Royal institute of technology

Master of Science thesis

Liquidity and corporate bond pricing on the Swedish market

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Stockholm, Sweden 2014

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Abstract

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Liquidity and corporate bond pricing

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In this thesis a corporate bond valuation model based on Dick-Nielsen, Feldhütter, and Lando (2011) and Chen, Lesmond, and Wei (2007) is examined. The aim is for the model to price corporate bond spreads and in particular capture the price effects of liquidity as well as credit risk. The valuation model is based on linear regression and is conducted on the Swedish market with data provided by *Handelsbanken*. Two measures of liquidity are analyzed: the bid-ask spread and the zero-trading days. The investigation shows that the bid-ask spread outperforms the zero-trading days in both significance and robustness. The valuation model with the bid-ask spread explains 59% of the cross-sectional variation and has a standard error of 56 bps in its pricing predictions of corporate spreads. A reduced version of the valuation model is also developed to address simplicity and target a larger group of users. The reduced model is shown to maintain a large proportion of the explanation power while including fewer and simpler variables.

Sammanfattning

I denna uppsats undersöks en värderingsmodell för företagsobligationer, baserad på studierna av Dick-Nielsen, Feldhütter, och Lando (2011) och Chen, Lesmond, och Wei (2007). Syftet med modellen är att kunna prissätta företagsobligationer med precision och i synnerhet hantera priseffekten av likviditet och kreditrisk. Värderingsmodellen är baserad på linjär regression och är tillämpad på den svenska marknaden. Den underliggande datan i undersökningen är tillhandahållen av Handelsbanken. Två mått av likviditet är analyserade: bid-ask-spreaden och noll-handlingsdagarna. Undersökningen visar att likviditetsmåttet för bid-ask-spreaden överträffar måttet för noll-handlingsdagarna i både signifikans och robusthet. Värderingsmodellen, med bid-ask-spreaden som likviditetsmått, förklarar 59% av variationen, mätt i justerat r-kvadrat värde. Standardfelet för modellen är 56 baspunkter. Vidare utvecklas också en reducerad version av värderingsmodellen i syfte att vara mer praktiskt användbar och tillgänglig för en större användargrupp. Undersökningen visar att den reducerade modellen bibehåller en stor del av förklaringsgraden av den ursprungliga modellen, samt att den inkluderar färre och enklare variabler.

Acknowledgements

I would like to express my gratitude to associate professor Camilla Landén at *KTH*. Your guidance helped me in all the time of my research and writing of this thesis. Also, thank you for the classes you gave in stochastic theory which encouraged to me choose the subject.

I would also like to express my sincere thanks to my supervisors Fredrik Bohlin and Cecilia Pettersson at *Handelsbanken Capital markets*, for the continuous support throughout the research project. Your ideas, enthusiasm and patience are greatly appreciated. My sincere thanks also go to Jonas Nilsson for giving me the opportunity to do my thesis work at *the Model validation group*.

Contents

1 Background

1.1 Introduction

Corporate bond spreads became substantially wider with the onset of the sub-prime crisis. Studies such as Dick-Nielsen, Feldhütter, and Lando (2011) shows that a large proportion of the spread widening was due to a decrease in liquidity. As the sub-prime crisis started, investors were rushing to safer investments. Since corporate bonds were considered risky assets, their market activity cooled down. Corporate bonds became more difficult to sell and investors then required a higher yield. The flight-to-quality caused a major decrease in liquidity, which resulted in a growing liquidity premia and wider corporate bond spreads.

The price impact of liquidity now caught the interest and attention of investors, policy makers and financial institutions among others. There was an increased need to find a more thorough and precise measure for liquidity to price corporate bonds. Many recent studies use quantitative methods to decompose corporate bond spreads. In particular, Bao, Pan, and Wang (2010) shows the price impact of liquidity on the U.S. market. This paper adds to the body of research with a quantitative investigation of corporate bond prices, but with a new scope.

The main objective of this thesis is to apply and investigate a valuation model for corporate bonds on the Swedish market. The aim is for the model to capture the price effects of default risk as well as liquidity for the underlying bonds. The model is chosen to be a linear regression based on corporate bond and macro economic data. It relies on the assumption that corporate bond spreads are composed of a nondefault component (such as government bonds), credit risk and liquidity.

Although many existing valuation models are well designed and have high precision, they often are unintuitive and complex and thus target a more limited group of users. This thesis addresses this situation by adding simplicity as a subsidiary aim. The aim is for the model to consist of intuitive components and to be fairly simple to use in pricing applications and thus making it available to a wider range of users. Therefore an additional version of the valuation model is included in the investigation. This model is called *the reduced model* and serves as a complement to *the standard model*. Furthermore, each included variable and the model as a whole should be robust. The study regards investment grade rated corporate bonds.

The model is chosen to be composed of variables outlined by Dick-Nielsen, Feldhütter, and Lando (2011) and Chen, Lesmond, and Wei (2007). Each of these studies provides thorough and robust models of the significant factors in corporate bond spreads. Two additional variables regarding credit default swaps are also included from Bao, Pan, and Wang (2010). The empirical application of this model has been made on data provided by *Handelsbanken*. The data has been extracted from *Bloomberg* and includes corporate bond information and macro economic data of the Swedish market. The time horizon spans from February to December 2013. The reduced model only uses bond-specific information and market information and yields a larger sample, while the standard model also includes corporate information and yields a smaller sample.

