LAPPEENRANNAN
TEKNILLINEN YLIOPISTO

Lappeenranta University of Technology

School of Business

Finance

Valuation of Convertible Bonds in Finland

AB30A8000 Kandidaatintutkielma

Bachelor's Thesis

Atte Rissanen

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1. Introduction

Convertible bonds are complex financial instruments that combine the characteristics of stocks and bonds. They are bonds that offer a possibility to convert the bond into a predetermined amount of stocks during a particular period. Unlike stocks, convertible bonds have limited loss potential because they also have characteristics of fixed income securities. Some convertible bonds are also callable, meaning that the issuer of the bond has an option to buy back the bond. This may lead to forced conversion.(Da, 2004)

The objective of this study is to create an easily comprehendible pricing method, which can be applied for any convertible bonds anywhere in the world. This will be established by modifying earlier pricing methods and combining their characteristics. Later this method will be tested empirically by pricing two of the most liquid Finnish convertible bonds to investigate whether their market prices are below theoretical fair values. The market prices will be analyzed on the valuation date of November the 10th, and their fair values will be calculated using the modified pricing method approach. Evidence of convertible bond under pricing has been previously found in various researches (see for example King, 1986 and Ammann et al. 2001), but there has been no such research conducted in the Finnish market. Market prices of two convertible bonds will be analyzed on the valuation date of November the 10th, and their fair values will be calculated using the modified pricing method approach.

For both of the valued bonds, the results of the theoretical value differed from the observed market prices. The bonds were underpriced by 7.56 % and 3.73 %. Evidence suggests that this could be because of the fact that the options embedded in the convertible bonds are not valued correctly.

This paper is organized as follows; first the basic characteristics of bonds with embedded options will be introduced. Second, there will be an introduction of the Finnish bond market. Third, different pricing models will be introduced and the modified valuation approach will be created. Fourth, introduction of the data used in the valuation process. Finally, the results of the empirical study will be presented.

2. Different types of bonds and previous research

2.1 Convertible bonds

A convertible bond is a bond combining characteristics of both stocks and bonds. Convertible bonds differ from regular bonds because of the embedded option of converting the bond into a predetermined number of stocks of the issuing company according to the conversion ratio. Convertible bonds may also be convertible into stock of a company different from the issuer. These are referred to as exchangeable convertible bonds. This offers the possibility to gain from rising stock prices with limited loss possibility (Ammann et al. 2001). When a buyer executes the option to convert the bonds into shares he may receive existing stock or new shares just issued. If the received shares are newly issued, there will be a dilution effect that has to be taken into account in the valuation process (Da, 2004). Although convertible bonds are considered low risk instruments, they have potential to gain from a rise in the price of the underlying stock 60 to 70%. From a company's point of view, convertibles are a tempting opportunity to raise debt, because it offers a possibility save in interest payments. Because of the embedded option to convert the bond into stock, the coupon payment of a convertible bond is normally lower than the coupon of an equivalent straight bond would be, making it an excellent alternative to raise money (Bogoslaw, 2009).

If a convertible bond is not callable by the issuing company, the option embedded in the bond can be executed at any given time. This increases the value of the option significantly. In this case the rational thing to do would be to just wait until the bond matures and collect the coupon payments and finally just as the bond is about to reach its maturity to convert into the underlying asset given that the option is in-the-money (Brennan & Schwarz, 1977)

2.2 Callable bonds

Callable bonds are bonds that have an embedded option similarly to the convertible bond, but the option belongs to the issuing company. They are bonds that can be called back by the issuing company at a predetermined price. Reasons for executing the option may vary but the simplest reason for calling back the bond is when cheaper sources of debt are available. As interest rates fluctuate, or if a company's credit rating improves, cheaper sources for debt may be provided. For example, if a company previously issued a bond that pays a 8% coupon as interest rates are high, the company will need to continue paying the five percent coupon, even if they now could sell their bonds with only a coupon of 6%. If the company were to have a call option on the issued bond, they could buy back the bond paying a coupon of 6% and re issue a new bond paying only 6% coupon. This is a valuable option for the company and it suggests that the price value of the bond is higher for the issuing company and lower to the bondholder, because of call risk. (Athanassakos, 2004)

2.3 Convertible callable bonds

Convertible callable bonds are bonds that have two options embedded in them. They have both the characteristics of callable and convertible bonds. They can be converted into a predetermined amount of underlying stock but they can also be called back by the issuing company. This may lead to "forced conversion", which means that, given that the option is in-the-money, the holder of the bond has to execute the option to convert the bond. If the bond holder does not convert, the issuing company buys back the bond at a predetermined value. While the call option for the buyer increases the value of the bond for the buyer of the bond, the call option of the issuer similarly decreases the value. The call option usually can be enforced either when the stock price reaches a certain price or a certain date. In some cases the call option can be also enforced at any given time. (Athanassakos, 2004)

2.4 Previous research on convertible bonds

Because the convertible bond markets are relatively small, there has been relatively little research conducted on the subject. A number of papers describe different theoretical approaches for convertible bond pricing. (See for example Margrabe, 1978 and Ingersoll, 1977).

There has also been empirical research conducted on the subject of convertible bond pricing in the past. King (1986) was the first to examine empirically bond valuation using a model based on the theoretical pricing models of Ingersoll (1977) and Brennan and Schwartz (1977). He finds examining the market prices of American convertible bonds that they were on average 3.75% lower than model prices, using a sample of 103 bonds. He also finds that when out-of-the-money convertible bonds are underpriced, the at- or in-the-money convertible bonds are slightly overpriced.

Carayannopoulos (1996) also follows the theoretical fundaments of Brennan and Schwartz (1977,1980) with the exception that in his model the interest rate process is done by following the mean-reverting process suggested by Cox et al. (1985). Carayannopoulos made also some simplifying assumptions similar to King (1986) concerning the capital structures of the issuing companies. The study investigates 30 of the most commonly traded American bonds for a period of one year beginning from the fourth quarter of 1989. His results imply a mean under pricing of 12.9%. As King (1986) Carayannopoulos also suggests that out-of-the-money convertible bonds are more significantly underpriced.

Athanassakos and Carayannopoulos (2000) investigated the US Treasury bond market with a sample of 1239 convertible bond price observations. Using a method which divides the value of the convertible bond into a straight bond and a stock component they found evidence that the under pricing of these risk free convertible bonds is so significant that often imply negative conversion option prices. This is particularly peculiar keeping in mind that the basic fundaments on finance imply that option prices cannot be negative.

