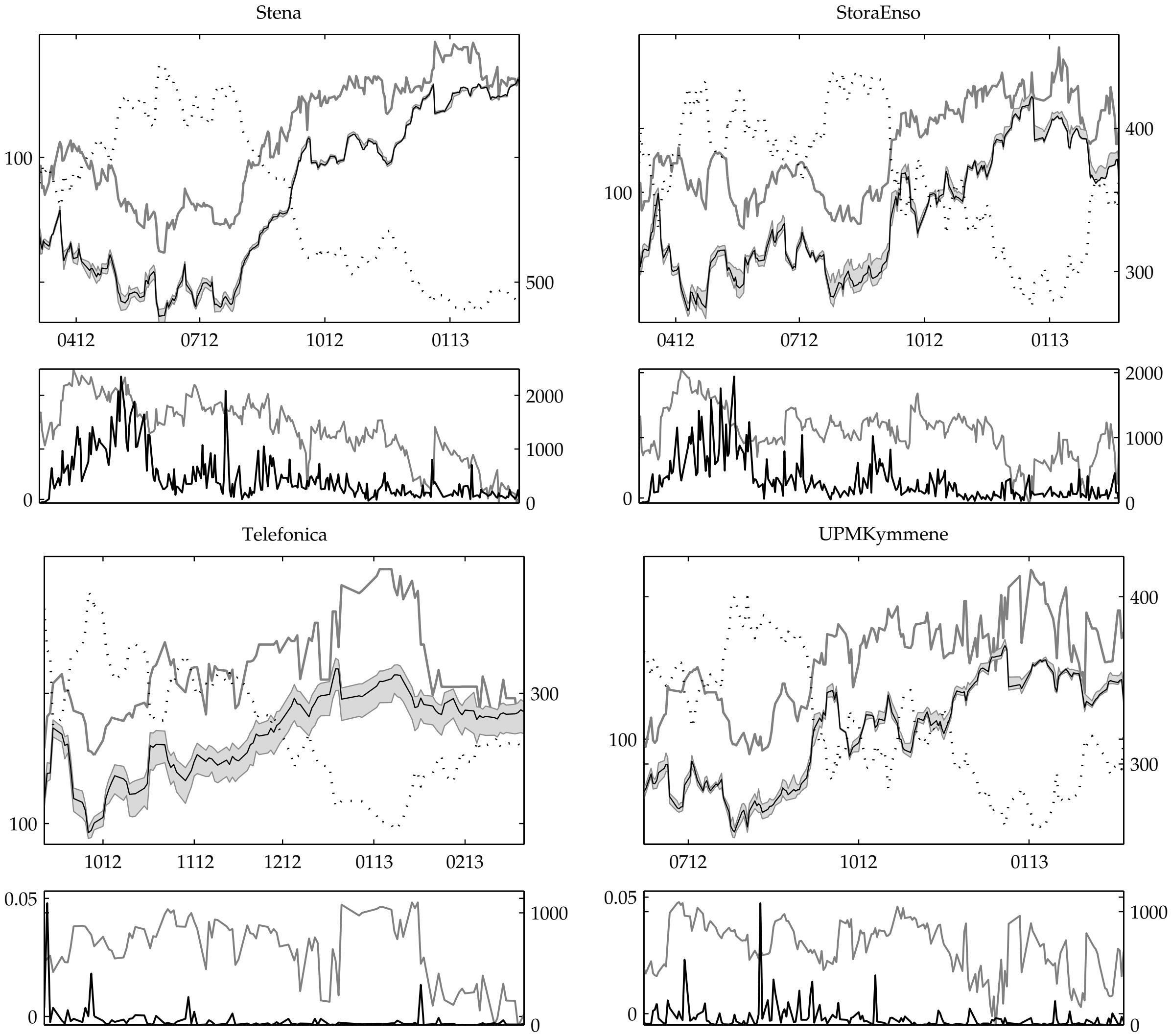
The results from the remainder of the reference entities (see figures 6, 7 and 8) largely vindicates our results for Nokia, although most of the remaining reference entities display a somewhat more erratic behavior with mispricing spreads that vary substantially over time. This appears to be largely driven by differences in how the observed and theoretical prices react to changes in the implied credit risk. Interestingly, while the CLNs of Nokia, Stena and ArcelorMittal display a pattern of observed CLN prices being clearly driven by changes in the 5-year CDS spread, the remaining instruments have a more indistinct relationship to implied credit risk. While all of the CLNs display a relatively high level of dependence to the CDS spreads during the early period of the sample, that relationship is more ambiguous in the later period of the sample. Obviously, some other factor or factors influence the observed prices; this discrepancy is discussed more in-depth in section 6.5.

Figure 6 – Observed and theoretical CLN prices I



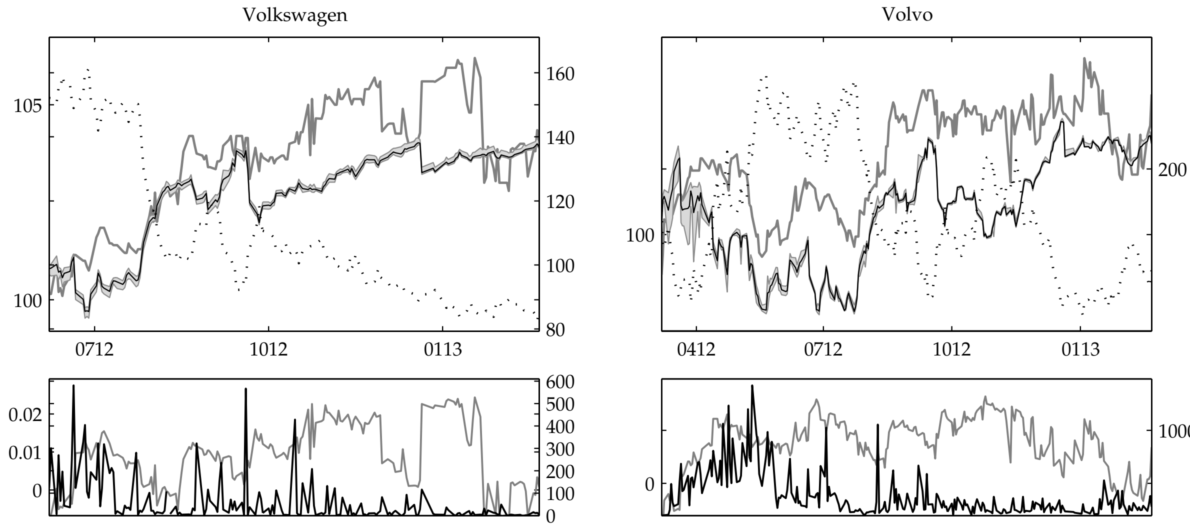
The upper chart depicts the CLN price (gray) and model price (black) on the left axis with the 5-year CDS (dashed) on the right axis. The lower chart shows the price spread on the left axis (gray) and volume on the right axis (black).

