“Returns to defaulted corporate bonds”

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Returns to defaulted corporate bonds

Abstract

The paper studies the return patterns for defaulted bonds at default time and nine months after. The author identifies and describes an strong overshooting effect, where the large negative return at default is followed by strong positive returns for a number of time periods. The article tests statistically for short-term excess return in a sample of 374 defaulted U.S. corporate bonds. There is a robust overshooting effect also after the author has controlled for market and liquidity risk. The average expected recovery rate during the time period of 2001-2010 is estimated to be seven percentage points lower at the first month after default than the present value of the recovery rate nine months later.

Keywords: bond pricing, recovery rate.
JEL Classification: G12, G33.

Introduction

The pricing of defaulted bonds have become a hot topic in the aftermath of the financial crisis. From being a marginal phenomenon, it has become a very real aspect of owning a corporate bond portfolio. Some aspects of standard bond pricing, such as, for example, influence from liquidity risk can also be valid for defaulted bonds. However, very little is known apart from schedules of short-term recovery rates. I fill the gap in the litterature, by studing return patterns for defaulted bonds using time series tests. I also show that the excess return I have found cannot be eliminated by the risk factors used by other studies of bond pricing.

There are reasons to believe that there is biased pricing for defaulted bonds and subsequently that recovery rates might be depressed. First, defaulted bonds might have the same factors influence their pricing as non-defaulted bonds (liquidity, default risk, and interest rate risk). Second, the market for defaulted securities can exhibit information asymmetries, where buyers and sellers have different information on the value of the bonds. There could also be other risks then ones I controll for when testing for mispricing. If there exists other risks that are not properly controlled for in the tests, they could give a result that suggestes that bonds are mispriced.

The pricing of non-defaulted corporate bonds is influenced by liquidity risk. Ericsson and Reneby (2003) find that bond spreads incorporate a substantial liquidity component in addition to the default risk. The less liquid a bond is in the study of Chen, Lesmond and Wei (2005) the higher the yield spread, and de Jong and Driessen (2005) find that liquidity is a priced factor in a multi-factor model. If corporate bond prices are sensitive to liquidity before default, there is no reason to think that they are less sensitive after default. The systematic part of the default risk is priced according to Weinstein (1981), Berndt and Lookman (2006), and Thorsell (2008). I expect the market beta to increase after default due to the fact that the bond owners have the possibility to convert their bond into equity. This means that the future pay offs from the defaulted bond can be the residual payments from the issuer, rather than the coupons. For a defaulted bond there is uncertainty about if the bond will become equity or not, so the bond market beta should be somewhere in between a bond beta and an equity beta. The interest rate risk is ignored here, since it is not likely a major contributor to the risk of a defaulted corporate bond.

In a default situation for a company there are also new reasons for trading its securities. Some investors, such as pension funds and insurance companies, are not allowed to hold high risk assets, creating an increase in the supply of the defaulted bond in the market. Other investors specialize in this type of high risk assets. This specialization could potentially create a situation of information asymmetry[1]. The existence of vulture funds indicates there might be opportunities to earn good returns on distressed or defaulted assets.

The holders of defaulted corporate bonds have to find some means of knowing that their bonds are worth. A natural choice is to look at what has been recovered in earlier defaults, making the historic recovery rates the norm also for future recovery rates. The cross-sectional studies of recovery rates started with Altman and Kishore (1996). Recovery rates are now studied by the rating agencies as a matter of routine (Moody, 2010). Altman and Kishore (1996) shows that industry and the seniority

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[1] Financial organizations that specialize in distressed securities, such as near default or defaulted bonds or shares, are commonly referred to as vulture funds.

of a bond matters for the recovery rate in the cross-section. They cannot show that investment grade status, size of issue, or longevity before default has any impact on the recovery rate. The frequent studies of the cross-section can be self-fulfilling, but should not influence a possible bias. That is, any pre-existing bias can be strengthened by the success of the cross-sectional studies since it is the only information available on recovery rates. There are three ways of defining the recovery rate of defaulted bonds in the literature:

- recovery of the face value of the bond;
- recovery of market value preceding the default; or
- tranformation into an equivalent, but default-free bond.

These three methods are all based on an instant change into a safe asset. If there are unlimited trading opportunities, the three methods are equivalent. If it is not possible to immediately sell the bond at its intrinsic value, then the variation in the recovery rate of the defaulted bond is important for the value. The recovery rate of face value is typically calculated as the market price one month after default of the bond divided by the face value. The recovery rate of market value is the market price one month after default of the bond divided by the market price one month before default.

There are issues that can generate bias in the recovery rate; post default risk and information asymmetry between investors. Altman and Pompeii (2003) show that the market value divided by the face value of defaulted bonds varies from 0.15 to 0.74 and differs from year to year. The bonds in their sample are the defaulted bonds that are included in the Altman-NYU Salomon Center Defaulted Bond Index.

To measure the potential bias in the cross-sectional default rates there are a few possible methods:

- the repayments from defaulted bonds could be summed and discounted for a net present value;
- the returns from vulture funds could be tested for excess returns; or
- the return on bonds of defaulted issuers could be tested for excess returns.

The repayments from defaulted firms are difficult to study since the data is not public and it often takes a long time until the default is resolved and/or bankruptcy is finalized. This means that it is not only hard to find the data, but many things can happened during the long time period that elapsed since default. The main problem with studying vulture funds is that there is a collection of assets in the funds at any time. Some of these assets might be recently defaulted bonds, but there can be many other assets as well. Further, the vulture fund managers may add value to the defaulted securities after default and such a study can be biased to increase the value of the assets at default. I use the third method and study the return on bonds of companies that have defaulted on their securities. I use data from a limited number of months. The reasons for studying a short time period after default are that it takes time to do value enhancing restructurings, so the short time period does not include too much of value enhancing measures by the company, and it is possible that the recovery rate is depressed by a larger than usual supply just after default due to a supply effect.

The underlying claim that is tested in this study is;

Claim 1. The market price of a recently defaulted bond is biased.

Multiple regression analysis is used to test the claim. The test is operationalized as a test if the one month recovery rate estimation is biased. I calculate the cross-sectional recovery rate (as can be compared to for instance Moody's (2010)), and introduce time-series tests on defaulted corporate bond returns. The bond factors used to explain the excess returns do not in fact explain the returns. The common liquidity have no strong bearing on the excess return after default. However, the equity risk factors are different from zero and significant. This suggests that there is mispricing for defaulted bond returns. In untabulated tests using only the 2001-2006 time period, neither liquidity nor equity factors are significant[1]. This indicates that the crisis in the end of the period the bonds behave more like equity. The estimated recovery rates ares seven percentage points "too low" on average to make the excess return go away during the period of 2001-2010.

In the next Section, the model for bond values are described. In Section 2 the tests and calculations that deviate from standard asset pricing tests are presented. The summary statistics of the sample and how the sample selection was done is described in Section 3. The results are presented and discussed in Section 4. Concluding remarks are presented in the last Section.

1. Model for corporate bond value

The purpose of this Section is to explain how the default value of the bond relates to the before default value and to describe how the bond recovery value can be compared over time periods after

[1] I have run all tests in this paper using the shorter pre-crisis time period of 2001-2006, and the excess returns are similar to the ones presented, i.e., the main results do not depend on the financial crisis.

default. The value of the bond (V) at time t is equal to the discounted present value of the expected value of the bond value at date $t+1$.

$$V_t = e^{-r_t} E[V_{t+1} + C_{t+1}]. \quad (1)$$

For simplicity assume that the coupon is zero ($C_{t+1} = 0$). Defining the default probability between t and $t+1$ as $\pi_{t,t+1}$ I assume it is exogenous. Define the value of the bond at time $t+1$ as V^d_{t+1} for the default state and V^s_{t+1} in the survival state. The value of the default state is the recovery value. The survival value of the bond is ultimately the promised payment. The states of default or survival are mutually exclusive, so equation (1) can be decomposed into:

$$V_t = e^{-r_t}\left(E\left[\pi_{t,t+1}V^d_{t+1}\right] + E\left[(1-\pi_{t,t+1})V^s_{t+1}\right]\right). \quad (2)$$

The default probability of a safe bond is by definition $\pi_{t,T} = 0$ and the safe bond value at maturity (T) is thus equal to its face value $V_T = 1$. The payment in default is the object of interest, so define the payment in default function as $\delta : f_{t+1} \to V^d_{t+1}$. The set of factors f_{t+1} contain all information necessary to determine the payment in default (V^d_{t+1}). δ can be seen as the time-varying exchange rate between the promised payment and the payment at default, so $\delta(f_{t+1}) \le V^s_{t+1}$. Assuming a constant probability of default (π) gives the valuation formula at time t before default at time τ ($t < \tau$):

$$V_t = \pi e^{-r_t} E[\delta(f_{t+1})] + (1-\pi)e^{-r_t} E[V^s_{t+1}], \quad (3)$$

and after default $t > \tau$:

$$V_t = e^{-r_t} E[\delta(f_{t+1})]. \quad (4)$$

Assuming that creditors take over when a company defaults on its debt payments. This implies that the company is then free of all debt and there cannot be any additional defaults. Since I study only a short time after default, this assumption should not influence the results.

