Common Risk Factors in the Cross-Section of Corporate Bond Returns

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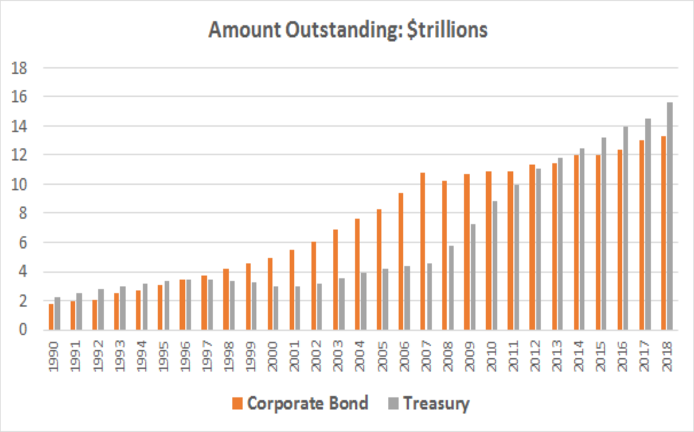
Why are we interested in the corporate bond market?

- Corporate bond market, both primary and secondary, has increased substantially over time.
- Over the past three decades, we have a relatively good understanding on the cross-sectional variations in stock returns, but far less on the cross section of corporate bond returns.
- Corporate bonds play an increasingly important role in institutional investors' portfolios than at any time in the past.
  - **bond-fund** assets roughly doubling from 2008 to 2013
    source: Investment Company Institute Annual Report (2014)
  - **bond funds** have attracted multiple times more inflows compared to the combination of equity, MMF, and other funds over this period
    source: Feroli, Kashyap, Schoenholtz, and Shin (2014)

The U.S. Corporate Bond Market



- $1.74T in 1990; $13.27T in 2018; growth rate is 7.6%
- Annual issuance of $1.3 trillion ($0.3 tril for stocks) since 2010
- Daily trading volume between $12.6 to $19.7 billion
- Corporate bonds are primarily held by institutional investors

Related Literature

- Numerous studies on stock returns, option returns, and hedge fund returns, even bond yields; *less* is known on **corporate bond returns**
  - Likely due to the dearth of high-quality corporate bond return data and the complex features of corporate bonds
- In the corporate bond return literature,
  - Earlier studies focus on aggregate bond indices and bond portfolios, Fama and French (1993), Elton et al.(1995), Blume, Leim, and Pate (1991)
  - Recently, firm-level studies with quoted and traded data include Gebhardt et al.(2005), Lin, Wang, and Wu (2011), Jostova et al. (2013), Bessembinder, Kahle, Maxwell, and Xu (2009) etc.
  - Two most recent papers examine whether equity market anomalies can explain bond returns: Chordia, Goyal, et al. (2015), Choi and Kim (2015)
  - Established factors include (i) MKT^E, SMB, HML, MOM, LIQ and (ii) MKT^B, TERM, DEF, MOM^B, LIQ^B.

Performance of Existing Factor Models: Part I

Test assets: 25 corporate bond portfolios sorted by size and maturity

Model 1: MKT^E, SMB, HML, MOM, LIQ

	Short	2	3	4	Long
Small	0.38	0.53	0.58	0.42	0.55
2	0.31	0.47	0.51	0.52	0.51
3	0.24	0.38	0.41	0.43	0.53
4	0.23	0.31	0.41	0.37	0.50
Big	0.14	0.31	0.40	0.41	0.52
Avg α	**0.42**	(p-GRS: <0.01)			

	Short	2	3	4	Long
Small	0.10	0.09	0.07	0.07	0.09
2	0.10	0.10	0.05	0.05	0.07
3	0.17	0.13	0.10	0.05	0.01
4	0.13	0.08	0.07	0.04	0.02
Big	0.05	0.04	0.05	0.03	0.02
Avg R^2	**0.07**				