Figure 7 – Observed and theoretical CLN prices II



The upper chart depicts the CLN price (gray) and model price (black) on the left axis with the 5-year CDS (dashed) on the right axis. The lower chart shows the price spread on the left axis (gray) and volume on the right axis (black).

Figure 8 – Observed and theoretical CLN prices III



The upper chart depicts the CLN price (gray) and model price (black) on the left axis with the 5-year CDS (dashed) on the right axis. The lower chart shows the price spread on the left axis (gray) and volume on the right axis (black).

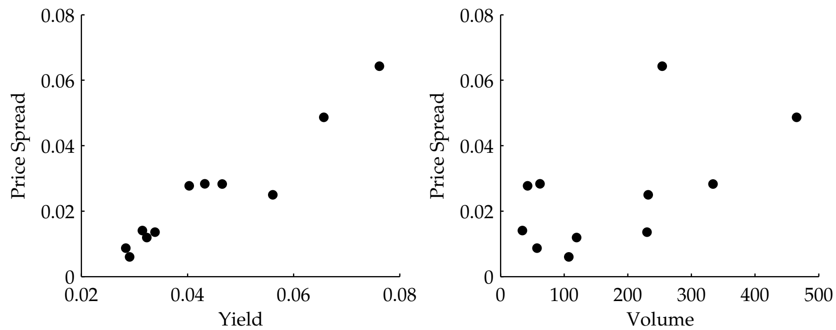
Another important observation is that the average spread between observed and theoretical prices appears to vary significantly between different reference entities. While the observed prices of some CLNs are relatively close to their theoretical prices on average, displaying small average spreads, some display more significant overpricing. The latter is especially true for Nokia and Stena. There appears to exist three different price categories of CLNs; those that are only slightly overpriced on average (0.6 -1.4%), those that are relatively overpriced (2.5 – 2.8%) and those that display more substantial overpricing (4.9 – 6.4%) (see Table III).

Table III – CLN and model descriptives

	Mean CDS	**Med CDS**	**Mean Vol**	**Med Vol**	**Mean Yield**	**Med Yield**	**Mean ∆Spread**	**Med ∆Spread**	**Mean ∆Yield**	**Med ∆Yield**
ArcelorMittal	444	467	232	109	5.61%	5.58%	2.50%	2.86%	0.58%	0.67%
Carlsberg	112	107	107	55	2.91%	2.95%	0.60%	0.64%	0.14%	0.14%
Ericsson	160	161	120	57	3.23%	3.24%	1.19%	1.19%	0.28%	0.27%
Metso	154	149	34	10	3.15%	3.10%	1.40%	1.35%	0.32%	0.31%
Nokia	789	843	254	201	7.62%	7.96%	6.43%	6.73%	1.54%	1.63%
Stena	642	665	465	322	6.57%	6.50%	4.87%	5.11%	1.19%	1.25%
StoraEnso	367	367	334	235	4.65%	4.74%	2.83%	2.93%	0.67%	0.70%
Telefonica	282	280	42	10	4.03%	4.11%	2.77%	3.09%	0.63%	0.70%
UPM-Kymmene	324	317	62	28	4.33%	4.24%	2.83%	3.02%	0.66%	0.71%
Volkswagen	109	103	58	16	2.84%	2.78%	0.87%	0.90%	0.20%	0.20%
Volvo	183	178	230	133	3.38%	3.37%	1.36%	1.48%	0.32%	0.35%

One topic of particular interest is what drives the magnitude of the divergence between observed and theoretical prices. Although the sample is too small to allow for any formal statistical testing, it is noteworthy that the interest certificates displaying the largest magnitude of mispricing all have relatively high average yields. This is consistent with the results of previous studies on structured products, which have found statistically significant relationships between mispricing and the coupon rate at issuance (Burth et al., 2001; Rathgeber and Wang, 2011). Since our study takes a secondary market perspective, the yield rather than the coupon rate should be considered a possible determinant of the mispricing.

Figure 9 – Cross section of yield, volume and mispricing spread



Under the assumption of a frictionless market, the observed pattern indicates that individual investor's ability to value risk is decreasing with increasing risk, since the mispricing is increasing with the average yield of the reference entity (see Figure 9). However, once again, it is important to note that the sample size is very limited and does not allow any formal testing. The volume, on the other hand, does not appear to have any clear impact on the magnitude of the mispricing, although the two most overpriced CLNs, Nokia and Stena, have high trading volumes.

6.2 Relaxing the recovery rate assumption

The valuation made up until this point have relied on the assumption that the ex-post recovery rate will equal that of a senior unsecured CDS contract, which is 40% by convention. In order to study the effects of an altered recovery rate, we now relax that assumption. Using Nokia as an example, we calculate daily prices under the assumption of three different ex-post recovery rates; 70%, 40% and 10%.

Figure 10 – Nokia CLN with different recovery rates

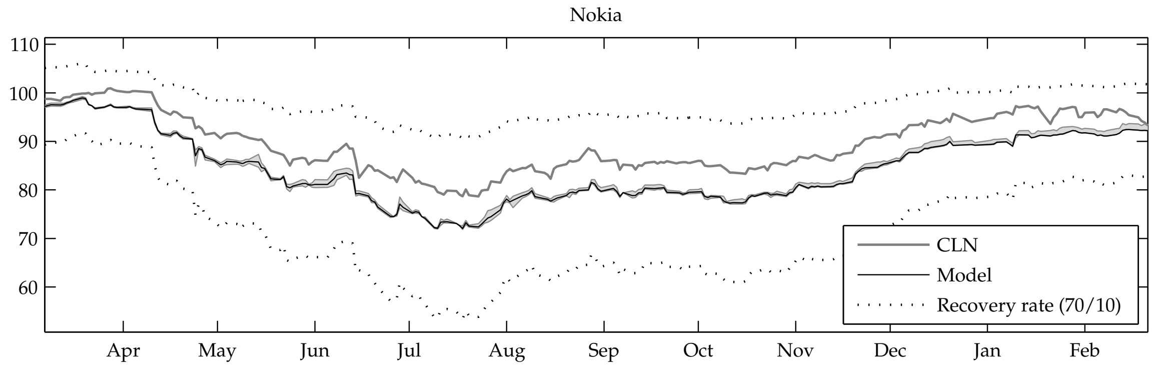


Figure 10 clearly demonstrates the impact that variations in the recovery rate have on the theoretical price of Nokia. Extending the analysis to include all reference entities in Table IV, this pattern persists. Under the assumption of a 10% recovery rate, all CLNs are significantly overpriced, under the 70% recovery rate assumption on the other hand, all CLNs appear to be underpriced. One could make the argument that the individual investors make their own assessment of the recovery rate and values the CLNs accordingly. For all CLNs, a 50% recovery rate puts the mispricing within a 1% interval. For Metso, Telefonica and UPM-Kymmene, a 55% recovery rate minimizes the mispricing. However, all major studies, including Altman and Kishore (1996) and Moody's long term estimate (Moody's, 2004, 2009, 2011), puts the average recovery rate around 40%. On an industry level, the data is very limited but Moody's (2004) provide industry averages for the period 1982 – 2003. They put the industry average for Telecommunications (Nokia, Telefonica) at 23.2% and Ocean Transportation (Stena) at 38.8%. While Ocean Transportation is close to the average of the whole sample, Telecommunications has the lowest historical average of any industry. For the corresponding period, Automotive (Volkswagen, Volvo) and Industrial (Metso) had recovery rates of 33.4% and 35.4%, respectively. An estimate for Pulp and Paper industry (Stora Enso, UPM-Kymmene) is not available. If we assume that the individual investors make their own assessment of the recovery rate, then 50 – 55% are rather optimistic estimates. However, we acknowledge that the data is limited.

