ERASMUS UNIVERSITY ROTTERDAM

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Bachelor Thesis [IBEB]

Convertible Bond Underpricing. Liquidity Explanation

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Abstract

This study is aimed at increase the understanding of convertible bonds underpricing, their relation to the liquidity factors and constructing a significant identifier of the liquidity for convertible bonds. It will also attempt to unify regular and Rule 144A convertible bonds with liquidity factors. The main findings of the paper are the following: the underlying stock's bid-ask spread has a negative relation to the future underpricing of the convertible bond, but only for rule 144A bonds. This is consistent with findings of Henderson and Tookes (2012) and their search friction theory. Regular and Rule 144A convertible bonds do not share common liquidity factors. Alternatively, bond turnover ratio data suggests that liquidity has the same negative effect on both 144A and regular convertible bonds underpricings, however these results are not reliable.

1. Introduction

Convertible bond is not the most recent development on the financial market, they have been issued for around 150 years. There has been a substantial rise in their popularity over the last 20 years along with other securities. According to Securities Industry and Financial Markets Association the total corporate bond market debt in U.S. increased from 4075.5 billion dollars in 2002 to 9216.2 billion at the end of 2018. The increased interest can be majorly attributed to the highly volatile market trends in these years including the internet boom and financial crisis that changed the way securities are traded and handled. Such rapid and unpredictable changes make investors look more for the alternative type of investments that lower yields at the expense of reduced risk.

Convertible bonds are so called hybrid securities, due to their nature to of having properties of both a stock and a bond. This complexity and versatility of this instrument is therefore what makes it increasingly popular. For the most part of its maturity period, a convertible bond behaves as a regular company bond and share the properties such as being safe investment and having low liquidity. However, a convertible bond can also be exchanged to a predetermined amount of shared when it matures, unless the it is not defaulted, which is usually the biggest risk factor of this security. Moreover, convertible bonds can also be issued with various imbedded call and put provisions, further diversifying their use.

In addition, convertible bond is also a security that can be issued under Rule144A. This rule was approved in April 1990 by U.S. Securities and Exchange Commission and is directed towards “qualified institutional buyers” (QIB) allowing them to trade 144A securities with no registration. This was done to increase market liquidity and decrease the costs of regulations.

However, convertible bonds along with other types of debt and equity issues historically have been experiencing a persistent trend. Security underpricing is not a new topic in academic research in finance. The literature has its roots in 1980, when researches like Logue (1973) and Ibbotson (1975) found that company stocks of the initial public offerings are often sold at the price considerably higher than their initial value on the first day of trading. This implied that companies are not raising much capital as they theoretically can, and their stocks are sold at an underpriced value. These papers spiked a long chain reaction of empirical analysis of underpricing on both underpricing of IPOs and later other securities.

Despite the vast research done on IPOs and moderate amount of research on SEOs, hybrid securities such that convertible bonds are still not fully understood.

Finally, there has been a certain rise in liquidity theories connecting it to the underpricing of securities over the years for example Ellul and Pagano (2006) and Henderson and Tookes (2012). Ellul and Pagano complemented IPO underpricing theory with secondary-market liquidity factors after most of the literature has already been written and considered complete. They found a negative relationship between the liquidity factors and IPO underpricing. Henderson and Tookes on the other hand used the theory developed by Ellul and Pagano's and tested it on Rule 144A convertible bonds, also finding a negative relation and used it as an application to their information friction theory.

The literature on both topics is still scarce however, in spite of increasing academic and economic interests. This study is aimed at further increasing the understanding of convertible bonds underpricing, their relation to the liquidity factors and constructing a significant identifier of the liquidity for convertible bonds. It will also attempt to unify regular and Rule 144A convertible bonds with liquidity factors.

The main findings of the paper are the following: the underlying stock's bid-ask spread has a negative relation to the future underpricing of the convertible bond, but only for rule 144A bonds. This is consistent with findings of Henderson and Tookes (2012) and their search friction theory. Alternatively, bond turnover ratio suggests that liquidity has the same negative effect on both 144A and regular convertible bonds underpricings, however these results are not reliable.