Model 2: MKT^B, DEF, TERM, MOM^B, LIQ^B

	Short	2	3	4	Long
Small	0.10	0.09	0.07	0.07	0.09
2	0.10	0.10	0.05	0.05	0.07
3	0.17	0.13	0.10	0.05	0.01
4	0.13	0.08	0.07	0.04	0.02
Big	0.05	0.04	0.05	0.03	0.02
Avg α	**0.33**	(p-GRS: <0.01)			

	Short	2	3	4	Long
Small	0.35	0.48	0.51	0.40	0.49
2	0.28	0.39	0.42	0.45	0.40
3	0.20	0.29	0.27	0.30	0.38
4	0.18	0.24	0.28	0.24	0.37
Big	0.12	0.28	.31	0.32	0.39
Avg R^2	**0.18**				

Takeaway: A large proportion of variance in bond portfolio returns can *NOT* be explained by the commonly used stock or bond market factors - low R^2 and large α.

Performance of Existing Factor Models: Part II

Test assets: 30 corporate bond portfolios sorted by industries

		Model 1			Model 2		
Industry #	Description	Alpha (α)	$t(\alpha)$	R^2	Alpha (α)	$t(\alpha)$	R^2
1	Food	0.37	3.33	0.10	0.25	2.42	0.23
2	Beer	0.28	3.19	0.05	0.22	2.59	0.14
3	Tobacco	0.43	2.40	0.08	0.39	2.11	0.03
4	Games	0.79	2.24	0.13	0.69	1.92	0.13
5	Books	0.55	1.86	0.38	0.44	1.40	0.32
6	Household	0.45	2.17	0.10	0.39	1.85	0.09
7	Clothes	0.68	2.24	0.26	0.40	1.43	0.37
8	Health	0.48	2.69	0.02	0.41	2.32	0.09
9	Chemicals	0.52	2.42	0.35	0.40	1.79	0.29
10	Textiles	0.66	1.59	0.03	0.48	1.13	0.04
11	Construction	0.70	3.17	0.17	0.56	2.75	0.31
12	Steel	0.75	2.72	0.18	0.77	2.60	0.09
13	Fabric	1.33	2.49	0.02	1.08	1.97	0.01
14	Electrical equipment	0.65	1.94	0.11	0.38	1.09	0.06
15	Automobiles	0.76	2.52	0.25	0.54	1.71	0.20
16	Transportation equi	0.47	1.30	0.03	0.33	0.91	0.03
17	Mines	0.35	1.14	0.06	0.17	0.56	0.10
18	Coal	0.48	1.27	0.02	0.30	0.83	0.10
19	Oil	0.65	1.04	0.01	0.48	0.76	0.02
20	Utilities	0.28	2.42	0.07	0.19	1.95	0.33
21	Communication	0.37	2.43	0.13	0.21	1.49	0.30
22	Services	0.43	2.42	0.17	0.28	1.65	0.29
23	Business equipment	0.39	2.59	0.17	0.26	1.83	0.28
24	Paper	0.50	2.08	0.24	0.37	1.52	0.24
25	Transportation	0.54	3.40	0.13	0.44	3.10	0.34
26	Wholesale	0.46	2.59	0.12	0.30	1.86	0.28
27	Retail	0.54	2.36	0.12	0.37	1.64	0.17
28	Restaurant	0.40	1.55	0.14	0.28	1.09	0.16
29	Finance	0.43	3.30	0.08	0.36	2.85	0.15
30	Other	0.73	3.27	0.15	0.55	2.55	0.25
	Average	**0.55**	$p<0.01$	**0.13**	**0.41**	$p<0.01$	**0.18**

This Paper is Motivated by

(1) Prominent risk characteristics in the corporate bond market.

- *Downside Risk:* bondholders are more sensitive to downside risk
  - since the upside payoffs are capped, bond payoffs become concave in the investor beliefs, whereas equity payoffs are linear.
- *Credit Risk:* firms issuing bonds suffer from the potential default risk
- *Illiquidity:* It has always been harder to sell bonds than stocks
  - OTC trading mechanism
  - non-standardized bond issuance, say, GE has only one stock but more than 1,000 types of bonds with different yields, maturities, and even currency denominations

This Paper is Motivated by

(2) Investors type and their risk attitudes in the corporate bond market.