The three standard ways to define the default payment function can be described as: recovery of face value of the bond $\delta(f_{t+1}) = k_1$, recovery of market value $\delta(f_{t+1}) = k_2 V_t$, and recovery in a safe bond $\delta(f_{t+1}) = k_3 V^s_{t+1}$, where k_1, k_2 and k_3 are constants. In the recovery of a safe bond an investor receives a fraction (k_3) of a safe bond that otherwise has the same characteristics as the defaulted bond. All three methods are point estimates. If there are risk adjusted excess returns after default it is not possible to trade the defaulted bond and get an economic value that corresponds to any of the the three methods. This transaction problem can make empirical estimates for default payments using the three methods invalid.

If liquidity is poor after default, a bond owner is exposed to the variability of the asset price and an unknown holding period. This can result in changing values of the recovery rate and a simple model of this is:

$$\delta_q(f_{t+1}) = \frac{\delta(f_{t+q})}{\prod_{i=t+1}^{t+1+q}(1+\rho_i)}, \quad (5)$$

where q is the number of time periods after default, and ρ_i the discount rate. I use the risk adjusted discount rate in a capital asset pricing model (CAPM) setting. The value of the bond at default depends on the return on the asset $\delta(f_{t+1})$ function and the length of the holding period q.

2. Test method

To test the recovery rates variability over time some initial calculations have to be made. I define the the default time not as when the bond issuer formally defaulted on the obligation, but the time when the market adapted the bond price to include the future default of the firm on the interest or principal[1]. In practice this means that the largest negative price adjustment for each time series is defined as the default period. The extreme price decreases in 2008 for almost all assets makes the defaults that took place in 2007 to be ascribed to 2008. In unreported tests that exlcudes the financial crisis yields similar results as the tests in the study. The systematic underpricing at default is smaller (four percentage points instead of seven).

All returns are measured excluding the accrued interest[2]. Only in cases where the bond is repaid in

[1] The price adjustment occurs when investors realize that the company will not be able to service the debt. The actual default date is the date the service is due.

[2] Even if investors' claims on principal or interest are equivalent from an economic perspective, they might be treated differently in the prescription clauses of the bonds. There are instances of different prescription times for principal and interest. In addition to smaller differences in contractual treatment, Asquith and Robert Gertner and David Scharfstein (1994) find that banks almost never forgive principal as part of any comprehensive debt restructuring that include subordinated public creditors.

full this exclusion matter. This is not common for defaulted bonds, so the impact on my results should be minimal. All tests have also been done also with returns including the accrued interest. The difference in results are minimal and if anything the inclusion of the accrued interest increases the excess return and risk-adjusted discounted recovery rate.

2.1. Cross-section. The cross-sectional recovery rates are presented as averages, but calculated using OLS, since this facilitates calculating measures on variability such as the explained variation (R^2).

2.2. Time-series. To test if the market price of a defaulted bond is biased, the returns are tested for excess returns. The idea is to find out if the defaulted bonds have returns that exceed their risk compensation. A defaulted bond can be seen as something that is between debt or equity, since the true status typically is unknown at the time of default. If the debt is serviced in the future, it might return to being a "normal" bond, but there can also be conversion into equity. This unknown status implies that either factors important for corporate bond pricing or equity pricing might be useful in risk-adjusting the defaulted bond returns.

Factors that have been found to influence corporate bond pricing in earlier studies are tested for my sample of defaulted bonds. This means that I test CAPM market risk factor and liquidity risk factors on returns from defaulted bonds. The market risk factor can be expected to increase in size after the default simply from the bond taking on a more equity like pay-off profile. The earlier tests are complemented with tests for liquidity risk in defaulted bonds. I construct bond liquidity factor series in Section 3.1. In addition to the test of bond factors I test the Fama and French factors as designed by Kritzman (2010), which have been successful in explaining equity returns.

The statistical models used to test for significance of factors are standard portfolio tests, with portfolio formation dependent on industry and seniority. The estimation equation can be seen in equation (6):

$$R_t - R_t^f = \alpha + \beta F_t + \varepsilon_t, \tag{6}$$

where R_t is the simple return of a bond at time t, R^f is the risk free return, F_t is a vector of factors, and ε_t is the error term. All tested factors are not zero cost portfolios. This implies that for the non-zero cost portfolios the average value of the factors can influence the estimated intercept, and hence the estimated excess return. As it turns out, this is not a problem since the intercepts are about the same size when the non-zero cost portfolios are included as when they are not included.

Studies on equity portfolio returns typically use value-weighted portfolios. My portfolios are equally weighted, since the market capitalization cannot be determined from my data set. It is also unclear what a value weighting would result in when equity values are very low, and bond values are reduced. The choice of equally weighted portfolios can give smaller issue bonds a relative large impact on the results.

2.3. Present value of recovery rates. To estimate the economic significance of the post default variations in the recovery rate, I calculate the present value of the recovery rate of face value (market price of the bonds divided by their face value) after default. I adjust the interest rate for market risk to see if the estimate for $\delta_{\tau+n}$ over time differs from the "at default" recovery rates for both book and market values. The discounting is presented below in equation (8).

Defaulted bonds are assets which need to generate risk-adjusted returns for investors to hold them. There should thus be an insignificant excess return (alpha) and insignificant betas if the use of a risk free asset as a proxy for the recovery value is a good assessment. The variability in price of the safe asset is by nature small, and the default probability is also small (empirically fractions of a percent per month). If the value in default is too depressed, then there should be excess returns in the months following the default. These excess returns are the fingerprints of the too low recovery rate. The sample is randomly divided into two groups to avoid discounting with in-sample betas. The first group is used to calculate betas for industry and seniority:

$$R_t^j - R_t^f = \alpha_j + \beta_j F_t + \varepsilon_t, \tag{7}$$

where R_t^j is the return on bond j at time t, R_t^f is the risk free return, F_t is a vector of factors, and ε_t is the error term. Time (t) runs from the time of default (τ) for k periods. The coefficient estimates are used for calculating the discount rate in the next equation.

The second group is used to calculate the out-of-sample present value of the equivalent recovery rate of face value ($RR = \dfrac{CleanPrice}{FaceValue}$). This operation is done to make the recovery rates comparable over time. Note that the excess return test is sufficient to answer the question of bias in the recovery rate at default. The present value of the recovery rates is calculated as:

$$PV(RR_{\tau+n}) = \frac{RR_{\tau+n}}{\prod_{i=\tau}^{\tau+n}(1+R_i^f + \hat{\beta}F_i)}, \quad (8)$$

where alpha is assumed to be zero and beta ($\hat{\beta}$) is the mean estimated parameter from the first group[1] estimated in accordance with equation (7). Equation (8) is used to calculate the present value up to nine months after default (n). The reason for this relatively short period is that the tests are if the recovery rate might be depressed at the time of default, not if there is a drift in the asset value.

3. Data

The sample consists of 247 companies with 374 defaulted bond price series. No company has issued more than 3.5 percent of the bonds in the sample. The sample is collected from the Thomson/Datastream database. All bonds in the sample have fixed coupons. The sample period covers almost ten years from January 2001 to August 2010. The bond returns have been winzorized at the one percent level. The winsorization decreases the number of high positive returns.

A problem with corporate bond data is typically thin trading and trade reporting. For the average bond in the Datastream sample, trade volume is registered in the ISMA TRAX system[2] in 11 percent of all months.

Datastream does not only rely on the TRAX system for price information, but mainly source their corporate bond data from FT Interactive Data (FTID). FTID uses market transactions and calculates prices using, amongst other things, bid information from their fund clients. According to FTID, prices are calculated to reflect verifiable information to the extent that it is formative for the good faith opinion of FTID as to what a buyer would pay for the bond in a current sale.

The price information has a tendency to go stale after the default, i.e., the same price is repeated during several time periods in the data set. If there is a problem with stale prices, the intercepts in the CAPM tests are negative since there is a financing cost (R^f), but no income from the bond. The default event seems to create trading volume. The average turn-over five months after default is 24 percent higher than the average turnover five months before default, measured in terms of face value.

Summary return statistics for the sample of defaulted bond are presented in Table 1. The return statistics are calculated using returns from ten months before and ten months after default for each bond.

