Jump and volatility risk in the cross-section of corporate bond returns

Xi Chen Junbo Wang, Chunchi Wu

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1.Introduction

aggregate risks--stock return: focused on the time series

- aggregate volatility has important implications for asset prices in the **cross-section** (Ang et al., 2006; Chung , 2019)

- a significant temporal relation between systematic **jump risk** and **stock** market returns (Bates, 1991; Santa, 2010; Yan, 2011).

➡ whether jump risk is priced in the cross-section of corporate bond returns ?

1.Introduction

Debate： whether aggregate jump and volatility priced separately?

- market more volatile when there are large price movements➡ jump and volatility risk are alike
- Aggregate volatility risk is a combination of **jump** and **diffusive** risk and earlier cross-sectional studies did not attempt to separate these effects (Ang et al., 2006a,b)

Branger et al. (2007) present a general equilibrium model with both jumps and stochastic volatility

Bates (2008) develops a model with risk- and crash-averse investors, who treat jump and diffusive risk differently and require separate premiums

Chen (2010) proposes a model that links jump risk to macroeconomic shocks and finds that both jump and Brownian risks are important determinants of the credit risk premium.

1.Introduction

Empirical：

- Cremers et al. (2015) are the first to investigate both jump and vol risk in the cross-section of stock returns--high return sensitivities to aggregate jump risk have low expected returns: investors are **crash-averse-- seek to hedge against extreme events**

- However, it remains unclear whether jump risk is priced in other classes of risky assets, such as corporate bonds

stock risk factor ofen priced in bond;

contingent claims for cash flows of the same firm;

Firms with bond issues have **higher exposure to bankruptcy** risk than those without.

2.Research design

2.1. The pricing of jump risk

A structural model for corporate debts with jump:

$$
\begin{aligned}
dV_t &= \widehat{\mu} V_t dt + \sigma V_t d\widehat{W}_t \boxed{- \nu V_{t-} d(N_t - \widehat{\lambda} t)} \\
&= (\widehat{\mu} + \nu \widehat{\lambda}) V_t dt + \sigma V_t d\widehat{W}_t - \nu V_{t-} dN_t,
\end{aligned}
$$

Firm′ s income before interest expense $V_{i,t}$ follows a stochastic process that includes a geometric Brownian motion with average growth rate $\hat{\mu}$ and volatility σ, and a jump process.
where W_t is a standard Brownian motion, N_t is a jump process, $\hat{\lambda}$ is the jump intensity, v is the loss rate when a jump shock occurs, and $N_t - \hat{\lambda} t$ is the compensated jump process.

2.Research design

2.1. The pricing of jump risk

Assume that the firm's debt is a consol bond with a coupon payment C. When a firm is solvent, the claim on the firm's asset satisfies the equation:

$$\boxed{\frac{1}{2}\sigma^2 V_t^2 \frac{\partial^2}{\partial V^2} F(V_t) + (\mu + \nu\lambda) V_t \frac{\partial}{\partial V} F(V_t) - rF(V_t) + C} + \lambda[F(V_{t-}(1-\nu)) - F(V_{t-})] = 0$$

merton(1974)BS定价的偏微分方程

$$\begin{cases} V_t < C \\ V_t(1-\nu) < C \end{cases} \xrightarrow{\text{assume}} F(V_t(1-\nu)) = 0$$

$$\frac{1}{2}\sigma^2 V_t^2 \frac{\partial^2}{\partial V^2} F(V_t) + (\mu + \nu\lambda) V_t \frac{\partial}{\partial V} F(V_t) - rF(V_t) + C - \lambda F(V_{t-}) = 0.$$

subject to $F(C) = 0.$ $V_t \to \infty, F(V_t) \to \dfrac{C}{r+\lambda}$

2.Research design

2.1. The pricing of jump risk

$$\frac{1}{2}\sigma^2 V_t^2 \frac{\partial^2}{\partial V^2} F(V_t) + (\mu + \nu\lambda) V_t \frac{\partial}{\partial V} F(V_t) - rF(V_t) + C - \lambda F(V_{t-}) = 0.$$

subject to $F(C) = 0.$ $V_t \to \infty, F(V_t) \to \dfrac{C}{r+\lambda}$

$$\Downarrow$$

$$F(V_t) = \frac{C}{r+\lambda}\left[1 - \left(\frac{V_t}{C}\right)^b\right] \qquad b = -\frac{1}{\sigma^2}\left[(\mu + \nu\lambda) - \frac{\sigma^2}{2} + \sqrt{\left(\mu + \nu\lambda - \frac{\sigma^2}{2}\right)^2 + 2(r+\lambda)\sigma^2}\right]$$

both jump(λ) and volatility (σ) risk affect the value of corporate bonds.

2.Research design

2.1. The pricing of jump risk

The yield spread of this bond is given by:

$$s(V_t) = y_t - r = \frac{C}{F(V_t)} - r = \frac{r + \lambda}{1 - \left(\frac{V_t}{C}\right)^b} - r$$

The expected bond return at time t in the first-order approximation is equal to:

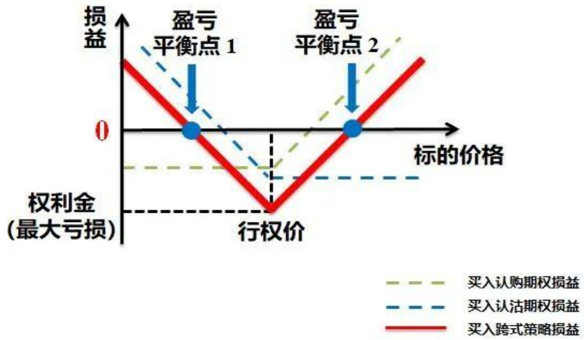
$$E_t(R_{t+1}) = y_t \times \ dt - MD \times \Delta y_{t+1} \qquad y_t = \frac{r+\lambda}{1-\left(\frac{V_t}{C}\right)^b}$$

Setting dt = 1, $E_t(R_{t+1}) - r = (y_t - r) - MD \times \Delta y_{t+1}$

- both jump and volatility risk affect the bond's expected return.σ➡b
- jump and volatility risk are **priced separately** in expected corporate bond returns.

2.Research design

2.2. Jump and volatility factors



Two option trading strategies（Cremers et al.， 2015）：

JUMP：market **(delta)-neutral** and **vega-neutral** but **gamma-positive**

- Long： **1** market-neutral at-the-money straddle with a **shorter** maturity
- Short： **<1** unit of market-neutral at-the-money straddle with a **longer** maturity.

Due to a **positive gamma：** **positive return** - **a large move**.

2.Research design

2.2. Jump and volatility factors

VOLA： market **(delta)-neutral** and **gamma-neutral** but **vega-positive**

- Long： **1** market-neutral at-the-money straddle with a **longer** maturity
- Short： **<1** unit of market-neutral at-the-money straddle with a **shorter** maturity.

Due to a **positive vega**： **positive return** - **volatility increases**

two pairs of at-the-money call and put **S&P 500 Index options** on one trading day, and another two pairs of at-the-money options the next day

➡ portfolios daily returns on the jump and volatility risk factors.

2.Research design

2.3. Jump and volatility betas

预期：负，风险厌恶

$$R_t^i = \alpha_i + \beta_{MKT_t}^i \cdot MKT_t + \beta_{MKT_{t-1}}^i \cdot MKT_{t-1} + \beta_{X_t}^i \cdot X_t + \beta_{X_{t-1}}^i \cdot X_{t-1} + \varepsilon_t^i$$

- R_t^i : return in excess of the one-month Treasury bill rate (bond i in month t)
- MKT_t : excess return on the stock market portfolio
- X_t : return on either the jump or volatility risk factor mimicking portfolio

- rolling 24-month window
- exclude other conventional risk factors to reduce noise(Ang,2006; Cremers,2015)
- bond transactions infrequent➡prices not respond quickly➡add lagged➡ $\beta_{X_t}^i + \beta_{X_{t-1}}^i$ as beta

3.Data

- enhanced TRACE : transaction data of all publicly traded corporate bonds
- Mergent FISD : bond issue- and issuer-related characteristics

data clean:

- exclude bonds with call, put, and conversion options, sinking funds, and bonds backed by assets or mortgages
- exclude bonds maturity <1 or >30   Bessembinder et al. (2009)
- eliminate cancelled, corrected, commission, and small (below $100,000) trades

➡ 9104 bonds issued by 1737 firms from July 2002 to June 2019.