– *Institutional Investors:*
insurance companies, mutual and pension funds, soverign wealth funds,etc

– *Investor Risk Preference*

	Conditional Approach*	Unconditional Approach†
Corporate Bond Market	Risk Aversion	Risk Aversion
MKT^{Bond}	14.70	16.55
VW index	12.58	12.29
EW index	12.12	12.63
Stock Market	Risk Aversion	Risk Aversion
S&P 500 index	5.51	3.50
CRSP VW index	7.51	3.71

∗ Engle, Lilien, and Robins (1987) GARCH-in-Mean model

† Pindyck (1988)

- Bond investors are more risk averse and cautious than equity investors

Corporate Bond Data

- Pricing data are compiled from five sources:
  - [D,T] Enhanced TRACE (2002-2016)
  - [D,T] Bloomberg (1998-2002)
  - [D,T] NAIC (1994-2013)
  - [M,Q] Datastream (1990 - 2013)
  - [M,Q] Lehman Brothers fixed income database (Lehman), 1973-1998
- Data filtering rules:
  - Remove bonds that are not traded in the U.S. public market;
  - Remove bonds that are structured, mortgage backed or asset backed
  - Remove bonds with private placement, or under Rule 144A
  - Remove bonds under convertible contract
  - Remove bonds with floating coupon payment
  - Remove bonds if price$<$ $5 or time-to-maturity $<$ 1yr
- Bond characteristics are from Mergent Fixed Income Securities Database (FISD), including rating, coupon, bond type, option features, etc.

Measuring Return and Cross-sectional Predictors

- Excess return on corporate bond i at month t,

$$R_{i,t}^{excess} = r_{i,t} - r_{f,t} = \left(\frac{P_{i,t} + AI_{i,t} + Coupon_{i,t}}{P_{i,t-1} + AI_{i,t-1}} - 1 \right) - r_{f,t}$$

  - Final sample includes 1,243,543 bond-month returns for 38,957 bonds issued by 4,079 firms during July 2002 to December 2016.

- Cross-sectional Predictors:

– Downside Risk: 5% VaR, the 2nd lowest return over the past 36 months
  - alternative: 10% VaR, 10% expected shortfall

– Credit Risk: bond-level credit rating from 1(AAA) to 10(BBB-), ..., to 21(C)
  - alternative: distance-to-default, implied CDS spread

– Illiquidity: $ILLIQ = -Cov_t(\Delta p_{itd}, \Delta p_{itd+1})$ in Bao, Pan, and Wang (2011)
  - alternative: Roll's measure, Amihud measure

– Bond Market β: comovement with bond mkt return (based on ML bond index)

Summary Statistics

	N	Mean	Median	SD	5th	25th	75th	95th
Bond return (%)	1,243,543	0.68	0.50	3.13	-3.66	-0.68	1.86	5.59
Rating	1,243,543	8.32	7.65	4.05	2.25	5.52	10.35	16.30
Year-to-maturity	1,243,543	9.49	6.60	8.26	1.51	3.59	12.81	26.69
Size ($billion)	1,243,543	0.39	0.27	0.48	0.01	0.77	0.50	1.35
Downside risk	579,333	5.84	4.08	5.78	1.17	2.46	6.96	16.75
Illiquidity	977,011	2.14	0.46	5.17	-0.23	0.07	1.99	10.16
Bond market beta	584,223	1.12	1.01	1.15	0.15	0.58	1.67	3.72

Correlation	Credit Risk	Maturity	Size	VaR	ILLIQ	β^{Bond}
Rating	1	–0.138	–0.021	0.383	0.117	0.089
Maturity		1	–0.042	0.171	0.106	0.356
Size			1	–0.108	–0.160	0.076
VaR				1	0.323	0.195
ILLIQ					1	0.098
β^{Bond}						1

Downside Risk and Expected Corporate Bond Returns

- The mean-variance theory by Markowitz (1952) assumes either (i) an investor has quadratic preference, or (ii) normality of the distribution.
- Bai, Bali, and Wen (2016) show that the empirical distribution of corporate bond returns is skewed, peaked around the mode, and has fat tails – that is, extreme returns occur more frequently than predicted by the normal distribution. ▸ Normality Test
- Therefore, the traditional measures of risk (e.g., volatility) may not be sufficient, especially in extraordinary periods.

