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Debt Market Illiquidity and Correlated Default Risk

Abstract

We empirically test the theoretical prediction of the impact of debt market liquidity on correlated default risk. Confirming the theory, our results indicate that the lower debt market liquidity, leads to an economically significant increase in the correlated default risk. Also consistent with theory, we show that this effect is more pronounced for short-term debt.

JEL Classification: G01; G12; G13

Keywords: Default Correlation; Debt Market Liquidity; Credit Default Swap (CDS); Debt Maturity; Correlation in Default Probabilities

1. Introduction

A crucial issue for bond portfolios is the default correlation between different firms, which undermines diversification benefits. Thus, understanding the dynamics of correlated default risk is essential to fixed-income pricing and risk management and is of great interest to academicians and practitioners. The recent financial crisis in particular has sparked interest in understanding correlated default risk and the role played by liquidity and short-term debt. As pointed out by Nickerson and Griffin (2017), credit rating agencies made official statements expressing concerns about default correlation (Moody's, 2010; Standard & Poor's, 2013). In their "Material Loss Reports", the FDIC and OCC attribute the banking failure in the recent crisis to the interplay of liquidity and credit risk. Anecdotal evidence suggests that the failures of Lehman Brothers and Bear Sterns during the recent financial crisis was mainly due to their significant exposure to short-term debt (Brunnermeier and Pedersen, 2009; Krishnamurthy, 2010). Our knowledge, however, about factors driving default correlation is limited. Das et al. (2007) and Duffie et al. (2009) show that commonly used observable variables have little power in explaining firms' default correlation.

We use the insight of the theoretical model of He and Xiong (2012b) to examine the dynamics of correlated default risk. To understand the connection between rollover risk and credit risk, He and Xiong (2012b) develop a theoretical model; and one of the implications of their model is that debt market liquidity can be a common factor explaining firms' correlated default risk and that this risk is more pronounced for short-term debt. Guided with this theory, our paper contributes to this debate by providing first empirical evidence on the dynamics of correlated default risk and its significant relationship with short-term debt and debt market liquidity.

Prior research in this area has focused predominantly on the credit spread puzzle (Collin-Dufresne et al., 2001; Eom et al., 2004; Longstaff et al., 2005; Chen et al., 2007; Covitz and Downing, 2007; Ericsson et al., 2009; Huang and Huang, 2012), on measuring bond liquidity and its pricing implications in the bond market (Ericsson and Renault, 2006; Lin, Wang, and Wu, 2011; Bao et al., 2011; Dick-Nielsen et al., 2012; de Jong and Driessen, 2012; Friewald et al., 2012; Acharya et al., 2013; Imbierowicz and Rauch, 2014; Pelizzon et al., 2016; Docherty and Easton, 2016; Bongaerts, de Jong, and Driessen, 2017), and on

measuring credit risk premium and its relative magnitude vis-à-vis liquidity premium (Gilchrist and Zakrajsek, 2012; Schwert, 2017; Schwarz, 2017; Berndt et al., 2018). Theoretical literature also investigates the interaction between liquidity and credit risk premium (Goldstein and Paudyal, 2005; Ericsson and Renault, 2006; Wagner, 2007; Cai and Thakor, 2008; Gatev et al., 2009; Acharya et al., 2010; Acharya and Viswanathan, 2011; Gorton and Metrick, 2011; He and Xiong, 2012a,b; He and Milbradt, 2014). Our paper differs from these studies, as our research question is fundamentally different. We borrow from this literature and use developed measures of bond market liquidity and credit risk premium to investigate the dynamics of correlated default risk and test the predictions made in the theoretical literature. Therefore, the most notable difference between our paper and these studies is the use of a measure of correlated default risk (recently developed by Javadi et al, 2017) as the dependent variable instead of other traditional measures such as corporate bond yield spread, CDS spread, sovereign bond spreads, etc.