Table IV – Average mispricing for different recovery rates

Recovery rate (%)	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
ArcelorMittal	11.2%	9.7%	8.3%	6.8%	5.3%	3.9%	2.5%	0.9%	**-0.5%**	-2.0%	-3.5%	-4.9%	-6.4%
Carlsberg	2.9%	2.5%	2.1%	1.7%	1.3%	1.0%	0.6%	0.2%	**-0.2%**	-0.5%	-0.9%	-1.3%	-1.7%
Ericsson	4.4%	3.9%	3.3%	2.8%	2.3%	1.7%	1.2%	0.6%	**0.1%**	-0.4%	-1.0%	-1.5%	-2.1%
Metso	4.7%	4.1%	3.6%	3.0%	2.5%	1.9%	1.4%	0.8%	0.3%	**-0.3%**	-0.8%	-1.4%	-1.9%
Nokia	21.3%	18.7%	16.2%	13.6%	11.1%	8.5%	6.4%	3.5%	**0.9%**	-1.6%	-4.2%	-6.7%	-9.2%
Stena	16.1%	14.2%	12.3%	10.3%	8.4%	6.5%	4.9%	2.7%	**0.8%**	-1.1%	-3.1%	-5.0%	-6.9%
StoraEnso	9.8%	8.6%	7.4%	6.3%	5.1%	3.9%	2.8%	1.6%	**0.4%**	-0.8%	-2.0%	-3.1%	-4.3%
Telefonica	8.4%	7.5%	6.5%	5.5%	4.6%	3.6%	2.8%	1.7%	0.8%	**-0.2%**	-1.1%	-2.1%	-3.1%
UPM-Kymmene	9.2%	8.1%	7.1%	6.0%	4.9%	3.8%	2.8%	1.7%	0.6%	**-0.5%**	-1.6%	-2.6%	-3.7%
Volkswagen	3.2%	2.8%	2.4%	2.0%	1.6%	1.2%	0.9%	0.5%	**0.1%**	-0.3%	-0.7%	-1.1%	-1.5%
Volvo	5.0%	4.4%	3.8%	3.2%	2.6%	1.9%	1.4%	0.7%	**0.1%**	-0.5%	-1.1%	-1.7%	-2.3%

A more fundamental question is whether individual investors can actually be assumed to make any assessment of the recovery rate prior to making an investment. For several reasons, it appears unlikely that they could make a more sophisticated estimate than the quoted rate or long-term average. The relative scarcity of data also applies to individual investors, who cannot be assumed to have any reliable long-run industry averages. This leaves them with the option of making a company specific recovery rate assessment. Such an assessment would be based on valuing the scrap value of the firm's assets at the event of default – a rather complicated valuation that requires knowledge beyond that of a typical layman investor.

6.3 Accounting for counterparty credit risk

In CLN valuations, it is often assumed that the issuing counterparty is risk-free. However, as the minibond scandal in Hong Kong and Singapore shows (see section 2.2.2), the risk of counterparty default may be important to account for in the valuation of structured products. In order to account for the counterparty credit risk, a copula function is introduced as outlined in the theory section (see section 4.5). This model enables us to construct a bivariate distribution from the univariate distributions. To calculate fair theoretical prices using the copula model, a default correlation between the reference entity and financial counterparty has to be assumed. This is done in a manner analogous to the market practice (see section 4.5.3)

The estimations of our augmented valuation model indicate significantly lower theoretical prices when accounting for counterparty credit risk. The mispricing spread under the assumption of a 40% recovery rate increases between 2.1% and 4.1% depending on the reference entity. The inclusion of counterparty credit risk penalizes the low risk CLNs since their principal repayment suffer from an incremental default risk effect that is proportionally larger relative to that of high risk CLNs. Thus, the required recovery rate needed to justify the valuation also changes asymmetrically between the different CLNs.

The high required recovery rates needed to justify the valuation also give ample evidence that investors likely do not value the counterparty credit risk when investing in Nordea's CLNs. The required rates are consequently significantly above the long-term average of 40%, sometimes above 70%, a remarkably high rate only observed in the public utilities industry in Altman and Kishore (1996) study of long-term industry recovery rates. That individual investors do not appear to value counterpart credit risk is not entirely unsurprising however. Arora et al. (2012) show that even institutional investors tend to value counterparty credit risk only to a very limited extent, and not at all when the counterparty is a financial firm. The authors perceive this as evidence that investors still consider financial counterparties "too big to fail". It is possible that Swedish individual investors share that sentiment.

Table V – Average mispricing for different recovery rates with counterparty risk

Recovery rate (%)	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
ArcelorMittal	14.3%	12.6%	11.0%	9.4%	7.8%	6.1%	4.5%	2.9%	1.3%	**-0.4%**	-2.0%	-3.6%	-5.2%
Carlsberg	9.1%	8.3%	7.6%	6.9%	6.2%	5.5%	4.7%	4.0%	3.3%	2.6%	1.8%	1.1%	**0.4%**
Ericsson	10.2%	9.4%	8.5%	7.6%	6.8%	5.9%	5.1%	4.2%	3.3%	2.5%	1.6%	0.7%	**-0.1%**
Metso	10.2%	9.3%	8.5%	7.6%	6.8%	5.9%	5.1%	4.2%	3.4%	2.5%	1.7%	0.8%	**0.0%**
Nokia	24.9%	22.2%	19.5%	16.7%	14.0%	11.2%	8.5%	5.8%	3.0%	**0.3%**	-2.4%	-5.2%	-7.9%
Stena	19.4%	17.4%	15.3%	13.2%	11.1%	9.0%	7.0%	4.9%	2.8%	**0.7%**	-1.4%	-3.5%	-5.5%
StoraEnso	14.5%	13.1%	11.7%	10.2%	8.8%	7.4%	6.0%	4.5%	3.1%	1.7%	**0.3%**	-1.2%	-2.6%
Telefonica	12.3%	11.2%	10.0%	8.8%	7.7%	6.5%	5.3%	4.2%	3.0%	1.8%	0.7%	**-0.5%**	-1.6%
UPM-Kymmene	13.8%	12.5%	11.1%	9.8%	8.5%	7.2%	5.8%	4.5%	3.2%	1.9%	**0.6%**	-0.8%	-2.1%
Volkswagen	8.9%	8.2%	7.5%	6.8%	6.1%	5.4%	4.7%	4.0%	3.3%	2.6%	1.9%	1.2%	**0.5%**
Volvo	10.6%	9.7%	8.8%	7.8%	6.9%	6.0%	5.1%	4.16%	3.2%	2.3%	1.4%	**0.5%**	-0.5%