The liquidity measure has been chosen as in Chen, Lesmond, and Wei (2007). These are two separate liquidity measures, namely the proportional bid-ask spread and the percentage zero-trading days of quarters. These liquidity measures use data of daily bid-ask quotes of corporate bonds. Because of the strengths and weaknesses of each measure, both liquidity estimators are employed to determine their impact on corporate bond yield spreads. This increases robustness and sheds light on the relative power of each liquidity measure.

1.2 Preparatory work

Prior to the choosing of a regression model, other options have been examined. More theoretical models such as Merton (1974) have been excluded since they are complexly specified and thus pose a high risk of mis-specifications. Such models also contradict the subsidiary aim.

Moreover, other liquidity measures have also been examined, of which many have been excluded because of their required detail level in data. Well known measures like Amihud (2002) require data on trading volumes, The LOT-measure from Chen, Lesmond, and Wei (2007) and Roll (1984) require transaction specific trading data and the λ-measure from Dick-Nielsen, Feldhütter, and Lando (2011) require both trading volumes and transaction data. These measures have their advantages but are not feasible for the available data on the Swedish market. A recurring problem with using other existing models is that they often rely on extensive databases such as *TRACE* (The Trade Reporting and Compliance Engine) and such types of public databases do not exist on the Swedish market today. Other variables regarding the credit spread from both Dick-Nielsen, Feldhütter, and Lando (2011) and Chen, Lesmond, and Wei (2007) have also been left out as a consequence of the limited data source [1].

[1] Excluded variables: Leverage ratio, forecast dispersion, amount issued and equity volatility.

2 Empirical methodology

In this chapter, *the valuation model* is presented. The valuation model is intended for corporate bond pricing and is the essential component of this study. The model is based on linear regression on a set of dependent variables for liquidity and credit risk.

There are two versions of the valuation model: *the standard model* and the *the reduced model*. In Section 2.1.1 and in Section 2.1.2, summaries of the standard model and the reduced model are given, respectively. Hereafter when referring to *the valuation model*, both the standard model and the reduced model are considered.

In Section 2.2, the variables of the valuation model are explained in detail and their references. Lastly in Section 2.3, a description is given for the underlying data sample of the investigation. Moreover, the method of the data extraction from *Bloomberg* is explained.

2.1 The valuation model

2.1.1 The standard model

The standard model is the version that includes all the three variable categories of credit risk: firm specific, bond specific and macroeconomic variables and two additional variables for credit default swaps. The standard model is fully stated in the following equation

$$\begin{aligned}
\text{Spread}_{it} = \eta_0 &+ \eta_1 \text{ Liquidity}_{it} \\
&+ \eta_2 \text{ Bond age}_{it} \\
&+ \eta_3 \text{ Coupon}_{it} \\
&+ \eta_4 \text{ Time-to-maturity}_{it} \\
&+ \eta_5 \text{ Operating income to Net sales}_{it} \\
&+ \eta_6 \text{ Long term debt to Assets}_{it} \\
&+ \eta_{7-10,pretax} \text{ PreTax Coverage dummies}_{it} \\
&+ \eta_{11} \text{ Net debt to Capitalization} \\
&+ \eta_{12} \text{ 10y Swap}_{it} + \eta_{13} \text{ 10y} - \text{1y Swap}_t \\
&+ \eta_{14} \text{ CDS-dummy} + \eta_{15} \text{ 5y CDS-spread} \\
&+ \eta_{16} \text{ Credit Rating} + \epsilon_{it}.
\end{aligned} \tag{2.1}$$

The subscript *"it"* refers to bond i, quarter t and Liquidity_{it} refers to one of the liquidity measures: the bid-ask spread or the zero-trading days, presented in Section 2.2.1.

The dependent variable in the valuation model, denoted $Spread_{it}$, is the corporate bond yield over swap rates, as in Dick-Nielsen, Feldhütter, and Lando (2011). It is calculated as the difference between the bond yield and the interpolated maturity-matched swap rate.

2.1.2 The reduced model

The reduced model is the version of the valuation model that only includes one of the liquidity measures and two variable categories of credit risk: the firm specific and the macroeconomic variables. It is developed to address the subsidiary aim: to consist of simpler components and to be easier to apply in pricing applications, preferably without losing too much power of explanation. The reduced model is stated in the following equation

$$\begin{aligned}\text{Spread}_{it} = \eta_0 &+ \eta_1 \text{ Liquidity}_{it} \\ &+ \eta_2 \text{ Bond age}_{it} \\ &+ \eta_3 \text{ Coupon}_{it} \\ &+ \eta_4 \text{ Time-to-maturity}_{it} \\ &+ \eta_5 \text{ 10y Swap}_{it} + \eta_6 \text{ 10y} - \text{1y Swap}_t \\ &+ \eta_7 \text{ Credit Rating} + \epsilon_{it}.\end{aligned} \tag{2.2}$$

2.2 Dependent variables

Hibbert, Kirchner, Kretzschmar, Li, McNeil, and Stark (2009) shows how corporate bond spreads can be decomposed into a liquidity premium and a credit risk premium. For the valuation model, these blocks are represented by a set of dependent variables in a linear regression. The dependent variables are presented in the following sections.