This article makes two key contributions. First, consistent with the theory, we find empirical support for the notion that lower debt market liquidity has a positive and economically significant effect on correlated default risk and that the effect is stronger for speculative issues and during the recent crisis. This result is consistent with He and Milbradt (2014) who develop and solve a theoretical model that endogenizes the bond market illiquidity in the He and Xiong (2012b) framework. It is also in line with the empirical findings of Gopalan et al (2014) who show that firms with greater exposure to rollover risk have lower credit quality and that the effect is more pronounced for non-investment grade firms and during recessions. However, while their focus is on the impact of rollover risk on credit rating, we study the effect on correlated default risk of debt market liquidity. Second, also confirming the theory, we provide evidence that default correlation is significantly higher for short-term debt. Our results are consistent with those in Diamond and He (2014) in that they both show the negative aspect of short-term debt. However, our focus is on the correlated default risk whereas they study the effect of debt maturity on debt overhang and firm investment.

Furthermore, this result is also consistent with the theoretical prediction in He and Xiong (2012a) and Morris and Shin (2016)¹.

Overall, our empirical evidence, at the very least, shows the necessity of better understanding the dynamics of correlated default risk, highlights its complicated relationship with debt maturity and bond market liquidity, and calls for theoretical models to incorporate the interplay of these factors. These new models can guide empirical research, and together they have significant implications for all the stakeholders in the fixed income market including regulators and policy makers.

2. Theoretical Framework

He and Xiong (2012b) develop a theoretical model that analyzes the interaction between bond market liquidity and credit risk premiums. In the presence of an illiquid debt market, to keep the firm alive, equity holders must absorb rollover losses when replacing maturing bonds with new bond issues. Debt market illiquidity depresses the price of newly issued bonds and leads to an increase in rollover losses to equity holders. Thus, absorbing rollover losses by equity holders is rational if the value of keeping the firm alive outweighs rollover losses. A key implication of the He and Xiong (2012b) model is that due to the rise in rollover costs, the deterioration in debt market liquidity can lead equity holders to choose to default at a higher threshold. Based on this key insight, they suggest that debt market liquidity can be a common factor explaining firms' default correlation.

Moreover, their model signifies the link between maturity risk and rollover risk. Consistent with Leland and Toft (1996), He and Xiong (2012b) prove that the firm's default boundary increases as its debt maturity decreases and that a deterioration in debt market liquidity exacerbates this effect. Their model suggests that the effect of rollover risk is more pronounced for short-term debt since it exposes equity holders to larger rollover losses. Thus, firms with short-term debt due to their greater rollover losses have a higher default

¹ Our paper is different from two recent papers by Nickerson and Griffin (2017) and Phelan (2017). We are interested in the relationship between correlated default risk and debt market liquidity and debt maturity. However, the former paper develops a framework to estimate realized default correlation in structured securities and contrasts that to the assumptions used by credit rating agencies, whereas the latter develops a theoretical model that implies that correlated loan payoffs can give rise to financial intermediation. Our results also complement the findings in Pu and Zhao (2012), who find significant comovement in CDS spreads.

threshold and face greater default risk. Therefore, a deterioration in debt market liquidity that raises the default boundary across the board makes correlated defaults more probable for these firms. In other words, the theory predicts that correlated default risk is more pronounced for short-term debt.

A direct test of these predictions has been a challenge because it requires a reliable measure of correlated default risk, which was not previously available in the literature. In this paper, however, we use a measure of correlated default risk to empirically test these theoretical predictions. To the best of our knowledge, our paper is the first empirical study to shed more light on the relationship between correlated default risk, debt market liquidity, and maturity.