Table 1. Monthly sample returns for defaulted bonds

Asset	Observations	Mean	Std. dev.	Skewness	Kurtosis	Min	Max
Entire sample	374	-0.01	0.15	-1.13	14.04	-1.00	0.58
Senior secured	38	-0.01	0.13	-1.66	23.05	-1.00	0.58
Senior unsecured	149	-0.01	0.16	-1.13	12.69	-1.00	0.58
Senior subordinated	70	-0.02	0.16	-1.20	12.84	-0.99	0.58
Subordinated	25	-0.00	0.16	-0.19	10.13	-0.99	0.58
Junior subordinated	46	-0.00	0.13	-1.46	16.42	-0.99	0.58
Unknown	46	-0.01	0.13	-0.88	17.17	-0.99	0.58
Oil & gas	10	-0.01	0.18	-0.41	9.09	-0.86	0.58
Basic material	43	-0.00	0.15	-0.58	14.10	-1.00	0.58
Industrials	41	-0.01	0.14	-1.45	17.18	-0.98	0.58
Consumer goods	54	-0.01	0.18	-1.12	11.53	-1.00	0.58
Health care	16	0.01	0.15	-0.93	14.64	-1.00	0.58
Consumer services	89	-0.01	0.14	-0.75	13.74	-0.99	0.58
Telecommunications	46	-0.02	0.18	-1.33	11.03	-1.00	0.58
Utilities	46	-0.00	0.11	-2.47	24.67	-0.99	0.58
Financial	7	-0.02	0.16	-1.25	13.71	-0.96	0.58
Technology	22	-0.02	0.17	-0.91	10.82	-0.94	0.58

Note: This Table presents returns from a sample of 279 defaulted corporate bonds. The bonds are collected from Thomson/Datastream. The return for each bond-month is the clean price return $\left(\frac{P_t - P_{t-1}}{P_{t-1}}\right)$. The seniority of the bonds has been identified from the EDGAR database. Bonds where the seniority has been unclear are classified as unknown. The classification into industries follows the ICB standard.

[1] Each bond is assigned a post-default beta in accordance with what grouping it belongs to.
[2] ISMA (the International Securities Market Association) is the self-regulatory organization and trade association for the international securities market (including the Eurobond market). ISMA TRAX is the ISMA trade matching and regulatory reporting system for the OTC markets.

There is a large negative return in each bond return series (the default) and this influences all moments of the return series. The maximum returns are all the same due to the winzorinzing. The mean return for the entire sample is negative, as well as for all groups in the sample. The standard deviations are high compared to the mean returns. The implication from the high standard deviation is that there is substantial differences between bond returns wihtin the sample, as well as within each segmentation. The skewness is negative and the kurtosis is high, so the sample that include before and after the default is non-normal.

The sample characteristics for the defaulted bonds can be expected to be different from a random sample of corporate bonds. The reason is that a random sample contains few defaults compared to this sample. I present the number of bonds with values exceeding their face value and the bonds with value less than two percent of the face value after default in Table 2.

Table 2. Bounce back and drop dead bonds after default

Category/month	1	2	3	4	5	6	7	8	9
Active bonds	374	373	373	371	369	365	364	361	361
Value > face value	16	17	16	18	20	19	22	22	23
Value < 2 percent face value	61	56	56	55	52	52	52	54	53

Note: This Table presents the number of bonds that recover after default and the number of bonds that are valued at less than 2 percent of face value up to nine months after the default event.

Few bonds bounce back to becoming priced as normal bonds after a default event. In my sample only 6.1 percent have values that exceed their face value after a default event. On the other side of the spectrum 14.1 percent of bond are worth less than two percent of their face value nine months after default. The number of highest priced bonds and the number of lowest priced bonds remain at about the same magnitude during the time period I study.

3.1. Liquidity measures. The liquidity risk is important for the pricing of corporate bonds, as it is mentioned before. There are many ways to operationalize the liquidity measure; three ways are measures of traded volume, market impact of a large transaction, and the size of the difference between the bid-and-ask spreads. The available bond data has low frequency (monthly) and contains only prices and traded volumes, so the return and volume based liquidity measures are used. In addiotion to the bond based measures, I also use two factors based on share prices. The idea with the share price based factors is that they capture general sensitivity of asset prices against systematic liquidity risk.

The two share based series are calculated according to Pástor and Stambaugh (2003) and Sadka (2006). The Pástor and Stambaugh set of series are available from 2001 through 2008. The Sadka series are available from 2001 through 2005. The Pástor and Stambaugh series are based on a volume reversal coefficient. They find that their market wide liquidity factor is priced. To complement the share price based liquidity measures, measures for liquidity risk are calculated from a sample of 10,742 U.S. corporate bond price series.

From the sample of corporate bond price series innovations are calculated in line with what Pástor and Stambaugh (2003) do for the stock market. Monthly data give a limited number of data points. The idea is to calculate the return response to trading volume. The response coefficient for each bond (i) is calculated using the OLS regression:

$$r^e_{i,t+1} = \theta_i + \phi_i r_{i,t} + \gamma_i \, sign\left(r^e_{i,t}\right) \cdot v_{i,t} + \varepsilon_{i,t}, \qquad (9)$$

where $sign(\cdot)$ is a function that takes on -1 or 1 depending on the sign of the input, and the variables are defined as in Pástor and Stambaugh (2003).

Table 3. Defined variables

$r_{i,t}$	the clean price return on bond i in month t
$r^e_{i,t}$	$r_{i,t} - r_{m,t}$, 0 where $r_{m,t}$ is the average clean price return on all the bonds in the sample during month t.
$v_{i,t}$	the nominal traded volume reported in the TRAX system for bond i in month t.
$\varepsilon_{i,t}$	the residual.

The gamma (γ) coefficient is the excess return response to trading volume. The $sign(\cdot)$ function eliminates the difference between positive and negative excess returns, making the coefficient linear in absolute volume. The underlying economic idea is that an increase in trading volume inflates the return in the first time period and when the trading volume decreases in the next time period the returns decrease, i.e., a return reversal. If this idea is correct the gamma can be expected to be negative on average. High trading volumes should be associated with negative excess returns in the next time period[1]. Only bond month observations where there is trade volume

[1] This is true, the mean γ for all bonds in the sample is negative -2.0e-009 with a standard deviation of 1.3e-007.

reported in TRAX are included in the regression. Monthly return observations with abnormally high (+10%) and low (-10%) returns are excluded. This gives 3,174 coefficient estimates for the entire period. For each time period the average gamma estimate is calculated:

$$\hat{\gamma}_t = \frac{1}{N}\sum_{i=1}^{N}\hat{\gamma}_{i,t}. \quad (10)$$

The average return response coefficient is a measure of how large the average return reversal is in the next time period. Pástor and Stambaugh (2003) have a problem with an upwards trend in their sample of NYSE and AMEX bonds. My shorter sample period does not exhibit this problem, and it does not have significant serial correlation[1], so the innovation is calculated in a similar manner, but exclude the dollar value scaling quota:

$$\Delta\hat{\gamma}_t = a + b\Delta\hat{\gamma}_{t-1} + c\hat{\gamma}_{t-1} + u_t. \quad (11)$$

The regression in equation (11) produces serially uncorrelated residuals. The residuals are the part of the changes in return response coefficients that does not depend on earlier changes or levels of return response coefficients. The idea is to clean the return response innovations from time series dependencies.

I calculate the innovation (L_t) in liquidity from the residuals (u_t):

$$L_t = \frac{1}{100}\hat{u}_t. \quad (12)$$

The rescaling by 100 is done according to Pástor and Stambaugh (2003), but is not necessary for the bond series, since the traded volumes typically are large in comparison to the returns. The effect of not rescaling means that the factor values are very small and that there will be some very large liquidity beta estimates.

In addition to the share-based series and the above bond liquidity measure, a second bond liquidity measure, AILLIQ, is calculated in line with Amihud (2002)[2]. More precisely, the AILLIQ measure is defined here as:

$$AILLIQ_t = 1/N_j\sum_{k=1}^{Nj}\frac{|r_{k,t}|}{v_{k,t}}, \quad (13)$$

where N_j is the number of bond observations in month t, $r_{k,t}$ is the clean price net return for bond k during period t, and $v_{k,y}$ is the reported daily average nominal volume in the TRAX system. $AILLIQ_t$ is thus the average quota between absolute clean price return and reported transaction volume. In the first month included (February 2001) there are 72 quotes. This is the smallest number of quotes in the sample and the maximum is 1,066.

The measures for liquidity risk are all based on changes in return in relation to trading volumes. The pair wise correlation between the liquidity series is calculated, to see if there are similarities between the different liquidity series.

Table 4. Pairwise correlation between liquidity measures

	AILLIQ	$\hat{\gamma}_t$	L_t	PS level	PS innov.	Sadka TF	Sadka PV
$\hat{\gamma}_t$	0.47						
	(0.00)						
L_t	0.280	0.31					
	(0.00)	(0.00)					
PS Level	-0.25	0.08	0.30				
	(0.01)	(0.44)	(0.00)				
PS Innov	-0.11	-0.13	0.27	0.74			
	(0.28)	(0.20)	(0.01)	(0.00)			
Sadka TF	-0.09	0.21	0.02	-0.02	-0.15		
	(0.48)	(0.11)	(0.86)	(0.90)	(0.24)		
Sadka PV	-0.18	0.22	0.02	0.04	0.09	0.25	
	(0.16)	(0.09)	(0.88)	(0.78)	(0.49)	(0.05)	

Note: This Table presents the pair wise correlations between the different measures of liquidity for the maximum available time periods for each measure. The measures are the AILLIQ measure, as calculated in equation (13), and the $\hat{\gamma}_t$, as calculated in equation (10). The L_t measure is the innovations in liquidity in the bond market, as calculated in equation (12). The two PS series (Level and Innov) are the level and innovations for the stock market in accordance with Pástor and Stambaugh (2003). The two Sadka series are fixed (TF) and variable (PV) price effects, calculated according to Sadka (2006). In parenthesis below each pair wise correlation is the p-value.