Ammann et al. (2003) conducted a research on convertible bond pricing on the French market. The French market was chosen because of the availability of accurate daily market prices and the large size of the French market. Their sample included 21 of the most liquid convertible bonds which included 7 exchangeable convertible bonds that may be exchanged into stock of company that differs from the issuing company. Using a Binomial-tree model with exogenous credit risk to calculate the theoretical values of bonds, using 18 months of daily market price data, ranging from February 19, 1999 to September 5, 2000, they found an average under pricing of 3.24%. For comparison they also computed the prices using the component and Margrabe model as well. The component model implied an under pricing of 8.74 % and the Margrabe model an under pricing of 5.60%.

The optimal call strategy of convertible callable bonds is another point of focus for research. An investigation conducted by Brennan and Schwartz's (1977) shows that the optimal time for a company to call back its bond is when the conversion value first exceeds the call price. Athanassakos (2004) also suggests that in the case of callable convertible bonds, optimally the firm should call the bond the moment the conversion value exceeds the call price, because usually the reason for issuing callable convertible bonds is that for some reason the firms was not able to issue equity. To improve their balance sheet, companies will want to force conversion from debt to equity as soon as they can. Even though most studies are consistent with the before mentioned studies, there is still debate concerning the optimal call policy.

3. The Finnish market

The market for convertible securities is relatively small. As of the year 2000 the global market for convertible securities reached an approximate value of $470 billion. At that time the market size for convertible securities in the US alone was 160 billion. For comparison the US stock market value in 2000 was approximately 10 trillion. Although the market is rather small, it is growing all the time. (Da 2004)

The Finnish bond market is a small and a new market and very few companies see convertible bonds as an attractive to raise capital. The first significant convertible bond by a publicly traded company was issued by Enso-Gutzeit, later known as Stora-Enso in 1980 (Markku Hietala et al. 1980). The size of the bond was 110 million Finnish marks

To this day convertible bonds remain rare in Finland. Only 55 corporate bonds were issued for Finnish investors between 2004 and 2008 (Bank of Finland, 2009). In Finland bonds are traded only Over-The-Counter by bond traders so finding market prices is not an easy task. There is no public record kept of bond trades or market prices so very few private investors trade with convertible bonds. Because no record of bond is kept, the market prices of the bonds were obtained from Danske Bank, where the Bloomberg trading software is in use. The Finnish convertible bond market is subject to low liquidity because of its small size and unavailability of information. Even the liquidity of Finnish government bonds has gone down lately because of recent economic development.

The fact that the Finnish convertible market is highly illiquid may cause even further mispricing than is found in previous research but it may also mean that because of the possible mispricing more arbitrage opportunities can be found.

4. Valuation methods

4.1 Valuation of a straight bond

All bonds excluding zero-coupon bonds pay a periodical coupon. These coupon payments and the face value of the bond, which is received at the end of the bonds maturity, are all the cash flows that will be received by the owner of the bond. To calculate the theoretical value of the bond, these future cash flows need to be discounted to their present value. The accurate approach for doing this is to use a different zero rate for each cash flow. These zero rates can be calculated by alternate methods such as the bootstrapping method. Another important factor in bond valuation is the bond's yield which is the discount rate that, when applied to all cash flows from the bond, gives us the market price. The yield can also be calculated for the theoretical bond value. (Hull, 2006)

4.2 Pricing methods for convertible bonds

Because of the complex nature of callable convertible bonds their pricing has certain difficulties. When the value of a straight corporate bond is affected by interest rates and the default risk of the issuing company the convertible bond's price is affected also by the share price and the volatility of the stock.

The earliest model created for pricing convertible securities is the break even analysis. This method merely compares the advantage of owning the convertible to owning the underlying share directly. This method is not so much a pricing method but rather a way to check if the bond should be converted or kept and does not account for any of the option features. (Da, 2004)

Another early and quite commonly used model for pricing convertible bonds is the Margrabe model. Margrabe (1978) implemented the Black & Scholes option pricing model to price the embedded option of the convertible bonds. He first introduced the convertible bonds which can be viewed as a sum of a straight bond and an option that

gives the holder the right to convert the bond into a certain number of the underlying stock.

The drawback of this model is that Margrabe's method for pricing the option is the Black & Scholes formula which means that the embedded option is assumed to be an European option. A European option can only be exercised at a specific time when in reality the almost all convertible bonds can be converted prior to maturity. (Ammann et al. 2003)

While Ammann et al. (2003) Criticize the use of the Black and Scholes model being used for pricing the embedded option it may be in fact implemented in certain situations. An example of such a situation would be when the convertible bond is also callable. As discussed earlier, an issuing company may use its call option to force conversion. If conversion is forced for a specific date the call option can be valued using the Black and Scholes model. (Athanassakos, 2004)

One of the most commonly used pricing models according to number of empiric research conducted is the binomial tree model which is derived from the binomial tree option pricing approach introduced by Cox, Ross and Rubinstein (1979). In this approach the value of the convertible bond is priced calculating different values for each branch of the binomial tree. Ammann et al. (2003) constructed a binomial tree with a 100 time steps. The condition for all end nodes of the tree is

$$\omega_T = Max(n_T S_T, kN) \quad (1)$$

Where ω_T is the fair value of the convertible bond at maturity T, n_T is the conversion ratio, S_T is the equity price at time T, k is the final redemption ratio at time T in percentage points of the face value, and N is the face value of the convertible.

Tsiveriotis and Fernandes (1998) and Hull (2000) propose an approach that divides the value of a convertible bond into a stock component and a straight bond component. By dividing the convertible bond into a straight bond and a stock component, an option to be precise, offers a relatively more easily comprehendible approach but there has been even less empirical research using this model than the binomial tree model. This may

be due to the fact that the option to trade the bond is embedded and cannot be traded separately.

This approach was used by Athanassakos and Carayannopoulos (2001) to value US Treasury convertible bonds. They consider the long position in a convertible the same as a portfolio consisting of a long position in a nonconvertible bond and, with the same coupon, maturity, and risk, and a long position in an American type call option. They describe the value of the bond as

$$B_{conv}(t,T) = B_{nconv}(t,T) + C(t,T) \quad (2)$$

Where *t* is the current date, *T* is the date of the maturity of the bond and the option, $B_{conv}(t,T)$ is the value of the convertible bond, $B_{nconv}(t,T)$ denotes the value of an equivalent nonconvertible bond. and *C(t,T)* represents the value of the correspondent embedded option.