How to measure downside risk?

1. Value at Risk (VaR)
   - how much the value of a bond could decline over a given period of time with a given probability
   - 5% VaR, the second lowest return in the past 36 months
   - The original VaR measures are multiplied by -1

2. Expected Shortfall (ES)
   - conditional expectation of loss given that loss is beyond the VaR level
   - 10% ES, the average of four lowest return in the past 36 months
   - The original ES measures are multiplied by -1

3. Tail Risk
   - conditional variance of loss given that loss is beyond the VaR level
   - not adopted in this paper due to insufficient data

Univariate Portfolios of Corporate Bonds Sorted by Downside Risk

Quintiles	Average VaR	Average return	10-factor alpha	Average portfolio characteristics				
				β^{Bond}	ILLIQ	Rating	Mat	Size
Low VaR	1.59	0.21	0.03	0.55	0.57	7.02	4.43	0.56
		(1.10)	(1.09)					
2	2.95	0.34	0.05	0.82	1.15	7.69	7.07	0.46
		(2.99)	(1.35)					
3	4.38	0.44	0.04	1.06	1.82	7.91	10.39	0.43
		(2.77)	(0.79)					
4	6.71	0.62	0.19	1.44	2.72	8.64	13.26	0.41
		(3.02)	(1.98)					
High VaR	15.72	1.20	0.75	2.52	5.20	12.16	12.15	0.34
		(4.18)	(3.16)					
High−Low Return/Alpha diff.	14.13***	0.99***	0.72***					
	(9.94)	(3.95)	(2.82)					

10-factor: (i) MKT^E, SMB, HML, MOM, LIQ, and (ii) MKT^B, TERM, DEF, MOM^B, LIQ^B.

- Bonds in High-VaR earn 8.6%∼11.9% per annum higher returns
- The superior performance comes from the long leg (high-VaR bonds)
- Robust for alternative downside risk proxies (10%VaR and 10% exp shortfall)

Controlling for Bond Characteristics

Controlling for credit rating				
	All	IG	NIG	
VaR, 5 − VaR,1	0.46**	0.38**	0.78***	
10-factor alpha diff.	(2.60)	(2.46)	(3.38)	
Controlling for maturity				
	All	Short	Medium	Long
VaR, 5 − VaR,1	0.91***	0.64***	0.81***	0.99***
10-factor alpha diff.	(4.10)	(2.66)	(2.88)	(4.59)
Controlling for size				
	All	Small	Large	
VaR, 5 − VaR,1	0.65***	0.79**	0.60***	
10-factor alpha diff.	(3.48)	(2.37)	(3.08)	
Controlling for illiquidity				
	All	Liquid	Illiquid	
VaR, 5 − VaR,1	0.72***	0.38**	1.16***	
10-factor alpha diff.	(3.90)	(2.48)	(3.55)	

- Robust across rating, maturity, size, and illiquidity groups
- Pronounced for high-yield, long-term, small, and illiquid bonds