3. Data

Das, Freed, Geng, and Kapadia (2006) and Das, Duffie, Kapadia, and Saita (2007) show that correlation in defaults primarily stems from the correlation in default probabilities. Using this insight and following Javadi et al. (2017), we construct a measure of default correlation using five-year credit default swap (CDS) spreads. The CDS spreads are from July 2002 to August 2013 and are obtained from MARKIT. It is a well-established fact that CDS contracts are extremely liquid and efficient. More specifically, CDS spreads reflect the changes in the credit risk of the reference entities faster than their corresponding fixed-income issues (Blanco et al., 2005; Ericsson et al., 2009). These characteristics make CDS spreads an ideal proxy for default probabilities (Friewald et al., 2014). Furthermore, using correlation of CDS spreads avoids reliance on structural assumptions under the risk neutral framework to infer default probabilities. Thus, the correlated movements in CDS spreads can be an efficient and close proxy for the correlated movements in the respective reference entities' default probabilities. Therefore, the measure of default correlation for issue i is defined as the monthly average pairwise correlation in daily CDS spreads of issue i with all other issues in each month.

The focus of this study is to analyze the effect of debt market liquidity on the correlated default risk. Thus, it is crucial to have a reliable liquidity measure for the bond market. Corporate bonds are far less liquid than equities; a very small number of bonds trade on a daily basis. Consequently, it is necessary to have a liquidity proxy that goes beyond the standard transaction-based measures. Following Friewald et al.

(2012), we construct a bond-level Amihud measure of illiquidity; then, following Bao et al. (2011), we aggregate this measure to market level by taking its monthly average across all issues. Amihud is the price impact of trading on bonds, and it is calculated as an individual bond's average absolute return scaled by its trading volume.

$$Amihud\ Illiquidity_{i,t} = \frac{1}{N_t} \sum_{j=1}^{N_t} \frac{|r_j|}{v_j} \quad (1)$$

We obtain the prices and volume from the Trade Reporting and Compliance Engine (TRACE); to calculate the bond returns, we follow Bessembinder et al. (2009). We specifically focus on the Amihud measure because prior research finds that it captures illiquidity more effectively than other measures (Dick-Nielsen et al., 2012; Friewald et al., 2012).

Table 1 presents the summary statistics of the variables. Our sample has 71,853 monthly observations that span from July 2002 and August 2013. The average default correlation in our sample is 0.29, with a standard deviation of 0.24 reflecting substantial variation in this measure. In an average month, debt market illiquidity has a mean value of 0.1. 67% of our sample is comprised of investment-grade issues and the mean time to maturity is a little over 9 years. An average firm in our sample has a volatility of 30% with a leverage ratio of about 29%.

Table 1: Descriptive Statistics

Stats	N	Mean	Median	Stddev
Default Correlation	71,853	0.290	0.290	0.24
<u>Debt Market Illiquidity Measure</u>				
Amihud	134	0.100	0.090	0.06
<u>Firm Characteristics</u>				
Investment Dummy	71,853	0.670	1.000	0.47
Maturity (in Years)	71,853	9.310	6.420	8.69
Leverage	71,853	0.290	0.240	0.18
Volatility	71,853	0.300	0.240	0.21
<u>Macro Factors</u>				
r10 (%)	134	3.600	3.840	(0.98)
SP Return (%)	134	0.473	1.106	(4.40)
Slope	134	1.570	1.770	(0.92)
ebp (%)	134	-0.011	-0.255	(0.79)

4. Empirical Findings

4.1 Main Findings

To study the effect of debt market liquidity on the correlated default risk, we employ the following panel regression as our baseline model.

$$Def. Corr_{i,t} = \alpha + \beta_1 Illiquidity_t + \beta_2 \mathbf{X}_{i,t} + \varepsilon_{i,t} \quad (2)$$

where $DefCorr_{i,t}$ is the measure of default correlation as defined earlier and $Illiquidity_t$ is the measure of debt market illiquidity; $\mathbf{X}$ is a vector of control variables that includes two indicator variables for crisis (between December 2007 and June 2009 as defined by the Fed) and investment grade issues, excess bond premium (ebp), leverage $_{i,t}$, 10-year Treasury note ($r10$), return on S&P500 ($SP Return_t$), slope of the yield curve ($Slope_t$), and Volatility $_{i,t}$. In choosing these variables, we followed the literature (Collin-Dufresne et al., 2001; Ericsson et al., 2009; Das et al., 2007; Duffie et al., 2009; Gilchrist and Zakrajsek, 2012).² Standard errors are clustered by firm.