6.4 Market frictions

Our theoretical pricing model provides us with an indirect way of studying the market frictions of the interest certificate market. The pricing model implicitly assumes frictionless financial markets where changes in the perceived credit risk, information derived from the CDS spreads, is immediately reflected in the price of the interest certificate. While some of the interest certificates display a pattern of high dependence to changes in CDS spreads, certain certificate prices display seemingly erratic relationships to the implied credit risk during periods of our estimation. This explains why the mispricing spread between observed and theoretical prices varies over time for many instruments. While the theoretical prices are perfectly responsive to changes in the implied credit risk, the observed prices are not.

In order to study the drivers of the observed prices, we regress observed CLN returns on CDS spreads including equity and volume as control variables. The model is corrected for non-stationarity using first differencing, this is confirmed by the Augmented Dickey-Fuller (ADF) test. The results are presented in Table VI. As expected based on the graphical results, the CLN returns of Nokia, Stena, StoraEnso, UPM-Kymmene and ArcelorMittal are found to be highly dependent on changes in the CDS spreads. The CDS spreads of Telefonica, Ericsson, Volkswagen and Volvo are also found to be significant, but with somewhat lower t-test statistics. The remainder of the instruments are found to be non-dependent to the changes in the CDS spreads. As previously discussed, we would expect a very high dependence to credit risk. The case of non-dependence is in fact a remarkable result since it implies that the observed prices are not driven by any clear risk-reward relationship. Even the relatively low t-test statistics of Telefonica, Ericsson and Volvo are surprising. For some reason, the pricing mechanism of the market is dysfunctional for some of the CLNs in the sample. To explain the pricing pattern and particularly why the mispricing spreads varies over time, we need to elaborate further on what might be driving the observed prices.

Table VI – CLN regressions

$log(CLN_{t+1}/CLN_t) = \alpha + (VOL_{t+1} - VOL_t) + log(Equity_{t+1}/Equity_t) + log(CDS_{t+1}/CDS_t)$						
	y	α	VOL	Equity	CDS	R^2
ArcelorMittal		-0.0002 (-0.3873)	-2.7559 (-0.8561)	-0.0426 (-1.4334)	-0.1364 (-5.2234***)	0.1914
ADF	*-14.65****		*-15.90****	*-12.65****	*-10.32****	
Carlsberg		0.0001 (0.3861)	-1.2357e-06 (-0.5810)	0.0071 (0.3650)	-0.0258 (-1.2697)	-0.0018
ADF	*-20.41****		*-25.50****	*-17.58****	*-12.76****	
Ericsson		8.6355e-05 (0.2761)	-2.9785e-07 (-0.1754)	0.0038 (0.1833)	-0.0391 (-2.6845***)	0.0202
ADF	*-21.96****		*-27.01****	*-15.86****	*-14.18****	
Metso		3.5255e-05 (0.1022)	4.3711e-08 (0.0104)	0.0207 (1.2239)	-0.0081 (-0.4571)	-0.0038
ADF	*-16.09****		*-24.15****	*-13.48****	*-15.58****	
Nokia		7.4433e-05 (0.1458)	1.1295e-06 (0.6290)	0.0215 (1.5231)	-0.1424 (-7.8667***)	0.2938
ADF	*-16.20****		*-27.06****	*-14.30****	*-13.25****	
Stena		-2.8040e-05(-0.0718)	-1.6239e-06 (-1.3798)	n/a	-0.18079 (-7.6304***)	0.1966
ADF	*-17.79****		*-24.53****		*-10.26****	
StoraEnso		8.5438e-05 (0.3513)	-4.1775e-07 (-0.4967)	-0.0007 (-0.0458)	-0.0875 (-6.6266***)	0.2071
ADF	*-15.89****		*-26.57****	*-15.83****	*-12.53****	
Telefonica		0.0001 (0.1675)	-1.4436e-06 (-0.2922)	0.0915 (1.4408)	-0.0650 (-2.3844**)	0.0822
ADF	*-13.49****		*-26.64****	*-10.80****	*-9.22****	
UPM-Kymmene		0.0002 (0.3040)	2.1920e-06 (0.6366)	-0.0057 (-0.1705)	-0.1021 (-3.6063***)	0.0853
ADF	*-18.53****		*-22.34****	*-13.66****	*-10.10****	
Volkswagen		9.2375e-05 (0.3039)	-1.6589e-06 (-0.6741)	0.0100 (0.4983)	-0.0303 (-2.257**)	0.0255
ADF	*-16.97****		*-23.36****	*-13.14****	*-10.18****	
Volvo		0.0002 (0.7511)	2.4434e-07 (0.2581)	0.0233 (1.6205)	-0.0195 (-2.1404**)	0.0490
ADF	*-17.95****		*-27.29****	*-15.29****	*-14.62****	

Regression coefficients with t-statistics in parentheses. */**/*** Significant at the 0.10/0.05/0.01 level.

7 Discussion

Our theoretical price estimation reveals a pattern of consistent overpricing for all CLNs in the sample, although the exact degree varies between different reference entities. Part of this premium can likely be explained by the fact that investors are unable to replicate the positions themselves, why the bank should be able to charge some form of intermediary rent (Burth et al., 2001). However, this does not, explain the varying magnitude of mispricing between different reference entities. While the variation in the mispricing likely relies on several factors, one plausible explanation lies in the incomplete market structure of the interest certificate market. It is not possible to sell interest certificates short, as is typically the case for structured products. Assuming a world of heterogeneous risk estimates, restrictions on short selling can have some profound implications for the market pricing mechanism. With increasing prices, investors who deem the new lower yield level insufficient relative to the credit risk should react by selling the CLN and pocket the difference between their perceived fair price and the observed price. They cannot, however, drive down the prices by taking short positions. Therefore, the market price of the product should reflect only the risk estimate of the most optimistic category of investors. This could tend to inflate the observed prices relative to theoretical prices (Miller, 1977).