Bond-level Fama-MacBeth Regressions

	Intercept	VaR	Rating	ILLIQ	β^{Bond}	β^{DEF}	β^{TERM}	Maturity	Size	REV	Adj. R^2
(1)	−0.011	**0.064**									0.086
	(−0.10)	(4.88)									
(2)	0.127	**0.052**				−0.006	0.002	−0.002	−0.012	**−0.122**	0.173
	(0.96)	(4.36)				(−1.03)	(0.23)	(−0.46)	(−0.84)	(−9.24)	
(3)	−0.182		**0.068**								0.054
	(−1.32)		(3.84)								
(4)	−0.130		**0.064**			−0.008	0.018	**0.015**	−0.001	**−0.119**	0.155
	(−1.23)		(2.84)			(−1.46)	(1.28)	(2.12)	(−1.00)	(−9.36)	
(5)	0.463			**0.081**							0.028
	(3.41)			(6.45)							
(6)	0.304			**0.066**		−0.007	0.041	0.007	0.030	**−0.079**	0.152
	(2.68)			(6.32)		(−0.90)	(1.37)	(1.17)	(0.99)	(−5.29)	
(7)	0.209				**0.486**						0.055
	(1.72)				(3.15)						
(8)	0.224				**0.318**	**−0.023**	0.026	0.004	−0.053	**−0.069**	0.156
	(2.50)				(2.14)	(−2.76)	(1.63)	(0.72)	(−1.13)	(−3.27)	
(9)	−0.195	**0.111**	0.031	**0.047**	−0.097						0.144
	(−1.37)	(5.29)	(1.50)	(6.22)	(−0.94)						
(10)	−0.178	**0.106**	0.030	**0.041**	−0.097	−0.002	0.003	0.002	0.000	**−0.132**	0.217
	(−1.55)	(4.72)	(1.48)	(5.25)	(−0.95)	(−0.31)	(0.31)	(0.30)	(3.22)	(−8.51)	

Downside risk and illiquidity have a pervasive effect on future bond returns.

▸ Orthogonalized Risk Characteristics

Robustness

- Using equal-weighted portfolios
- Using firm-level analysis
- Subsample for non-financial firms
- Subsample across business conditions (CFNAI index)
- Subsample excluding the financial crisis
- Longer sample period from 1975 to 2016
- Alternative measures for downside risk
- Alternative measures for credit risk
- Alternative measures for illiquidity

Common Risk Factors

Bond-implied Risk Factors

- Bivariate portfolios (independent sorting) that mimick downside risk, credit risk, and liquidity risk.
  - DRF vw-avg return diff b/w High-VaR and Low-VaR across rating.
  - LRF vw-avg return diff b/w High-ILLIQ and Low-ILLIQ across rating
  - CRF avg of CRF_{VaR} and CRF_{ILLIQ}, where CRF_{VaR} is vw-avg return difference b/w High-Credit and Low-Credit across VaR (ILLIQ)

- These bond risk factors generate economically larger risk premia in economic downturns.

	All time		Low Economic Activity	
	mean	*t*-stat	mean	*t*-stat
DRF	0.70%	(3.60)	0.84%	(2.34)
CRF	0.43%	(2.78)	0.75%	(0.81)
LRF	0.52%	(5.02)	1.17%	(3.10)

- They also have low correlations with existing stock and bond market factors. Specifically, the correlation b/w DRF and stock market factors are in the range of -0.08 to 0.13.

Do the existing factor models explain the DRF, CRF, and LRF factors?

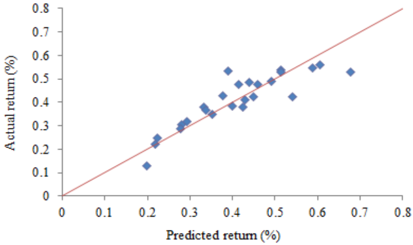
$$NewFactor_t = \alpha + \sum_{k=1}^{5} \beta_k Factor_{k,t}^{Stock} + \sum_{l=1}^{5} \beta_l Factor_{l,t}^{Bond} + \varepsilon_t,$$

	Model 1 5-factor Stock	Model 2 5-factor Bond	Model 3 10-factor
DRF alpha	0.83	0.79	0.80
t-stat	(2.90)	(3.19)	(2.76)
CRF alpha	0.44	0.34	0.35
t-stat	(2.92)	(2.01)	(1.89)
LRF alpha	0.37	0.32	0.32
t-stat	(3.15)	(2.79)	(2.45)

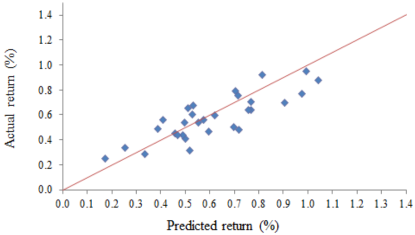
- The alphas remain economically and statistically significant!
- New risk factors represent an important source of common return variation missing from the long-established risk factors.

