Comoment Risk in Corporate Bond Yields and Returns

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- Price formation in fixed income instruments is reflected in both yields and returns (Jarrow, 1978).
- With few exceptions, bond literature has examined yields and returns separately.
    - Credit spread determinants are hard to identify, certainly driven by a systematic factor (Collin-Dufresne et al., 2001).
    - Bond returns hardly explained by equity return factors (Fama and French, 1993, Lin, Wang and Wu, 2011, Bai, Bali and Wen, 2016) but also subject to a systematic factor (Gebhardt et al., 2005, Koijen et al., 2010).
- Investigate a common source of risk for bond yields and returns through a comoment factor analysis.

- Asset pricing literature: Required returns reflect investors' preferences with respect to higher moments
  - GE models of Rubinstein (1976), Kraus and Litzenberger (1976),
  - Application to equity returns (Harvey and Siddique, 2000, Barone-Adesi et al., 2004, for skewness, Dittmar, 2002, for kurtosis),
  - Existence of coskewness and cokurtosis premiums (Lambert and Hübner, 2010).
- Our goal: Challenge this framework for corporate bonds.
- Because of the default event, unconditional bond returns display large left skewness and positive kurtosis. What are bond investors' preferences? How do they impact on corporate bond pricing?

- Decomposition of corporate bond default excess return into
  - A systematic default risk premium: Model-dependent, ex ante reward for default risk exposure,
  - A net excess return: Ex post market correction.
- Comoment factor analysis of these two components using index and sub-indices bond portfolios.
- Highlight bond investors specific preferences
  - All comoments up to order four contribute significantly and positively to the systematic default risk premium,
  - Mostly cokurtosis that affects net excess return negatively.
- Assess the relative importance of tail risk (kurtosis) wrt to downgrading risk (covariance) across the maturity spectrum.

- Arbitrage-free, continuous-time economy. The *net excess return* of a bond is
  - The difference between realized return and its time-dependent expectation.
  - Formally, for a bond with time to maturity τ

$$R_t^{NET}(\tau) = R_t(\tau) - \mathbb{E}_{t^-}^{P}\left[R_t(\tau)\right].$$

- Unconditional expectation of net excess return is zero.
- But realized returns can diverge from their conditional expectation (Elton, 1999).
- We conjecture these deviations could be systematic.

Comoment Risk in Corporate Bonds

François, Heck, Hübner & Lejeune

Motivation

Summary of findings

Bond return decomposition

Data

Estimation results

Comoment factor analysis

Conclusion

- Reduced-form model of defaultable bond (Duffie and Singleton, 1999, Duffee, 1999, Bakshi et al., 2006). Bond price is given by

$$B_t(\tau) = \mathbb{E}_t^Q \left[\exp\left(-\int_t^{t+\tau} (\tilde{r}_u + \tilde{s}_u)\, du \right) \right],$$

with $\mathbb{Q}$-dynamics

$$\begin{aligned} d\tilde{r}_t &= (\kappa_0 + \lambda_0)\left(\frac{\kappa_0 \theta_0}{\kappa_0 + \lambda_0} - \tilde{r}_t \right) dt + \sigma_0 \sqrt{\tilde{r}_t}\, d\tilde{W}_t^0 \\ d\tilde{v}_t &= (\kappa_1 + \lambda_1)\left(\frac{\kappa_1 \theta_1}{\kappa_1 + \lambda_1} - \tilde{v}_t \right) dt + \sigma_1 \sqrt{\tilde{v}_t}\, d\tilde{W}_t^1 \\ \tilde{s}_t &= \alpha + \beta \tilde{r}_t + \tilde{v}_t. \end{aligned}$$

- Bond price and yield are available in closed-form (affine two-factor square root process model)

$$B_t(\tau) = a_0(\tau)\, a_1(\tau)\, e^{-\alpha\tau - b_0(\tau)(1+\beta)\tilde{r}_t - b_1(\tau)\tilde{v}_t}.$$