3.Data

- daily prices： the trade size-weighted average of intraday prices

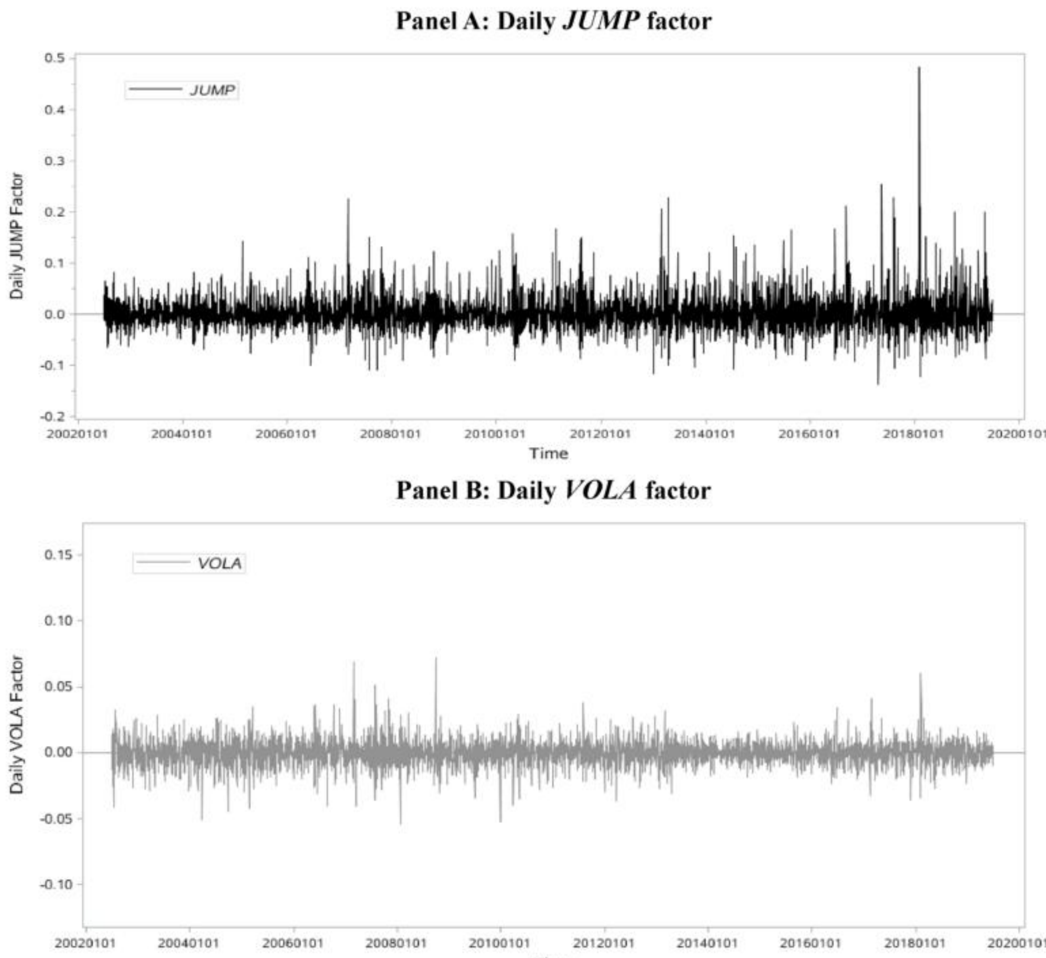
$$R_t = \frac{(P_t + AI_t) + C_t - (P_{t-1} + AI_{t-1})}{P_{t-1} + AI_{t-1}}$$

P_t: month-end price ; AI_t:accrued interest ; C_t:coupon payment if any.

- The S&P 500 Index option data are from OptionMetrics.

  Consider the S&P 500 Index options with a maturity of 30 days as shorter-dated options and 60 days as longer-dated options

3.Data



- For jump risk, there are more positive (up) jumps, especially in the later part of our sample period coincident with the recent long bull market

3.Data

	Mean	Std. dev.	Median	Q1	Q3
Panel A: Bond characteristics					
Rating	6.0605	3.6590	5.0000	4.0000	8.0000
Size	0.9043	7.0857	0.4000	0.2000	1.0000
Maturity	6.7467	6.4923	4.2083	2.3750	8.4611
Age	5.9171	5.2535	4.3222	1.8583	8.2667
Coupon	5.7011	1.9752	5.8750	4.3750	7.1250
Panel B: Risk factors					
MKT	0.0073	0.0418	0.0118	−0.0143	0.0324
SMB	0.0014	0.0243	0.0017	−0.0145	0.0179
HML	−0.0007	0.0246	−0.0023	−0.0140	0.0129
DEF	0.0029	0.0172	0.0029	−0.0064	0.0137
TERM	0.0032	0.0199	0.0019	−0.0077	0.0141
LIQ	0.0000	0.0039	−0.0002	−0.0015	0.0011
VIX	18.9696	8.5121	16.2842	13.4793	21.4011
JUMP	0.0358	0.1001	0.0225	−0.0234	0.0944
VOLA	−0.0002	0.0332	−0.0009	−0.0224	0.0234
Panel C: Betas					
Excess return	0.0043	0.0192	0.0028	−0.0028	0.0111
Raw return	0.0054	0.0191	0.0040	−0.0015	0.0122
β_{MKT}	0.0217	0.1701	0.0147	−0.0306	0.0701
β_{SMB}	−0.0043	0.1962	−0.0091	−0.0528	0.0384
β_{HML}	0.0031	0.2039	0.0008	−0.0663	0.0597
β_{DEF}	0.3165	0.4543	0.2246	0.0568	0.5003
β_{TERM}	0.3614	0.3073	0.3198	0.1671	0.5312
β_{LIQ}	0.1620	1.7051	0.1691	−0.2758	0.5788
β_{VIX}	−0.0003	0.0017	−0.0002	−0.0008	0.0002
β_{JUMP}	−0.0524	0.0958	−0.0448	−0.0896	−0.0118
β_{VOLA}	−0.0406	0.1785	−0.0216	−0.1147	0.0494

- frequent **large up jumps** in sample can explain the positive average return

3.Data

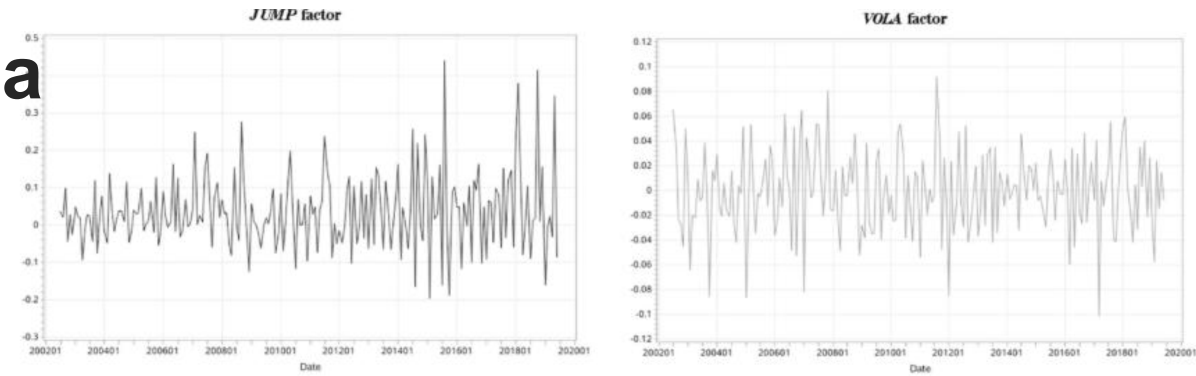


Fig. 3. Monthly returns on the *JUMP* and *VOLA* factors. This figure shows the monthly return series of the *JUMP* and *VOLA* factors constructed by the investable option approach from July 2002 to June 2019.