2.2.1 Liquidity measures

For each month, the proportional bid-ask spread is calculated as the ask price minus the bid price divided by the average bid price and ask price for that quarter. The ask price is the highest ask price and the bid price is the lowest bid price each quarter. The second liquidity measure is the percentage zero-trading days for bonds. It is calculated as the percentage of trading days of each month where the bond did not trade. Both of these liquidity measures follow the definitions given in Chen, Lesmond, and Wei (2007).

2.2.2 Macro economic factors

Two macro economic variables are introduced to include the general effects of the economic environment as in Dick-Nielsen, Feldhütter, and Lando (2011). The first variable is the slope of the swap curve, defined as the difference between the 10-year and 1-year swap rate. The second is the 10-year swap rate.

2.2.3 Bond specific variables

As in both Dick-Nielsen, Feldhütter, and Lando (2011) and Chen, Lesmond, and Wei (2007), bond age, time-to-maturity and coupon rates are added to the valuation model. Houweling, Mentink, and Vorst (2003) shows that these variables are linked to liquidity. Bonds with higher coupons are taxed more throughout the life of the bond, making them less desirable than bonds with lower coupons.

Credit ratings are well known measures of credit risk and is added to the valuation model as in Chen, Lesmond, and Wei (2007). This study is limited for investment grade rated bonds, corresponding to BBB[1] and higher on the rating scale. In the valuation model, credit ratings are transformed in the following manner: the credit rating variable takes on the value 4 for the rating AAA, 3 for AA, 2 for A, and 1 for BBB. Ratings are primarly used from Standard and Poor's. If this rating is missing, the rating from Moody's is used. And If this rating is missing, the rating from Fitch is used. If all bond-level ratings are missing for a corporate bond, issuer-level ratings are used in the aforementioned order. If all ratings are missing, the bond is discarded from the data set.

Note that a different variable definition of credit ratings is proposed in Dick-Nielsen, Feldhütter, and Lando (2011). In the mentioned study, the credit rating is implemented with a regression model for each rating category. This method increases the precision of the model but also requires a broader data set for the variables to be significant. Because of the limited data set in this investigation, the simpler option opted in Chen, Lesmond, and Wei (2007) is chosen.

2.2.4 Firm specific variables

The ratio of Operating income to Net sales and ratio of Long term debts to Assets are added to the valuation model, as in both Dick-Nielsen, Feldhütter, and Lando (2011) and Chen, Lesmond, and Wei (2007). Moreover, the ratio of Net debt to Capitalization is also added to the valuation model. This is a slightly modified version of the variable Total debt to Capitalization, used in Chen, Lesmond, and Wei (2007). These factors represent the economical strengths of firms and are linked to credit risk.

[1]or Baa in Fitch

Pretax interest rate coverage (hereafter, IRC) is generally defined as the ratio of EBIT to interest expenses. IRC expresses how easily a company can cover its interest rate expenses and is linked to credit risk. The distribution of this variable is normally highly skewed and as in Blume, Lim, and MacKinlay (1998), the skewness is managed by creating four pretax dummies. These dummies, denoted $\eta_{7-12,pretax}$ PreTax Coverage dummies, allows for a non-linear relationship with the spread. The pretax dummies are defined as follows:

Let C_{it} be the interest rate coverage for firm i in quarter t. Then the interest rate coverage, denoted $\eta_{7-12,pretax}$ PreTax Coverage dummies, is equal to

$$\sum_{j=1}^{4} \eta_{j,pretax} c_{jit}.$$

where c_{jit} is defined in Table 2.1.

	c_{1it}	c_{2it}	c_{3it}	c_{4it}
$C_{it} \in [0,5)$	C_{it}	0	0	0
$C_{it} \in [5,10)$	5	$C_{it} - 5$	0	0
$C_{it} \in [10,20)$	5	5	$C_{it} - 10$	0
$C_{it} \in [20,80]$	5	5	5	$C_{it} - 20$

TABLE 2.1: Definition of pretax dummies

The variables for IRC are added similarly as in both Dick-Nielsen, Feldhütter, and Lando (2011) and Chen, Lesmond, and Wei (2007).

2.2.5 Credit default swaps

For each bond, data for the corresponding 5 year credit default swap (hereafter, CDS) is applied as in Bao, Pan, and Wang (2010). The CDS spread is represented by a variable, η_{15} 5y CDS-spread, plus an additional dummy denoted, η_{16} CDS-dummy. The CDS dummy takes on the value 1 if the bond has credit default swaps traded on its issuer. It serves as a correction factor to make the model compatible for bonds without a corresponding CDS contract. The 5 year CDS spread is included since it is connected to the credit risk of the bond, as showed in for example Hibbert, Kirchner, Kretzschmar, Li, McNeil, and Stark (2009). The 5 year contract is chosen since it is in general the most liquid one.

2.3 Implementation details

The underlying data used in the investigation is provided by *Handelsbanken*. Initially a raw data list of 12710 bonds was extracted from *Prime*. All non-callable corporate bullet bonds and with currency *SEK* were then chosen, reducing the list to 2306 bonds. By referring to the *ISIN* codes the bonds, data covering the mentioned variables in Section 2.2 were then extracted from *Bloomberg*. The available *Bloomberg* data limited the sample to ranging from February to December 2013.

Finally, the liquidity estimates were calculated for the bonds and the final sample of quarterly quotes took form. The bonds with missing information were discarded for each of the data samples of the standard and the reduced valuation model. The final sample of quarterly quotes included 266 observations for the standard model and 502 observations for the reduced model.