Factor Model Performance: Predicted vs Realized Returns

25 Size/Mat-sorted Portfolio

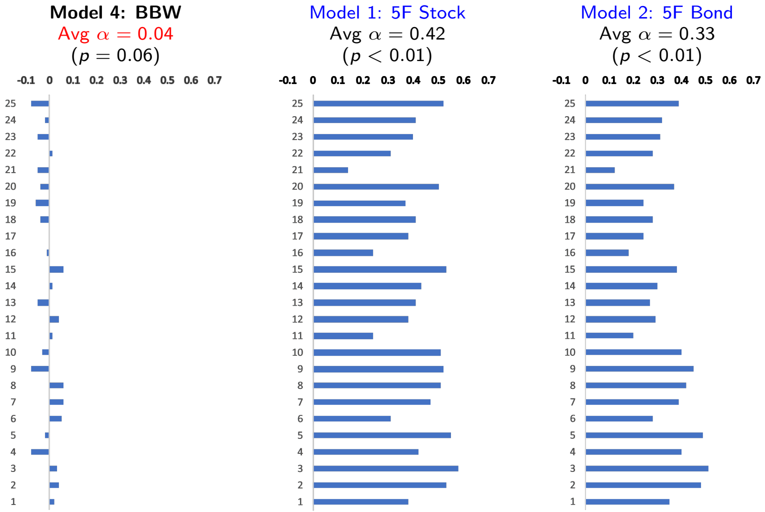


30 Industry Portfolios



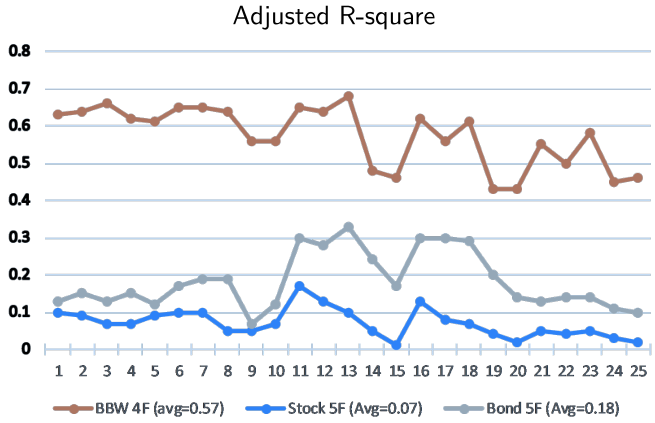
Factor Model Performance: α

Test assets: 25 corporate bond portfolios sorted by size and maturity



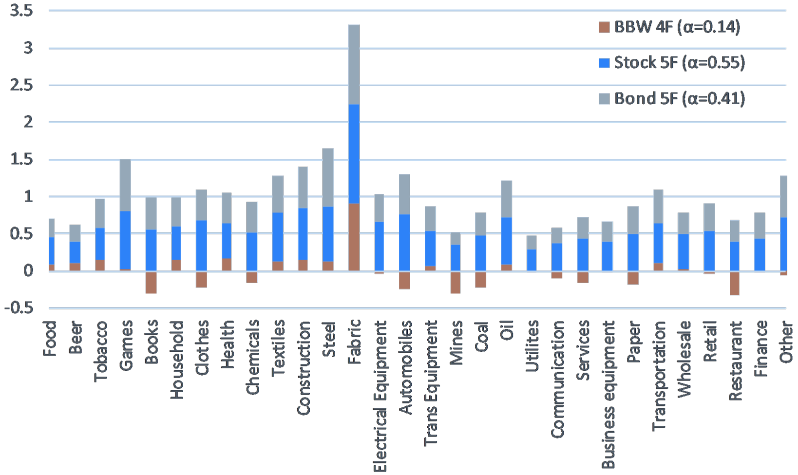
Factor Model Performance: R^2

Test assets: 25 corporate bond portfolios sorted by size and maturity



Factor Model Performance: α

Test assets: 30 corporate bond portfolios sorted by industry



Summary

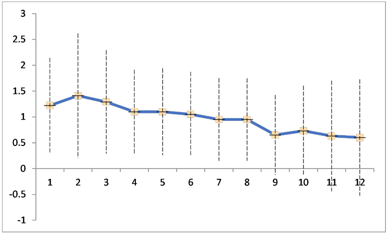
- We construct bond-implied common risk factors: DRF, CRF, LRF. They are essential to price the cross-section of corporate bond returns and outperform all factor models ever documented.

- Downside risk is probably mostly important in predicting bond returns, on top of credit, liquidity, and market risk, with an annual premium 8.6%$\sim$11.9%.

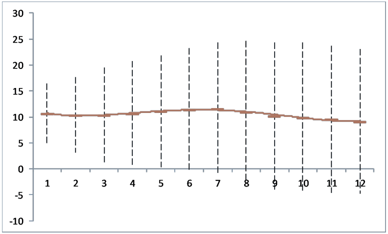
Follow-up Research