The rest of the paper is structured in the following way: Section 2 provides the literature review, relevant academic findings will be discussed there, Section 3 describes main hypotheses tested in the paper. Section 4 presents data and methodology, Section 5 describes the empirical results of the models tested and Section 6 concludes the findings.

2. Literature review

The research of this paper relies on the precious studies is based on four main topics: convertible bond pricing studies, security underpricing studies and liquidity studies and studies regarding rule 144A. The topics are often interconnected.

The pricing literature on convertible bonds stated relatively late. Due to the complexity of the security, it often requires considerable computational power. Nevertheless, the first research papers on pricing of convertible bonds are done by Ingersoll (1977) and Brennan and Schwartz (1977). They suggested using differential equations with using underlying firm value as the main variable. In later papers. Later the model was updated by Brennan and Schwartz (1980) by including the stochastic interest rate as the pricing variable, however the improvement from using the stochastic term was insignificant, and therefore can be neglected. Buchan (1998b) extends the model further, by including firm value as an endogenous default risk variable and uses Monte Carlo procedure to solve the equations.

Alternatively, Tsiveriotis and Fernandes (1998) use a different approach to calculate price. They split the convertible bond into its bond and stock components and then construct a portfolio, which they solve using partial differential equations for both sides to calculate the price of the convertible bond. Their research is based on McConnell and Schwartz (1986) that suggested to use stock price in valuation of the convertible bond price.

The underpricing literature started around the same period with the IPO studies, namely papers by Logue (1973) and Ibbotson (1975) They first record that the stocks issued by the company that goes public are usually sold at the significantly higher price by the end of the first day of trading. The first study on convertible bond underpricing however, does not appear until the paper published by King (1986) who studied 103 U.S. convertible bonds with the average underpricing of 3.75%. His model was estimated using the underlying firm value. Later, Carayannopoulos (1996) published a paper studying 30 American convertible bonds, his model included the firm value as well as stochastic interest rates and finds a 12.90% underpricing. Both papers also suggested that deeply out-of-the-money bonds are underpriced, and at-the-money or in-the-money convertibles are slightly overpriced. Buchan (1998a) tests the arbitrage strategy by going long on an equally weighted portfolio of convertible bonds and taking short positions on the corresponding company stocks and Treasury notes for the period from 1989 to 1996 and reports

an average return of 0.755% monthly. Ammann et al. (2003) make a study on the French market instead. They used the Tsiveriotis and Fernadez (1998) to study the 21 most liquid convertible bonds over 18 month of daily price data. An average underpricing of more than 3% is calculated. The authors suggest, that despite picking the most liquid stocks, part of the underpricing can be attributed to liquidity. Chan and Chen (2006) find that lower rated Bonds have higher underpricing, and if the convertible bonds are not downgraded, the underpricing disappears within the first 500 days after the issue and even earlier for higher rated bonds. In addition, underpricing also increases after a significant drop in the underlying stock price. Duca at al (2012) studies the difference between two periods from 1984 to 1999 and from 2000 to 2008 and prove that the 3.9% increase in underpricing between them can be explained by arbitrage strategies that induce price pressure on the stocks.

Ellul and Pagano (2006) are the first to study after-market liquidity for IPO underpricing as a complementary theory to the vast research of IPO underpricing, and find significant result. Gupta et al. (2008) also studied syndicated loans pricing and how expected after-market liquidity may influence them. Henderson and Tookes (2012) made a big study on Rule 144A convertible bonds. They were the first to document the importance of search frictions in the pricing of convertible bonds. The paper finds that repeated interactions between banks and investors play a major role in determining bank fees when the bonds are issued. These finding contradicts the “favoritism” hypothesis that states that underpricing works as a reward instrument from banks to their favorite clients. Moreover, based on research by Ellul and Pagano (2006) and Gupta et al. (2008) they find a statistically significant negative relation between convertible bond underpricing and several after-market liquidity proxies.

Helwege and Wang (2017) study mega-bonds or bonds with offering amount more than one billion, they find that moega bonds offer higher liquidity, which is in turn balanced by the increase of price pressure, suggesting splitting bond offerings for better efficiency. Nagler and Ottonello (2018) study underpricing before and after crisis period and using instrumental variable prove that post-crisis increase in underpricing can be attributed to the aggregate decrease in inventory capacity of the dealers.