The main part of data from *Bloomberg* have been matched directly for the corresponding variables while some others have been adjusted to match for quarterly quotes of the valuation model. A description of the *Bloomberg* fields and their periodicity is given in Table 2.2. Yearly data and current data[2] are approximated as equal in each quarter of 2013. As a consequence, data error arise from any periodic variation.

Later on in the investigation, it was discovered that the data sample had trading days missing for a subset of the corporate bonds. For example, one could observe that several independent corporates had similar non trading days. The issue was not addressed since the error was hard to detect and unsystematical. A solution would require a detailed investigation of the data sample and was left out due to the limited time frame.

[2]Data denoted *Current* are extracted from December 2013

Variable	Bloomberg field	Periodicity
I-spread	BLP_I_SPRD_MID	Quarterly
G-spread	BLOOMBERG_MID_G_SPREAD	Quarterly
Bid price	PX_BID	Daily
Ask price	PX_ASK	Daily
Bond age	ISSUE_DT	Quarterly
Coupon rate	CPN	Fixed
Time-to maturity	TIME_TO_MATURITY	Quarterly
10y Swap	PX_LAST	Quarterly
10y - 1y Swap	PX_LAST	Quarterly
5y CDS-spread	PX_LAST	Quarterly
Credit rating	RTG_SP, RTG_MOODY, RTG_FITCH, RTG_SP_LT_LC_ISSUER_CREDIT, RTG_MOODY_LONG_ISSUE_LEVEL, RTG_MDY_ISSUER	Current
Pre-Tax IRC	INTEREST_COVERAGE_RATIO	Yearly
Op. income to Sales	OPER_INC_TO_NET_SALES	Quarterly
Lt. debt to assets	LT_DEBT_TO_TOT_ASSET	Quarterly
Net debt to Capitalization	NET_DEBT_%_CAPITAL	Quarterly

TABLE 2.2: Bloomberg fields for corporate bond variables

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3.1 Summary statistics

The summary statistics of the data sample used in the investigation is presented in Table 3.1. It contains details of average liquidity and yields for all the non-callable corporate bonds from February to December 2013. The table is separated into two panels, one for the standard model and one for the reduced model and with each panel classified by credit rating.

To do a general check of the quality of the data samples used in the investigation, a comparison is made with Chen, Lesmond, and Wei (2007). In the mentioned study, one can see that higher rated bonds are overall more frequently traded and thus more liquid. The liquidity and yield spread statistics in the current table does not show any clear trends. Instead, the liquidity seems to fluctuate over the rating categories.

Avg Liquidity &	Credit Rating			
Yield spreads	AAA	AA	A	BBB
	Panel A: The standard model			
Zeros (%)	9.69215	14.84484	21.68761	34.23303
Bid-ask	0.08143	0.020971	0.058314	0.007925
Yield spread	65.25107	73.361	94.20458	70.398
N	100	16	124	26
	Panel B: The reduced model			
Zeros (%)	7.885201	6.874956	24.03861	34.23303
Bid-ask	0.060083	0.023363	0.05477	0.007925
Yield spread	53.2283	43.70218	92.11001	70.398
N	227	117	133	26

TABLE 3.1: Summary statistics of the data samples used in the investigation. Panel A covers the data sample used for the standard valuation model and Panel B covers the data sample of the reduced model. % Zeros is the average percentage zero-trading days for quarters. Bid-ask is the average proportional bid-ask spread derived from quarterly quotes. The yield spread is the average difference between the bond yield and the yield of a comparable maturity matched swap rate, known as the I-spread in Bloomberg. N stands for the number of observations of the sample set.

The variations over ratings are stronger for the sample of the standard model, possibly because it has less observations than sample of the reduced model.

Furthermore, there are no clear trends observed for the average bid-ask spreads. The bid-ask spread levels seems to fluctuate across ratings. However, it does seem that the higher rated bonds are somewhat more frequently traded since the zero-trading days increases as the bond ratings decreases. The average yield spread should also increase with decreased rating since there is a higher credit risk premium for lower rating. This trend is quite noisy for both the samples of the reduced and standard model.

In summary, the findings of the summary statistics of Chen, Lesmond, and Wei (2007) on the behavior of liquidity and yields spread does not correlate well with the current summary statistics. As mentioned, the sizes of the samples may be too small in the investigation since the trends seem to be somewhat closer for the reduced model in comparison with the standard model. Another explanation could be that the general assumptions are not valid for the Swedish market. No evidence found supports the latter explanation.

3.2 Initial liquidity measure tests

Many theoretical models, such as Amihud and Mendelson (1986), predict that investors demand higher yields for less liquid assets to compensate for liquidity risk. As a result, for similar cash flows in the future, less liquid assets will have lower prices. Since a bond yield is a promised yield given known cash flows, the lower prices of less liquid bonds lead to higher bond yields and thus higher yield spreads.

An initial test is made to see if the chosen liquidity proxies can explain the yield spread levels on the Swedish market. This is done by a linear regression of the yield spread over swap rates, solely using one of the liquidity proxies as a dependent variable. The results of the initial liquidity measure tests are shown in Table 3.2.