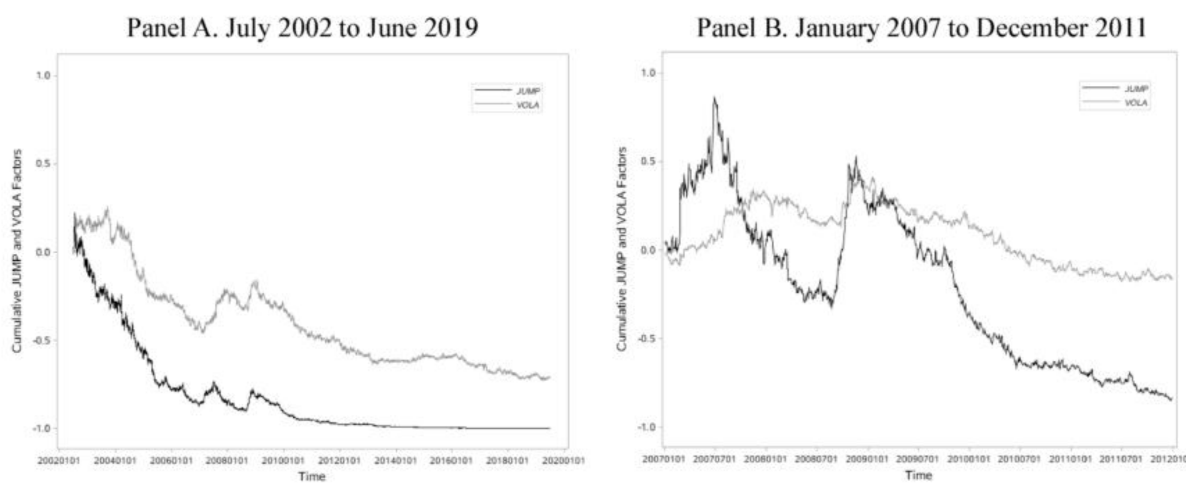


Fig. 4. Cumulative daily returns on the *JUMP* and *VOLA* factors

- JUMP factor is more volatile.
- both strategies earn negative average returns in the long term

3. Data

We estimate the betas of standard risk factors over rolling two-year horizons using the following time series regression:

$$R_t^i = \alpha_i + \beta^i_{MKT_t} \cdot MKT_t + \beta^i_{SMB_t} \cdot SMB_t + \beta^i_{HML_t} \cdot HML_t + \beta^i_{DEF_t} \cdot DEF_t + \beta^i_{TERM_t} \cdot TERM_t + \beta^i_{LIQ_t} \cdot LIQ_t + \varepsilon^i_t,$$

$R_{i,t}$ and risk factors are measured over a two-year investment horizon

S	P														
	β_{MKT}	β_{SMB}	β_{HML}	β_{DEF}	β_{TERM}	β_{LIQ}	β_{VIX}	β_{JUMP}	β_{VOLA}	*ILLIQ*	*Maturity*	*Age*	*Coupon*	*Size*	*Rating*
β_{MKT}		−0.1833	0.1548	−0.4800	0.0571	0.0530	−0.2977	−0.0101	−0.0121	0.0179	−0.0072	0.0111	0.0580	0.0234	0.1805
β_{SMB}	−0.2039		−0.1003	−0.0292	0.1320	−0.0393	0.0642	0.0462	−0.0463	0.0059	0.0095	0.0303	0.0106	−0.0050	−0.0276
β_{HML}	0.1359	−0.1046		−0.2595	0.1234	0.0167	0.0345	0.0096	−0.0288	0.0307	0.0090	0.0026	0.0161	0.0103	0.0881
β_{DEF}	−0.3678	−0.0251	−0.2076		−0.0950	−0.0483	0.0756	−0.0415	−0.0872	0.0753	0.1683	0.0367	0.0926	−0.0188	0.1075
β_{TERM}	0.0854	0.1049	0.0811	−0.0182		−0.1319	0.0210	−0.1081	−0.1090	0.1131	0.4655	0.0116	0.1259	0.1039	−0.0188
β_{LIQ}	−0.0086	−0.0698	−0.0449	0.0381	−0.0910		−0.0292	−0.0270	0.0089	−0.0199	−0.0166	0.0007	−0.0063	0.0046	−0.0148
β_{VIX}	−0.3547	0.0617	0.0355	0.0768	0.0024	−0.0628		0.1936	0.1279	−0.0282	−0.0020	−0.0338	−0.0711	0.0257	−0.1701
β_{JUMP}	−0.0534	0.0677	0.0383	−0.0803	−0.1958	−0.0622	0.2254		0.2385	−0.1233	−0.1533	−0.0211	−0.0782	0.0418	−0.0961
β_{VOLA}	−0.0301	−0.0285	0.0040	−0.1339	−0.1564	0.0097	0.1373	0.2258		−0.1373	−0.1599	−0.0732	−0.1318	0.0521	−0.1890
ILLIQ	−0.0039	0.0052	0.0154	0.1301	0.2589	−0.0237	−0.0285	−0.1261	−0.1493		0.3665	0.3605	0.3266	−0.4761	0.2674
Maturity	0.0399	−0.0030	0.0028	0.1396	0.6592	−0.0125	−0.0170	−0.2090	−0.2107	0.4809		0.1957	0.3326	−0.0660	0.1221
Age	−0.0114	0.0495	−0.0007	0.0936	−0.0295	−0.0068	−0.0218	−0.0162	−0.0666	0.4653	0.1030		0.7185	−0.3301	0.2847
Coupon	0.0590	0.0213	0.0235	0.1703	0.1682	−0.0034	−0.0800	−0.1089	−0.1641	0.4542	0.3692	0.6967		−0.2238	0.4505
Size	0.0423	−0.0283	−0.0096	−0.0230	0.1411	0.0122	0.0047	0.0027	0.0430	−0.5224	−0.0474	−0.3660	−0.2535		−0.2049
Rating	0.1533	−0.0011	0.0868	0.2222	0.0191	−0.0112	−0.1639	−0.1029	−0.2035	0.3048	0.1562	0.2907	0.4699	−0.2406	

The Spearman (Pearson) correlation between βJUMP and βVOLA is 0.23 (0.24), which is quite moderate

4.Empirical results

Panel A: Mean betas, excess returns, characteristic-adjusted returns, and alphas of quintile portfolios

	Portfolios sorted by β_{JUMP}						
	1	2	3	4	5	5–1	t-stat
β_{JUMP}	−0.2109	−0.0831	−0.0383	−0.0001	0.1132	0.3241***	(7.97)
β_{VOLA}	−0.0978	−0.1520	−0.0677	−0.0351	−0.1257	−0.0279	(-0.09)
Return	0.1235	0.0916	0.0746	0.0668	0.0656	−0.0578***	(-5.18)
AdjRet	0.0154	0.0073	0.0010	−0.0036	−0.0234	−0.0388***	(-3.94)
Return Alpha	0.1077	0.0759	0.0613	0.0589	0.0354	−0.0724***	(-11.83)
AdjRet Alpha	0.0241	0.0103	−0.0003	−0.0033	−0.0358	−0.0599***	(-9.90)

	Portfolios sorted by β_{VOLA}						
	1	2	3	4	5	5–1	t-stat
β_{JUMP}	−0.0478	−0.0189	−0.0123	−0.0159	0.0091	0.0570	(0.60)
β_{VOLA}	−0.4597	−0.1674	−0.0666	0.0143	0.2283	0.6880***	(8.47)
Return	0.1224	0.0910	0.0763	0.0732	0.0628	−0.0596***	(-4.77)
AdjRet	0.0146	0.0075	0.0032	−0.0021	−0.0270	−0.0416***	(-5.20)
Return Alpha	0.0942	0.0793	0.0627	0.0654	0.0397	−0.0545***	(-5.23)
AdjRet Alpha	0.0172	0.0146	0.0028	−0.0018	−0.0379	−0.0551***	(-11.83)

- There is no evidence of a monotonic relation between β_{JUMP} and β_{VOLA} across the quintiles sorted on either factor loading.
- β_{JUMP} (β_{VOLA}) quintile portfolios (5–1) is −5.78% (−5.96%) per biennium, or −24.08 (−24.83) bps per month;**bonds with high sensitivities to jump (volatility) risk have low returns.**
- rating/maturity-adjusted excess returns: robust

4.Empirical results

Panel B: Mean values of other betas and bond characteristics of quintile portfolios