It is also important to discuss the possible implications of Nordea's role as the market maker on the secondary market. A market maker is different from a broker since, rather than just matching buy and sell orders, the market maker takes an active position in the market, placing its own capital at risk. Ultimately, the goal of the market maker is to profit by buying low and selling high, while also guaranteeing the liquidity of the market. To ensure liquidity, the market maker typically has an inventory target, which will influence the bid and ask prices (Duffie, 2012). This will influence the observed prices and could potentially explain some of the ambiguity in the price – credit risk relationship.

Despite the overpricing we have identified, interest certificates have obviously managed to appeal individual investors in Sweden. There might be several reasons that have influenced their popularity. First of all, for individual investors, the fixed-income market in Sweden is severely limited due to the high investment thresholds of corporate bonds. Nordea interest certificates thus enable individual investors to take positions in credit risk exposures they would not otherwise be able to take. Especially in the light of the volatile stock market landscape of the last few years, the demand for diversification through fixed-income investment has likely increased, which might explain much of the product's popularity. However, all interest certificates have not been equally popular; the median daily volume ranges from 10 (Telefonica and Metso) to 322 (Stena) (see Table III). There appear to be two factors that influences the attractiveness of the interest certificates. First, the interest certificates with high volume all have relatively high yields. Second, the interest certificates of firms unfamiliar to Swedish individual investors appear to be penalized volume-wise relative interest certificates of Swedish corporates or well-known Nordic firms. This could be interpreted as a result of the well-documented home market bias effect (French and Poterba, 1991; Coval and Moskowitz, 1999).

There are natural reasons why CLNs with low yields should be unattractive to individual investors despite more reasonable risk-adjusted returns relative to the high yield CLNs. This relates to the investment opportunity set of individual investors, which includes one form of risk-free investment unavailable to institutions, namely certificates of deposit (CDs) protected by the Swedish deposit insurance. On May 9th, 2013, the best available interest rates for CDs in Sweden for a one year and five year deposit was 3.1% and 3.6% respectively. Yields below or equal to these rates should be unattractive to individual investors since they can make a more attractive risk-free investment. For CLN prices that indicate yield levels below these CD rates, we hypothesize that the CLN prices should have no obvious relation to credit risk since the investors that accept such yields are either uninformed or have other motives. This might help explain why the low yield CLNs of Volkswagen, Carlsberg, Ericsson, Metso and Volvo display erratic patterns throughout or during periods of our sample that are not reflected by changes in the implied credit risk. One possible factor that could make these products attractive despite these yield levels is the fact that the CLNs can be purchased through IPS ("Individuellt pensionssparande" – a Swedish voluntary individual pension scheme) and ISK ("Investeringssparkonto" – investments savings account), both of which are subject to a different tax legislation. Rather than paying a 30% tax on financial income, these accounts are levied with a tax on the capital invested of approximately 0.5% (2012). Thus, the post tax-yield could potentially still be attractive.

It is also important to briefly touch upon the relative novelty of the product. Since Swedish private investors have little experience of fixed-income investments, it is possible that some learning effect could influence the mispricing over time. This is supported by the generally decreasing mispricing spreads in the end of our sample time period. At the same time, it is in the late period of the sample, when liquidity dries up, that we observe the most ambivalent relationship between CDS spreads and observed prices, why it is difficult to evaluate any learning effect.

Limitations

We acknowledge that this study is subject to some limitations. First, the implied default probabilities inferred from observed CDS spreads are risk-neutral forward looking probabilities. Since the future is uncertain by definition, these will include an ex-ante uncertainty premium that results in future looking probabilities that are higher relative to historical ex-post default probabilities. This could result in deflated prices. However, in this particular case, it is unlikely to affect the valuation significantly since the CDS contract used to finance the CLN coupons are also valued based on a forward looking risk-neutral valuation. Second, we make an assumption about the term structure of the default probabilities, assuming they follow a stepwise function rather than interpolating a continuous default curve. In the case of a steep CDS term structure, this might lead to minor overestimation errors of the expected cash flow, leading to slightly inflated prices. It is also important to touch briefly on the fact that copula functions have received some critique for their treatment of default correlation subsequent to the financial crisis. However, in our case, the overpricing is significant despite the inclusion of counterparty credit risk, why the exact magnitude of the counterparty component of the mispricing is of minor importance. Lastly and most importantly, our limited sample size makes our findings indicative and not statistically certain. However, the results of our research are supported by the findings of previous papers.

Further research

Most of the reasonable possible research extensions relates directly to our limited sample size. First of all, given a larger sample from several issuers, our general results could be confirmed statistically. Given the novelty of the product, the market is not yet sufficiently large to allow for a cross-sectional analysis, but recently, Nordea has introduced four new CLNs on the Swedish market as well as five on the Norweigan market. Thus, a future cross-sectional study of the product either in a Swedish or Nordic context may well be possible. Given our results, such a study might also be able to investigate the price – credit risk relationship of the CLNs in more detail. Finally, if more issuers enter the CLN market, it would also be interesting to study the effect of increased competition. Arguably, the present pricing might include some form of monopoly rent, since no competitors provide similar investment opportunities with low required minimum investments.

8 Conclusion

Similar to previous studies on structured products, we find evidence of significant overpricing in the interest certificate (CLN) market, ranging from 0.6% to 6.43%. We argue that the model assumption of a 40% recovery rate, the historical long-term average and the rate employed by the issuer internally, is the most reasonable assumption individual investors can be believed to make and that different beliefs about the recovery rate cannot explain the observed mispricing. When we account for the counterparty credit risk exposure in the issuer, the magnitude of the mispricing increases significantly. However, based on evidence from the institutional investor market (Arora et al., 2012), it is likely that investors perceive the counterparty as "too big to fail", which might explain why the counterparty risk is not priced in the CLNs.

Perhaps the most intriguing result of our research is that the observed price - credit risk relation is far from unambiguous. While some of the CLNs in the sample are found to be highly dependent on changes in implied credit risk, the price movement of all CLNs cannot be explained by variation in credit risk. Some CLNs are found to have a non-dependent relation to credit risk, while others display degrees of dependence on changes in CDS spreads that are lower than would be expected. Our conclusion is that there are market frictions that implicate the pricing mechanism. Previous empirical studies of the interaction between CDS and credit spreads have found similar patterns, which have been attributed mainly to limited liquidity of bonds (Blanco et al., 2005). It is plausible that CLNs, being a form of synthetic bonds, suffer from the same liquidity shortcomings. This is largely supported by the volume data of the CLNs; the four CLNs with the highest dependence on CDS spreads are also those with the highest average and median daily volumes.

The results of our study have several implications for individual investors. Nordea's CLNs widen the investment opportunity set of individual investors, but at the cost of a premium. Since the dependence to daily changes in the credit risk varies widely between the different CLNs, investors who want to take speculative positions should take this aspect into consideration.