Athanassakos and Carayannopoulos (1998) have also modified this approach so that it can also be used for risky corporate bonds. To value the corporate nonconvertible bond they estimate yield to maturity of the risky corporate bond. To find out the yield to maturity of the bond they split it into two parts: the risk free equivalent government bond, which has the same coupon and maturity, and a yield spread

$$YTM_{nconv}(t,T) = YTM_{gov}(t,T) + yield\ spread \quad (3)$$

Where $YTM_{nconv}(t,T)$ represents the yield to maturity of a nonconvertible corporate bond. $YTM_{gov}(t,T)$ represents the yield to maturity of an equivalent government bond. The *yield spread* represents an additional compensation investor's demand because of the default risk and other factors unique to the corporate bond.

The estimation of the yield to maturity of the equivalent government bond is done by calculating the zero rate curve for the U.S. government using U.S. Treasury STRIPS. U.S. Treasury STRIPS are zero coupon bonds with maturities spanning 30 years. By fitting a curve to the observations of the STRIPS interest rates, any zero rate can easily be found for any date. The price of the equivalent government bond is then calculated

by discounting all future cash flows implied by the fitted Treasury STRIPS zero rate curve. The yield to maturity is then calculated using the theoretical price of the equivalent government bond.

The yield spread at a specific time is assumed to be a function of default risk, taxation, and call risk.

$$Yield\ spread = f(default\ risk, call\ risk, taxation) \quad (4)$$

Default risk is the risk that the issuer of the bond may not be able to make the coupon payments. Call risk, when the bond is callable, needs to be incorporated because the issuing company has the option to buy back the bond at a predetermined call price. Taxation also included because in the U.S. Treasury issues are subject to different taxation as corporate securities.

4.3 The modified valuation approach

The valuation approach used in this study is similar to the approach of Athanassakos's. The value of the convertible bond will be calculated by splitting the value of the convertible securities into a stock component and straight bond component. Hence the price of the bond will be

$$B_{conv}(t,T) = B_{nconv}(t,T) + C(t,T) \quad (5)$$

Where:

t = current date

T = date of the maturity

$B_{conv}(t,T)$ = value of the convertible bond

$B_{nconv}(t,T)$ = value of an equivalent nonconvertible bond

C(t,T) = value of the embedded option

All other components will be calculated following Athanassakos and Carayannopoulos (1998), except the value of the embedded option. This value will be calculated using a binomial tree approach. This is due to the complicated nature of the embedded option and the value restraints caused by the possible call option of the issuing firm. The binomial tree model can easily be modified to take into effect the possibility of a call option of the issuing firm. This is done by modifying the binomial tree so that all end nodes where the conversion value exceeds the call price. This pricing method is based on the assumption that the optimal call strategy for a firm is to force conversion the conversion value exceeds the call price, as Athanassakos (2004) and Brennan and Schwarz (1977) conclude.

The valuation will be conducted in the following fashion. After mapping out the cash flows of a convertible bond issued by corporation, an equivalent risk free bond will be manufactured and its theoretical value will be calculated. This will be done by discounting all the cash flows of the equivalent straight government bond with zero rates specific to cash flow date.

The zero rates will be calculated by using 1,2,3,4,5,6,7,8,9,10,11 and 12 month Euribor rates and for beyond twelve months, by using the zero rates of benchmark bonds issued by the Finnish government. These spot rates are available from the Bank of Finland. After getting the necessary observations a regression analysis is made to calculate zero rates between observation dates with sufficient accuracy. This will be done using an equation introduced by Athanassakos and Carayannopoulos (2001)

$$r_{it} = a_0 + a_1 x_{it} + a_2 x_{it}^{1/2} + a_3 x_{it}^2 + a_4 x_{it}^3 + a_5 ln x_{it} \quad (6)$$

Where,

r_{it} = zero rate at time t

x_{it} = time to maturity of the Euribor or benchmark bonds measured in days

a = the coefficient

After getting the theoretical value of the equivalent straight government bond its yield to maturity will be calculated using standard practices.

To adjust the yield to maturity to match the risky corporate bonds yield to maturity a yield spread must be added. Unlike mentioned by Athanassakos and Carayannopoulos (2001), in Finland one does not need to incorporate taxation into the yield spread equation because in Finland the taxation for income from government bonds and corporate bonds does not differ. Because a valid estimate for default risk can be assumed to be Standard & Poor's ratings the yield spread will be calculated using yield spreads of bonds issued by corporation with similar credit ratings as the ones of the issuers of the bonds valued.

If the issuing corporation does not have Moody's or a Standard & Poor's rating, the default risk of the issuing company must be calculated. Although the default risk contains In this thesis the default risk will be calculated using the Altman Z Score:

$$Z = 0{,}012X_1 + 0{,}014X_2 + 0{,}033X_3 + 0{,}006X_4 + 0{,}999X_5 \quad (7)$$

Where,

X_1 = Net working capital/total assets

X_2 = Retained earnings/total assets

X_3 = EBIT/total assets

X_4 = Market value of common and preferred stock/book value of debt

X_5 = Sales/total assets

The Altman Z Score range 1.81-2.99 represents the "zone of ignorance". Companies located in that range are considered to be B-BBB class. All companies scoring 3 or higher are considered A rated or better.

The credit rating retained from the Altman Z Score will also be compared to the rating calculated by Standard & Poor's Corporate Rating Criteria illustrated below.

Financial Ratios	AAA	AA	A	BBB	BB	B	CCC
EBIT Interest Coverage	23,8	13,6	6,9	4,2	2,3	0,9	0,4
EBITDA Interest Coverage	25,3	17,1	9,4	5,9	3,1	1,6	0,9
Funds from Operations/Total Debt (%)	167,8	77,5	43,2	34,6	20	10,1	2,9
Free Operating Cash Flow /Total Debt (%)	104,1	41,1	25,4	16,9	7,9	2,6	-0,9
Total Debt/EBITDA	0,2	1,1	1,7	2,4	3,8	5,6	7,4
Return on Capital (%)	35,1	26,9	16,8	13,4	10,3	6,7	2,3
Total Debt/Capital	6,2	34,8	39,8	45,6	57,2	74,2	101,2

Table 1. S&P Corporate Rating Criteria 2005.

Evaluating the credit rating and thus, the default risk of the company by using purely the quantitative data of the Altman Z Score and the criteria illustrated in table 1 is a necessary simplification because a comprehensive evaluation of a company's credit risk would not be in proportion with the rest of this bachelor's thesis.