- Under P, the expected instantaneous return on the bond with *constant time to maturity* can be decomposed into (Yu, 2002)

$$\underbrace{\tilde{r}_t}_{\text{A}} - \underbrace{b_0(\tau)\,\tilde{r}_t\lambda_0}_{\text{B}} - \underbrace{\left[b_0(\tau)\,\beta\tilde{r}_t\lambda_0 + b_1(\tau)\,\tilde{v}_t\lambda_1\right]}_{\text{C}} + \underbrace{\tilde{s}_t - s_t}_{\text{D}}$$

A: Risk-free rate.
B: Interest rate risk premium (μ_t^r).
C: Systematic default risk premium (μ_t^{SYS}).
D: Default event premium.

- Default event premium can be diversified away in a (well diversified) corporate bond portfolio (Jarrow, Lando, Yu, 2005).
- Hence, at the portfolio level

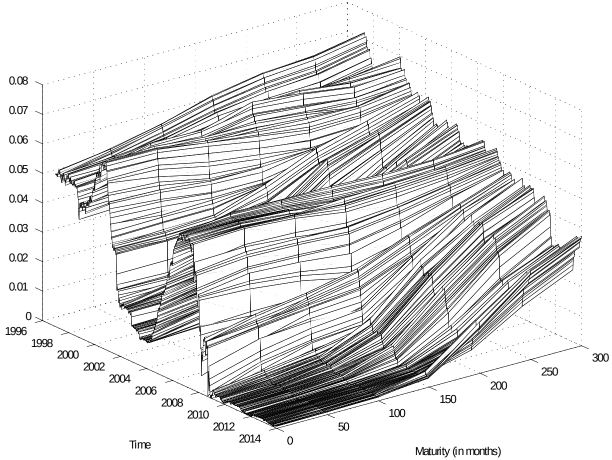
$$R_t^{NET}(\tau) = R_t(\tau) - \tilde{r}_t - \mu_t^r - \mu_t^{SYS},$$

or, equivalently

$$\underbrace{R_t(\tau) - \tilde{r}_t - \mu_t^r}_{\text{A}} = \underbrace{\mu_t^{SYS}}_{\text{B}} + \underbrace{R_t^{NET}(\tau)}_{\text{C}}.$$

A: Excess default return, i.e. difference between the return on the defaultable bond portfolio and the return on the default-free bond with same maturity.
B: Systematic default risk premium. Reward for exposure to default risk. Must be positive.
C: Net excess return. Ex post adjustment for market conditions.

- Treasuries
  - U.S. risk-free term structure from FRED St-Louis Fed.
  - Weekly (Wednesday) data spanning Jan 1997 to Dec 2013.
  - Seven maturities (0.25, 0.5, 1, 2, 5, 10 and 20 years).



- Corporate bond indices
  - Dow Jones Corporate Bond Indices (96 bonds for Composite). Weekly frequency. Jan 1997-Dec 2013 period.
  - Three sectorial sub-indices: Financials, Industrials, Utilities.
  - Four maturities: 2Y, 5Y, 10Y and 30Y.

		2Y	5Y	10Y	30Y
Coupon	Mean	5.79	6.20	6.24	7.00
	Median	6.07	6.48	6.38	6.97
	SD	1.25	0.82	0.90	0.51
Yield	Mean	4.30	5.10	5.71	6.58
	Median	4.91	5.39	5.81	6.57
	SD	1.98	1.58	1.28	1.00
Duration	Mean	2.36	4.45	7.11	12.53
	Median	2.37	4.40	7.01	12.57
	SD	0.14	0.41	0.36	0.82