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Appendix A Tables and figures

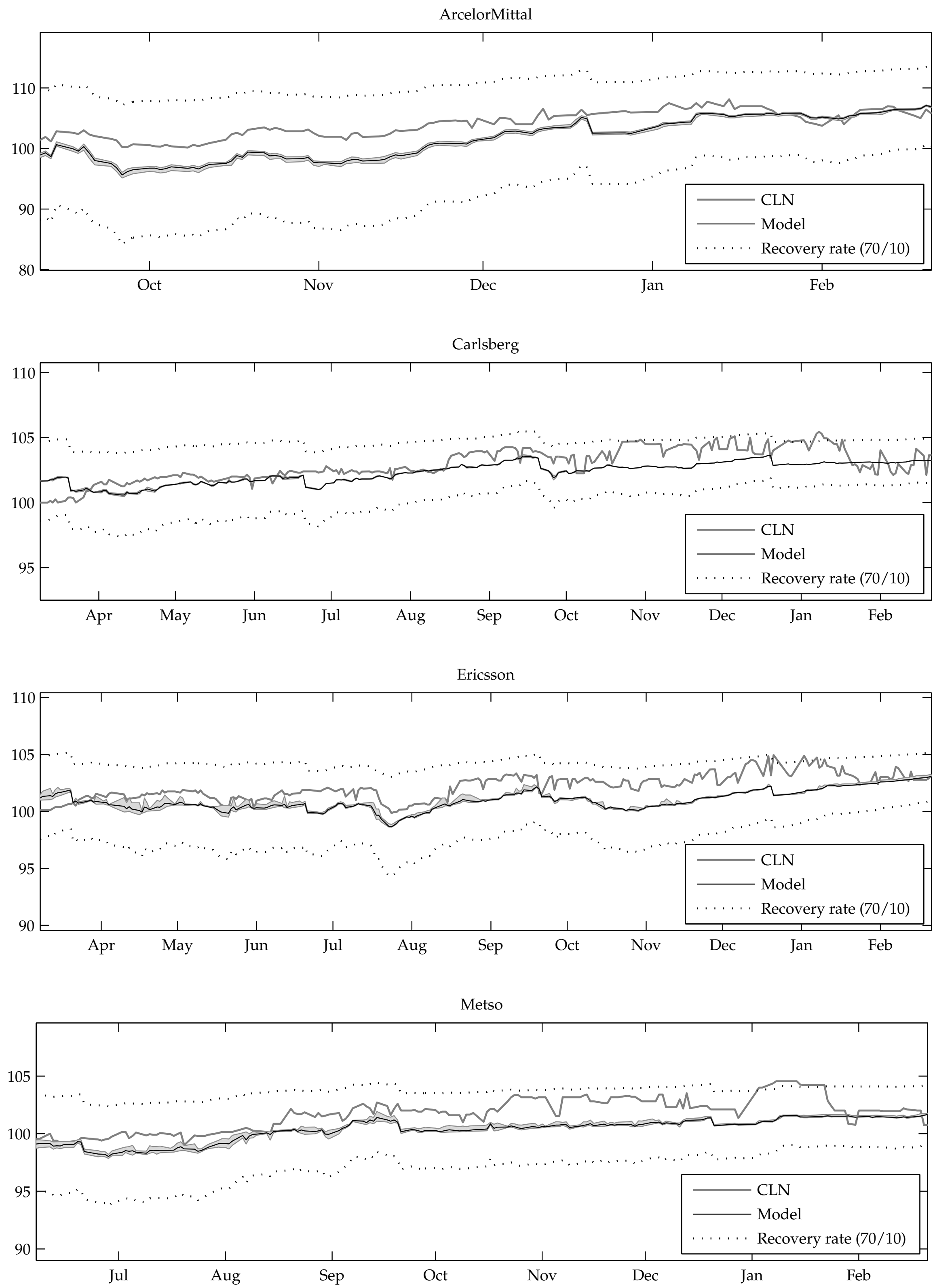

Figure 11 – Varying the recovery rate I

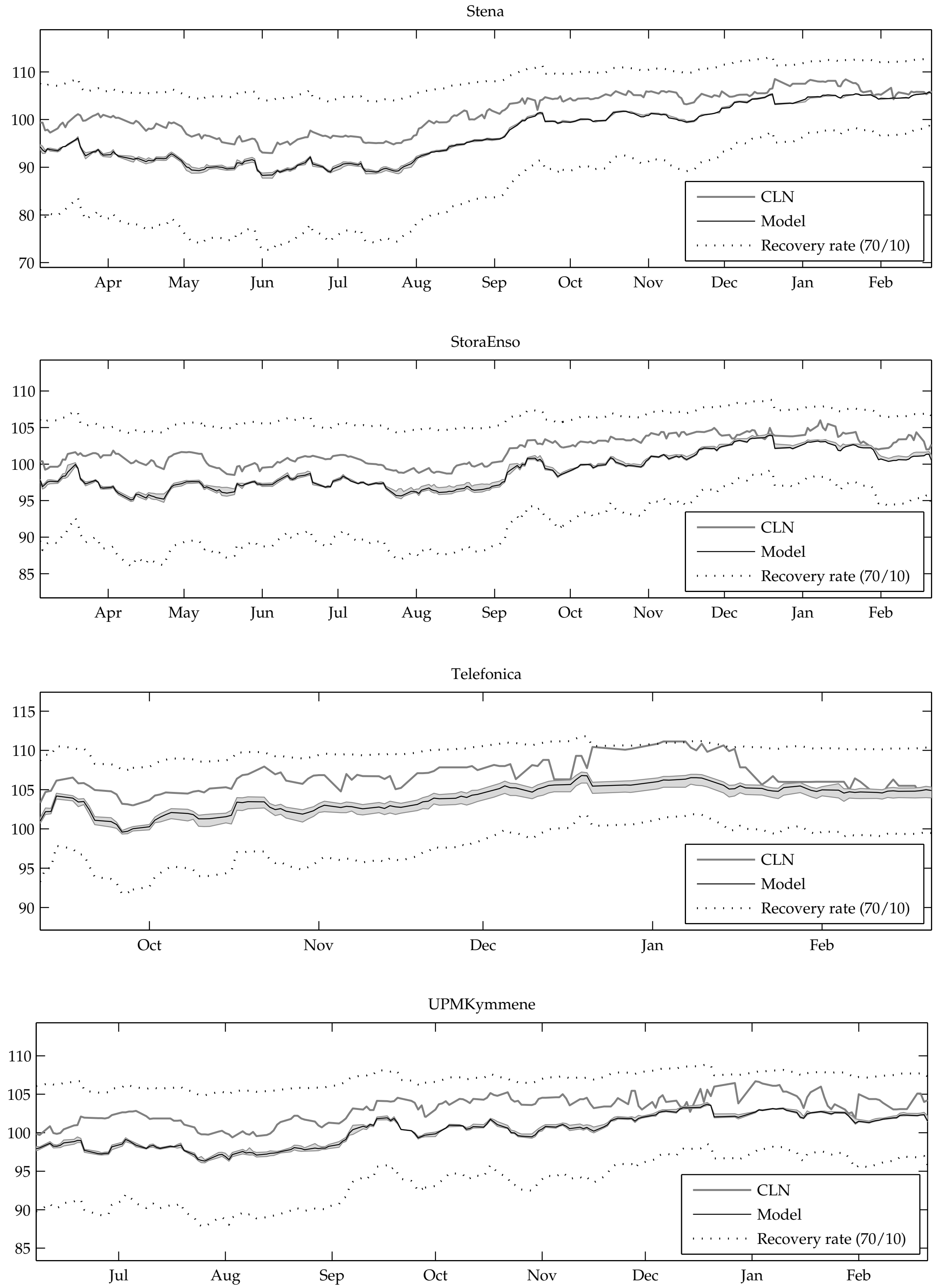

Figure 12 – Varying the recovery rate II

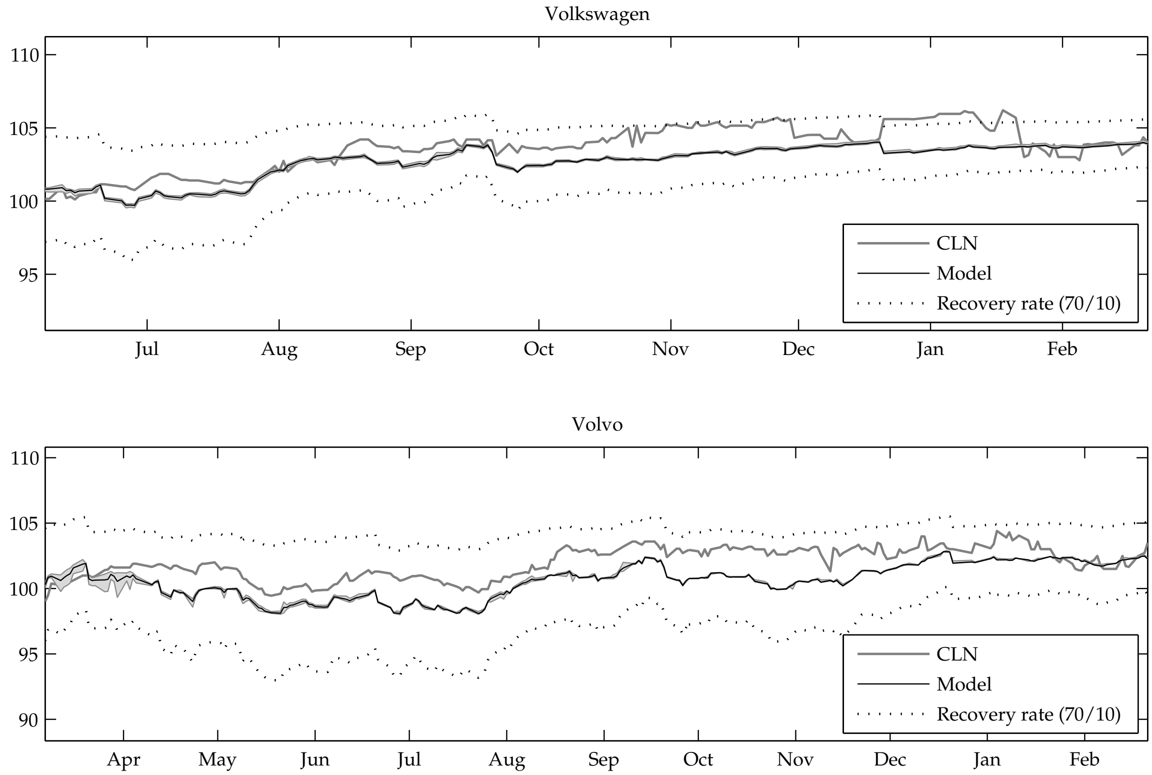

Figure 13 – Varying the recovery rate III

Table VII – Duration

Company	Duration
Arcelor Mittal	4.2
Carlsberg	4.3
Ericsson	4.3
Metso	4.4
Nokia	4.1
Stena	4.0
StoraEnso	4.1
Telefonica	4.3
UPMKymmene	4.4
Volvo	4.3

Table VIII – Monthly descriptives

		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
ArcelorMittal	Mean price spread	n/a	n/a	n/a	n/a	n/a	n/a	3.34%	3.93%	3.72%	2.02%	1.08%	-0.25%
	Mean vol	n/a	n/a	n/a	n/a	n/a	n/a	703	378	152	91	73	74
Carlsberg	Mean price spread	-0.94%	0.74%	0.36%	0.55%	0.50%	0.48%	0.79%	1.12%	1.40%	0.98%	0.77%	-0.20%
	Mean vol	148	280	283	137	71	56	78	68	39	50	58	43
Ericsson	Mean price spread	-0.47%	1.03%	0.84%	1.27%	1.25%	1.19%	1.30%	1.89%	1.87%	1.90%	1.25%	0.24%
	Mean vol	158	256	289	166	84	89	133	78	40	47	75	28
Metso	Mean price spread	n/a	n/a	n/a	0.75%	1.27%	0.98%	1.25%	1.75%	2.13%	1.46%	1.96%	0.35%