To test the prediction that default correlation is more pronounced for short-term issues, we augment this model by including two different measures of maturity: y_25p and y_75p are indicator variables that are equal to 1 if the maturity of a bond is in the first and fourth quartile of maturity distribution in our sample, respectively. The other measure is time to maturity, expressed in years, for each bond issue in each month.

Table 2 presents the results of our panel regressions for our variable of interest. The coefficient on Amihud, the measure of debt market illiquidity, is positive and significant in all specifications. Model 2 provides the first empirical evidence consistent with the He and Xiong (2012b) theory that default correlation is more pronounced for short-term debt. Default correlation is about 3% higher for short-term bonds, as evident from the positive significant coefficient of y_25p . Also consistent with the theory, we find the opposite to be true for long-term bonds. The coefficient on y_75p is negative significant, indicating that default correlation is lower for long-term bonds. The last two models include the control variables.

² Appendix provides more detail information on these variables and their data sources.

Model 5 substitutes the two y_{25p} and y_{75p} indicator variables for *maturity*. The negative coefficient on maturity (coefficient estimate = -0.014; t-stat = -7.03) is consistent with our previous findings and indicates one-year shorter maturity increases default correlation by about 1.4% after controlling for other variables. In both models, the size of Amihud coefficient increases to 1.7 and remains significantly positive. To get a sense of the economic significance of the impact of debt market illiquidity on default correlation, we use the standard deviation of Amihud that is reported in Table 1. Focusing on Models 4 and 5, Amihud's coefficient of 1.7 indicates that a one standard deviation (0.06) increase in Amihud illiquidity (i.e., one standard deviation deterioration in debt market liquidity) leads to about a 10.2% increase in default correlation. Figure 1 depicts the relationship between default correlation and debt market illiquidity as measured by Amihud.

Table 2: Default Correlation and Base Model Debt Market Liquidity

VARIABLES	Default Correlation as Dependent Variable				
	(1)	(2)	(3)	(4)	(5)
Amihud _t	0.946*** (33.840)	0.932*** (32.990)	0.830*** (20.780)	1.736*** (24.930)	1.784*** (25.520)
$y_{25p_{i,t}}$		0.036*** (7.860)	0.032*** (6.770)	0.024*** (5.020)	
$y_{75p_{i,t}}$		-0.032*** (-4.770)	-0.028*** (-4.010)	-0.016** (-2.140)	
Investment Dummy _{i,t}			-0.036*** (-5.130)	-0.022*** (-3.180)	-0.016** (-2.460)
Crisis _t			0.028*** (4.290)	0.112*** (17.500)	0.112*** (17.540)
Volatility _{i,t}				-0.051*** (-2.810)	-0.042** (-2.350)
Leverage _{i,t}				-0.080** (-2.210)	-0.066* (-1.960)
$r10_t$				-0.017*** (-6.010)	0.003 (0.680)
SP Return _t				-0.099** (-2.530)	-0.076* (-1.950)
Slope _t				0.003 (0.980)	-0.000 (-0.010)
ebp _t				-0.115*** (-19.970)	-0.118*** (-20.520)
Maturity _{i,t}					-0.014*** (-7.030)
Constant	0.189*** (66.180)	0.189*** (62.750)	0.218*** (35.040)	0.186*** (10.940)	0.242*** (12.980)
Observations	71,853	71,853	71,853	71,853	71,853
R-squared	0.0576	0.0604	0.0632	0.0980	0.1026

This figure presents the 12-month moving average of *Aggregate Default Correlation* (left axis) and *Amihud Illiquidity* measure over our sample period (right axis). The shaded area, December 2007 to June 2009, reflects financial crisis.