[1] The first order serial correlation is 0.20, slightly below Pastor and Stambaugh's 0.22, but not significant.

[2] Both bond series are calculated from February 2001 through 2010. Amihud sums over days when there has been trading, while here only the months when the TRAX system has reported trading volume is used in the cross-sectional calculations. Amihud calculates the absolute mean average daily return and here the absolute monthly return is calculated from clean prices, ignoring the possible effect of the accrued coupon.

The bond-based series (AILLIQ, $\hat{\gamma}_t$, and L_t) have low correlations with the share-based series. Only a few of the correlations between bond and share series are significantly different from zero. This is unexpected, since all series are expected to measure liquidity risk. The liquidity series seems to measure different aspects of liquidity since they are different from each other. The implication is that more than one liquidity measure needs to be used in the later tests.

3.2. Institutional setting. A company enters into default if: it fails to pay interest on the due date, it fails to pay the principal on the due date, it breaches any other covenants or warranties connected to the securities and the failure continues, or it declares itself in bankruptcy, insolvency or reorganization.

Firms in financial distress have a number of options for how to avoid bankruptcy. The two main options are to do an informal restructuring with the creditors or to file for bankruptcy protection under Chapter 11 of the U.S. bankruptcy code. Asquith and Gertner and Scharfstein (1994) find that only 42 of their 102 financially distressed firms file for bankruptcy. The firms try to avoid going into Chapter 11 since the process is costly. The way firms handle their distress situation helps to determine the value of the defaulted bonds.

Investors can purchase corporate bonds at issue or in the secondary market. On the secondary market corporate bonds are either traded over-the-counter or on an exchange. Only some of the corporate bonds that are traded through an exchange are formally listed. All bonds in the sample are quoted and traded at the New York Stock Exchange (NYSE). Most of the bonds in the sample (at least 80 percent) have or have had equities listed on one of the U.S. exchanges. The companies that have listed equity are required to follow standard disclosure and reporting regulations. There is no listing agreement for a debt issuer on NYSE, but the regulations for listed companies state that the issuer must release all relevant information immediately upon determining that the interest or principal will not be paid in full.

4. Results

4.1. Cross-section. The cross-sectional recovery rates are in line with the data of other studies, for instance by Altman and Kishore (1996) or the yearly Moody's report. Moody has a larger sample since they include bonds from several countries. The figures here include only US corporate bonds, so the parameters differ somewhat from Moody's. In Tables 5 through 7 the recovery rate based on market value grouped by seniority and industry is calculated.

Table 5. Average market value recovery rate on defaulted corporate bonds per year by seniority

	Senior sec.		Senior unsec.		Senior subo.		Subordinated		Junior sub.		Unknown	
Year	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number
2001	0.80	5	0.51	11	0.48	3	0.34	2	0.21	10	0.78	9
2002	0.85	9	0.49	69	0.43	22	0.43	9	0.58	10	0.63	9
2003	0.43	10	0.35	8	0.28	10	0.53	5	0.82	6	0.77	4
2004	0.98	1	0.55	5	0.52	9	-	0	-	0	0.96	1
2005	0.83	2	0.64	20	0.56	6	0.68	5	0.73	13	0.76	4
2006	0.94	2	0.71	4	0.46	3	0.75	1	0.79	3	0.97	1
2007	-	0	0.31	1	-	0	-	0	-	0	-	0
2008	0.65	3	0.43	19	0.49	11	0.41	3	0.29	2	0.34	3
2009	0.56	4	0.36	11	0.45	4	-	0	0.54	2	0.46	14
2010	0.52	2	0.04	1	0.01	2	-	0	-	0	0.99	1
Average	0.68	38	0.49	149	0.43	70	0.51	25	0.57	46	0.63	46
Book rate	0.55	38	0.30	149	0.25	70	0.24	25	0.43	46	0.50	46
Median	0.84		0.51		0.45		0.53		0.65		0.62	
Std. dev.	0.32		0.27		0.29		0.19		0.29		0.30	

Notes: This Table presents the average recovery rate for defaulted bonds. The recovery rate is calculated from clean prices as $1+\frac{P_t-P_{t-1}}{P_{t-1}}$.
The book rate is the average clean price on the month after default divided by the par value. Each estimate is followed by the number of observations used to calculate it.

The seniority of a corporate bond is an indicator for the level of the recovery rate. There is a pattern where both the average market and the book recovery rate are higher for the senior bonds and the junior subordinated bonds. There is a smile pattern in the average recovery rate. This is a bit unexpected, but could be caused by only less risky firms or firms with fixed assets being able to issue junior debt. The book recovery rates are lower than the recovery rates of market values. There are two reasons for this. First, the book recovery rate incorporates all price adjustments before the default and the recovery rate of market value only what is lost during the month of default. Second, the recovery rate of market value is calculated with a smaller denominator, due to the partial adjustment in price taking place before default. The lower recovery rate of book value indicates that the market, to some extent, has not anticipated the defaults.

I divide the sample into the ten ICB sector code industries and present the average recovery rate of market value in Table 6.

Table 6. Average market value recovery rate on defaulted corporate bonds per year by industry

	Oil & gas		Basic material		Indust.		Consumer goods		Health care		Consumer services		Telecom		Utilities		Financial		Tech	
Year	Rate	Nr	Rate	Nr	Rate	Nr	Rate	Nr	Rate	Nr	Rate	Nr	Rate	Nr	Rate	Nr	Rate	Nr	Rate	Nr
2001	-	0	0.41	4	0.65	3	0.43	3	-	0	0.76	9	0.37	4	0.48	15	0.78	1	0.17	1
2002	-	0	0.51	4	0.55	18	0.63	6	0.55	9	0.61	25	0.38	36	0.64	20	0.19	3	0.48	7
2003	0.68	2	0.48	13	0.32	6	0.41	4	0.29	3	0.69	12	0.05	2	-	0	-	0	0.20	1
2004	0.87	2	0.28	2	0.47	2	0.45	5	0.04	1	0.98	2	0.96	1	0.98	1	-	0	-	0
2005	-	0	0.88	2	0.82	2	0.58	10	0.88	3	0.69	19	-	0	0.72	9	-	0	0.34	4
2006	-	0	-	0	0.61	2	0.64	8	-	0	0.95	2	-	0	0.95	1	-	0	0.95	1
2007	-	0	-	0	-	0	-	0	-	0	0.31	1	-		-	0	-	0	-	0
2008	0.38	4	0.45	14	0.51	4	0.35	7	-	0	0.45	6	-	0	-	0	0.42	1	0.58	5
2009	0.57	1	0.51	4	0.63	4	0.48	10	-	0	0.43	9	0.16	3	-	0	0.40	1	0.27	3
2010	0.99	1	-	0	-	0	0.04	1	-	0	0.26	4	-	0	-	0	-	0	-	0
Average	0.62	10	0.48	43	0.54	41	0.50	54	0.53	16	0.62	89	0.36	46	0.62	46	0.45	7	0.44	22
Median	0.64		0.49		0.60		0.54		0.56		0.58		0.28		0.74		0.40		0.41	
Std. dev.	0.30		0.24		0.30		0.31		0.29		0.25		0.26		0.31		0.32		0.28	

Notes: This Table presents the average recovery rate for defaulted corporate bonds. The recovery rate is calculated from clean prices as $1+\frac{P_t - P_{t-1}}{P_{t-1}}$. Each estimate is followed by the number of observations used to calculate it.

In general, each year has only a few data points, so it is not possible to draw any strong conclusions on the time variation from this grouping. From a risk perspective the Telecom, Financial and Technology sectors show the lowest averages and the lowest medians. The standard deviations are in the same magnitude for all segmentations indicating a substantial spread in all segments. For example, the standard deviation for the oil & gas industry is 48.4 percent of the mean.

Firms in different industries typically have different compositions of assets. The recovery rates grouped by seniority and industry are presented in Table 7.

Table 7. Average market recovery rate on defaulted corporate bonds by seniority and industry

	Senior Sec.		Senior Unsec.		Senior Subo.		Subordinated		Junior sub.		Unknown	
Industry	Rate	Nr	Rate	Nr	Rate	Nr	Rate	Nr	Rate	Nr	Rate	Nr
Oil & gas	0.90	1	0.57	5	0.72	1	-	0	-	0	0.57	3
Basic material	0.45	8	0.46	10	0.50	13	0.54	3	0.48	2	0.48	7
Industrials	0.61	5	0.64	14	0.41	18	-	0	0.72	1	0.67	3
Consumer goods	0.39	3	0.47	21	0.37	16	0.75	1	0.70	10	0.84	3
Health care	-	0	0.51	11	0.58	4	0.65	1	-	0	-	0
Consumer services	0.65	8	0.53	27	0.46	9	0.58	12	0.75	13	0.75	20
Telecomm.	0.91	1	0.34	29	0.81	1	0.42	5	0.30	6	0.31	4
Utilities	0.92	9	0.61	19	0.29	1	0.01	1	0.43	12	0.74	4
Financial	-	0	0.70	3	0.28	3	0.17	1	-	0	-	0
Technology	0.87	3	0.38	10	0.38	4	0.39	1	0.50	2	0.19	2

Note: This Table presents the average recovery rate for defaulted bonds. The recovery rate is calculated from clean prices as $1+\frac{P_t - P_{t-1}}{P_{t-1}}$.