Liquidity measure & Variable	Standard model		Reduced model	
	Bid-ask	% Zeros	Bid-ask	% Zeros
Coefficient	**129.7284****	**0.125545**	**136.0705****	**0.366807****
	(6.084235)	(0.604097)	(8.210745)	(2.770491)
N	266	266	503	503
Adjusted R^2	0.119654	0.0024	0.116845	0.013124

TABLE 3.2: Regression tables of the yield spread on liquidity measures. ** denotes significance at the 1% level, while * denotes significance at the 5% level. Corresponding t-statistics are given parentheses positioned under each of the coefficients.

The results show that both of the two liquidity measures are positive and significantly associated with the underlying yield spreads for the sample of the reduced model. On the other hand, for the sample of the standard model the percentage zero-trading days measure is not significant.

This may be an indicator that, in order to perform, the percentage zero-trading days measure has a greater need of a larger sample size. Another possible explanation is that the sample bias, mentioned in Section 2.3, could be more concentrated in the sample of the standard model and thus disturbing the measure more. Dick-Nielsen, Feldhütter, and Lando (2011) also implies that this estimate does not capture as much of the liquidity effects as the bid-ask spread.

By looking at the reported adjusted R^2, we can see that the bid-ask spread provides almost identical explanation power of 12% in yield spread for both the samples of the standard model and the reduced model. The percentage zero-trading days shows a weaker result and explains 1.3% of the sample of the reduced model and only 0.13% of the sample of the standard model in cross-sectional variation in the yield spread.

Overall, the liquidity is a significant factor in yield spreads, as suggested in Amihud and Mendelson (1986). The proportional bid-ask spread is concluded to be a consistent measure of liquidity whereas the zero-trading days measure is a rather more insecure measure, particularly for the sample of the standard model. Both measures will be used in the investigation where the results of the zero-trading days will be looked at with more precaution.

3.3 The yield spread effects of liquidity and credit risk

In this section, the results of the regressions of the valuation model are presented. Four regressions are made in total, one for each of the two liquidity measures for the standard and reduced model. The regression tables are shown in Table 3.3. To conclude if they can be used for corporate bond valuation, an analysis of the regression models as whole and its included variables is made.

The most telling finding is that the bid-ask spread is significant and positively associated with the underlying yield spreads for both the standard and reduced model. The zero-trading days liquidity estimate, on the other hand, is positively significant for the reduced model but insignificant for the standard model. Positive signs for the bid-ask spread coefficients indicate that higher bid-ask spreads gives wider corporate spreads. Likewise for the zero-trading days, the positive coefficients in both models indicate that higher number of days without trades gives wider spreads. The interpretation of the sings agrees with Amihud and Mendelson (1986). The bid-ask spread outperforms the zero-trading days measure with its significance. This agrees with the initial liquidity and yield spread tests, in Section 3.2.

The coefficients for time-to-maturity are positively significant for all four regressions. A longer time-to-maturity could indicate a higher risk of default since it possibly could occur during a longer period. Therefore the positive sign is reasonable.

The coefficients for bond age are negative and significant for all four regressions. There are no certain interpretations to be made in this case on the meaning of their coefficients. A possible explanation for the negative coefficient signs is that some of the bonds have lived through the sub-prime crisis. As we know, the sub-prime crisis caused major spread widening for corporate bonds and the negative coefficients could be an indicator of the cool down of the crisis, which lead to tighter spreads.

Furthermore, the coefficients for credit rating are negative, which is in line with the assumption that higher rating directly indicates lower credit risk which gives narrower yield spreads. The credit rating coefficients are significant across all regressions.

The variables describing economic environment, the 10 year swap rate and the slope of the swap curve, are all significantly associated with the underlying yield spreads across all four regressions with varying signs of their coefficients. In the corresponding valuation models of Dick-Nielsen, Feldhütter, and Lando (2011), these variables are also significant across all regression and their coefficient signs also vary across regressions for different ratings classes. Consequently, no certain conclusions can be drawn from the signs.

High levels of pretax IRC indicate financially healthy firms and are likely to produce a low yield spread. In the two regressions of the standard model, the pretax variable coefficients have negative signs for the first dummy and varying signs for the second dummy. The third and fourth pretax variables were discarded from the valuation model since none of the bonds in the samples had data of pretax IRC covering those ranges.

In both of the regressions, only the first pretax dummies are significant. The negative signs of these variables somewhat confirms the previous statement. Even so, the lack of significance from the remaining two dummies and that the sample does not fully cover all levels makes it difficult to draw any certain conclusions from this result.

High levels of Operating income to Net sales indicate financially healthy firms and are likely to produce a low yield spread. The coefficients of Operating income to Net sales are negative in both regressions of the standard model. The signs of the coefficients agrees with the previous statement. However, the coefficients are insignificant in the regressions, making the results weak. Furthermore, high levels on Long term debt to Assets indicate highly levered firms and imply a high yield spread. The coefficients of Long term debt to Assets are positively significant in both of the regressions of the standard model. This confirms the initial statement.

High levels of Net debt to Capitalization generally indicate that firms carries higher credit risk and imply a high yield spread. For the regressions of the standard model, both of the coefficients are significant and negative. A negative sign may be a contradiction to the given interpretation. A possible explanation is that Net debt to Capitalization is correlated to other similar variables such as Operating income to Sales or Long term debt to Assets and that they trade explanation power from each other. The multicollinearity argument is also strengthened by the fact that these variables have high variance[1]. It should also be stated that the valuation model is a prediction model and not a structural model of the pricing factors. Consequently, this means that even if there may be sign contradictions, such as the previously mentioned one, it does not necessarily mean that the model is weak in predictions.