Statistics for Composite index

Benefits of using DJ bond index data

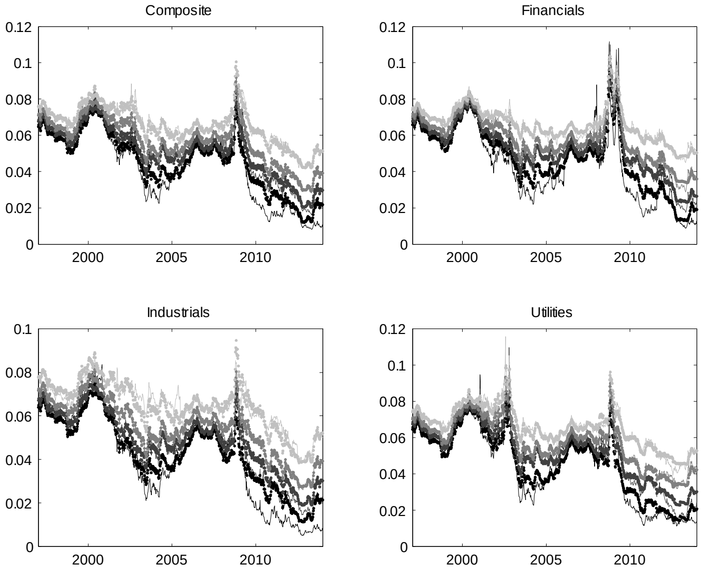
- Indices capture the systematic component of credit risk and eliminate the default event premium.
- Indices are constructed to reduce the exposure to liquidity risk (e.g. preference for on-the-run issues, minimum nominal...).
- Working with four maturities with targeted durations allows to control for term premiums.
- Calculation of premiums is not biased by the pull-to-par phenomenon inherent with individual bond prices.
- Availability of three sub-indices allows to construct comoment factors with respect to the composite index.

- Quasi-linear Kalman filter (Duffee, 1999, Chen and Scott, 2003)
  - To estimate risk-free rate parameters $(k_0, \lambda_0, \theta_0, \sigma_0)$.
  - To retrieve a smoothed estimate of the risk-free rate process $\tilde{r}_t$.
- Plug these estimates into a second Kalman filtering
  - To estimate default intensity parameters $(k_1, \lambda_1, \theta_1, \sigma_1)$.
  - To retrieve a smoothed estimate of the default intensity process $\tilde{v}_t$.
  - To estimate the correlation β between the spread process $\tilde{s}_t$ and the risk-free rate process $\tilde{r}_t$.
- Second step applied to the composite index and the three sub-indices.