The cross-sectional recovery rates are in line with earlier results. This is of course given from the fact that the use the same data, but it seems like the smile pattern identified in Section 4.1 is present in the industry and concumer services indistries. From Tables 5 and Table 6 it is clear that there is time variation in the recovery rates. A different type of time variation is the theme of the next Section, the after default time return variation.

4.2. Time-series. Time-series of defaulted bond returns are problematic, since they contain both stale prices and 'dead cat bounces'[1]. Stale prices will in this setup give zero returns on the bond and make it harder to find excess returns. In later periods when the potentially stale price adjusts, it is easier to find excess returns. Cross-sectional smoothing should alleviate this problem. For a schematic overview of what happened to the mean returns of defaulted corporate bonds I include Figure 1. The mean excess return in Figure 1 is calculated as: $R_\tau = \frac{1}{N}\sum_{i=1...N}(R_{\tau,i} - R_\tau^f))$, where N is the number of bonds, τ is the time period, $R_{\tau,i}$ return on bond i, and R_τ^f the risk free rate. The cumulative mean excess return is the cumulative sum of the presented mean excess returns.

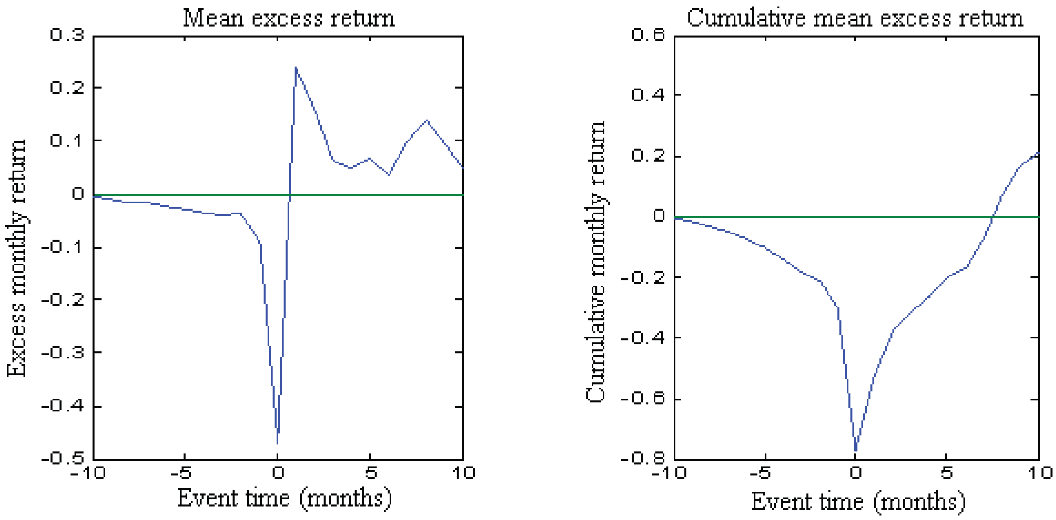

Fig. 1. Mean excess return on defaulted corporate bonds 2001-2010

The mean excess return from corporate bonds is negative before the default occurs, implying that investors adjust their pricing before the default. This adjustment can also have happened for many bonds not entering into the default state, so it does not necessarily carry any information. More interesting is that, as can be seen in Figure 1, the mean excess return is consistently positive after the default. The fairly sharp rise in returns in the months after the default implies that there might be an overshooting effect, at least for the mean excess return.

The positive mean excess return after default raises the question of what bonds perform well after the default. Is it the same bonds that consistently do well in a turnaround situation? To try and answer this question I rank the sample into deciles depending on their return one month after the default.

Table 8. Average excess return in decile portfolios after default

Portfolio/month	1	2	3	4	5	6	7	8	9	10	Mean	ρ
Portfolio 1	-0.43	1.44	-0.01	0.04	0.15	0.06	0.37	0.46	0.19	0.18	0.24	-0.49
Portfolio 2	-0.17	0.06	0.08	0.16	0.13	0.00	0.09	0.03	0.09	0.13	0.06	0.05
Portfolio 3	-0.08	-0.03	0.04	0.07	0.01	0.03	0.07	0.06	0.08	0.05	0.03	0.39
Portfolio 4	-0.02	0.01	0.08	0.06	0.07	0.04	-0.00	0.02	0.03	0.01	0.03	0.28
Portfolio 5	-0.00	0.01	0.34	0.01	0.04	0.01	0.01	0.01	0.40	0.02	0.08	-0.29
Portfolio 6	-0.00	0.09	0.09	0.03	0.10	-0.00	0.37	0.97	-0.01	0.01	0.16	0.08
Portfolio 7	0.02	0.04	0.02	0.02	-0.00	0.03	0.04	0.00	0.02	0.02	0.02	-0.13
Portfolio 8	0.09	-0.01	0.03	0.01	-0.01	0.09	0.03	0.02	0.03	0.04	0.03	-0.37
Portfolio 9	0.27	-0.05	0.03	-0.02	0.13	0.08	0.07	0.09	0.06	0.03	0.07	-0.29
Portfolio 10	2.77	0.01	-0.06	0.14	0.09	0.01	0.08	0.09	0.12	0.00	0.33	-0.03
Mean	0.24	0.16	0.06	0.05	0.07	0.03	0.11	0.18	0.10	0.05	0.11	0.28

Notes: This Table presents the average clean price excess return for decile portfolios ranked on log excess return the month after default. The average log excess return for each decile portfolio is presented for ten months following the default. ρ is the first order autocorrelation coefficient for the mean excess returns in each portfolio.

[1] A dead cat bounce is when a moderate rise in the price of a stock follows a spectacular fall, with the connotation that the rise does not indicate improving circumstances.

From the mean excess returns per portfolio in Table 8 it is not evident that some bonds will recover more than others, or that there is any pattern from the return ranking. Longer ranking periods have been tested, but the results are similar with no clear pattern in the cross section. The median variability for the portfolio returns is 0.01, with two outliers (Portfolios 1 and 8). The potential turn around in excess returns after default is present in all ten portfolios. The strong excess returns could however be explained by risk. The correlations are fairly large, but not significant.

4.2.1. Risk explanations. Two risks for corporate bonds can be expected to survive a default: the market and the liquidity risks. The market risk could even be expected to increase since the bond after default has a pay-off profile more resembling that of a share. Predicting how the liquidity risk should change is not as clear cut. The increase in volume after default decreases the risk associated with selling the bonds, but trading on asymmetric information could increase the risk.

The initial test on the entire sample of defaulted corporate bonds is presented in Table 9 below. I test for excess returns before and after the default event. All the liquidity factors calculated in Section 3.1 are used, but only four of them are presented in Table 8. The excluded ones are not significant and the intercept and market beta are no different than the ones presented in Table 9. The risk factors defined by Fama and French (1992) are also used as additional controls, and reported in Table 1 in Appendix. The results are similar to the ones in Table 9, where the SMB and HML coefficients are significant before default. After default HML is significant if not combined with any of the liquidity factors. SMB is significant in two tests. The intercept and market beta are only marginally different when the SMB and HML factors are included.

Table 9. Return beta representation for the one-factor model and the liquidity factor

Panel A. Bond betas before default										
Intercept	-0.03	(-7.62)	-0.01	(-2.19)	-0.03	(-7.70)	-0.03	(-8.82)	-0.03	(-7.73)
β_{Market}	0.60	(9.85)	0.43	(6.39	0.60	(9.31)	0.57	(9.06)	0.29	(4.45)
β_{AILLIQ}			-11,538	(-5.87)						
$\beta_{P\&SBond}$					-758,884	(-0.79)				
$\beta_{P\&SStock}$							0.13	(2.16)		
β_{Sadka}									2.07	(2.51)
Obs.		3,188		3,188		3,148		3,033		2,393
R^2		0.03		0.04		0.03		0.04		0.01
$\overline{R}^2$		0.03		0.04		0.03		0.04		0.01
Panel B. Bond betas after default										
Intercept	0.09	(5.42)	0.07	(2.24)	0.09	(5.29)	0.05	(4.22)	0.05	(3.69)
β_{Market}	0.98	(2.46)	1.00	(2.43)	0.98	(1.99)	0.53	(4.98)	0.49	(4.06)
β_{AILLIQ}			11,697	(0.85)						
$\beta_{P\&SBond}$					190,417	(0.03)				
$\beta_{P\&SStock}$							0.02	(0.16)		
β_{Sadka}									-0.07	(-0.03)
Obs.		3,591		3,591		3,591		2,892		2,497
R^2		0.00		0.00		0.00		0.00		0.00
$\overline{R}^2$		0.00		0.00		0.00		0.00		0.00
$R^e = \alpha + \beta F + \varepsilon$										

Notes: In this Table the one-factor model, and two-factor liquidity models, are tested on a sample of defaulted bonds, measured in default time. Panel A consists of the estimated coefficients before the default event and Panel B consists of the estimated coefficients after the default. The data is pooled for ten months before default (Panel A) and ten months after default (Panel B). The market beta (β_{Market}) uses the market factor by Fama and French (1992). The liquidity measures are based on the studies of Amihud (2002), Pástor and Stambaugh (2003) and Sadka (2006). The specifications of the liquidity measures are described in Section 3.1, equations (12) and (13). The t-statistics are presented within parenthesis and calculated using robust standard errors.