	Portfolios sorted by β_{JUMP}					Portfolios sorted by β_{VOLA}				
	1	2	3	4	5	1	2	3	4	5
β_{MKT}	0.0585	0.0427	0.0313	0.0315	0.0571	0.0582	0.0398	0.0360	0.0338	0.0533
β_{SMB}	−0.0400	−0.0337	−0.0176	−0.0067	−0.0176	0.0047	−0.0249	−0.0155	−0.0268	−0.0530
β_{HML}	0.0149	−0.0145	−0.0062	0.0126	0.0399	0.0353	0.0010	−0.0052	0.0041	0.0113
β_{DEF}	0.1959	0.0900	0.0459	0.0264	0.1471	0.2517	0.0830	0.0215	0.0278	0.1218
β_{TERM}	0.6016	0.4607	0.3891	0.3372	0.4521	0.5694	0.4699	0.3710	0.3542	0.4767
β_{LIQ}	0.0758	−0.1368	−0.1559	0.1252	−0.3771	0.1419	0.0451	−0.0830	−0.1674	−0.4057
Rating	7.5553	6.0148	5.4987	5.3665	7.2849	8.3397	6.2253	5.3646	5.1742	6.6147
Size	0.8685	1.2307	1.0198	1.0707	0.8728	0.7877	1.1286	1.2280	1.0899	0.8274
Maturity	9.2092	5.2054	3.6606	3.6150	7.4619	9.0549	5.5115	3.8219	3.6976	7.0735
Age	7.8259	6.8376	6.4631	6.3088	8.0571	8.3496	6.8552	6.3178	6.3048	7.6636
Coupon	6.0405	5.4937	5.1938	5.0198	5.8795	6.2342	5.5416	5.1229	5.0263	5.7025

- the negative relation between cross-sectional bond returns and β_{JUMP} (β_{VOLA}) is not correlated with systematic variations in **conventional betas** or **bond characteristics.**

5×5 independent double sorts on β_{JUMP} and β_{VOLA} each month

Panel A: Average excess return of 5×5 independent sorts by β_{JUMP} and β_{VOLA}

β_{JUMP}	β_{VOLA} 1	2	3	4	5	5–1	t-stat
1	0.1345	0.1216	0.1179	0.1125	0.0663	−0.0681***	(-6.41)
2	0.1079	0.0906	0.0835	0.0910	0.0858	−0.0222**	(-2.50)
3	0.1064	0.0785	0.0668	0.0676	0.0749	−0.0315**	(-2.22)
4	0.1017	0.0817	0.0629	0.0581	0.0638	−0.0378**	(-2.05)
5	0.0695	0.0774	0.0712	0.0636	0.0438	−0.0257**	(-2.03)
5–1	−0.0650***	−0.0441***	−0.0467***	−0.0489***	−0.0225**		
t-stat	(-5.31)	(-3.75)	(-4.20)	(-3.72)	(-2.56)		

Panel B: Summary of bond characteristics

β_{JUMP}	β_{VOLA} 1	2	3	4	5	1	2	3	4	5
	Number of Bonds					Rating				
1	78	38	22	22	44	8.4580	7.0224	6.6932	6.6852	7.7001
2	36	50	46	42	32	7.6768	5.9745	5.4756	5.6018	6.1405
3	21	42	61	53	28	7.9463	5.7880	4.9524	4.9389	5.7637
4	22	40	49	54	39	8.0745	6.1964	4.9857	4.7316	5.4132
5	47	35	27	33	62	8.7653	6.9452	6.1086	5.6130	6.5733
	Size					Coupon				
1	0.8301	0.8564	1.9220	0.9654	0.5594	6.2656	5.8876	5.8199	5.8682	6.1308
2	0.8294	1.1333	1.8707	1.3753	0.6794	6.0171	5.4929	5.3002	5.3768	5.8051
3	0.6718	1.1299	1.0185	1.1558	0.7814	6.1246	5.3892	4.9648	4.9662	5.4354
4	0.6261	1.1486	1.0369	1.0695	0.9449	6.2266	5.5218	4.8533	4.7879	5.1905
5	0.5283	0.8545	0.9803	0.8915	1.0199	6.4288	5.9101	5.4960	5.2053	5.6002
	Maturity									
1	10.3579	8.4640	7.7085	7.8736	8.4783					
2	7.8747	4.9966	4.1397	4.5527	6.0760					
3	7.5376	4.1085	2.9283	2.7537	4.5768					
4	7.7759	4.5468	2.8071	2.5128	4.3328					
5	9.0789	6.4476	5.1134	4.6927	7.2250					

- jump and volatility risk contain separate information and do not subsume each other ; robust in all segments of bonds with different characteristics.

4.Empirical results

5 × 5 double- sorting on β_{JUMP} and β_{VOLA} each month

Panel A: Long-short excess returns and alphas for each quintile portfolio sorted by {β\vphantom{β}_{JUMP\vphantom{JUMP}}}

{β_{{JUMP}}}	Long-short returns for each quintile portfolio							Long-short alphas for each quintile portfolio						
control variable	1	2	3	4	5	H-L	*t*-stat	1	2	3	4	5	H-L	*t*-stat
Maturity	−0.0483***	−0.0442***	−0.0364***	−0.0297***	−0.0671***	−0.0451***	(-3.83)	−0.0452***	−0.0423***	−0.0458***	−0.0567***	−0.1308***	−0.0642***	(-7.87)
Coupon	−0.0204**	−0.0351**	−0.0438***	−0.0581***	−0.0819***	−0.0479***	(-4.49)	−0.0459***	−0.0712***	−0.0427***	−0.0768***	−0.0993***	−0.0672***	(-15.56)
Size	−0.0852***	−0.0538***	−0.0498***	−0.0542***	−0.0449***	−0.0576***	(-4.98)	−0.1222***	−0.0529***	−0.0684***	−0.0563***	−0.0388***	−0.0677***	(-11.43)
Age	−0.0358***	−0.0457***	−0.0599***	−0.0594***	−0.0792***	−0.0560***	(-4.93)	−0.0602***	−0.0483***	−0.0490***	−0.0758***	−0.1109***	−0.0688***	(-11.40)
β_{MKT}	−0.0616***	−0.0424***	−0.0364***	−0.0403***	−0.0816***	−0.0524***	(-5.07)	−0.0857***	−0.0452***	−0.0435***	−0.0515***	−0.1116***	−0.0675***	(-13.06)
β_{SMB}	−0.0753***	−0.0486***	−0.0402***	−0.0433***	−0.0575***	−0.0530***	(-4.98)	−0.0986***	−0.0616***	−0.0429***	−0.0582***	−0.0787***	−0.0680***	(-11.78)
β_{HML}	−0.0618***	−0.0388***	−0.0398***	−0.0411***	−0.0825***	−0.0528***	(-5.17)	−0.0879***	−0.0363***	−0.0392***	−0.0457***	−0.1167***	−0.0652***	(-11.67)
β_{DEF}	−0.0663***	−0.0341***	−0.0402***	−0.0477***	−0.0700***	−0.0517***	(-5.18)	−0.0905***	−0.0317***	−0.0359***	−0.0592***	−0.1053***	−0.0645***	(-13.49)
β_{TERM}	−0.0742***	−0.0427***	−0.0414***	−0.0360***	−0.0462***	−0.0481***	(-4.62)	−0.0741***	−0.0374***	−0.0517***	−0.0661***	−0.0923***	−0.0643***	(-12.69)
β_{LIQ}	−0.0685***	−0.0406***	−0.0402***	−0.0416***	−0.0664***	−0.0515***	(-5.24)	−0.0951***	−0.0560***	−0.0410***	−0.0362***	−0.0932***	−0.0643***	(-11.98)

Panel B: Long-short excess returns and alphas for each quintile portfolio sorted by β_{VOLA}