After calculating the yield spread and the yield to maturity of an equivalent straight government bond, the yield spread of the straight corporate bond will be calculated by

$$YTM_{nconv}(t,T) = YTM_{gov}(t,T) + \ yield\ spread \tag{8}$$

With now obtaining the yield to maturity of the equivalent straight corporate bond the option price is added to get the value of the convertible government bond. The option price is obtained by using the binomial tree model. The binomial tree is constructed by using standard practices:

Su

S

Sd

In the illustration S denotes the stock price, $u = \exp\left(\sigma\sqrt{\Delta t}\right)$, $d = \frac{1}{u}$, where σ is the volatility of the underlying stock and Δ is the length of time interval for each step of the binomial tree. The risk neutral probability for an upward movement is $\frac{r-q-u}{u-d}$, where r is the risk free rate, q is the dividend yield over Δt.(Da, 2004)

5. Data

5.1 Bond specifications

The method for estimating price of the equivalent government bonds requires data from the three sources; the risk free Euribor rates, the government benchmark bonds and the valued bond itself. The specific attributes of the bond were taken by using the Bloomberg trading software which is used by trade specialist. The bonds chosen for the pricing are the two most liquid corporate bonds issued by Finnish companies. As the bonds liquidity increases the bonds bid-ask spread decreases. This results in more accurate market prices.

Nokian Renkaat is the largest manufacturer of tires and coating materials in the Nordic countries. The company manufactures tires for automobiles and special tires for heavy machinery. In addition, Nokian Renkaat owns the largest tire retail chain in the Nordic countries, Vianor, with over 500 stores in over 15 countries. In 2008 Nokian Renkaat had revenue of 1080.9 Million Euros and they generated a net income of 139.90 Million Euros. In 2007 Nokian Renkaat issued a convertible bond of 150 Million Euros. Bond specifics illustrated in the table below.

Issuer:	Nokian Renkaat
Issue date:	28.6.2007
Term:	7 years
Redemption Date:	20.6.2014
Nominal Value:	100000 Eur
Interest Coupon:	Zero Coupon Bond
Conversion Price:	37,41996804
Conversion Ratio:	2672,37
Call Option:	No
Redemption price:	123
Market price at issue:	100
Bloomberg Ticker:	NOKREN0 06/20/14

Table 2. Nokian Renkaat Bond specification

From Table 2 one can clearly observe that the bond is of a simple nature. As one can observe from the table the bond is not a coupon bearing bond. When a bond does not

pay any coupon it is referred to as a Zero-Coupon Bond. Because of the lack of interest payment the redemption price is higher than the nominal value. In this case it is 123% meaning that when the bond matures, if not converted, each 100000€ will be redeemed at123000€. The bond is convertible, but not callable and the bond can be converted at any given time when the owner of the bond wishes to do so.

Talvivaara Mining Company Plc. is an internationally significant producer of base metals producer focusing primarily on nickel and zinc. The Talvivaara polymetallic deposits, Kuusilampi and Kolmisoppi, are one of the largest known nickel resources in Europe with enough ore to support production for an estimated more than 60 years. Until 2008 they had not generated any sales, but they had assets of 873.95 Million Euros. In 2008 they issued a convertible bond of 84.9 Million Euros to finance the enhancement of Talvivaara's metal processing facility.

Issuer:	Talvivaara
Issue date:	10.5.2008
Term:	5 years
Redemption Date:	10.5.20013
Nominal Value:	100000 Eur
Interest Coupon:	5,25
Conversion Price:	7,387
Conversion Ratio:	13537,423
Call Option:	No
Redemption Price	100
Market price at issue:	100
Bloomberg Ticker:	TALVLN5 1/4

Table 3. Talvivaara Bond specification

As can be observed from table 3, the Talvivaara Bond is a convertible bond but not callable just as the Nokia Renkaat bond. It bears a coupon of 5.25% which means that as the coupon is paid semiannually the payment will be 2625 €.

5.2 The Zero rates

To construct the zero rate curve, which is necessary for the pricing of the equivalent government bond requires 1 to 12 month Euribor rates and from beyond twelve months government benchmark bonds. Daily Euribor rates are available from various reliable sources, but in this case they were obtained from the bank of Finland. To obtain the zero rates of government benchmark bonds one can also use the official website of the Bank of Finland. Below the rates of the valuation date of November the 10th 2009.

EURIBOR	
1 month	0,431
2 months	0,574
3 months	0,715
4 months	0,807
5 months	0,896
6 months	0,992
7 months	1,038
8 months	1,081
9 months	1,124
10 months	1,157
11 months	1,192
12 months	1,229

Table 4

Government Benchmark	
23.2.2011	1,03
15.9.2012	1,78
4.7.2013	2,15
15.9.2014	2,53
4.7.2015	2,75
15.9.2017	3,32
4.7.2019	3,54

Table 5.

Because the valuated bonds have different cash flow dates as the zero rate dates a regression analysis is made from the observations to. In order for the regression to be valid the Adjusted R-square, which represents the percent amount of how much the regression analysis explain. A confidence level of 0.05 is chosen which means that the P-value must be below 0.05 for the regression to be reliable. The regression equation used is as presented in paragraph 4.3.

$$r_{it} = a_0 + a_1 x_{it} + a_2 x_{it}^{1/2} + a_3 x_{it}^2 + a_4 x_{it}^3 + a_5 ln x_{it} \quad (6)$$

First when running the regression the P-values of the regression were not at a sufficient level. To correct this, the x_{it}^3 observations were eliminated and the regression was run again. The second regression provided the following results

Regression Statistics				Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Multiple R	0,9964		Intercept	-1,4684956	0,649282	-2,26172	0,040156	-2,8611	-0,07592	-2,86107	-0,07592
R Square	0,9927		X Variable 1	0,00359978	0,001206	2,98388	0,009862	0,00101	0,00619	0,001012	0,00619
Adjusted R Square	0,9907		X Variable 2	-3,176E-07	1,13E-07	-2,81774	0,013694	-6E-07	-7,6E-08	-5,6E-07	-7,6E-08
Standard Error	0,0925		X Variable 3	-0,1695469	0,077248	-2,19485	0,045538	-0,3352	-0,00387	-0,33523	-0,00387
Observations	19		X Variable 4	1,80459467	0,652456	2,76585	0,015165	0,40522	3,20397	0,405216	3,20397

Table 6. Regression analysis summary output.