Three of the liquidity risk factors are significant before the default event. None of the liquidity factors are significant after default. Either the measures of liquidity risk do not influence pricing for bond in default, or the measures are inadequate for capturing the liquidity risk. The AILLIQ and P&S bond betas are very large, as anticipated[1]. However, they do not seem to influence the size of the intercept much and are insignificant, so the potential problem with bias in the intercept is most likely minor.

The intercepts in Panel A are negative, indicating that bonds have poor returns before a possible default. The estimated betas are high for corporate bonds (0.29-0.60) compared to betas for going concerns estimated by Weinstein (1981) (mean betas against stock market 0.03-0.21 during the period of 1964-1972) or Thorsell (2008) (0.06 during the period of 2001-2005). Now, these bonds are part of a choice-based sample, and do default, but this pattern could be present in other bonds as well, so it is not a certain indicator of imminent default. The risk measures in the test do not do a good job at capturing the variability, as measured by the R^2 (1 percent). The intercepts and the market betas are all significantly different from zero, but some of the liquidity coefficients are not. The low significance of the liquidity coefficients is puzzling, considering that trading volumes tends to increase both before and after default, and that liquidity risk is a common explanation for corporate bond returns. The liquidity factors have only slightly higher significance if the market beta is left out of the regressions. Hence it is not the market beta that crowds out the liquidity factors.

After the default event, in Panel B, the sample can be considered to be a random selection of defaulted bonds. The intercepts turn positive (0.05-0.09) and are significant. Considering that the intercepts are the average monthly unexplained excess return, they are very high. The median unexplained excess return is about 0.0 percent per month. This difference between mean and median indicates that the distribution is non-normal. The robust standard errors defined by White (1980) are used to decrease the problem with non-normality. The market beta of the defaulted bonds increase to 0.49-1.00, as could be expected from the bond becoming more equity-like. The variance in the clean price returns increases from a mean of 0.04 before default to a mean of 1.03 after default. As could be expected from the significant intercept and insignificant parameter estimates the R^2 is zero.

The performance of the tested risk factors and the large positive intercept from Table 8 indicates that a portfolio of defaulted bonds acquired at default generates excess returns. The spread of returns in Table 7 is fairly even, and it looks like most defaulted bonds have an expected positive return. The conclusion is that the average bond is underpriced in the default month, and that at least the risks I have tested are not the sole reason for this underpricing.

Market risk, and to some extent liquidity risk, seems to be important for the pricing of defaulted bonds. The large variation in post default returns and earlier cross-sectional results on industries and seniority give cause to investigate if the risk profile differs in these dimensions.

4.2.2. Seniority. The debt priority order in bankruptcy determines in what order bonds value is recovered in bankruptcy. The different priority bonds typically get paid in different fractions (see Table 5 for the markets estimates at default). The standard deviation also differs between the different priorities. It could thus be expected that both the intercept and the market beta varies depending on priority ranking. The data on the priority ranked portfolios is presented below in Table 10.

Table 10. Return beta representation for seniority ranked portfolios

Panel A. Bond betas before default							
Priority	Intercept		β_{Market}		Obs.	R^2	$\overline{R}^2$
Senior secured	-0.02	(-1.69)	0.42	(2.50)	310	0.02	0.02
Senior unsecured	-0.03	(-5.16)	0.60	(6.01)	1317	0.03	0.03
Senior subordinated	-0.03	(-4.32)	0.84	(6.22)	629	0.06	0.06
Subordinated	-0.04	(-3.20)	0.62	(2.60)	203	0.03	0.03
Junior subordinated	-0.04	(-5.16)	0.59	(4.23)	367	0.05	0.04
Unknown	-0.00	(-0.20)	0.45	(1.74)	328	0.01	0.01
Panel B. Bond betas after default							
Senior secured	0.10	(1.17)	2.91	(1.79)	358	0.01	0.01
Senior unsecured	0.13	(3.54)	0.81	(1.20)	1401	0.00	0.00
Senior subordinated	0.09	(2.95)	-0.08	(-0.13)	644	0.00	0.00
Subordinated	0.10	(2.56)	1.57	(1.90)	249	0.01	0.01
Junior subordinated	0.05	(2.45)	1.16	(2.62)	457	0.01	0.01
Unknown	0.04	(3.98)	1.14	(5.98)	392	0.08	0.08
$R^e = \alpha + \beta F + \varepsilon$							

Notes: In this Table the one-factor model is tested on a sample of defaulted bonds, measured in default time. Panel A consists of the estimated coefficients before the default event and Panel B consists of the estimated coefficients after the default. The data is pooled for ten months before default (Panel A) and ten months after default (Panel B). The market beta (β_{Market}) uses the market factor defined by Fama and French (1992). The t-statistics are presented in parentheses and calculated using robust standard errors.

[1] This is a result from the choice not to rescale the liquidity measures.

The tests for the priority ranked sample in Table 9 have similar results as the entire sample in Table 9. The explained variation (R^2 and $\overline{R}^2$) is still low, indicating that the risk, as measured by the tested factors, has little to do with the returns post default. The intercepts for the seniority groups are negatively correlated before and after default. This is shown for the seniority grouped sample in Figure 2 below.

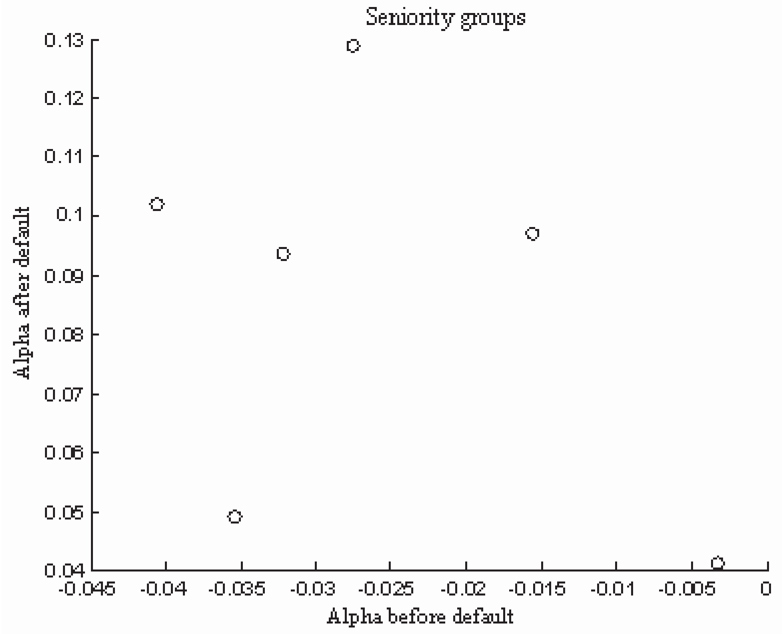

Fig. 2. Intercepts before and after default for seniority grouped sample

The negative correlation before and after default is valid for the entire sample, and to a lesser degree for the industry and return ranked groups. The alphas before default and the alphas after default have a negative correlation coefficient of -0.38. The alphas after default are positive, so either the negative correlation is a sign of an overshooting effect (mispricing) or there are unknown risks that are not controlled for. To the extent that the risks in Table 8 and Table 1 (in Appendix) are controlled for the intercept is still significant and positive. If the explanation is mispricing, then the size of the overshooting is different for different seniorities.

4.2.3. Industry. The sample is divided into industry portfolios and test are presented for market risk in Table 10 below. The idea is that the assets and leverages are similar within industries but differ between industries. The industry sample should help to give an indication if there are specific industry risks that generate the results in Table 8.