β_{VOLA}	Long-short returns for each quintile portfolio							Long-short alphas for each quintile portfolio						
control variable	1	2	3	4	5	H-L	*t*-stat	1	2	3	4	5	H-L	*t*-stat
Maturity	−0.0428***	−0.0427***	−0.0447***	−0.0348***	−0.0745***	−0.0479***	(-5.38)	−0.0340***	−0.0431***	−0.0470***	−0.0391***	−0.1145***	−0.0556***	(-7.49)
Coupon	−0.0163**	−0.0209*	−0.0430***	−0.0571***	−0.0897***	−0.0454***	(-4.53)	−0.0293***	−0.0285***	−0.0278***	−0.0559***	−0.0969***	−0.0477***	(-8.54)
Size	−0.0969***	−0.0632***	−0.0531***	−0.0357**	−0.0317	−0.0561***	(-4.23)	−0.1079***	−0.0562***	−0.0573***	−0.0196**	−0.0135	−0.0509***	(-5.43)
Age	−0.0274***	−0.0366**	−0.0652***	−0.0568***	−0.0816***	−0.0535***	(-4.11)	−0.0299***	−0.0224**	−0.0416***	−0.0599***	−0.0936***	−0.0495***	(-5.23)
β_{MKT}	−0.0575***	−0.0353***	−0.0306***	−0.0309***	−0.0887***	−0.0486***	(-4.91)	−0.0641***	−0.0185**	−0.0313***	−0.0434***	−0.0878***	−0.0490***	(-5.91)
β_{SMB}	−0.0779***	−0.0471***	−0.0361***	−0.0348***	−0.0591***	−0.0510***	(-4.85)	−0.0698***	−0.0540***	−0.0326***	−0.0428***	−0.0637***	−0.0526***	(-5.86)
β_{HML}	−0.0766***	−0.0336***	−0.0338***	−0.0397***	−0.0710***	−0.0509***	(-4.90)	−0.1110***	−0.0312***	−0.0232**	−0.0332***	−0.0521***	−0.0502***	(-6.12)
β_{DEF}	−0.0748***	−0.0351***	−0.0342**	−0.0425***	−0.0617***	−0.0496***	(-4.74)	−0.0686***	−0.0332***	−0.0313***	−0.0458***	−0.0671***	−0.0492***	(-6.78)
β_{TERM}	−0.0807***	−0.0450***	−0.0399***	−0.0390***	−0.0408***	−0.0491***	(-6.10)	−0.0714***	−0.0435***	−0.0329***	−0.0525***	−0.0634***	−0.0528***	(-9.92)
β_{LIQ}	−0.0714***	−0.0281***	−0.0267**	−0.0404***	−0.0719***	−0.0477***	(-4.89)	−0.0780***	−0.0385***	−0.0128	−0.0293***	−0.0626***	−0.0443***	(-5.88)

- the negative premia of jump and volatility risk we identify are robust to controlling for the effects of conventional risk betas and bondcharacteristics.

Fama-MacBeth cross-sectional regressions

Intercept	β_{MKT}	β_{SMB}	β_{HML}	β_{DEF}	β_{TERM}	β_{LIQ}	β_{JUMP}	β_{VOLA}	*ILLIQ*	*Coupon*	*Size*	*Rating*	*Age*	*Maturity*	Adj. R^2
0.0704***							−0.0202***								0.062
(3.38)							(-5.13)								
0.0696***	0.0037	0.0029	0.0020				−0.0199***								0.095
(3.45)	(1.52)	(0.94)	(1.24)				(-5.03)								
0.0608***	0.0083*	0.0060	0.0037	0.0136**	0.0107***		−0.0186***								0.161
(3.29)	(1.93)	(1.41)	(1.36)	(2.10)	(3.03)		(-5.40)								
0.0595***	0.0091*	0.0029	−0.0004	0.0188*	0.0089*	0.0137*	−0.0180***								0.176
(3.28)	(1.83)	(0.94)	(-0.09)	(1.82)	(1.89)	(1.91)	(-5.61)								
0.0163	−0.0002	−0.0029	−0.0044	0.0068	0.0034	0.0124**	−0.0146***			0.0154***	−0.0039***	0.0146**	−0.0044***	0.0096*	0.338
(1.24)	(-0.05)	(-0.93)	(-0.93)	(1.17)	(0.89)	(2.11)	(-4.64)			(6.25)	(-4.28)	(2.14)	(-2.87)	(1.88)	
0.0024	−0.0003	−0.0030	−0.0047	0.0068	0.0035	0.0127**	−0.0143***		0.0037	0.0154***	−0.0018	0.0144**	−0.0047***	0.0084*	0.347
(0.16)	(-0.13)	(-0.98)	(-0.98)	(1.21)	(0.92)	(2.14)	(-4.74)		(1.33)	(5.99)	(-0.97)	(2.13)	(-2.62)	(1.77)	
0.0719***								−0.0181***							0.062
(3.39)								(-4.37)							
0.0720***	0.0016	0.0004	0.0020					−0.0181***							0.094
(3.45)	(0.84)	(0.13)	(1.17)					(-4.36)							
0.0626***	0.0069	0.0048	0.0053*	0.0138**	0.0117***			−0.0181***							0.156
(3.31)	(1.55)	(1.00)	(1.75)	(2.04)	(3.17)			(-6.05)							
0.0611***	0.0074	0.0017	0.0016	0.0182*	0.0104***	0.0134**		−0.0175***							0.171
(3.31)	(1.45)	(0.46)	(0.39)	(1.84)	(2.97)	(1.97)		(-6.25)							
0.0182	−0.0011	−0.0037	−0.0029	0.0064	0.0049*	0.0121**		−0.0152***		0.0158***	−0.0039***	0.0137**	−0.0050***	0.0095	0.333
(1.32)	(-0.35)	(-1.14)	(-0.67)	(1.14)	(1.69)	(2.12)		(-5.54)		(6.74)	(-4.40)	(1.96)	(-3.71)	(1.63)	
0.0037	−0.0012	−0.0038	−0.0032	0.0064	0.0053*	0.0123**		−0.0149***	0.0040	0.0158***	−0.0017	0.0134*	−0.0053***	0.0083	0.343
(0.24)	(-0.40)	(-1.20)	(-0.74)	(1.20)	(1.82)	(2.15)		(-5.44)	(1.37)	(6.43)	(-0.94)	(1.94)	(-3.29)	(1.51)	
0.0661***							−0.0182***	−0.0128***							0.108
(3.23)							(-5.50)	(-3.52)							
0.0662***	0.0029	0.0016	0.0027				−0.0179***	−0.0131***							0.137
(3.30)	(1.50)	(0.54)	(1.45)				(-5.51)	(-3.84)							
0.0593***	0.0078*	0.0068	0.0053*	0.0122*	0.0086***		−0.0172***	−0.0141***							0.191
(3.22)	(1.84)	(1.40)	(1.72)	(1.78)	(2.60)		(-6.11)	(-5.23)							
0.0581***	0.0084*	0.0039	0.0018	0.0167	0.0073**	0.0125**	−0.0168***	−0.0136***							0.204
(3.21)	(1.70)	(1.07)	(0.44)	(1.63)	(2.00)	(1.96)	(-6.12)	(-5.04)							
0.0154	−0.0002	−0.0019	−0.0025	0.0058	0.0032	0.0114**	−0.0127***	−0.0124***		0.0154***	−0.0036***	0.0133*	−0.0044***	0.0092*	0.356
(1.15)	(-0.06)	(-0.65)	(-0.58)	(0.96)	(1.02)	(2.15)	(-5.36)	(-7.01)		(6.44)	(-4.36)	(1.92)	(-2.94)	(1.75)	
0.0024	−0.0003	−0.0021	−0.0028	0.0058	0.0033	0.0117**	−0.0124***	−0.0123***	0.0034	0.0154***	−0.0017	0.0131*	−0.0047***	0.0082*	0.366
(0.17)	(-0.10)	(-0.72)	(-0.65)	(1.00)	(1.09)	(2.18)	(-5.51)	(-6.70)	(1.20)	(6.14)	(-0.96)	(1.92)	(-2.68)	(1.65)	

- these two risk factors are separately priced in the corporate bond market.

4.Empirical results

- Consistent with theory: financial contracting theory (e.g.Smith and Warner, 1979) : high volatility increases stock value but decreases bond value.

- The premia of jump and volatility risk are also **different** in bonds and stocks:

  Cremers(2015): R_{h-l} for β_{VOLA} is about half of that sorted on β_{JUMP} in the stock market.