From table 6 it is visible that the P-values were all below the chosen confidence level of 0,05 and that the adjusted R-square value is 0.99. This means the regression analysis is valid and can be used for predicting zero rates. With the modification of the regression by disregarding the x_{it}^3 the regression equation is corrected to:

$$r_{it} = a_0 + a_1 x_{it} + a_2 x_{it}^{1/2} + a_3 x_{it}^2 + a_4 ln x_{it} \quad (9)$$

5.3 The yield spread

To evaluate the yield spread by following the approach introduced by Athanassakos and Carayannopoulos (2001), who state that the yield spread, consist of the following function:

$$Yield\ spread = f(default\ risk, call\ risk, taxation) \quad (10)$$

When estimating the yield spread between Finnish government bonds and corporate bonds, the functions last variable, taxation, does not need to be included. This is because in Finland the taxation does not differ between capital derived from corporate and government bonds. Another variable of the function, call risk, does not need to be included in the yield spread function because of the nature of both corporate bonds. Neither of the bonds is callable, which means that there is no risk that the bond will be called by the issuing company prior to its maturity.

This leaves us with only one variable in the yield spread function: default risk. Because neither of the companies in question has credit ratings the credit rating must be calculated from the financial ratios of the companies using the rating criteria illustrated in table 1 and the Altman Z Score. After calculating the issuing companies' credit ratings, the yield spread is calculated comparing risk free returns with returns from Merrill & Lynch Bond indices with the same credit ratings.

5.3.1 Nokian Renkaat's Credit Rating and yield spread

All data required to calculate the credit rating for Nokian Renkaat was taken from the annual report of 2008. Nokian Renkaat's Altman Z Score was 3.40 placing it at a high level of A. The results of the S&P Corporate rating criteria are illustrated in the table below.

Financial Ratios	Nokian Rankaat	
EBIT Interest Coverage	3,37431694	BB
EBITDA Interest Coverage	4,140710383	BB
Funds from Operations/Total Debt (%)	54,48 %	A
Free Operating Cash Flow /Total Debt (%)	90,97 %	AA
Total Debt/EBITDA	1,052457935	AA
Return on Capital (%)	22,9	A
Total Debt/Capital	22,46 %	AA

Table 7. Nokian Renkaat S&P Corporate Rating Results

The results of the S&P Corporate Rating Criteria were consistent with the results of the Altman Z Score. From the table 7 one can observe that that only two of the rating criteria's were below A class and three of the criteria's were above A class. By taking into effect both test results one can safely assume Nokian Renkaat to be rated A grade.

The benchmark bond index chosen was BOFA ML EMU CORP LGE CAPA 3-5Y(E) total return index. This is a Merril & Lynch bond index which follows A rated corporate bonds in the EMU zone with a maturity of 3-5 years. The Nokian Renkaat convertible bond falls well into this range. The return of this index since the beginning of the index on September the 15th 2005 has been 9.73% and at the same date the 5 year risk free

rate of government bonds was 2.64 %. This gives us a yield spread of 7.09 %. Because of using historical yield spreads instead estimated yield spread has to be adjusted because recent economic development have caused abnormally high yield spreads and interest rates have a tendency for mean reversion. The adjustment is made by the following formula so that the yield spread can be implemented on the bond in question.

$$Adjusted\ Yield\ Spread = \left(\frac{2}{3}\right) * (1 + yield\ spread) + \left(\frac{1}{3}\right) * 1 - 1 \quad (11)$$

This formula is also used for adjusting historical Beta coefficients to represent the future Betas (Encyclopedia of Finance, 2006). The adjusted yield spread for Nokian Renkaat was 4,729 %

5.3.2 Talvivaara's Credit Rating yield spread

The credit rating of the Talvivaara Corporation cannot be calculated using the same criteria as Nokian Renkaat. This is due to the fact that Talvivaara has not had any sales in the last five years so all the financial ratios that include information from the income statements are invalid. Only rating criteria based purely on balance sheet information can be applied. The lack of sales does not mean that the company is unsuccesful, but rather that the company is expected to generate its profits in the future. Because of the invalidity of the financial ratios one must compare other mining companies with similar backgrounds and balance sheets. The competing companies can be benchmarked to evaluate Talvivaara's credit rating.

The search for competing companies is conducted by using the Thomson One Banker and searching for companies which have a CIG Code indicating that they are focused in Diversified Metals & Mining. After careful examination of the companies none of the companies were valid for comparison. Talvivaara is a company that has not yet began its mining operations but is expected to generate steady income for decades to come. Also the company has ground breaking technology used in its mining processes so actually none of the companies that may be seen as competitors can be benchmarked to evaluate Talvivaara's credit rating.

Because both of the previously introduced methods have failed in estimating the credit rating a more unconventional approach must be taken. The credit rating will be given based only on balance sheet information and more qualitative estimation criteria. The Total Debt to Capital ratio of the company was 46.5 per cent placing the company in the BBB rating class. Talvivaara also has a current ratio of 3.2 and a quick ratio of 2.6. According to Kinnunen et al. (2004) the before mentioned ratios are considered to be good when they are above 2 and 1, respectively. Another aspect to consider is the market's confidence in the company. This is estimated by using information from DataStream. Talvivaara is also listed in the London Main Marker so the past stock performance of Talvivaara is compared against the FTSE all share index. Since mid May, the the price of the Talvivaara stock has climbed 40 percent. In this time the FTSE all share has only risen by 20 percent. This indicates that investor's confidences in Talvivaara are high. By taking into account all the before mentioned factors and their consistency, Talvivaara is given a credit rating of BBB.

The benchmark Bond index chosen was BOFA ML EMU CORP LGE CAP BBB 3-5Y(E). This is a Merril & Lynch bond total return index for large companies with a credit rating of BBB in the EMU zone and bond maturity of 3-5 years, making it an excellent benchmark. For the past five years the return of this index has been 18.63 % as the risk free yield of the five year government at same time was 3.07 %, giving us a yield spread of 15.56 %. By using the adjusted yield spread formula the yield spread is adjusted to 10.37 %.