Table 10. Return beta representation for industry ranked portfolios

Priority	Intercept		β_{Market}		Obs.	R^2	$\overline{R}^2$
Panel A. Bond betas before default.							
Oil & gas	-0.03	(-3.00)	1.10	(6.93)	84	0.36	0.36
Basic material	-0.03	(-4.06)	0.52	(4.20)	387	0.04	0.04
Industrials	-0.02	(-2.19)	0.44	(2.78)	342	0.02	0.02
Consumer goods	-0.02	(-1.45)	0.72	(3.10)	449	0.02	0.02
Health care	-0.01	(-0.53)	0.37	(1.82)	143	0.02	0.02
Consume services	-0.02	(-2.44)	0.85	(5.18)	740	0.03	0.03
Telecommunications	-0.04	(-4.71)	0.57	(3.45)	407	0.03	0.03
Utilities	-0.02	(-4.57)	0.12	(1.26)	358	0.00	0.00
Financial	-0.07	(-2.75)	0.19	(0.45)	56	0.00	0.00
Technology	-0.06	(-4.27)	0.56	(2.24)	188	0.03	0.02
Panel B. Bond betas after default.							
Oil & gas	0.07	(2.09)	1.50	(2.86)	90	0.08	0.07
Basic material	0.17	(2.80)	-1.39	(-1.24)	424	0.00	0.00
Industrials	0.04	(2.62)	0.59	(2.15)	374	0.01	0.01
Consumer goods	0.23	(2.26)	3.49	(1.67)	476	0.01	0.00
Health care	0.21	(1.33)	1.98	(0.64)	154	0.00	0.00

Table 10 (cont.). Return beta representation for industry ranked portfolios

Priority	Intercept	β_{Market}	Obs.	R^2	$\overline{R}^2$	Priority	Intercept
Panel B. Bond betas after default.							
Consumer services	0.04	(2.69)	1.21	(3.69)	826	0.02	0.02
Telecommunications	0.02	(1.36)	0.91	(4.25)	437	0.04	0.04
Utilities	0.05	(2.11)	0.17	(0.38)	456	0.00	0.00
Financial	0.32	(1.41)	-2.29	(-0.53)	69	0.00	0.00
Technology	0.10	(2.95)	1.57	(2.77)	195	0.04	0.03
$R^e = \alpha + \beta F + \varepsilon$							

Notes: In this Table the one-factor model is tested on a sample of defaulted bonds, measured in default time. Panel A consists of the estimated coefficients before the default event and Panel B consists of the estimated coefficients after the default. The data is pooled for ten months before default (Panel A) and ten months after default (Panel B). The market beta (β_{Market}) uses the market factor defined by Fama and French (1992). The t-statistics are presented in parentheses and calculated using robust standard errors.

The pattern for intercepts and betas are similar to Table 9 and Table 10. Industry segmentations after default reveals betas in excess of one for a few industries. This is slightly surpricing since that would indicate that the defaulted bonds in these industries have higher risk than an investment in the market. If the test is run on a pre-crisis sample of 2001-2006, only one beta value is in excess of one. This indicates that the financial crisis has increased the percieved riskyness of the defaulted bonds.

4.2.4. Return ranked portfolios. As an additional robustness test, the return ranked portfolios from Table 8 are tested for market risk. The default and ranking months are not included in the tests. The test against the market risk is presented in Table 12.

Table 11. Return beta representation for return ranked portfolios

Priority	Intercept		β_{Market}		Obs.	R^2	$\overline{R}^2$
Panel A. Bond betas before default							
Portfolio 1	-0.04	(-3.97)	1.31	(8.24)	359	0.16	0.16
Portfolio 2	-0.03	(-4.54)	0.46	(3.56)	343	0.04	0.03
Portfolio 3	-0.01	(-0.45)	0.24	(0.79)	316	0.00	0.00
Portfolio 4	-0.01	(-1.02)	0.45	(3.26)	316	0.03	0.03
Portfolio 5	-0.03	(-3.19)	0.18	(0.91)	335	0.00	0.00
Portfolio 6	-0.03	(-2.24)	0.63	(2.71)	295	0.02	0.02
Portfolio 7	-0.02	(-2.48)	0.21	(1.61)	226	0.01	0.01
Portfolio 8	-0.01	(-2.23)	0.33	(2.89)	311	0.03	0.02
Portfolio 9	-0.03	(-4.72)	0.66	(4.80)	367	0.06	0.06
Portfolio 10	-0.05	(-2.47)	0.73	(2.43)	286	0.02	0.02
Panel B. Bond betas after default							
Portfolio 1	0.26	(1.90)	3.60	(1.63)	296	0.01	0.01
Portfolio 2	0.08	(6.91)	0.51	(2.48)	342	0.02	0.01
Portfolio 3	0.03	(2.89)	0.85	(4.27)	336	0.05	0.05
Portfolio 4	0.03	(3.13)	0.71	(3.33)	325	0.03	0.03
Portfolio 5	0.10	(1.76)	-0.55	(-0.49)	320	0.00	0.00
Portfolio 6	0.17	(1.53)	0.75	(0.32)	247	0.00	0.00
Portfolio 7	0.02	(4.19)	0.32	(2.87)	338	0.02	0.02
Portfolio 8	0.02	(2.13)	0.86	(4.65)	341	0.06	0.06
Portfolio 9	0.04	(2.97)	1.32	(5.03)	329	0.07	0.07
Portfolio 10	0.03	(1.47)	1.30	(3.80)	264	0.05	0.05
$R^e = \alpha + \beta F + \varepsilon$							

Note: In this Table the one-factor model is tested on a sample of defaulted bonds, measured in default time. Panel A consists of the estimated coefficients before the default event and Panel B consists of the estimated coefficients after the default. The data is pooled for ten months before default (Panel A) and ten months after default (Panel B). The market beta (β_{Market}) uses the market factor defined by Fama and French (1992). The t-statistics are presented in parentheses and calculated using robust standard errors.

The results for the intercepts and betas and their significance levels before the default event are similar to the earlier tests (in Tables 9, 10, and 11). The intercepts are, like in the other tests, positive and often significant.

The results from this sections shows that the overshooting effect at default time cannot be attributed to the proxies for market risk or liquidity risk. Further, it is also not possible to segment out which bonds have the overshooting effect. It is present across the line when segmentations are done on seniority, industry and return ranking. This indicated that the reason for the mispricing at default is mispricing.

4.3. Present value of recovery rates. The excess returns that follow the default event cannot be explained by the tested risk factors (market risk, SMB, HML and seven different liquidity factors). The intercepts are significant and large (in the range of 0.01-0.13) after default. The high returns and the low impact of the tested risk factors indicate that the recovery rate might be biased (too low) one month after default.

Another way of looking at the excess returns post default is to discount the future recovery rates to the default date. If the present values deviate from the recovery rate at default there is a bias. The question is how large the bias is, and if it is economically significant. For this purpose, the recovery rate of market value in column (1), the recovery rate of face value (3) and the present value of the recovery rates of face value (4)-(11) are calculated during nine months after default in Table 12. The average market beta is used to calculate discount rate. The market beta increases from 0.24 to 0.63 between the first and second half of the sample. This change in market beta means that the earlier discounted recovery rates are discounted using a too low discount rate, but that later periods have a more correct discount rate.

Table 13. Risk-adjusted discounted recovery rates

Asset/recovery rate	Market	Book										
		τ	+1	+2	+3	+4	+5	+6	+7	+8	+9	Obs.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Entire sample	0.52	0.59	0.40	0.40	0.40	0.42	0.43	0.43	0.45	0.46	0.47	227
Senior secured	0.68	0.71	0.56	0.59	0.62	0.62	0.63	0.64	0.64	0.63	0.62	23
Senior unsecured	0.59	0.51	0.32	0.32	0.33	0.33	0.34	0.34	0.35	0.36	0.37	94
Senior subordinated	0.43	0.45	0.27	0.28	0.28	0.30	0.34	0.37	0.39	0.40	0.41	40
Subordinated	0.55	0.39	0.23	0.24	0.24	0.24	0.25	0.25	0.27	0.30	0.30	15
Junior subordinated	0.52	0.66	0.41	0.43	0.45	0.47	0.48	0.51	0.53	0.53	0.56	28
Unknown	0.71	0.70	0.53	0.53	0.54	0.57	0.57	0.57	0.58	0.66	0.70	31
Oil & gas	0.71	0.57	0.45	0.43	0.42	0.44	0.45	0.46	0.46	0.47	0.53	5
Basic material	0.45	0.47	0.23	0.27	0.27	0.29	0.31	0.33	0.35	0.38	0.43	26
Industrials	0.55	0.60	0.44	0.43	0.43	0.45	0.47	0.49	0.49	0.51	0.52	24
Consumer goods	0.62	0.53	0.35	0.35	0.36	0.39	0.40	0.46	0.51	0.51	0.51	31
Health care	0.47	0.71	0.43	0.46	0.45	0.45	0.52	0.47	0.49	0.52	0.51	9
Consumer services	0.65	0.62	0.45	0.44	0.45	0.46	0.47	0.47	0.47	0.49	0.49	54
Telecomm.	0.50	0.33	0.17	0.22	0.19	0.20	0.19	0.20	0.22	0.27	0.25	29
Utilities	0.54	0.80	0.54	0.58	0.59	0.58	0.59	0.57	0.59	0.63	0.67	28
Financial	0.40	0.12	0.04	0.07	0.09	0.11	0.11	0.11	0.16	0.11	0.11	4
Technology	0.40	0.44	0.34	0.34	0.38	0.39	0.40	0.43	0.43	0.38	0.36	14

Note: This Table presents the net present value of the future book recovery rates discounted with a risk-adjusted interest rate. $PV(RR_{\tau+n}) = \frac{RR_{\tau+n}}{\prod_{i=\tau}^{\tau+n}(1+r_i^f+\hat{\beta}F_i)}$. RR_τ is the recovery rate at default time τ, R^f the risk free interest rate, n is the number of periods after default, $\hat{\beta}$ is the estimated standardized covariance for the asset, and F is the market return.

The results in Table 12 are conclusive in the sense that recovery value increases as the months go by (4)-(11). For the entire sample the average mean discounted recovery value nine months out (11) is seven percentage points higher than the recovery value one month after default (3). The standard method for calculating the recovery rate that uses one month after default seems to underestimate the recovery value by about 17.5 percent. The cross-sectional variation is there, both in terms of seniority and industry, but the result with increasing recovery rate over time is robust. Investors that sell corporate bonds one month after default receive, on average, a lower risk-adjusted price for their bonds than investors that wait. Further, using the biased measure of default value will bias price and return estimates. This result could be expected since it is the same result as found in Section 4.2, even if the magnitude in terms of recovery rates was unknown.