3. Hypotheses

From the general theory of underpricing of different securities, a lot of papers pointing out the presence of liquidity as an explanatory variable for it, for example Ellul and Pagano (2006) tested if after-market liquidity variables can explain the IPO underpricing and found significant results when the topic was has already been excessively researched. The theory is very versatile as well, as any security traded is connected to liquidity.

Convertible bonds are so called hybrid securities and attract modern investors with the increased interest because of high versatility and relatively low risk. They are however are largely unstudied because of their complex nature and computational limitations that were lifted only after the majority on of other underpricing literature was already peaking. Moreover, a lot of research papers when studying underpricing, specifically choose Bonds issued under Rule 144A or exclude them from the data completely focusing only on the regular convertible bonds. No study has tried to unify them yet and liquidity could be a good measure. It is therefore interesting to test liquidity factors against the underpricing of both bond types simultaneously to see the real difference in their liquidity and the difference of their effect on underpricing.

On one hand using the literature by Ellul and Pagano (2006) suggested that for IPO's initial underpricing is negatively related to second market liquidity, because investors are being compensated for the expected illiquidity after the issue. Using the same reasoning, the underpricing of convertible bonds can also be attributed to issuers compensating investors for subsequent illiquidity, as bonds are traded much less often as stocks, and most of the trades happen on the first day. Both bond types experience this effect to a certain extend. On the other hand, Henderson and Tookes (2012) published a big study on Rule 144A convertible bonds and according to his findings, there is a negative relation between after-market liquidity factors and convertible bond underpricing. As a result, there are mixed expectations. Moreover, by definition of Rule 144A are supposed to be more liquid as they can be more easily traded between trusted issuers, at the expense of temporary hold on public trading.

Finally, it would be interesting to find an identifier similar to Ellul and Pagano (2006) that would have a predictive power for the convertible bond future underpricing.

As the starting point of the research, one of the important liquidity factors was mentioned by Nagler and Ottonello (2018). The market crisis resulted into decrease of the dealer inventory capacity, which in turn decrease the over-the-counter market liquidity, so a higher level of underpricing should be present to compensate for it, therefore the starting hypothesis is the following:

H1: The convertible bond underpricing is higher in the post-crisis period

To test whether liquidity is a determinant of the underpricing, first two liquidity proxies were chosen from Chan et al (2007), the study on different liquidity factors of bond markets. Two measures of bond liquidity are then chosen, namely bid-ask spread and the turnover ratio. The turnover ratio is the ratio of total trading volume of a security over a certain period divided by the total amount outstanding. In theory, higher liquidity would allow convertible bonds to be issued with less underpricing, because investors would not have to be compensated for it. Therefore, the second hypothesis is:

H2: A convertible bond underpricing is inversely related to its liquidity factors.

The liquidity proxies described in the second hypothesis should theoretically reflect the true liquidity of the bond issued, however, such information is revealed only after the convertible bond is issued and therefore lacks the predictive power. Therefore, instead of using the bid-ask spread of the convertible bond or its turnover ratio, it is reasonable to use the liquidity of the underlying stock instead. The convertible bonds and the shares of the company have a lot of common factors and the data of the stock is available before the convertible bond issue, since the company has to be public. So, the next step is to test whether the stock liquidity before the convertible bond issue is a good proxy for the future bond liquidity. In particular, the bid-ask spread. Next, the third hypothesis can be formalized:

H3: The stock liquidity of the company issuing the convertible bond predicts the future underpricing

The 3rd hypothesis is the very interesting to study as it can be used in the future convertible bond pricing models and it is also related to bigger studies like Henderson & Tookes (2012), where after-market liquidity proxies also used explain underpricing.

Finally, convertible bond issued under Rule 144A and the regular convertible bond need to be compared to see if they share their liquidity proxies. Since Rule 144A bonds are considered to be more liquid, and according to Henderson and Tookes (2012), Rule 144A convertible bond underpricing must be effected by liquidity proxies more.