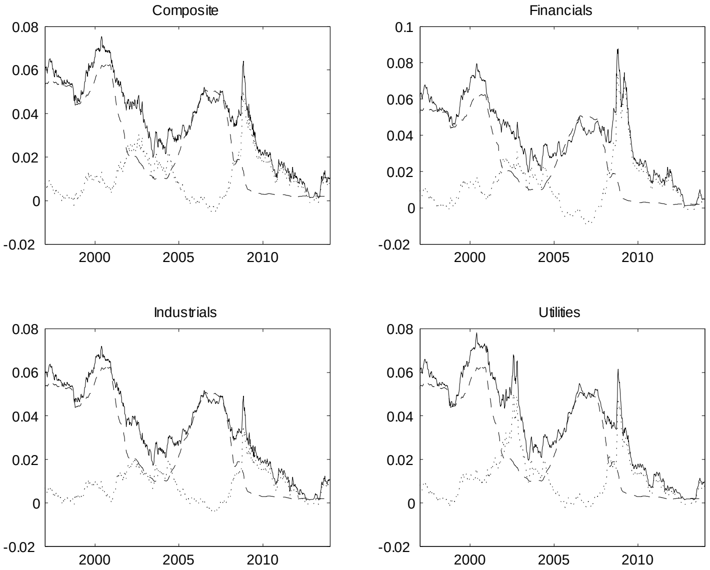
Parameter estimates

	κ_j	λ_j	σ_j	θ_j	β
Treasuries	0.2884 (0.0004)	−0.0466 (0.0034)	0.0372 (0.0009)	0.0505 (0.0005)	
Composite	0.0621 (0.1005)	−0.1046 (0.0711)	0.0746 (0.0102)	0.0236 (0.0025)	−0.3007 (0.1079)
Financials	0.1358 (0.1004)	−0.1003 (0.1597)	0.0876 (0.0334)	0.0251 (0.1208)	−0.3057 (0.2197)
Industrials	0.0303 (0.0045)	−0.1143 (0.4401)	0.0615 (0.0542)	0.0217 (0.0029)	−0.2833 (0.7309)
Utilities	0.0847 (0.1047)	−0.1120 (0.0581)	0.0731 (0.0020)	0.0174 (0.0002)	−0.1757 (0.0180)

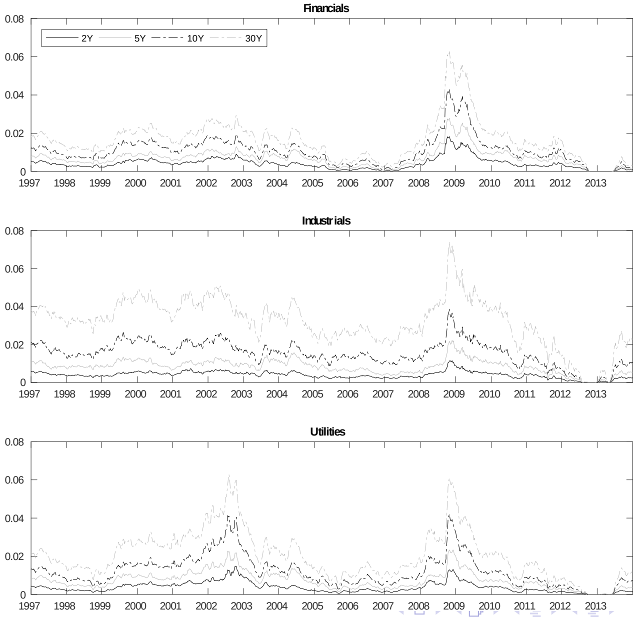
Corporate bond indices yields: Observed vs. fitted



Risk-neutral interest rate and bond spread processes



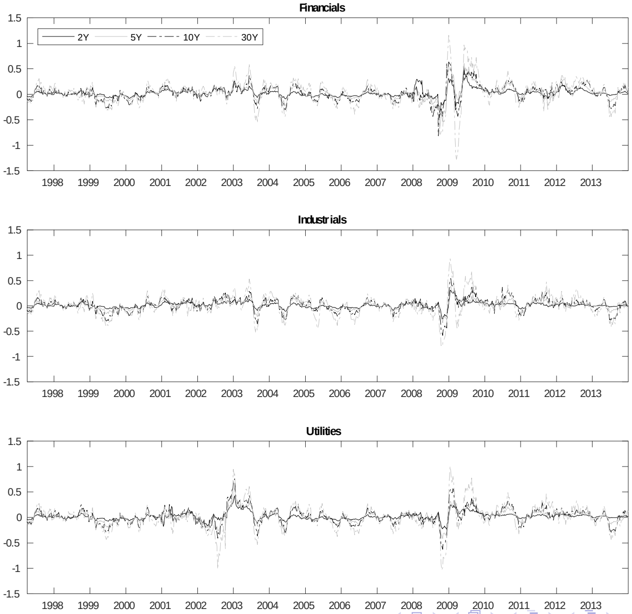
The systematic default risk premium



Computation of realized bond index returns

- Weekly (Wednesday) returns on total return series (account for accrued interests).
- Avoid short horizons: Noise + unreasonable investment horizon.
- We opt for a quarterly return horizon based on the literature on return predictability (e.g. Pastor and Stambaugh, 2009).
- We take weekly observations of these returns over a weekly moving window.