A higher CDS-spread should correspond to higher credit risk and therefore wider yield spread. In the two regressions of the standard model the CDS-spread comes out insignificant with different signs on its coefficient. The CDS-dummy has positive coefficients for both regressions, but is only significant for the regression with zero trading days as liquidity measure. Since the results are overall almost insignificant in the regressions, they are considered weak and thus no certain conclusions are made.

[1] Average value and standard deviation for LT Debt to Assets: 51.53, 0.4726. For Op. Income to Sales: 18.27, 0.2197. For Net debt to Capitalization: 70.87, 0.4795.

Regression & Variable	Standard model		Reduced model	
	1	**2**	**3**	**4**
Intercept	-10.6117	-1.11498	-50.55*	-53.9281*
	(-0.24112)	(-0.02469)	(-2.21985)	(-2.26067)
Bid-ask	**59.58831****		**79.75561****	
	(3.752976)		(6.10255)	
Zeros (%)		**0.032826**		**0.136154**
		(0.213193)		(1.280093)
Bond age	-10.7831**	-11.3255**	-6.71379**	-7.27425**
	(-7.69744)	(-7.89165)	(-9.01747)	(-9.49363)
Coupon	36.42066**	39.16246**	30.4512**	33.63266**
	(12.61627)	(13.64185)	(15.45789)	(17.03192)
Time-to maturity	2.139375**	2.25749**	2.599155**	2.812621**
	(3.247615)	(3.33616)	(5.631029)	(5.903767)
10y Swap	41.58969**	34.96052*	33.2263**	26.76876**
	(2.607837)	(2.132611)	(3.561243)	(2.768782)
10y - 1y Swap	-41.6049**	-40.4966**	-30.1883**	-25.8571**
	(-3.12366)	(-2.8936)	(-4.3638)	(-3.56307)
Credit rating	-39.6267**	-39.7934**	-19.767**	-18.2744**
	(-7.44149)	(-7.20977)	(-7.50859)	(-6.35095)
5y CDS-spread	0.013093	-0.03417		
	(0.077794)	(-0.19811)		
CDS-dummy	42.03309	51.23928*		
	(1.852266)	(2.209741)		
Pre-Tax D1	-21.3717**	-23.4606**		
	(-3.60585)	(-3.83174)		
Pre-Tax D2	28.5362	-32.20745		
	(1.641492)	(1.798818)		
Op. income to Net sales	-0.09371	-0.1597		
	(-0.42561)	(-0.70578)		
LT debt to Assets	1.824652**	1.846544**		
	(3.860587)	(3.78987)		
Net Debt to Cap.	-1.53963**	-1.5815**		
	(-3.2111)	(-3.1872)		
N	266	266	503	503
% Adj. R^2	0.576659	0.552986	0.499281	0.463386
Std. Error	56.57861	58.13914	48.57308	50.28398

Table 3.3: Regression table of the standard valuation model and the reduced valuation model. ** denotes significance at the 1% level, while * denotes significance at the 5% level. Corresponding t-statistics are given in the parentheses, positioned under each of the coefficients.

4 | Robustness Checks

In this chapter, two robustness checks are made for the valuation model, namely for endogeneity and for the chosen benchmark risk free rate.

4.1 Endogeneity

Endogeneity occurs when a regressor is correlated with the error term. For the valuation model, it is reasonable to check if one of the liquidity measures could contain information about the credit quality of a bond. It may, in that case, affect the yield through the credit risk part. This would make it difficult to interpret the main results purely in terms of liquidity costs and the model would be less reliable. To test for potential endogeneity, a residual augmented two-stage least squares t-test is employed. This is also known as the Durbin-Wu-Hausman test. The test is done for each of the four regressions of the valuation model, seen in Table 3.3. As an instrument variable for liquidity, *Bond age* is chosen and the variable is therefore excluded from the valuation model for this test. The results of the Durbin-Wu-Hausman test are shown in Table 4.1.

The Durbin-Wu-Hausman test shows one can reject the hypothesis that all liquidity measures, except the zero-trading days for the standard model, are endogenous. For the mentioned exception, no conclusions can be drawn about endogeneity. The Adjusted R^2 values are overall intact for the regressions with the bid-ask spread. This shows the

Liquidity measure & Description	Standard model		Reduced model	
	Bid-ask	% Zeros	Bid-ask	% Zeros
Instrument P-value	0.087352	0.238615	0.002531	0.033285
Significance F	0.000466	7.5E-07	2.86E-08	2.82E-16
Residual P-value	0.000951	4.14E-08	2.82E-16	0.24047
Adj. R^2	0.466808	0.848658	0.399338	0.363515
Comment	Exogenous	Invalid instrument	Exogenous	Exogenous

TABLE 4.1: Results of the Durbin-Wu-Hausman test for the regression models in Table 3.3. Bond age is the instrument variable. Significance F is the significance F value of the reduced form regression of the instrument variable. Residual P is the P-value of the liquidity replaced variable in the regression model. The replaced variable is the reduced form regression residual.

robustness of this liquidity measure. The zero-trading days for the standard model has a minor drop in adjusted R^2, illustrating its lack of power.