H4: Liquidity proxies explain Rule 144A Convertible bond underpricing better

4. Data and Methodology

4.a Methodology

To test the abovementioned hypotheses, several OLS regression models are constructed. The general view of the model is the following:

$$Underpricing = \alpha + \beta_1 * Liquidity + \beta_2 * Rule144A + \beta_3 * Rule144A * Liquidity + \Upsilon_i * Control + \varepsilon$$

The control variables chosen are the offering size, whether the bond issued is a mega-bond, bond credit rating, the length of maturity period in years, as well as maturity squared and finally the whether the bond is issued under 144A rule or not.

The offering size is commonly connected to the underpricing in many literature papers. In addition, according to Helwege and Wang (2017) mega-bonds or bonds with the offering amount bigger than one billion dollars are much more liquid than smaller offerings, and thus expected to have a negative effect on underpricing. The bonds credit rating is also a common factor in determining the underpricing. The variable is directly related to the perceived risk of default, therefore the lower the credit score is the more underpricing is required according to McConnell and Schwartz (1986). The variable is used in the model as a categorical variable for investment grade bonds, speculative grade bonds, extremely speculative or non-rated. Many literatures find that investment grade bonds are considerably less underpriced. Maturity as also included as with higher maturity periods, the uncertainty increases exponentially and require an increasing compensation for it in theory. The relationship is not necessarily linear, therefore maturity squared is also included to control for that. Finally, the dummy variable included for 144A rule bonds.

Both the interaction term between the liquidity factors and the Rule 144A dummy are present in the model to test the final hypothesis. Liquidity factors are most likely to have different effects on the bonds. In particular, 144A bonds are expected to be less more sensitive to the liquidity factors after-market liquidity proxies should not affect regular convertible bonds.

Next, the explanatory variables are going to be discussed. To test the first hypothesis the mean values of the underpricing are compared, separated by the 144A rule, to see the magnitude of the change in underpricing between two periods. For much clearer result, OLS regression of crisis dummy is run on underpricing with the interaction term is tested. If the predictions are true the crisis coefficient will be positive, and the interaction term coefficient with be negative, suggesting that 144A bonds are not as sensitive as regular convertible bonds to sudden changes in liquidity. This can be attributed to the trade limit only to QIB.

The second hypothesis is tested using two bond liquidity proxies. Since the underlying variable for both proxies is the same, they should be studied separately. Using the first model as the base, two new models are constructed with the synthesized bid-ask spread in one and the turnover rate in the other, both include the interaction term. The expected results of the models are the positive coefficient for the synthesized bid-ask spread and negative coefficient with the reversed signs for the interaction terms. A higher bid-ask spread signifies the decrease in liquidity the price of reselling the security increases taxing the transactions. On the other hand, higher turnover ratio signals that the bond is traded more often and is therefore easier to buy or sell.

The last hypothesis is tested identical to the second, however the underlying of company's stock bid-ask spread is used instead of the synthesized bond one, it also covers the period before the bond issuance and not after. Despite the differences the stock and the convertible bond of the same company share similar risks and the performance of the convertible bond is tied to its underlying asset. Moreover, low stock liquidity will increase the price of arbitrage strategies for the convertible bond, making it less attractive and as a result will require a higher underpricing. Those factors should be less prevalent for 144A convertible bonds, as they are for the mostly traded between trusted investors. As a result, we expect the coefficient to be negative for the bid-ask spread and the positive coefficient for the interaction term.

All hypotheses and model coefficients are tested at p=0.05 confidence level.

4.b Data

The convertible bond underpricing data was constructed using the Tsiveriotis and Fernandes (1998) pricing model using information from Mergent FISD for stocks from 01/07/2002 to 24/12/2017. The time frame was limited by the earliest data available and stops one year before the paper to be able to estimate other variables. The total amount of data points is 830.

The variables such as offering size, maturity estimated in years, and whether the convertible bond is issued under 144A are already available from the initial data. From there, mega-bond and 144A dummies as well as maturity squared were constructed. As stated before, mega-bond variable takes value one if the offering size is higher than one billion dollars and is zero otherwise. The crisis dummy variable was chosen to be zero if the convertible bond is issued before 16/12/2008 and one otherwise. The offering size variable is divided by 1000 and now represents the amount in millions to be more easily interpreted in results.