In addition to the calculations for Table 13 I have done in-sample tests using the generalized method of moments method (GMM) from work of Hansen (1982). When there are solutions to the moment conditions[1] the estimates deviate from the estimates in Table 13, but the pattern of increasing recovery rates over time is as strong as in Table 13. I have applied the efficient weighting matrix in the calculations. The use of GMM allows for calculations of t-statistics on the discounted present value of the future recovery rates in parallel to the estimates in Table 13. The estimates of discounted recovery rates are significantly different from zero. In the entire sample the default recovery rate is 0.35 and the nine month out recovery rate is 0.41. The difference between the default recovery rate and the nine months out present value of the recovery rate has a robust t-statistic of about 0.57 and is not statistically significant.

[1] $g_T(\hat{\theta}) = \begin{bmatrix} \hat{R}R - \dfrac{RR_{i,n}}{\prod_{j=1}^{n}(1+R_j^f+\hat{\beta}_i\lambda_j)} \\ \sum_{k=1}^{n} R_{i,k} - R_k^f - \hat{\beta}_i\lambda_k \end{bmatrix}$, where $\hat{R}R$ and $\hat{\beta}$ are the estimated parameters, i is the bond, n is the number of time periods the recovery rate is discounted, R^f is the risk free rate, λ is the market risk factor, and $R_{i,k}$ is the bond return on bond i in period k.

The return tests in Table 9 through Table 12 measure the same effect as the test of difference in recovery rates. The reason the former tests have significant results and the latter test not is that they are based on many more observations. For each 'entire sample' estimate of returns there are over two thousand observations (Table 9) and for the discounted recovery rate there are only 360 (Table 13).

The excess simple return for the entire sample is 0.05-0.09 per month. The difference between recovery rates (0.40 against 0.47) is only 17.5 percent over nine months. At first glance the monthly returns and the total difference in recovery rate seems unreconcilable. The reason for this apparent discrepancy is that the probability that an investor will receive the expected return or more is less than 50 percent[1]. Compounding over time means that the expected return is going to be higher than the median return, i.e., large returns with low probability increase the expected return.

Conclusions

The descriptive data on the cross-section for defaulted bonds aligns with previous findings on how defaulted bonds are priced. The findings in the post-default time-series data are new. The claim on the bias in recovery rate estimations is validated by the increases in the average discounted recovery rate.

My tests for excess returns in defaulted corporate bond returns give significant excess returns. The explained variation in excess return is low with R^2 values. The risks factors I use to explain the returns does not eliminate the excess return, as measured by alpha. The market factor influences the post default return for the majority of portfolios (as can be seen in Tables 10-12). The other factors give some help in explaining the returns. Perhaps most interesting is the weak performance of the liquidity factors, since they are important for pricing of corporate bonds for non defaulted bonds.

The remaining excess return, when risk factors are controlled for, is positive and significant in my sample, and in the robustness checks (seniority and industry). The dispersion of the returns increases after default, as can be (indirectly) seen in Table 8. I can not find a suitable risk explanation for the positive intercepts, so perhaps asymmetric information and investor specialization is the key to understanding the apparent mispricing. If it is mispricing, the owner of a default bond need not adjust the price when selling the bond as much has been done in my sample. The holder of a defaulted bond cannot regain the loss that was incurred at default, but there is no reason to abstain from the high unexplained returns following default. The high excess returns could also potentially spill over to bond prices before default, but the size of the difference between at default and future discounted recovery rates is small (17.5 percent), making this point less important.

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[1] Kritzman (2000) provides an intuitive explanation for this in Chapter 4 "Why the Expected Return Is Not to Be Expected".

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Appendix

Table 1. Return beta representation for the three-factor model and the liquidity factor

Panel A. Bond betas before default										
Intercept	-0.03	(-8.49)	-0.02	(-2.98)	-0.03	(-8.37)	-0.04	-(10.06)	-0.03	(-8.54)
β_{Market}	0.57	(8.39)	0.42	(5.59)	0.56	(7.79)	0.57	(8.49)	0.29	(3.52)
β_{SMB}	0.40	(8.76)	0.29	(6.07)	0.39	(8.68)	0.42	(10.99)	0.46	(7.23)
β_{HML}	0.48	(4.01)	0.20	(3.21)	0.43	(11.54)	0.63	(14.69)	0.37	(3.83)
β_{AILLIQ}			-9,397	(-3.97)						
$\beta_{P\&SBond}$					-387,883	(-0.40)				
$\beta_{P\&SStock}$							0.15	(2.52)		
β_{Sadka}									-0.93	(-0.74)
Obs.		3,154		3,188		3,148		3,033		2,393
R^2		0.04		0.04		0.04		0.05		0.02
$\overline{R}^2$		0.04		0.04		0.04		0.05		0.02
Panel B. Bond betas after default										
Intercept	0.09	(4.72)	0.06	(1.77)	0.09	(4.67)	0.04	(3.61)	0.06	(3.68)
β_{Market}	0.78	(2.07)	0.78	(1.74)	0.74	(1.29)	0.61	(4.71)	0.56	(3.94)
β_{SMB}	0.82	(1.90)	0.78	(2.37)	0.84	(2.44)	0.11	(0.75)	0.17	(0.69)
β_{HML}	0.71	(0.72)	0.94	(5.21)	0.73	(4.39)	0.66	(6.51)	0.93	(3.44)
β_{AILLIQ}			14,815	(1.04)						
$\beta_{P\&SBond}$					-1,789,445	(-0.25)				
$\beta_{P\&SStock}$							-0.09	(-0.63)		
β_{Sadka}									-3.90	(-1.08)
Obs.		3,591		3,591		3,591		2,892		2,497
R^2		0.00		0.00		0.01		0.00		0.00
$\overline{R}^2$		0.00		0.00		0.01		0.00		0.00
$R^e_{\tau,i} = \alpha + \beta F_{\tau,i} + \varepsilon_{\tau,i}$										

Notes: In This table the three-factor model is tested on a sample of defaulted bonds, measured in default time. Panel A consists of the estimated coefficients before the default event and Panel B consists of the estimated coefficients after the default. The data is pooled for ten months before default (Panel A) and ten months after default (Panel B). The market, the SMB and HML betas (β_{Market}, β_{SMB}, β_{HML}) uses the market factor defined by Fama and French (1992). The liquidity measures are based on Amihud (2002), Pástor and Stambaugh (2003) and Sadka (2006). The specifications of the liquidity measures are described in Section 4.1. The t-statistics are presented within parentheses and calculated using robust standard errors.

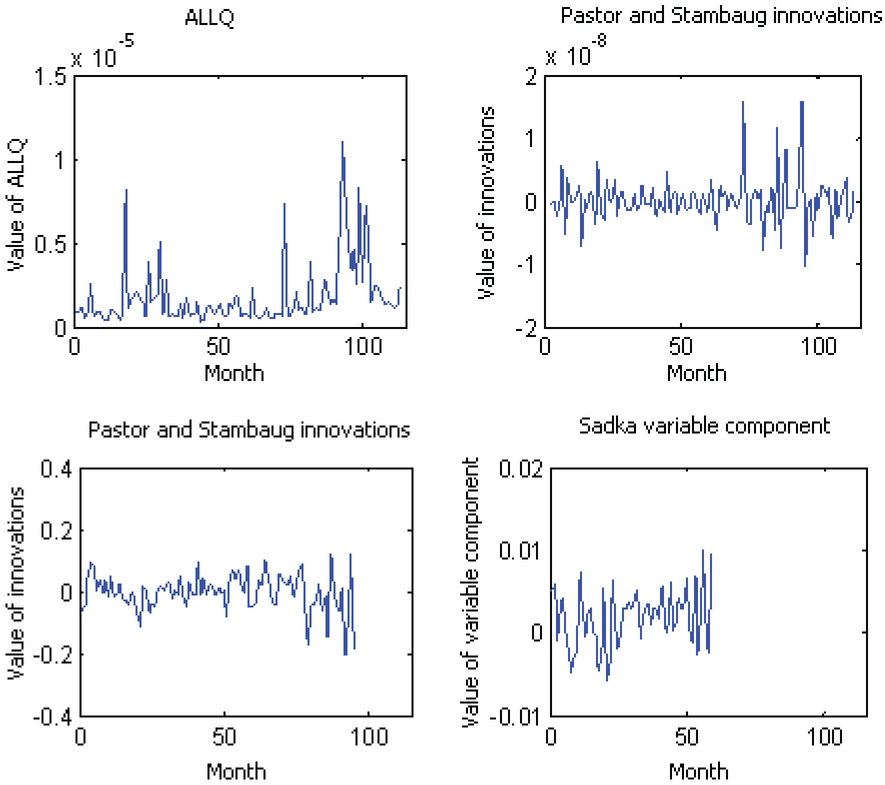

Fig. 3. Liquidity measures