Amihud alone can explain about 6% of the variation in default correlation. Inclusion of other control variables increases the R^2 to about 10%. This means around 90% of the variation in default correlation is left unexplained. Thus, while debt market liquidity has some explanatory power and has an economically significant impact, it is one of the factors - not the main common factor - driving default correlation. In fact, the R^2 s of our models are consistent with earlier findings that suggest limited explanatory power of observable firm-level and macroeconomic covariates (Das et al., 2007; Duffie et al., 2009).

Control variables predominantly have the expected signs. The crisis indicator variable has a positive significant coefficient, indicating that the default correlation rose significantly during the crisis. Similarly, the negative coefficient of the return on the S&P500 composite index implies that the correlation increases subsequent to a market downturn. This is consistent with a known empirical regularity that asset correlations increase following a market decline (Ang and Bekaert, 2002; Das and Uppal, 2004).

Investment-grade issues have a lower default correlation. This is intuitive since these issues have a lower default boundary that makes them less exposed to default correlation. Negative coefficient of the yield on the 10-year Treasury note (r_{10}) is consistent with Merton-type models. Overall, the default correlation measure moves as expected with structural variables that prior research shows to drive the correlation in default probabilities.

4.2 Robustness Check

While earlier work such as Longstaff et al. (2005) assumed that CDS include only credit risk, following the financial crisis the more recent literature acknowledges that CDS spreads also include a liquidity component (see for example Bongaerts et al., 2011; Tang and Yan, 2007; Junge and Trolle, 2015). In addition to the liquidity component, the recovery rate and counterparty risk can also affect CDS spreads. However, Arora, Gandhi, and Longstaff (2012) show that the economic impact of counterparty risk on CDS spreads is negligible: 645 basis points increase in the credit risk of a CDS dealer leads to only one basis point decrease in the CDS spread the dealer charges. Therefore, counterparty risk has little to no economic impact on correlation in CDS spreads. Moreover, the literature shows that recovery rates are very persistent and thus they are assumed to be constant (Friewald, Wagner, and Zechner, 2014; Berndt, Douglas, Duffie, and Ferguson, 2017; Bharath and Shumway, 2008; Hull, Predescu, and White, 2004; Altman and Kishore, 1996; Keenan, Shtogrin, and Soberhart, 1999; and Eom, Helwege, and Huang, 2004). Particularly in this analysis, given our one-month estimation horizon, we can assume that recovery rates are time-invariant over one month and therefore have no meaningful impact on CDS spread correlation. But to ensure that our measure of correlated default risk does in fact reflect correlated default risk and not the potential confounding effect of recovery rate and the liquidity in the CDS market, we orthogonalize this measure to correlation in CDS liquidity and recovery rates.

Following previous studies by Ashcraft and Santos (2009), Friewald, Wagner, and Zechner (2014), and Qiu and Yu (2012), we use MARKIT's number of contributors (market-makers) for each CDS spread as a proxy for CDS liquidity. Recovery rates are also obtained from MARKIT. Correlation in CDS liquidity for

issue i is defined as the monthly average pairwise correlation in the daily number of contributors of issue i with all other issues in each month. We calculate the correlation in the recovery rates in the same way. We orthogonalize the default correlation measure by calculating the residual from regressing default correlation measure on correlation in CDS spreads and correlation in recovery rates. Then, we run our model for this orthogonalized measure. Results are reported in Table 3.