The bond rating information was retrieved from Mergent Fixed Income Securities Database (Mergent FISD) using Wharton Research Data Services. The bond classification data was constructed similarly to Cai et al (2007) the following way: if the company was simultaneously rated by more than two rating agencies, the results are take in the order of Standard & Poor's, then Moody's and finally Fitch scores. When the credit score of a convertible bond is not available in the first month, it is assigned the next closest rating in the next 5 months. The bonds that haven't been rated are left in the dataset as "NR".

Finally, all bonds are classified into four categories: investment grade, speculative, extremely speculative and not rated. The total amounts of the convertible bonds are 52 with the investment grade score, 208 are speculative, 43 are extremely speculative and 527 of non-rated bonds.

To estimate bond bid-ask spread and bond turnover rate, additional information was retrieved from the TRACE database using the CUSIP9 code as an identifier. The testing period for both variables was chose to be one year. The difficulty of estimating liquidity of convertible bonds is in the fact that they are traded very infrequently. Most bonds are traded the most during the first day of trading and are rarely traded afterwards. Therefore, to capture the capture the liquidity of the bond, a large enough sample is required. Despite the vast array of intra-daily trade information, some bonds were traded only once or twice in that

period. The bid and ask daily variables are not available in TRACE or in any of other known sources, therefore an alternative synthetic variable is used. It is constructed by tracking all prices at which the bond was traded for one year after the issue, and then using the daily highest and lowest as substitutions for closing bid and ask. Then the percentage of the spread to its price is estimated and finally, the daily spreads are averaged over the number of days they were traded. To create turnover ratio, the quantity of bonds traded over the same period is estimated and then divided by the offer amount. Turnover ratio variables are not ideal however, according to TRACE, every transaction of bonds that is higher than one million is stated as "1MM+" (similarly there is a cap at five million for investment grade bonds called "5MM+") and those values were changed to the maximum amount known. Since many bonds appear to be traded for more than one million at once, there is no obvious skewness in data, except for small offerings, so the data was still used, under the assumption of higher estimation error. In addition, TRACE sometimes record wrong information, and four points were deleted from the data since they show extremely low prices at which the bonds were traded (less than 0.001 dollar). The final data for both variables included 219 estimations.

Finally, CRSP database was used for daily data on the underlying stocks of companies issuing convertible bonds. The bid and ask daily information are available there and bid-ask spreads very constructed daily. The window of the spreads of interest is chose to be from thirty-one to one days before the issue of the convertible bond. The period does not include the issuing day to avoid changes in bid-ask not contributed to liquidity and the average is taken over 30 days to avoid weekly and monthly fluctuations being represented. The bid ask-spread need to represent overall liquidity of the company issues. Due to the estimation error, some datapoints were so very close to zero, but appeared to be negative with the minimum of less than -0.0004, these variables were changed to zero. In addition, stocks are much more liquid than bonds, which in turn makes their bid-ask ratios relatively small, therefore all observations were multiplied by 10, for convenience.

The statistical summary is provided in table 1

Table 1: Statistical summary

Variable	Obs	Mean	Std. Dev.	Min	Max
Discount	830	0.178	0.123	-0.127	0.944
OffSize	830	281.172	335.059	3.85	4500
BOND_BA	219	0.007	0.006	0	0.046
Turnover	219	1.707	1.214	0.006	6.414
StockBA	830	0.012	0.026	0	0.608
MEGA	830	0.033	0.178	0	1
Rule144A	830	0.722		0	1
Crisis	830	0.445		0	1
Maturity	830	10.571	8.015	0.5	30
CreditRating					
1	43			0	1
2	208			0	1
3	52			0	1

5. Results

In this section the results of the test explained in Methodology will be discussed and interpreted. The first hypothesis to test was about finding whether the convertible bond underpricing is higher after the crisis in 2008. Table 2 shows the mean values of underpricing before and after crisis for both regular and 144A rule convertible bonds issues.