	Mean vol	n/a	n/a	n/a	101	45	39	32	47	8	9	25	2
Nokia	Mean price spread	2.06%	4.54%	5.93%	7.16%	8.15%	7.18%	6.79%	7.26%	6.66%	5.58%	5.35%	3.84%
	Mean vol	134	368	257	117	97	242	379	292	230	273	378	287
Stena	Mean price spread	5.82%	7.20%	6.05%	6.07%	5.96%	5.80%	4.23%	4.23%	4.13%	1.75%	2.11%	0.66%
	Mean vol	404	1053	1239	392	532	412	425	301	229	218	203	136
StoraEnso	Mean price spread	2.84%	4.58%	2.99%	2.82%	2.98%	2.94%	3.01%	3.16%	2.72%	0.85%	1.50%	2.13%
	Mean vol	260	829	855	342	270	351	283	233	113	150	164	152
Telefonica	Mean price spread	n/a	n/a	n/a	n/a	n/a	n/a	2.87%	3.40%	3.36%	2.58%	2.64%	0.60%
	Mean vol	n/a	n/a	n/a	n/a	n/a	n/a	178	41	19	15	27	8
UPMKymmene	Mean price spread	n/a	n/a	n/a	2.93%	3.54%	3.11%	2.74%	3.56%	2.92%	1.45%	1.95%	2.02%
	Mean vol	n/a	n/a	n/a	118	47	148	90	53	24	22	26	29
Volkswagen	Mean price spread	n/a	n/a	n/a	0.23%	0.81%	0.49%	0.80%	1.30%	1.76%	0.78%	1.16%	-0.11%
	Mean vol	n/a	n/a	n/a	198	100	40	79	53	28	23	11	7
Volvo	Mean price spread	-0.13%	1.59%	1.41%	1.75%	1.74%	1.38%	1.69%	2.22%	2.01%	0.95%	0.69%	0.04%
	Mean vol	250	591	651	263	184	171	165	107	84	88	125	97