4.2 Benchmark risk-free rate

The size of the corporate spread is strongly affected by the choice of benchmark risk-free rate. The dependent variable in the valuation model is the spread over swap rates, known as the I-spread in Bloomberg. As in Dick-Nielsen, Feldhütter, and Lando (2011), a robustness check on the liquidity measure is made by changing the nondefault component to government bonds, giving the G-spread. The results for the valuation model with the G-spread as dependent variable are shown in Table 4.2.

By comparing the regression tables of the valuation model with the G-spread and with the I-spread, one can investigate stability by looking at how the coefficients of the models vary, in particular the liquidity measures. Instability would be indicated if coefficients vary with great magnitude or loose significance.

For the bid-ask spread, the coefficients deviate 2.14 % and -0.77% for the standard model and the reduced model respectively. For the zero trading days, the coefficients deviate more: -24.5 % and -12.1% for the standard and the reduced model. The significances are intact for both measures. The results show that the bid-ask spread is a robust choice and that the zero trading days is a more unstable choice with regards to the choice of benchmark risk-free rate.

For the remaining credit risk variables, one can observe that almost all variables that are significant for the models using the I-spread as dependent variable, are also significant for the G-spread. This goes for all variables in the reduced model, except the intercept. For the standard model, this goes for all variables with one exception. The variable for time-to-maturity is significant for the standard model with bid-ask spread as liquidity measure for the I-spread while it is insignificant for the corresponding model with G-spread. But overall the significances are almost identical, which shows stability of the benchmark risk-free rate.

Regression & Variable	Standard model		Light model	
	1	**2**	**3**	**4**
Intercept	32.41813	41.62599	-15.0683	-19.0793
	(0.708144)	(0.888858)	(-0.63205)	(-0.76616)
Bid-ask	**58.33488****		**80.3761****	
	(3.532065)		(5.874386)	
Zeros (%)		**0.043484**		**0.154854**
		(0.272349)		(1.394671)
Bond age	-10.2406**	-11.3255**	-6.6038**	-7.15649**
	(-7.0277)	(-7.89165)	(-8.4722)	(-7.15649)
Coupon	37.33172**	39.16246**	30.78174**	34.00221**
	(12.43216)	(13.64185)	(14.92535)	(16.50447)
Time-to maturity	0.11075	2.25749**	0.932424*	1.146888*
	(0.161624)	(3.33616)	(1.929544)	(2.306089)
10y Swap	72.33485**	65.71513**	63.02926**	56.35884**
	(4.360416)	(-6.61444)	(6.452786)	(5.584185)
10y - 1y Swap	-97.2938**	-95.9931**	-79.5701**	-74.9962**
	(-7.02246)	(-6.61444)	(-10.9866)	(-9.8997)
Credit rating	-35.9277**	-36.0373**	-18.1294**	-16.4718**
	(-6.48616)	(-6.29645)	(-6.5779)	(-5.48371)
5y CDS-spread	-0.05893	-0.10523		
	(-0.33662)	(-0.58838)		
CDS-dummy	45.96548	55.00713*		
	(1.947285)	(2.287653)		
Pre-Tax D1	-21.8032**	-23.9084**		
	(-3.5365)	(-3.76565)		
Pre-Tax D2	28.8696	-32.57557		
	(1.596501)	(1.75451)		
Op. income to Sales	-0.07541	-0.14167		
	(-0.32994)	(-0.60376)		
Lt. debt to assets	1.669678**	1.693993**		
	(3.396186)	(3.352811)		
Net Debt to Cap.	-1.56226**	-1.60764**		
	(-3.13241)	(-3.12435)		
N	266	266	503	503
% Adj. R^2	0.585985	0.565536	0.515916	0.484195
Std. Error	58.85274	60.28868	50.85225	52.49191

TABLE 4.2: Regression tables of the standard model and the reduced model with using the G-spread as a dependent variable. ** denotes significance at the 1% level, while * denotes significance at the 5% level. Corresponding t-statistics are reported in the parentheses, positioned under each of the coefficients.

5 | Conclusion

In this final chapter the concluding remarks are given for the thesis. First, a brief summary is given of the aim and the results. Then the conclusions are presented, on if the valuation model has an ability to price corporate bonds. Also the subsidiary aim is regarded. Lastly, some potential improvements of the valuation model are discussed.

5.1 Summary

In this thesis, a valuation model for corporate bonds is investigated for the Swedish market. The aim is to develop a valuation model that captures the price effects of default risk as well as liquidity for the underlying bonds. The model is chosen to be a linear regression. Two liquidity measures are included in the model, namely the bid-ask spread and the percentage zero-trading days of quarters. The investigation is conducted on the Swedish market.

A subsidiary aim of this thesis is that the model should consist of simple components and be easy to use in pricing applications. Therefore an additional version of the valuation model is added, known as *the reduced model*. The reduced model only uses bond-specific information and market information and yields a larger sample, while the standard model also includes corporate specific information and yields a smaller sample. Furthermore, each included variable and the model as a whole should be robust and precise.

5.1.1 Empirical findings

The summary statistics were presented for the data samples used in the investigation. The statistics showed that the sample sizes are quite small, in particular for the standard model. Small sample sizes might lead to that dependent variables do not reach significance in the main regression models.

Initial tests were made on the liquidity measures by doing regression models, solely using one of the liquidity proxies as a dependent variable. The results showed that all measures are significant for both samples, except the zero trading-days for the standard model. This may be an indicator that, in order to perform, the percentage zero-trading days measure has a greater need of a larger sample size.