Table 2: Average underpricing around crisis

	Combined	Regular	144A
Before	0.147	0.129	0.152
After	0.203	0.239	0.185
Difference	0.056	0.109	0.033

The overall underpricing is increased by 5.6% for convertible bonds after the crisis. An interesting observation is that the Rule 144A bonds were underpriced more than regular convertible bonds before the crisis, but the situation reversed after the shock. 144A rule bonds increased in underpricing by 3.3% While regular convertibles jumped by 10.9%.

Finally, the regression models are constructed and shown in the Table 3 together for an easy comparison.

Table 3 Regression models

	Model 1	Model 2	Model 3	Model 4
Rule144A	0.008	-0.061	-0.142	-0.018
	(0.59)	(-0.58)	(-1.54)	(-1.27)
Crisis	0.085***	0.065***	0.079***	0.086***
	(5.54)	(3.23)	(3.75)	(5.59)
Crisis#144A	-0.06***	0.076	0.073	-0.052***
	(-.338)	(0.77)	(0.72)	(-2.92)
BondBA		1.259		
		(0.81)		
BondBA#144A		-9.385		
		(-1.29)		
Turnover			-0.018**	
			(-2.08)	
Turnover#144A			-0.022	
			(-0.29)	
StockBA				-0.022
				(-0.13)
StockBA#144A				1.899***
				(4.64)
OffSize	0.000***	0.000	0.000	0.000***
	(-4.62)	(-1.27)	(-0.97)	(-3.91)
Mega-bond	0.024	0.005	0.005	0.018
	(0.72)	(0.07)	(0.08)	(0.55)
Credit Rating				
Extremely Speculative	0.019	0.022	0.027	0.015
	(1.04)	(0.72)	(0.92)	(0.85)
Speculative grade	-0.044***	-0.024	-0.023	-0.049***
	(-4.49)	(-1.18)	(-1.12)	(-5.00)
Investment grade	-0.041**	-0.052	-0.026	-0.041**
	(-2.30)	(-1.52)	(-0.73)	(-2.35)
Maturity	0.000	0.000	0.001	0.001
	(0.17)	(-0.04)	(0.27)	(0.49)
Maturity2	0.000	0.000	0.000	0.000
	(-0.74)	(-0.53)	(-0.86)	(-1.04)
Intercept	0.000***	0.180***	0.200***	0.182***
	(10.88)	(5.19)	(5.98)	(10.39)
Observations	830	219	219	830
Adjusted R	0.164	0.154	0.165	0.187

The first hypothesis is tested in more detail in Model 1 with the Crisis and Crisis#144A coefficients. Similarly, to the previous results of the means, the Crisis effect on underpricings resulted in 0.143% increase for regular convertible bonds and 0.093% increase for rule 144A convertibles. The security of the process of bond issues under 144A rule can explain the smaller increase in underpricing.
In addition, consistent with other researches and to the liquidity theorem the offering size can explain some of the bond underpricing. Higher offering sizes cause investors to trade them more frequently, which in turn increase their liquidity, lowering the needed compensation for it through underpricing. Moreover, the extremely large offerings of more than one billion are even less underpriced by 8.5%. This is shown by the mega-bond dummy and consistent with previous research stating that mega-bonds are much more liquid than similar bonds of smaller issue sizes (Helwege et al, 2017).

Investment grade bonds and speculative grade bonds both have a slightly smaller underpricing comparing to other convertible bonds by 0.041% and 0.044% respectively. Maturity however, doesn't seem to explain any variation of the underpricing.
In conclusion of the first hypothesis, convertible bonds are more underpriced after the crisis with the smaller effect of the shock for rule 144A issues.

Next bond liquidity proxies will be tested to find if they can explain some of the underpricing. It should be noted that Models 2 and 3 only have 219 observations in comparison to other models, due to the unavailability of relevant data. Despite the smaller size, dataset should still be sufficient for testing.
First, synthesized bid-ask spread of the bond is added with the 144A interaction term as the explanatory variable. Unfortunately, despite having the coefficient signs consistent with liquidity hypothesis, neither of the new variables used gave a significant coefficient.
Model 3 uses the same dataset as Model 2 but uses bond turnover ratio is the liquidity proxy instead. The Turnover coefficient is equal to -0.018 and significant at 5% suggesting that stocks that are traded more often require less underpricing. This is consistent with the second hypothesis. The interaction term for rule 144A convertible bonds is not significant, which could mean that the underpricings of both types of convertible bonds are equally sensitive to liquidity factors, however, it is more likely that the coefficient is insignificant due to the estimation errors, and a relatively small size of 144A bonds in the new sample (only 14 observations out of 219). Therefore, the answer to the second hypothesis, whether bond liquidity factors can explain the underpricing, is mixed. The synthesized bid-ask spread of the bond doesn't seem

to explain any variation of the underpricing. The Turnover ratio however seems to work as a measure for convertible bonds in general but is otherwise unreliable.