  By contrast, our results: R_{h-l} for β_{JUMP} and β_{VOLA} are similar in the corporate bond market. (R_{h-l} for β_{JUMP})< stock

  ➡ Compared to stocks, corporate bonds are safer

Intra-rating jump and volatility risk pricing

Panel A: Distribution of betas by rating

Rating	Portfolios sorted by {β_{{JUMP}}}							Portfolios sorted by {β_{{VOLA}}}						
	1	2	3	4	5	5–1	t-stat	1	2	3	4	5	5–1	t-stat
AAA/AA	−0.1471	−0.0611	−0.0284	−0.0017	0.0631	0.2102***	(7.74)	−0.2702	−0.0934	−0.0307	0.0200	0.1585	0.4287***	(8.14)
A	−0.1827	−0.0774	−0.0381	−0.0052	0.0750	0.2577***	(8.40)	−0.3452	−0.1301	−0.0507	0.0220	0.1933	0.5385***	(7.26)
BBB	−0.2228	−0.0983	−0.0465	0.0008	0.1111	0.3339***	(8.04)	−0.4901	−0.2167	−0.1038	−0.0003	0.2256	0.7157***	(8.50)
Junk	−0.3026	−0.1174	−0.0445	0.0311	0.2409	0.5434***	(7.73)	−0.7226	−0.3288	−0.1537	−0.0014	0.3847	1.1073***	(11.99)

Panel B: Excess returns and alphas by rating

Rating	Returns							Alphas						
	1	2	3	4	5	5–1	*t*-stat	1	2	3	4	5	5–1	*t*-stat
β_{JUMP}														
AAA/AA	0.0765	0.0574	0.0489	0.0425	0.0552	−0.0213**	(-2.33)	0.0781	0.0617	0.0541	0.0444	0.0419	−0.0363***	(-4.90)
A	0.0975	0.0766	0.0626	0.0576	0.0633	−0.0342***	(-3.85)	0.0931	0.0712	0.0585	0.0560	0.0429	−0.0502***	(-5.35)
BBB	0.1328	0.1094	0.0960	0.0911	0.0789	−0.0539***	(-4.48)	0.1010	0.0889	0.0784	0.0764	0.0395	−0.0614***	(-6.53)
Junk	0.1760	0.1621	0.1493	0.1438	0.0682	−0.1078***	(-6.68)	0.1364	0.1138	0.0980	0.0969	0.0233	−0.1131***	(-11.53)
β_{VOLA}														
AAA/AA	0.0700	0.0557	0.0469	0.0482	0.0584	−0.0116	(-1.00)	0.0705	0.0532	0.0448	0.0504	0.0554	−0.0151	(-1.34)
A	0.0877	0.0748	0.0664	0.0639	0.0626	−0.0252**	(-2.40)	0.0806	0.0696	0.0616	0.0598	0.0491	−0.0315***	(-3.06)
BBB	0.1250	0.1081	0.0981	0.0953	0.0795	−0.0455***	(-3.69)	0.0970	0.0872	0.0781	0.0759	0.0483	−0.0487***	(-3.73)
Junk	0.1931	0.1718	0.1552	0.1455	0.0651	−0.1280***	(-7.20)	0.1138	0.1114	0.1156	0.1212	0.0157	−0.0981***	(-10.47)

Panel C: Cross-sectional regressions of individual bonds by rating

Rating	Intercept	β_{MKT}	β_{SMB}	β_{HML}	β_{DEF}	β_{TERM}	β_{LIQ}	β_{JUMP}	β_{VOLA}	*ILLIQ*	*Coupon*	*Size*	*Age*	*Maturity*	Adj. R^2
AAA/AA	0.0180	0.0073	0.0046	0.0008	0.0124*	0.0056*	0.0071*	−0.0035	0.0004	0.0030*	0.0141***	−0.0013	−0.0042	0.0058	0.564
	(1.21)	(1.47)	(1.14)	(0.22)	(1.70)	(1.76)	(1.80)	(-1.32)	(0.13)	(1.75)	(3.27)	(-1.05)	(-1.51)	(1.08)	
A	−0.0072	−0.0005	−0.0007	−0.0070	0.0022	0.0025	0.0103	−0.0050**	−0.0061***	0.0063**	0.0130***	0.0025	−0.0056**	0.0108*	0.425
	(-0.89)	(-0.25)	(-0.35)	(-1.01)	(0.50)	(0.75)	(1.42)	(-2.41)	(-3.33)	(2.08)	(5.30)	(1.33)	(-2.15)	(1.73)	
BBB	0.0480*	0.0071**	−0.0023	−0.0019	0.0087*	0.0083***	0.0055**	−0.0133***	−0.0084***	0.0046**	0.0162***	−0.0063**	−0.0044**	0.0115**	0.377
	(1.65)	(1.98)	(-1.10)	(-0.80)	(1.80)	(2.94)	(2.19)	(-4.65)	(-2.62)	(2.13)	(7.56)	(-2.16)	(-2.09)	(2.13)	
Junk	0.1363***	0.0015	−0.0027	−0.0005	−0.0002	0.0020	0.0170*	−0.0260***	−0.0322***	−0.0047	0.0065***	−0.0083	−0.0004	−0.0007	0.426
	(3.29)	(0.23)	(-0.36)	(-0.06)	(-0.02)	(0.28)	(1.88)	(-5.55)	(-6.39)	(-0.44)	(3.36)	(-1.14)	(-0.11)	(-0.17)	

Panel D: Cross-sectional regressions of individual bonds with rating dummy

Intercept	β_{MKT}	β_{SMB}	β_{HML}	β_{DEF}	β_{TERM}	β_{LIQ}	β_{JUMP}	β_{JUMP} × *Junk*	β_{VOLA}	β_{VOLA} × *Junk*	*ILLIQ*	*Coupon*	*Size*	*Rating*	*Age*	*Maturity*	Adj. R^2
0.0047	−0.0004	−0.0022	−0.0024	0.0060	0.0046	0.0116**	−0.0100***	−0.0083**	−0.0078***	−0.0143***	0.0038	0.0161***	−0.0015	0.0102	−0.0050***	0.0085*	0.388
(0.33)	(-0.12)	(-0.77)	(-0.57)	(1.06)	(1.52)	(2.18)	(-4.30)	(-2.29)	(-4.82)	(-4.09)	(1.37)	(6.30)	(-0.86)	(1.61)	(-2.96)	(1.74)	

- bonds with **lower ratings** are more sensitive to jump and volatility risk.
- larger firms issuing **AAA/AA** bonds are better able to weather these risks.
- Investors :pay higher prices for hedging against JUMP and VOLA risk for junk
- **Volatility risk** plays a bigger role than jump risk in pricing low-rated bonds.

5.Additional tests

- conditional skewness and kurtosis are related to jump risk (Chang, 2013; Cremers, 2015)➡JUMP could be a proxy for **coskewness** and **cokurtosis**?

$$R_t^i = \alpha_i + \beta_t^i \cdot R_{m,t} + \gamma_t^i \cdot R_{m,t}^2 + \varepsilon_t^i$$

$$R_t^i = \alpha_i + \beta_t^i \cdot R_{m,t} + \gamma_t^i \cdot R_{m,t}^2 + \kappa_t^i \cdot R_{m,t}^3 + \varepsilon_t^i,$$

market | systematic skewness | systematic kurtosis

- **bond market factors** constructed from the risk characteristics of corporate bonds can play a bigger role in corporate bond pricing than standard stock market factors(Bai et al., 2019)

$$R_t^i = \alpha_i + \beta_{MKT_t}^i \cdot MKT_t + \beta_{SMB_t}^i \cdot SMB_t + \beta_{HML_t}^i \cdot HML_t + \beta_{MKTb_t}^i \cdot MKTb_t \\ + \beta_{DRF_t}^i \cdot DRF_t + \beta_{CRF_t}^i \cdot CRF_t + \beta_{LRF_t}^i \cdot LRF_t + \varepsilon_t^i$$

- controlling for the stock market liquidity factor 、 bond return reversals and momentum 、estimation windows

Robust

5.Additional tests

波动性预期, non-tradable proxy

- volatility risk measured by innovations of **VIX** is negatively priced in the cross-section of corporate bond returns (Chung et al. (2019))