Paper 1: *In Search of Systematic Risk and Idiosyncratic Volatility Puzzle in the Corporate Bond Market (Bai, Bali, and Wen 2019)*

- Systematic Risk based on common risk factors (DRF, CRF, LRF) has a strong predictive power on the XS of future bond returns
- Idiosyncratic volatility has no explanatory power (no IVOL puzzle)
- Aggregate SR measure significantly predict future bond market return and bond market volatility (ICAPM)



Bond market return (1∼9M)

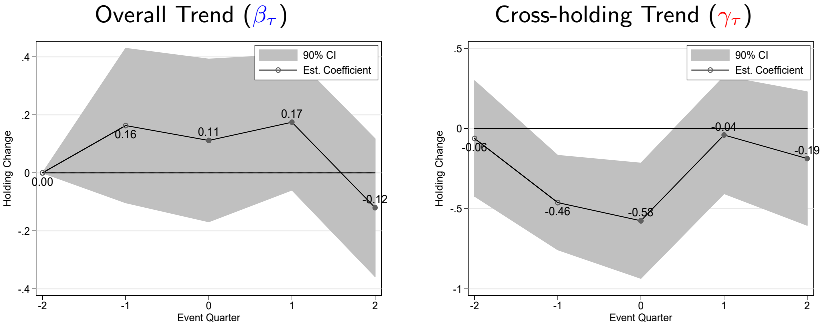


Bond market volatility (1∼7M)

Follow-up Research

Paper 2: *Cross-Asset Information Synergy in Mutual Fund Families (Bai and Auh 2019)*

$$\Delta H^{Equity}_{i,f,t+\tau} = \alpha_{f,t} + \beta_\tau \cdot \mathbb{D}_{i,t} + \gamma_\tau \cdot \mathbb{D}_{i,t} \cdot Cohold_{i,f,t-2} + \lambda_\tau \cdot Z_{i,t+\tau} + \varepsilon_{i,f,t+\tau}, \quad \tau \in [-2, 2]$$



Equity funds learn from sister bond funds around downgrading($\mathbb{D}$) events when creditors have more information and reduce holdings at least 1-qtr earlier

Thank you!