Next, the 3rd hypothesis is tested in Model 4. As mentioned in Section 3, both bid-ask spread of the bond and its turnover ratio measures are not useful for convertible pricing models and prediction, since the data become available after the issue. In hopes to solve this, the stock bid-ask spread is proposed as a proxy for the convertible bond market liquidity. The number of observations for the model is set back to 830 because, there is no need to compare Model 4 with Models 2 and 3 due to the difference in the nature of estimation.

The estimated Stock bid-ask spread coefficient is insignificant. However, the rule 144A interaction term coefficient is significant at 1% and is equal 1.899. These results suggest that while regular convertible bonds underpricing does not depend on its underlying stock liquidity. The rule 144A convertibles will have a significantly different underpricing depending on the liquidity of the stock. For example, using the descriptive statistic on standard deviation of the sample, we can estimate that on average, one standard deviation stock bid-ask spread of 0.026 contributes to the change in the underpricing by 4.9%. While the findings for rule 144A convertibles are consistent with the liquidity theorem, it is not clear however why bond bid-ask spread had no effect on regular convertible bond underpricing. Moreover, these results are conflicting with the results of Model 3 that state that there is no difference in underpricing between rule 144A and regular convertible bonds.

One possible explanation is that, according to studies as well as in this research, there is evidence that rule 144A convertible bonds are less underpriced. The rule 144A allows bonds to be more easily traded between trusted companies and therefore in theory provide better liquidity. Ritter at al. (2002) suggest that since bonds generally are not traded frequently, they do not require a compensation for liquidity. However, it is plausible that investors treat 144A bonds differently especially with the increase of arbitrage theories and therefore require a compensation for the loss in liquidity.

Based on the Model 4 the answer to the third hypothesis, whether underlying stock liquidity can explain the underpricing of the convertible bond seem to be yes only for rule 144A convertibles.

Finally, it's possible to answer the last hypothesis, whether Liquidity proxies explain Rule 144A Convertible bond underpricing better. The turnover ratio was significant only for both convertible bond types simultaneously, this suggests that both bonds share a common liquidity factor. More importantly, the

stock bid ask variable is only confident for Rule 144A convertible bond. Since this is the case, then it must explain something property that is only limited to Rule 144A convertible stocks. This is consistent with the definition of after-market liquidity proxies by Henderson & Tookes (2012), since regular convertible stacks are immediately accessible to the public market.

6. Conclusion

When analyzing underpricing in modern securities, many studies attribute some of the variance to liquidity. This paper attempts to solve the underpricing puzzle of convertible bonds through liquidity factors. Tsiveriotis and Fernandes (1998) model is used to construct the underpricing data, several models are constructed using different liquidity proxies. The main findings suggest that the underlying stock's bid-ask spread has a strong negative relation to the future underpricing of the convertible bond, but only for rule 144A bonds and has no effect on regular convertibles. A possible explanation lies in findings of Henderson & Tookes (2012) which state that underpricing has a negative relationship with the after-market liquidity proxies. The theory suggests that one of the ways search frictions have an effect on the underpricing is through the ability to find buyers in the secondary market. Since many investors would be interested in having an option of to easily sell the bond, they would pay a higher price for that. This is more prevalent in Rule 144A convertible bonds as regular convertible bonds can be traded publicly from day 1. The results also imply that do not share common aftermarket liquidity factors. Alternatively, a less reliable liquidity proxy namely bond turnover ratio suggests that liquidity has the same negative effect on both 144A and regular convertible bonds underpricings.

References

Alexander, G. J., Edwards, A. K., & Ferri, M. G. (2000). The determinants of trading volume of high-yield corporate bonds. Journal of Financial Markets, 3(2), 177-204.