Table 3: Residual Default Correlation and Debt Market Liquidity

VARIABLES	Residuals of Default Correlation as Dependent Variable				
	(1)	(2)	(3)	(4)	(5)
Amihud _{<i>t</i>}	0.846*** (30.150)	0.833*** (29.650)	0.781*** (19.100)	1.628*** (23.450)	1.666*** (24.030)
$y_{25p_{i,t}}$		0.033*** (7.580)	0.029*** (6.540)	0.019*** (4.280)	
$y_{75p_{i,t}}$		-0.029*** (-4.510)	-0.025*** (-3.770)	-0.011 (-1.600)	
Investment Dummy _{<i>i,t</i>}			-0.032*** (-4.780)	-0.015** (-2.220)	-0.010 (-1.610)
Crisis _{<i>t</i>}			0.016** (2.460)	0.093*** (14.940)	0.094*** (15.020)
Volatility _{<i>i,t</i>}				-0.034** (-2.000)	-0.027 (-1.600)
Leverage _{<i>i,t</i>}				-0.068* (-1.850)	-0.057* (-1.670)
$r10_t$				-0.013*** (-5.210)	0.002 (0.690)
SP Return _{<i>t</i>}				-0.110*** (-2.830)	-0.092** (-2.380)
Slope _{<i>t</i>}				0.015*** (4.740)	0.012*** (3.900)
ebp _{<i>t</i>}				-0.115*** (-20.100)	-0.116*** (-20.570)
Maturity _{<i>i,t</i>}					-0.011*** (-6.060)
Constant	-0.071*** (-24.670)	-0.070*** (-23.070)	-0.047*** (-7.320)	-0.112*** (-6.830)	-0.067*** (-3.780)
Observations	71,853	71,853	71,853	71,853	71,853
R-squared	0.0472	0.0496	0.0513	0.0876	0.0906

Results in Table 3 paint the same picture. The coefficient on debt market illiquidity has a positive and economically significant impact on default correlation that is comparable to that of Table 2. Short-term bonds are more susceptible to default correlation as evident by coefficients on y_{25p} , y_{75p} and *maturity*.

5. Conclusion

Using a newly developed measure of correlated default risk, we provide insight regarding the relationship between debt market illiquidity and correlated default risk. Specifically, we empirically test the predications of He and Xiong (2012b) theory. We find an empirical evidence consistent to the He and Xiong (2012b) theory that suggests that debt market illiquidity can be a factor driving correlated default. Moreover, as predicted by their theory, we show that correlated default risk is stronger for shorter-term debt. Overall, while our results are mainly consistent with the theory's predictions, the relatively small R^2 s of our models indicate that debt market liquidity is one factor, among others, driving default correlation and is not the main common factor.

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7. Appendix: List of Variables

<i>Crisis_t</i>	An indicator variable that equals one in the year-months spanning December 2007 to June 2009, ³ and zero otherwise.
<i>ebp_t</i>	Is excess bond premium, which represents the risk premium or average price of bearing exposure to credit risk in excess of the compensation for expected defaults, as estimated by Gilchrist and Zakrajsek (2012). ⁴
<i>Investment Grade_{i,t}</i>	A dummy variable that equals one if the bond issue's rating is at least BBB (or its equivalent depending on the rating agency, as reported by Mergent FISD), and zero otherwise.
<i>Leverage_{i,t}</i>	Following Collin-Dufresne et al. (2001), we calculate the firm's leverage ratio as the book value of debt divided by the sum of the market value of equity and the book value of debt. we obtain equity valuation from CRSP, which we match to the most recent quarterly book value of debt obtained from COMPUSTAT.
<i>r10_t</i>	Following Collin-Dufresne et al. (2001) and Ericsson et al. (2009), among others, the riskless rate is proxied by the yield on the 10-year Treasury note.
<i>SP Return_t</i>	Following Collin-Dufresne et al. (2001), we use the monthly return on the S&P500 composite index to control for overall market condition. Data is obtained from CRSP.
<i>Slope_t</i>	Following Collin-Dufresne et al. (2001) and Ericsson et al. (2009), among others, we define slope as the difference between the 10-year and 2-year Treasury yields.
<i>Volatility_{i,t}</i>	We use the firm's 30-day implied volatility as reported by OptionMetrics on the first day of the month to control for forward-looking measure of the firm's volatility.

³ We define the period as specified by the Federal Reserve. See "The Great Recession of 2007-09" (Federal Reserve Bank of New York, 2013).

⁴ We use the *ebp* data provided at: <http://people.bu.edu/sgilchri/Data/data.htm>