5.4 Option pricing data

Data required for valuating the option was acquired using Thomson One Banker that is an internet interface using information from Datastream. The necessary information in order to value the embedded option in the convertible bonds are volatility, stock price on valuation date of November the 10th 2009, execution price, risk free rate, dividend yield and the risk neutral probability of an upward movement. The volatility of the stock was calculated using one year of weekly data. This dataset is chosen because the weekly interval between observations eliminates most of the affect caused by noise traders and the time period of one year gives us 52 observations which are enough to calculate the

volatility. An exception was made on Talvivaara's behalf because it has only been listed in the OMX Helsinki since the 11th of May. Because of this, daily price observations were used to calculate Talvivaara's volatility to ensure a necessary number of observations. The execution price is the number of shares the bond is convertible to, divided by the nominal value of the convertible bond. The risk free rate is calculated with the zero rate regression equation. The dividend yield is calculated as a percentage of the stock price assuming that the company's dividend policy is not going to change. Finally the risk free probability of an upward movement which is calculated with the formula $\frac{r-q-u}{u-d}$. Given all the above mentioned criteria the following date was discovered:

	Nokian Renkaat	Talvivaara
Spot Price	17,23	4,12
Execution Price	37,42	7,39
Volatility	52,95 %	32,62 %
Risk free rate	2,65 %	2,15 %
Maturity	4,63 years	3,53 years
U	1,29	1,063
D	0,775	0,941
Risk neutral probality of an upward movement	0,438	0,491

Table 8. Option valuation data

6. Results

The straight bond prices were calculated discounting all future cash flows of the bonds to the valuation date of November the 10th 2009 with the calculated yields to maturity. The yields to maturities for the Nokian Renkaat and the Talvivaara bond are illustrated in the table below.

	Nokian Renkaat	Talvivaara
YTM of Risk Free Bond	2,43 %	2,01 %
Adjusted Yield Spread	4,73 %	10,37 %
Bond YTM	7,16 %	12,38 %

Table 9. Bond Yield Spreads

Using the yields to maturities of illustrated in table 9. The following straight bond prices were calculated:

	Nokian Renkaat	Talvivaara
Price of Straight Bond	89 579,06 €	83 002,46 €
Accrued Interest	-	2 481,16 €
Straight Bond Value	89 579,06 €	80 521,30 €

Table 10. Straight Bond Values

After the Straight values of the bond are calculated, the next step is to calculate the values of the options embedded in the convertible bonds.

A 100 step binomial tree was created to calculate the values of the embedded options. The value of the embedded option in the Nokian Renkaat convertible bond was 9861.05€ and the value of the embedded option in the Talvivaara convertible bond was 4873.47€.

	Nokian Renkaat	Talvivaara
OPTION VALUE PER SHARE	3,69 €	0,36 €
Amount of shares convertible	2672,37	13537,423
VALUE OF EMBEDDED OPTION	9 861,05 €	4 873,47 €

Table 11. Binomial tree results

As illustrated in the table 11 the embedded option in the Talvivaara bond allows conversion to larger number of shares than the Nokian Renkaat Bond, but because of much higher value of the Nokian Renkaat bond the value of the embedded option is higher for the Nokian Renkaat Bond.

The fair value of the convertible corporate bonds in calculated by adding the value of the embedded option to the value of the straight bond value. By simply summing up the results from table 10 and 11 the following results were found.

	Nokian Renkaat	Talvivaara
Strainght Bond Value	89 579,06 €	83 002,46 €
Option Value	9 861,05 €	4 873,47 €
Fair Bond Value	99 440,11 €	87 875,93 €
Market price	92 450 €	84 720 €
Underpricing	7,56 %	3,73 %

Table 12. Fair bond values and under pricing

The final results of the valuation are illustrated in table 12. As anticipated, both bonds were undervalued on the valuation date of November the 10th 2009. Interestingly, as can be seen from table 12, the straight bond values are below the market prices but when adding the option price to indoor order to acquire the fair value, the under pricing occurs. It is impossible to say why the markets are pricing the bonds below their fair values, but in light of the presented evidence, this might be due the fact that the embedded options are mispriced on the markets.

7. Conclusion

The object of this study manufacture an easily comprehendible valuation method for convertible bonds by combining characteristic of previously created pricing methods. This was established successfully by incorporating a binomial tree based option pricing model to the valuation approach introduced by Athanassakos and Carayannopoulos (2000). In addition an empirical examination conducted in which two convertible bonds issued by Finnish corporations were valued. The evidence provided in this paper suggests that both the convertible bonds were underpriced. The Nokian Renkaat convertible bond and Talvivaara convertible bond were underpriced by 7.56 % and 3.73 %, respectively. Similar results have previously been found in studies of the US and French convertible bonds market (See for example Amman et al. 2003), but this study was the first conducted on the Finnish convertible bonds market.

The reason, but not the explanation, for the findings may lie in the high illiquidity of the Finnish bond market as whole, which also includes convertible bonds. No market prices of convertible bonds are available for private investors without access to academic or expensive trading software that is used by bond traders. Also the number of convertible bonds issued by Finnish corporations is relatively small. In addition to the liquidity of the bonds, the calculated credit ratings may provide an explanation for the mispricing. If the markets evaluate the companies' credit ratings differently, the results of the pricing will be immediately different. Previously it is suggested by Athanassakos and Carayannapoulus (2000) that a reason for the under pricing of convertible bonds is due to the fact that convertible bonds are traded by equity traders who may be more focused on the security's equity than its straight debt value, but in Finland convertible bonds are usually traded by bond traders and not by equity traders. They also suggest that even negative option prices are often implied. In light of the evidence presented in the thesis, it can be assumed that the embedded options in the convertible bonds to convert the bond into a predetermined number of shares of the issuing company are mispriced and undervalued.

The data of this study was only on two convertible bonds and during the study some simplifications were made to make the pricing process possible. Because of this the results are not significant enough to make conclusion about the entire Finnish convertible bond market, but the framework and modified valuation method is valid and can be executed also with a larger set of data and executed with more accuracy, but it would not have been suitable in this purpose. Further study could also be conducted on the pricing of callable convertible bonds with the modified valuation method by making adjustments to the binomial tree used in the option pricing. Another question that has yet to be answered in Finland is that are convertible bonds issued at a price below their fair values.