Intercept	β_{MKT}	β_{SMB}	β_{HML}	β_{DEF}	β_{TERM}	β_{LIQ}	β_{VIX}	β_{JUMP}	β_{VOLA}	*ILLIQ*	*Coupon*	*Size*	*Rating*	*Age*	*Maturity*	Adj. R^2
-0.0272	-0.0250***	-0.0066	-0.0021	-0.0070	0.0164	0.0063	-0.0143***			0.0099**	0.0108***	0.0025	0.0314***	-0.0035*	0.0153**	0.331
(-1.59)	(-2.65)	(-0.62)	(-0.32)	(-0.89)	(0.96)	(0.99)	(-2.82)			(2.11)	(4.85)	(0.79)	(2.77)	(-1.77)	(2.43)	
0.0015	-0.0021	-0.0035	-0.0043	0.0067	0.0037	0.0126**	-0.0040**	-0.0133***		0.0040	0.0154***	-0.0017	0.0142**	-0.0046***	0.0086*	0.356
(0.10)	(-0.74)	(-1.24)	(-0.85)	(1.20)	(0.96)	(2.06)	(-2.38)	(-4.53)		(1.46)	(5.99)	(-0.92)	(2.15)	(-2.64)	(1.79)	
0.0030	-0.0034	-0.0043	-0.0027	0.0063	0.0055*	0.0121**	-0.0052***		-0.0142***	0.0041	0.0158***	-0.0016	0.0130*	-0.0053***	0.0085	0.354
(0.20)	(-1.04)	(-1.40)	(-0.59)	(1.16)	(1.92)	(2.06)	(-3.46)		(-5.70)	(1.47)	(6.44)	(-0.89)	(1.91)	(-3.30)	(1.52)	
0.0017	-0.0018	-0.0028	-0.0027	0.0057	0.0036	0.0116**	-0.0029**	-0.0118***	-0.0119***	0.0036	0.0154***	-0.0016	0.0130*	-0.0047***	0.0085*	0.373
(0.12)	(-0.57)	(-1.03)	(-0.58)	(0.98)	(1.20)	(2.09)	(-2.04)	(-5.12)	(-6.97)	(1.29)	(6.14)	(-0.91)	(1.93)	(-2.70)	(1.68)	

- the option-based jump and volatility risk factors do a good job in capturing the information in aggregate volatility.
- the tradable jump and volatility risk factors perform better than the non-tradable proxy for aggregate volatility, ΔVIX

(VIX is a **biased estimator** of volatility in the presence of price discontinuities (Du ,2011))

5.Additional tests

- whether jump and volatility risk are priced differently in times of stress when market uncertainty exacerbates and investors' risk aversion elevates
- December 2007 to June 2009 as the crisis period

	Intercept	β_{MKT}	β_{SMB}	β_{HML}	β_{DEF}	β_{TERM}	β_{LIQ}	β_{JUMP}	β_{VOLA}	*ILLIQ*	*Coupon*	*Size*	*Rating*	*Age*	*Maturity*	Adj. R^2
Panel A: May 2008–December 2010 in which a rolling window contains at least 6 months in the crisis period																
Crisis	0.0734***	0.0049	0.0035	0.0025	0.0017	0.0050	0.0204***	−0.0223***	−0.0185***	0.0012	0.0213***	−0.0057*	−0.0187	−0.0052	−0.0041	0.283
	(3.17)	(0.45)	(0.46)	(0.53)	(0.15)	(1.26)	(9.68)	(-6.22)	(-3.46)	(0.22)	(3.07)	(-1.69)	(-1.28)	(-0.70)	(-0.36)	
Normal	−0.0124	−0.0014	−0.0032	−0.0039	0.0066	0.0030	0.0099	−0.0104***	−0.0110***	0.0038	0.0142***	−0.0008	0.0197***	−0.0046***	0.0107***	0.383
	(-1.10)	(-0.46)	(-1.15)	(-0.81)	(1.05)	(0.81)	(1.59)	(-5.45)	(-8.72)	(1.16)	(9.23)	(-0.47)	(4.90)	(-4.30)	(2.81)	
Panel B: November 2008–June 2010 in which a rolling window contains at least 12 months in the crisis period																
Crisis	0.1065***	0.0062	0.0043	−0.0007	0.0060	0.0093**	0.0229***	−0.0230***	−0.0177***	−0.0012	0.0203***	−0.0094***	−0.0361**	−0.0048	−0.0125	0.256
	(6.25)	(0.41)	(0.37)	(-0.15)	(0.39)	(2.57)	(14.56)	(-4.76)	(-6.27)	(-0.28)	(2.79)	(-4.74)	(-2.43)	(-0.55)	(-1.10)	
Normal	−0.0101	−0.0011	−0.0028	−0.0030	0.0058	0.0026	0.0104*	−0.0112***	−0.0117***	0.0039	0.0148***	−0.0007	0.0190***	−0.0046***	0.0107***	0.379
	(-0.97)	(-0.39)	(-1.03)	(-0.64)	(0.97)	(0.77)	(1.79)	(-5.68)	(-7.82)	(1.31)	(8.01)	(-0.43)	(4.48)	(-4.28)	(2.76)	

- $\beta_{JUMP}, \beta_{VOLA}$: **more negative coefficient** in the crisis period,consistent with theory: Investors require larger premia for jump and volatility risk in times of stress.
- jump risk is a much more important pricing factor during the crisis period: Corporate bonds are very vulnerable to **default risk**- heightens during **stressed time**,

5.Additional tests

Predicting future jump and volatility risk

过去的beta建立投资组合的未来收益

Panel A: Sorted by past 2-year realized jump and volatility betas

Future realized	Portfolios sorted by past realized {β_{{JUMP}}} (t - 23, t)							Portfolios sorted by past realized {β_{{VOLA}}} (t - 23, t)						
\left (\vphantom{\left({{t}\ {1},{}{t}\ {24}}\right)}\right t+1,\hskip 0.25emt+24 \left)\vphantom{\left({{t}\ {1},{}{t}\ {24}}\right)}\right	1	2	3	4	5	5–1	*t*-stat	1	2	3	4	5	5–1	*t*-stat
Return	0.1148	0.0812	0.0697	0.0739	0.1180	0.0031	(0.28)	0.1243	0.0889	0.0700	0.0709	0.1042	−0.0201***	(-3.39)
AdjRet	0.0038	−0.0052	−0.0065	−0.0053	0.0098	0.0061	(0.90)	0.0064	−0.0002	−0.0061	−0.0057	0.0037	−0.0027	(-0.57)
Return Alpha	0.0769	0.0634	0.0565	0.0705	0.1089	0.0320***	(3.78)	0.1001	0.0738	0.0597	0.0618	0.0803	−0.0198***	(-2.84)
AdjRet Alpha	−0.0082	−0.0029	−0.0068	0.0009	0.0133	0.0216***	(6.92)	−0.0015	0.0026	−0.0031	−0.0010	0.0031	0.0046	(1.03)

Panel B: Sorted by predicted jump and volatility betas

过去的特征和beta预测β_{JUMP} β_{VOLA}

B1: Fama-MacBeth regressions for predicting β_{JUMP} and β_{VOLA}

Intercept	β_{MKT}	β_{SMB}	β_{HML}	β_{DEF}	β_{TERM}	β_{LIQ}	Lag β_{JUMP}	Lag β_{VOLA}	*ILLIQ*	*Skew*	*Kurt*	β_{MKTb}	*IVol*	*Coupon*	*Size*	*Rating*	*Age*	*Maturity*	Adj. R^2
Dependent variable: β_{JUMP}																			
−0.0091	−0.0025	0.0060	−0.0010	−0.0010	−0.0055***	−0.0005**	−0.0089	−0.0029	−0.0621**	0.0072**	0.0010*	0.8483***	−0.7819***	0.0698	−0.0008	−0.0035***	0.0014***	−0.0007	0.156
(-0.51)	(-0.53)	(1.39)	(-0.40)	(-0.47)	(-2.68)	(-2.03)	(-0.89)	(-0.60)	(-2.51)	(2.24)	(1.90)	(3.86)	(-2.87)	(0.66)	(-0.51)	(-5.44)	(4.15)	(-0.55)	
Dependent variable: β_{VOLA}																			
0.0445	0.0096	0.0502***	−0.0163	−0.0187	−0.0233	0.0014	0.0454	0.0003	−0.1122**	0.0388***	0.0246**	1.9969	−2.2808***	−0.1931	−0.0075	−0.0070**	0.0020**	−0.0023	0.266
(0.95)	(0.23)	(2.79)	(-1.58)	(-1.28)	(-1.64)	(0.56)	(1.23)	(0.01)	(-2.40)	(2.67)	(1.99)	(0.82)	(-2.71)	(-0.75)	(-0.97)	(-2.16)	(2.02)	(-0.77)	