Appendix B Credit default swaps

Credit default swaps emerged in the early 1990's as a method of transferring credit risk between different entities. In essence, it is an insurance contract where the protection buyer pays the protection seller to reimburse all or part of an eventual future credit loss on the reference entity. As an example, an investor that has a position in a corporate bond of a company could insure its position so that in the event of insolvency, suspended debt repayments or restructuring, she would receive its insured amount. A bank or another financial institution usually functions as an intermediary in this process, transmitting the credit risk to one or several third party investors. Hence, by the use of a CDS, credit risk can be split into smaller portions that are more digestible for the aforementioned third party investors. The buyer of the CDS pays a premium, the CDS spread, for her insurance, which the seller receives on a quarterly basis with the convention being the payoff on the standard IMM dates (20th of March, 20th of June, 20th of September and 20th of December). Thus, the protection buyer takes a long position and the protection seller a short position in the CDS contract. (Hull, 2009; Beinstein et al., 2006)[1]

There exist two methods of settlement for CDS contracts, cash and physical. In a cash settlement, the protection seller pays the protection buyer the difference between the par value and market price of a debt obligation on the reference entity. In physical settlement, the protection seller pays the protection buyer the par value of a debt obligation on the reference entity and receives a debt obligation on the reference entity in return. A typical example would be an investor hedging an exposure in a bond she owns; if a credit event occurs she receives the par value of the bond in return for the defaulted bond, the value of which goes to the protection seller who gets the recovery value determined in the bankruptcy, debt negotiation or restructuring process. In theory, the market value of the debt obligation and the recovery rate should converge so that: (Beinstein et al., 2006)

$$P_{Defaulted\,Bond} = R_{Defaulted\,Bond} \tag{26}$$

Therefore, the specific settlement procedure should have little or no economic difference, although the practical implications obviously are widely different since the holder of a defaulted credit note would have to enter into the legal process of claiming her recovery value.

CDS contracts can be written either on a single name entity or on a specific debt issue, such as a bond or other credit obligation. In the market, CDS contracts on single name entities are quoted in terms CDS spread and recovery rate. CDS are OTC (over-the-counter) instruments and the transparency and functionality of the market is promoted through ISDA (the International Swaps and Derivatives Association). Since 1999, the ISDA has worked

[1] European Standard Corporate CDS contract specifications: http://www.cdsmodel.com/

with standardizing the documentation on CDS, and although differences between contracts still persist, the general homogeny within the asset class has increased dramatically since the early days of the CDS market. The ISDA also serves another crucial role within the CDS market by arranging auctions where participating dealers submit bids for the debt obligations of defaulted reference entities. These auctions help settle default cases with large outstanding CDS volumes, notable cases include Lehman Brothers. [2]

From the perspective of the financial system, CDS contracts provide some substantial benefits. It allows banks to transfer credit risk away from their balance sheets, reducing the capital buffers kept for regulatory or risk management reasons, contributing to the market credit supply. As previously mentioned, CDS also allows credit risk to be distributed throughout the financial system, decreasing credit risk concentration. Finally, CDS spreads provide up-to-date information about the implied credit risk of reference entities, valuable information for investors and supervisory agencies. [3]

Despite these advantages, CDS contracts have been heavily criticized for the allegedly immoral way in which they can be used to take short positions on financially troubled firms and, even more notable in the debate, sovereign states. A CDS contract allows for speculation in the credit risk of an entity without the investor necessarily having any credit risk exposure to it. Hedge funds and other financial speculators have found this a practical way of placing their bets compared to shorting bonds, particularly since the CDS market is much more liquid than the underlying market. One case that has attracted significant attention during the past few years is that of the outstanding CDS volumes on Greece (officially The Hellenic Republic) and its related debt situation. Financial speculators used CDS contracts to speculate on a Greek default while political powers attempted to enforce a voluntary debt write-down specifically to avoid creating a credit event that would trigger the CDS and reward the financial speculators. (Bolton and Oehmke, 2013)

CDS - contractual features

This section formalizes the standard clauses of CDS contracts. This information is built on the standard elements of CDS contracts included in the majority of single entity CDS contracts, which follows the recommendations of the ISDA. (Beinstein et al., 2006)[4]

- The reference entity: The entity whose credit risk is transferred from the protection buyer to the protection seller.
- The reference asset: In the case of a single asset CDS, this specifies the credit obligation that is insured, such as a particular bond.

[2] see http://www.isdacdsmarketplace.com

[3] Ibid

[4] http://www.cdsmodel.com/

- The credit event: The conditions under which the CDS is triggered and the protection seller is required to pay the protection buyer the default payment. Typically, this includes event of:
  - Illiquidity: Failure to make debt repayments for liquidity reasons
  - Insolvency: Event of bankruptcy
  - Debt restructuring: Coupon reduction, maturity extension etc
  - Obligation default: Violation of bond covenants or other contractual features
- Notional CDS value: The value paid from the protection seller to the protection buyer in the case of a credit event.
- Start and Maturity dates of the CDS contract
- The CDS spread: The insurance premium paid by the protection buyer to the protection seller to insure the notional value in the case of a credit event. Measured in basis points.
- Premium payment frequency: Typically quarterly on March 20th, June 20th, September 20th and December 20th (the standard IMM dates)
- Day count convention: Specifies details on how to calculate accrual premium payments that are to be deducted from the default payment in the case of a default between premium payments. Also used to calculate accrued interest.
- Settlement terms: Physical or cash, see the main credit default swaps section.

CDS spreads and bond yields

The CDS spread represents the return in excess of the risk-free rate that a protection seller requires to agree to transfer the credit risk from the protection buyer to herself. It is the difference in required return for a risk-free and risky investment. Put in relation to corporate bonds, the CDS spread, c, should theoretically be equal to the bond yield of a bond on the underlying of equal maturity, y, minus the risk-free rate, r_f:(Hull, 2009)

$$c = y - r_f \tag{27}$$

Any violation of this condition would be a violation of the fundamental assumption of no arbitrage. There are some restrictions on this relation however. The treasury rate conventionally used in calculating bond credit spreads leads to a credit spread that might not solely represent credit risk but that might also include some other differentials between the risk profile of treasuries and corporate bonds, notably liquidity but also other risks. Instead of using the Treasury bill rate in calculating the CDS spread, a somewhat risky rate such as the

LIBOR/swap rate could be used; this is the practice amongst derivative traders. Such a rate, while credit risk-free, includes some of the aforementioned risks and if used consequently helps reduce the CDS spread to a pure credit measure, which is the basic assumption in the market. (Hull, 2009)