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Euribor rates. http://www.suomenpankki.fi/Stats/default.aspx?r=/tilastot/markkina-_ja_hallinnolliset_korot/euribor_korot_today_fi

9. Appendices

APPENDICE 1: Risk free rates udes for the zero rate curve

r	t	t^2	t^0,5	log(t)	t^3
0,431	30	900	5,477226	1,477121	27000
0,574	60	3600	7,745967	1,778151	216000
0,715	90	8100	9,486833	1,954243	729000
0,807	120	14400	10,95445	2,079181	1728000
0,896	150	22500	12,24745	2,176091	3375000
0,992	180	32400	13,41641	2,255273	5832000
1,038	210	44100	14,49138	2,322219	9261000
1,081	240	57600	15,49193	2,380211	13824000
1,124	270	72900	16,43168	2,431364	19683000
1,157	300	90000	17,32051	2,477121	27000000
1,192	330	108900	18,1659	2,518514	35937000
1,229	360	129600	18,97367	2,556303	46656000
1,03	463	214369	21,51743	2,665581	99252847
1,78	1025	1050625	32,01562	3,010724	1076890625
2,15	1314	1726596	36,24914	3,118595	2268747144
2,53	1745	3045025	41,7732	3,241795	5313568625
2,75	2034	4137156	45,09989	3,308351	8414975304
3,32	2825	7980625	53,15073	3,451018	22545265625
3,54	3474	12068676	58,94065	3,54083	41926580424

APPENDICE 2: Regression analysis output

SUMMARY OUTPUT

Regression Statistics	
Multiple F	0,997042
R Square	0,994093
Adjusted I	0,992405
Standard E	0,080487
Observati	19

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regressio	4	15,26302	3,815754	589,023	2E-15
Residual	14	0,090694	0,006478		
Total	18	15,35371			

	Coefficients	*ndard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95,0%*	*pper 95,0%*
Intercept	-1,58995	0,565804	-2,81007	0,013902	-2,80348	-0,37642	-2,80348	-0,37642
X Variable	0,003683	0,001054	3,495147	0,003569	0,001423	0,005944	0,001423	0,005944
X Variable	-3,1E-07	9,87E-08	-3,11387	0,00762	-5,2E-07	-9,6E-08	-5,2E-07	-9,6E-08
X Variable	-0,18292	0,067417	-2,71323	0,016815	-0,32752	-0,03832	-0,32752	-0,03832
X Variable	1,929919	0,568976	3,391915	0,004383	0,709586	3,150251	0,709586	3,150251

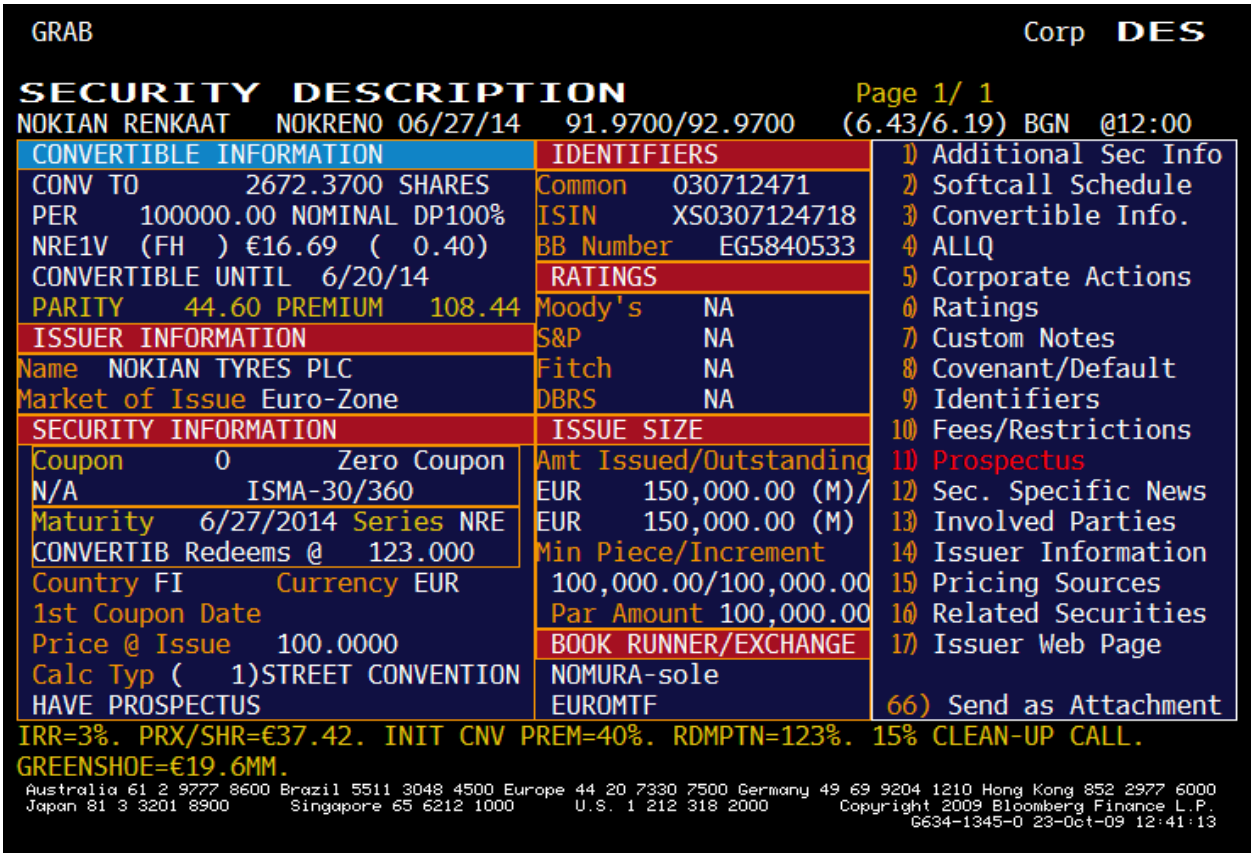
RESIDUAL OUTPUT

Observatio	*Predicted Y*	*Residuals*	*dard Resid*
1	0,369112	0,061888	0,871879
2	0,644753	-0,07075	-0,99677
3	0,775279	-0,06028	-0,84921
4	0,856514	-0,04951	-0,69755
5	0,915043	-0,01904	-0,26828
6	0,961494	0,030506	0,429764
7	1,000973	0,037027	0,521633
8	1,036228	0,044772	0,630742
9	1,068855	0,055145	0,776883
10	1,099829	0,057171	0,80542
11	1,129772	0,062228	0,876661
12	1,15909	0,06991	0,984889
13	1,258038	-0,22804	-3,21259
14	1,817002	-0,037	-0,52128
15	2,107637	0,042363	0,596808
16	2,51746	0,01254	0,176666
17	2,766377	-0,01638	-0,23072
18	3,301853	0,018147	0,255661
19	3,55069	-0,01069	-0,1506