Ammann, M., Kind, A., & Wilde, C. (2003). Are convertible bonds underpriced? An analysis of the French market. Journal of Banking & Finance, 27(4), 635-653.

Cai, N., Helwege, J., & Warga, A. (2007). Underpricing in the corporate bond market. The Review of Financial Studies, 20(6), 2021-2046.

Carayannopoulos, P., & Kalimipalli, M. (2003). Convertible bond prices and inherent biases. The Journal of Fixed Income, 13(3), 64-73.

Carayannopoulos, P., & Kalimipalli, M. (2003). Convertible bond prices and inherent biases. The Journal of Fixed Income, 13(3), 64-73.

Chan, A. W., & Chen, N. F. (2007). Convertible bond underpricing: Renegotiable covenants, seasoning, and convergence. Management Science, 53(11), 1793-1814.

Chan, E., Ahmad, M. F. H., & Wooldridge, P. (2007). Liquidity in an emerging bond market: a case study of corporate bonds in Malaysia. Bank of International Settlements (BIS) Working Paper Series.

Chan, E., Ahmad, M. F. H., & Wooldridge, P. (2007). Liquidity in an emerging bond market: a case study of corporate bonds in Malaysia. Bank of International Settlements (BIS) Working Paper Series.

Choi, D., Getmansky, M., & Tookes, H. (2009). Convertible bond arbitrage, liquidity externalities, and stock prices. Journal of Financial Economics, 91(2), 227-251.

Cornelli and Goldreich (2003)

Corwin, S. A. (2003). The determinants of underpricing for seasoned equity offers. The Journal of Finance, 58(5), 2249-2279.

Crabbe, L. E., & Turner, C. M. (1995). Does the liquidity of a debt issue increase with its size? Evidence from the corporate bond and medium-term note markets. The Journal of Finance, 50(5), 1719-1734.

Dass, N., & Massa, M. (2014). The variety of maturities offered by firms and institutional investment in corporate bonds. The Review of Financial Studies, 27(7), 2219-2266.

Duca, E., Dutordoir, M., Veld, C., & Verwijmeren, P. (2012). Why are convertible bond announcements associated with increasingly negative issuer stock returns? An arbitrage-based explanation. Journal of Banking & Finance, 36(11), 2884-2899.

Ellul, A., & Pagano, M. (2006). IPO underpricing and after-market liquidity. *The Review of Financial Studies*, *19*(2), 381-421.

Ginglinger, E., Matsoukis, L., & Riva, F. (2013). Seasoned equity offerings: Stock market liquidity and the rights offer paradox. Journal of Business Finance & Accounting, 40(1-2), 215-238.

Hahn, T., Ligon, J. A., & Rhodes, H. (2013). Liquidity and initial public offering underpricing. *Journal of Banking & Finance*, *37*(12), 4973-4988.

Helwege, J., & Wang, L. (2017). Liquidity and price pressure in the corporate bond market: evidence from mega-bonds.

Henderson, B. J., & Tookes, H. (2012). Do investment banks' relationships with investors impact pricing? The case of convertible bond issues. Management Science, 58(12), 2272-2291.

Jenkinson and Jones (2004)

King, R. (1986). Convertible bond valuation: An empirical test. Journal of Financial Research, 9(1), 53-69.

Nagler, F., & Ottonello, G. (2018). Structural changes in corporate bond underpricing. BAFFI CAREFIN Centre Research Paper, (2017-48).

Ranaldo, A., & Eckmann, A. (2004). Convertible Bonds: Characteristics of an Asset Class. UBS Research Paper.

Ritter, J. R., & Welch, I. (2002). A review of IPO activity, pricing, and allocations. The journal of Finance, 57(4), 1795-1828.

Rock (1986)

Wasserfallen, W., & Wydler, D. (1988). Underpricing of newly issued bonds: Evidence from the Swiss capital market. The Journal of Finance, 43(5), 1177-1191.

Wasserfallen, W., & Wydler, D. (1988). Underpricing of newly issued bonds: Evidence from the Swiss capital market. The Journal of Finance, 43(5), 1177-1191.