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APPENDIX

Normality Test for Corporate Bond Returns

Panel A: Time-series distribution of all corporate bond returns

		Skewness		Kurtosis		Normality
	Volatility	Positive	Negative	Positive	Negative	JB-stat
Total # of bonds	38,957	19,548	19,409	26,493	12,464	38,957
% of bonds significant	84.6%	48.0%	99.5%	67.7%	52.6%	79.9%
Median *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
% of bonds insignificant	15.4%	52.0%	0.6%	32.4%	47.4%	20.1%

Panel B: Cross-sectional distribution of monthly corporate bond returns

		Skewness		Kurtosis		Normality
	Volatility	Positive	Negative	Positive	Negative	JB-stat
Total # of months	150	118	32	150	0	150
# of months significant	150	118	32	150	0	150
Median *p*-value	0.00	0.00	0.00	0.00	0.00	0.00
# of months insignificant	0	0	0	0	0	0

Takeaway: the dist'n of bond returns is skewed, peaked around the mode, and has fat tails. Thus, *downside risk* – defined as a nonlinear function of volatility, skewness, and kurtosis – is expected to play a major role in the XS pricing of corporate bonds.

Orthogonalized VaR, Rating, ILLIQ, and β^{Bond}

$$
\begin{aligned}
VaR_{i,t} &= \lambda_{0,t} + \lambda_{1,t}\beta^{Bond}_{i,t} + \lambda_{2,t} Rating_{i,t} + \lambda_{3,t} ILLIQ_{i,t} + \epsilon^{VaR}_{i,t} \\
Rating_{i,t} &= \lambda_{0,t} + \lambda_{1,t}\beta^{Bond}_{i,t} + \lambda_{2,t} VaR_{i,t} + \lambda_{3,t} ILLIQ_{i,t} + \epsilon^{Rating}_{i,t} \\
ILLIQ_{i,t} &= \lambda_{0,t} + \lambda_{1,t}\beta^{Bond}_{i,t} + \lambda_{2,t} Rating_{i,t} + \lambda_{3,t} VaR_{i,t} + \epsilon^{ILLIQ}_{i,t} \\
\beta^{Bond}_{i,t} &= \lambda_{0,t} + \lambda_{1,t} Rating_{i,t} + \lambda_{2,t} VaR_{i,t} + \lambda_{3,t} ILLIQ_{i,t} + \epsilon^{\beta^{Bond}}_{i,t}
\end{aligned}
$$

	Int.	$VaR^{\perp}$	$Rating^{\perp}$	$ILLIQ^{\perp}$	$\beta^{Bond,\perp}$	β^{DEF}	β^{TERM}	Mat	Size	REV	Adj. R^2
(1)	0.690	**0.100**									0.032
	(2.91)	(4.94)									
(2)	0.660	**0.083**				-0.003	**0.038**	0.005	-0.029	**-0.099**	0.147
	(2.50)	(4.37)				(-0.51)	(2.17)	(0.81)	(-1.15)	(-6.14)	
(3)	0.557		0.022								0.022
	(2.74)		(1.25)								
(4)	0.362		0.013			-0.002	**0.035**	0.012	-0.000	**-0.112**	0.142
	(2.69)		(0.90)			(-0.37)	(2.40)	(1.78)	(-0.80)	(-7.85)	
(5)	0.617			**0.058**							0.010
	(2.73)			(6.87)							
(6)	0.379			**0.044**		-0.001	**0.047**	0.009	-0.013	**-0.093**	0.139
	(2.57)			(5.33)		(-0.19)	(2.26)	(1.42)	(-0.32)	(-5.68)	
(7)	0.825				-0.128						0.020
	(2.85)				(-1.25)						
(8)	0.494				-0.046	-0.005	**0.055**	**0.014**	-0.129	**-0.082**	0.134
	(2.73)				(-0.45)	(-0.86)	(2.01)	(2.13)	(-1.73)	(-4.80)	
(9)	0.665	**0.210**	0.142	**0.075**	0.529						0.136
	(3.06)	(4.68)	(1.30)	(6.65)	(1.02)						
(10)	0.652	**0.181**	0.127	**0.064**	0.454	-0.003	0.013	0.003	-0.000	**-0.097**	0.209
	(3.66)	(5.33)	(1.47)	(6.17)	(1.29)	(-0.50)	(1.07)	(0.45)	(-0.16)	(-6.52)	