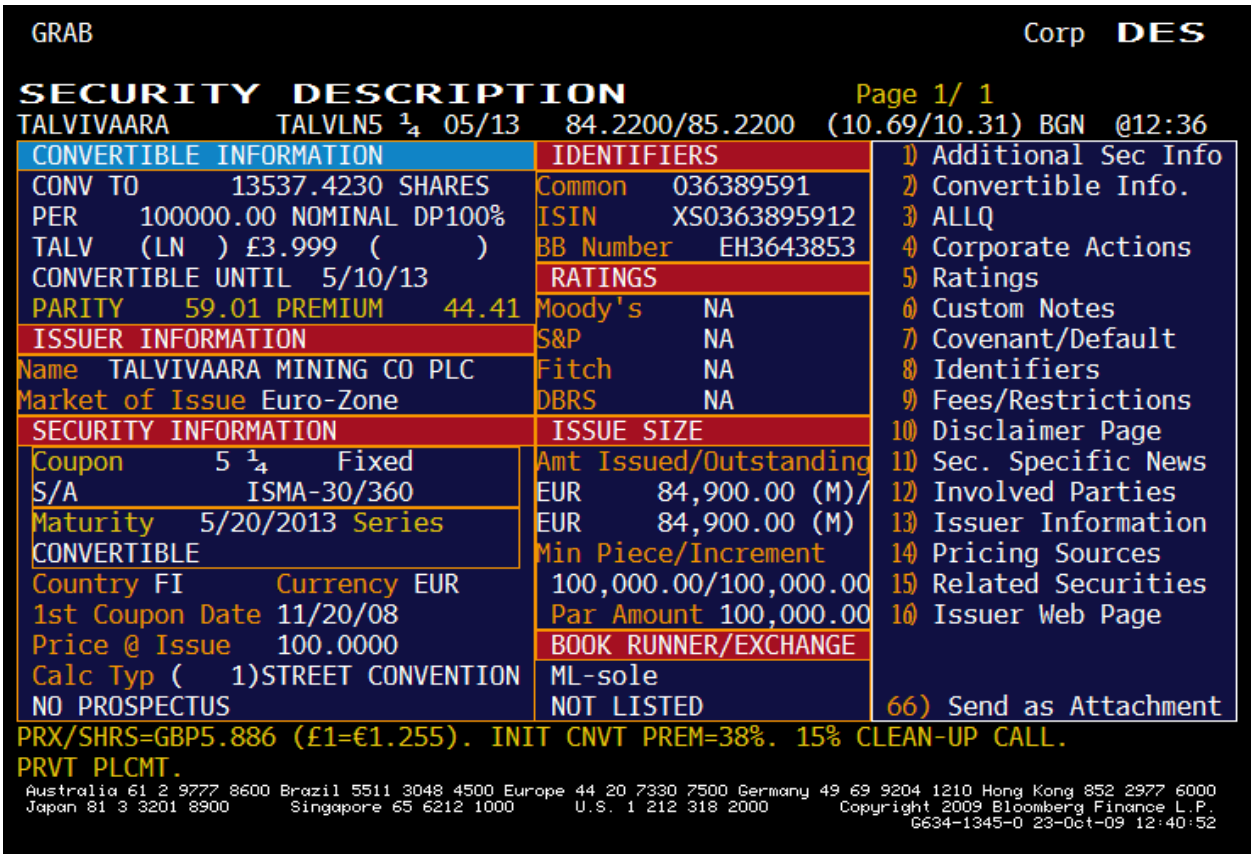
APPENDICE 3: Nokian Renkaat bond price on valuation date

APPENDICE 4: Talvivaara bond price on valuation date

APPENDICE 5: Nokian Renkaat bond information



APPENDICE 6: Talvivaara bond information



APPENDICE 7: Yield to maturity of an equivalent risk free bond to the Nokian Renkaat bond

days between	Spot Rates	CF	DCF
1646	2,426902	123000	110321,6

Date	Cash flow
10.11.2009	-110322
20.6.2014	123000
YTM->	0,023873

APPENDICE 8: Fair value of the straight Nokian renkaat bond

Date	Cash Flow	Fair Value
10.11.2009	-92450	
20.6.2014	123000	89579,06
		89579,06

APPENDICE 9: Yield spread for Nokian Renkaat bond

Date	Rate	Yield	Risk free yield	
15.9.2005	1,252			
10.11.2009	1,38	9,73 %	2,64 %	
	Yield spread	7,09 %		
	Adjusted ys.	4,73 %		

APPENDICE 10: Yield to maturity of an equivalent government bond to the Talvivaara bond

days between	Spot Rates %	CF	DCF
10	-0,20167	2625	2625
190	0,97526	2625	2611,74
370	1,168773	2625	2594,172
550	1,341862	2625	2572,63
730	1,519035	2625	2546,742
910	1,70032	2625	2516,499
1090	1,882892	2625	2482,125
1270	2,06391	102625	95548,77
			113497,7

Cash flow dat	CF
10.11.2009	-1
20.11.2009	
20.5.2010	
20.11.2010	
20.5.2011	
20.11.2011	
20.5.2012	
20.11.2012	
20.5.2013	1
YTM->	0,0

APPENDICE 11: Fair value of the straight Talvivaara bond

Price	-84720	10.11.2009	Fair value
Coupon	2625	20.11.2009	2616,374
Coupon	2625	20.5.2010	2465,86
Coupon	2625	20.11.2010	2324,006
Coupon	2625	20.5.2011	2190,311
Coupon	2625	20.11.2011	2064,308
Coupon	2625	20.5.2012	1945,554
Coupon	2625	20.11.2012	1833,631
Redmption	102625	20.5.2013	67562,31
			83002,36

APPENDICE 12: Yield spread for Talvivaara Bond

Date	Rate	Yield	Risk free yield.	
10.11.2004	1,05			
10.11.2009	1,265	18,63 %	3,07 %	
			Yield spread	15,56 %
			Adjusted ys	10,37 %

APPENDICE 13: Option Information for Talvivaara and Nokian Renkaat:

	Nokian Renkaat	Talvivaara
Spot Price	17,23	4,12
Execution Price	37,42	7,39
σ	52,95 %	32,62 %
Risk free rate	2,65 %	2,15 %
Maturity	4,63 years	3,53 years
U	1,29	1,063
D	0,775	0,941
Risk neutral probality of an upw ard movement	0,438	0,491
OPTION VALUE PER SHARE	**3,69 €**	**0,36 €**
Amount of shares convertible	2672,37	13537,423
VALUE OF EMBEDDED OPTION	**9 861,05 €**	**4 873,47 €**