B2: Portfolio sorts on predicted β_{JUMP} and β_{VOLA}

Future realized	Predicted β_{JUMP} $(t+1, t+24)$							Predicted β_{VOLA} $(t+1, t+24)$						
$(t+1, t+24)$	1	2	3	4	5	5–1	*t*-stat	1	2	3	4	5	5–1	*t*-stat
β	−0.1008	−0.0574	−0.0385	−0.0191	0.0083	0.1091***	(16.00)	−0.3065	−0.1721	−0.1044	−0.0489	0.0165	0.3230***	(6.80)
Return	0.1308	0.0975	0.0790	0.0670	0.0424	−0.0884***	(-3.44)	0.1377	0.1014	0.0777	0.0680	0.0384	−0.0993***	(-3.60)
AdjRet	0.0120	0.0001	−0.0002	−0.0013	−0.0122	−0.0242***	(-3.96)	0.0123	−0.0013	−0.0022	0.0022	−0.0128	−0.0251***	(-4.62)
Return Alpha	0.0967	0.0742	0.0664	0.0604	0.0409	−0.0558***	(-6.18)	0.1005	0.0770	0.0655	0.0653	0.0379	−0.0626***	(-6.75)
AdjRet Alpha	0.0079	0.0016	0.0020	−0.0001	−0.0135	−0.0214***	(-5.55)	0.0054	0.0021	0.0002	0.0055	−0.0155	−0.0209***	(-8.10)

- β_{JUMP} is strongly time-varying and cannot be predicted using only past realized betas.
- β_{JUMP} ， β_{VOLA} can be predicted, to construct investable portfolios

whether idiosyncratic volatility will have a significant effect in the multifactor model with volatility and jump risk.

Panel A: Cross-sectional regressions with idiosyncratic bond volatility

Inter.	{β_ {{MKT}}}	{β_ {{SMB}}}	{β_ {{HML}}}	{β_ {{DEF}}}	{β_ {{TERM}}}	{β_ {{LIQ}}}	{β_ {{JUMP}}}	{β_ {{VOLA}}}	*IVol*	*ILLIQ*	*Coupon*	*Size*	*Rating*	*Age*	*Maturity*	Adj. {{\curr \hskip0 R \vphantom{R}}^ {2}}
0.0099	−0.0044*	−0.0066*	−0.0033	0.0135***	0.0057**	0.0056**			0.0072***	0.0033	0.0153***	−0.0028	0.0145***	−0.0059***	0.0093**	0.348
(0.59)	(-1.88)	(-1.90)	(-1.33)	(3.28)	(2.30)	(2.24)			(2.61)	(1.33)	(6.58)	(-1.63)	(2.58)	(-3.77)	(1.96)	
0.0089	−0.0031	−0.0054*	−0.0020	0.0105***	0.0040	0.0043*	−0.0141***		0.0071***	0.0026	0.0149***	−0.0028*	0.0131**	−0.0051***	0.0085*	0.375
(0.57)	(-1.41)	(-1.70)	(-0.83)	(3.45)	(1.31)	(1.70)	(-4.92)		(2.78)	(1.03)	(6.29)	(-1.84)	(2.20)	(-3.04)	(1.95)	
0.0105	−0.0047*	−0.0060*	−0.0006	0.0119***	0.0057***	0.0054**		−0.0145***	0.0069**	0.0030	0.0151***	−0.0029**	0.0125**	−0.0056***	0.0083*	0.371
(0.68)	(-1.83)	(-1.88)	(-0.28)	(3.52)	(2.78)	(2.43)		(-5.45)	(2.38)	(1.19)	(6.53)	(-2.10)	(2.05)	(-3.58)	(1.66)	
0.0095	−0.0037	−0.0052*	−0.0004	0.0103***	0.0039	0.0046**	−0.0120***	−0.0117***	0.0070**	0.0024	0.0147***	−0.0029**	0.0121**	−0.0050***	0.0080*	0.393
(0.64)	(-1.56)	(-1.72)	(-0.18)	(3.53)	(1.45)	(1.96)	(-5.57)	(-6.68)	(2.57)	(0.95)	(6.27)	(-2.21)	(2.00)	(-2.97)	(1.76)	

Panel B: Cross-sectional regressions with idiosyncratic bond volatility by rating

Rating	Inter.	β_{MKT}	β_{SMB}	β_{HML}	β_{DEF}	β_{TERM}	β_{LIQ}	β_{JUMP}	β_{VOLA}	*IVol*	*ILLIQ*	*Coupon*	*Size*	*Age*	*Maturity*	Adj. R^2
AAA/AA	0.0181	0.0012	0.0000	0.0066***	0.0104**	0.0045	0.0015	−0.0040	−0.0013	0.0059***	0.0031*	0.0135***	−0.0016	−0.0044*	0.0056	0.594
	(1.35)	(0.68)	(0.00)	(3.98)	(2.48)	(1.38)	(0.78)	(-1.48)	(-0.52)	(2.69)	(1.93)	(3.24)	(-1.42)	(-1.65)	(1.04)	
A	0.0026	−0.0056*	−0.0027	0.0009	0.0088**	0.0022	0.0032	−0.0063***	−0.0060***	0.0079**	0.0058**	0.0116***	0.0008	−0.0063**	0.0105*	0.467
	(0.27)	(-1.78)	(-1.03)	(0.44)	(2.20)	(0.74)	(1.42)	(-2.81)	(-3.61)	(2.48)	(2.29)	(5.80)	(0.71)	(-2.38)	(1.84)	
BBB	0.0509*	0.0064*	−0.0053*	−0.0020	0.0142***	0.0013	0.0075***	−0.0119***	−0.0086***	0.0071	0.0043***	0.0140***	−0.0063***	−0.0042*	0.0107**	0.423
	(1.79)	(1.66)	(-1.93)	(-0.94)	(3.06)	(0.30)	(3.54)	(-4.21)	(-3.59)	(1.54)	(2.78)	(8.76)	(-2.98)	(-1.75)	(2.18)	
Junk	0.1241***	−0.0030	−0.0127**	0.0021	0.0247***	−0.0044	0.0108	−0.0268***	−0.0306***	0.0089***	−0.0051	0.0080***	−0.0089	0.0004	−0.0021	0.431
	(3.18)	(-0.62)	(-2.18)	(0.24)	(3.39)	(-0.41)	(1.59)	(-7.30)	(-6.02)	(3.24)	(-0.48)	(3.91)	(-1.30)	(0.09)	(-0.59)	

Panel C: Cross-sectional regressions with systematic and idiosyncratic bond volatility

Inter.	β_{MKT}	β_{SMB}	β_{HML}	β_{DEF}	β_{TERM}	β_{LIQ}	β_{JUMP}	β_{VOLA}	*SVol*	*IVol*	*ILLIQ*	*Coupon*	*Size*	*Rating*	*Age*	*Maturity*	Adj. R^2
0.0101	−0.0007	−0.0012	0.0048	0.0190**	0.0046	0.0096**	−0.0114**	−0.0113**	0.0040	0.0008	0.0061	0.0150***	−0.0009	0.0158***	−0.0029	0.0100***	0.540
(0.60)	(-0.37)	(-0.36)	(1.33)	(2.39)	(1.31)	(2.17)	(-2.32)	(-2.07)	(0.97)	(0.15)	(1.05)	(11.87)	(-0.65)	(2.74)	(-1.58)	(2.83)	
0.0079	−0.0025	−0.0019	0.0023	0.0256***	0.0057	0.0096**			0.0129***	−0.0007	0.0073	0.0147***	−0.0008	0.0177***	−0.0026	0.0074**	0.503
(0.44)	(-1.28)	(-0.45)	(1.14)	(2.76)	(1.42)	(2.26)			(3.25)	(-0.16)	(1.26)	(11.01)	(-0.47)	(2.90)	(-1.28)	(2.24)	

- IVOL is due to the omission of jump and vol risk in the conventional factor model➡×
- β_{JUMP} , β_{VOLA} robust; low rating
- Bai (2021)： control systematic risk, the effect of idiosyncratic risk becomes weaker

SVol, IVol （BBW residuals） ： SVol is subsumed by jump and volatility risk factors. SVol is significant while IVol is insignificant.

5. Conclusion

- A **structural model** to show that jump and volatility risk are separately priced factors in expected corporate bond returns.
- An **investable option approach** to separate the aggregate volatility factor into two orthogonal parts—jump and volatility risk factors
- Volatility and jump risk are **separately priced** in the corporate bond market. Bonds with high sensitivities to jump and volatility risk have **low returns.**
- The jump and volatility risk premia are larger for **lower-quality bonds** and in times of **stress** when external shocks and default risk are high.
- While the loadings of jump and volatility risk are **time-varying**, future betas can be **predicted**.