For the main investigation, four regressions were made: two for each liquidity measure for the standard and the reduced model. In the regressions for the bid-ask spread, 9 out of 15 variables were significant for the standard model and all 8 variables were significant for the reduced model. Both of the variables for the bid-ask liquidity measures were significant for both models. The adjusted R^2 levels showed that 58% and 55% of the variation was explained when using the bid-ask spread for the standard model and the reduced model respectively. For the zero-trading days, the liquidity measure was significant for the reduced model and insignificant for the standard model. For the regressions, 10 out of 15 variables were significant for the standard model and 7 of 8 variables were significant for the reduced model. 50% and 46% of the variability were explained by the standard model and the reduced model respectively. An analysis of the coefficient signs showed that no contradictions were found for using the valuation model for predictions.

The corresponding standard model of Chen, Lesmond, and Wei (2007) had lower levels in adjusted R^2: 48% and 46% for the bid-ask spread and zero-trading days respectively. However, this model included a slightly different set of credit risk variables. For example, the CDS-spread was not regarded. [1]

The Durbin-Wu-Hausman test was employed to test for endogeneity on the liquidity measures. The results showed that one can reject the hypothesis that all liquidity measures, except the zero-trading days for the standard model, were endogenous. For the mentioned exception, no conclusions could be drawn about endogeneity. The zero-trading days for the standard model had a minor drop in adjusted R^2, illustrating the lack of robustness of this liquidity estimate.

A second robustness test was made to see if the choice of benchmark risk free rate in the valuation model was stable. The test was done by changing the dependent variable from the I-spread to the G-spread and then analyzing the liquidity coefficients. The coefficients of the bid-ask measure in the model did not deviate significantly, which indicated robustness. The zero-trading days coefficients on the other hand deviated -24.5 % and -12.1% for the standard model and the reduced model. This was a somewhat unstable result, especially for the standard model. Overall, the significance of the independent variables was almost identical for the G-spread and the I-spread as dependent variables, which indicated stability.

[1] The corresponding model of Dick-Nielsen, Feldhütter, and Lando (2011) was not considered when comparing performances since it uses a different liquidity estimate. Standard error was not reported for none of the studies.

5.2 Theoretical implication

5.2.1 Zero-trading days

When looking at the results of the initial liquidity tests, one could already foresee that the zero-trading days liquidity estimate would not perform as well as the bid-ask spread. Although the zero-trading days showed significance for the sample of the reduced model, it was insignificant for the data sample of the standard model. This result indicated that the liquidity proxy needs a bigger sample size to perform. Furthermore, it was discovered that the data sample had trading days missing for a subset of the corporate bonds, as mentioned in Section 2.3. This issue directly causes noise for the zero-trading days, since it is directly measuring this quantity. As expected, this measure was weak, in accordance with Chen, Lesmond, and Wei (2007). But a total lack of significance and instability was not expected.

5.2.2 The bid-ask spread

The initial liquidity tests showed the potential power of the bid-ask liquidity estimate for both the standard and reduced model. The main investigation showed that the bid-ask spread liquidity estimate is strongly associated with the yield spread, for both the standard and the reduced model. Also considering the weaknesses in size and missing trading days of the data samples, the bid-ask spread withheld its significance in the main investigation. The strong results were enhanced by the robustness tests, which confirmed that the bid-ask spread is a stable measure for the choice of nondefault component and is exogenous with regards to credit risk.

5.2.3 Corporate bond valuation

The bid-ask liquidity estimate outperformed the zero-trading days with its significance and robustness for both the standard and reduced model. Therefore, the bid-ask spread will primarily be considered when addressing the aim of finding a valuation model for corporate bonds. The main conclusion of this thesis is that the valuation model with the bid-ask spread as a liquidity measure can predict corporate bond prices to some extent. The standard model explains 59% of the cross-sectional variation and it had a standard error of 56 basis points. Hence, the valuation model gives an indication of what the corporate bond price could be.

For the subsidiary aim, the reduced model succeeds in maintaining much of the precision of the standard model. All of the eight variables were significant, which is ideal. The reduced model explained 52% of the cross-sectional variation and had a standard error of 49 basis points. The result for the standard error was even stronger than for the standard model. The reduced model has fewer variables and needs substantially less data to perform. In that sense, it succeeds in being more easy to use than the standard model.

5.3 Future development of the valuation model

A significant improvement could be made for the valuation model by improving the detail level on the data for liquidity. In particular, it would constitute an improvement if the sample included transaction level data and trading volumes. As mentioned before, similar studies conducted on the U.S. market uses data from *TRACE*. These includes a larger set of bonds, longer history and more detailed trading data. Today, such data are not publicly available for the Swedish market. Bao, Pan, and Wang (2010) argues that with transaction level data, one can capture the liquidity effects connected to the depth and resilience of the market. This would substantially improve the liquidity estimations since the mentioned effects are not captured by the bid-ask spread, nor the zero-trading days.

A larger set of variables would also improve the model. As mentioned in the introduction, a large proportion of the variables from both Dick-Nielsen, Feldhütter, and Lando (2011) and Chen, Lesmond, and Wei (2007) were excluded. These variables are for leverage ratio, forecast dispersion, amount issued and equity volatility. Also, a larger data sample and a longer time horizon would improve the results, especially for the zero-trading days liquidity proxy. Lastly, if the sample bias of the missing trading days would be fixed, it would most probably improve the results of the zero-trading days.

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