Net excess returns



- Comoments of daily sub-index returns with the composite (market) index returns over a rolling window of 21 days, then retained on a weekly basis (Wednesdays).

$$\begin{aligned} coV_t^{\tau,i} &= cov_t\left[R_{\tau,i,t}, R_{M,t}\right], \\ coS_t^{\tau,i} &= cov_t\left[R_{\tau,i,t}, R_{M,t}^2\right], \\ coK_t^{\tau,i} &= cov_t\left[R_{\tau,i,t}, R_{M,t}^3\right]. \end{aligned}$$

		Financials		Industrials		Utilities	
		2Y	30Y	2Y	30Y	2Y	30Y
coV	Mean	5.36	20.75	3.74	20.86	3.96	21.26
	Median	2.78	15.96	2.76	16.36	2.65	16.38
	SD	19.19	19.35	4.15	17.24	5.56	20.30
coS	Mean	-0.12	-1.59	-0.27	-0.60	-0.32	-0.79
	Median	0.04	0.48	0.05	0.48	0.05	0.51
	SD	7.13	22.53	4.77	16.91	5.80	19.41
coK	Mean	8.45	16.24	3.18	13.98	3.62	15.37
	Median	0.78	4.12	0.75	4.47	0.67	4.43
	SD	73.00	68.06	17.45	52.39	20.12	61.73

Regression analysis

- Multivariate linear model

$$Y_t = \alpha_0 + \alpha_1 coV_t^* + \alpha_2 coS_t^* + \alpha_3 coK_t + \sum_{j \geq 4} \alpha_j Controls_{j,t} + \epsilon_t$$

  with Y_t representing either the systematic default risk premium $\left(\mu_t^{SYS}\right)$ or the net excess return $\left(R_t^{NET}\right)$.
- Covariance is orthogonalized with coskewness and cokurtosis. Coskewness is orthogonalized with cokurtosis.
- Standard set of controls is (Collin-Dufresne et al., 2001, Cremers et al., 2008, Maalaoui Chun et al., 2014)
  - Level of the yield curve (10-year Treasury yield),
  - Slope (30-year Treasury yield – 2-year Treasury yield),
  - VIX,
  - S&P500 returns.

	μ^{SYS} Financials					
		2Y			30Y	
	(1)	(2)	(3)	(1)	(2)	(3)
Const.	0.39***	-0.74***	-0.64***	1.50***	-2.42***	-1.98***
	(4.29)	(-7.21)	(-5.64)	(10.04)	(-5.94)	(-5.17)
coV*	2.65***		0.98	2.65**		1.24
	(2.45)		(1.52)	(2.47)		(1.51)
coS*	0.01		-0.02	3.67***		2.35***
	(0.02)		(-0.09)	(5.95)		(3.45)
coK	0.18***		0.07**	0.71***		0.39***
	(13.12)		(2.24)	(13.96)		(4.09)
Level		0.10***	0.09***		0.36***	0.41***
		(3.53)	(2.81)		(3.00)	(4.76)
Slope		0.09***	0.08***		0.31***	0.29***
		(3.40)	(3.10)		(3.18)	(3.70)
VIX		0.03***	0.02***		0.09***	0.06***
		(5.15)	(3.65)		(4.37)	(4.25)
S&P		1.16***	1.32***		4.14**	2.66**
		(2.72)	(2.73)		(2.44)	(2.18)
Adj. R^2	24.95	65.29	67.95	44.55	64.63	72.58

- Coefficients in percentages.
- Newey-West t−statistics in parentheses.

	μ^{SYS} Industrials					
	2Y			30Y		
	(1)	(2)	(3)	(1)	(2)	(3)
Const.	0.38***	-0.53***	-0.43***	3.06***	-3.15***	-2.88***
	(12.30)	(-6.69)	(-5.44)	(8.24)	(-4.68)	(-5.10)
coV*	3.67***		1.23**	1.52		1.44**
	(3.46)		(2.32)	(0.98)		(1.98)
coS*	0.67*		0.43	1.89*		1.99*
	(1.84)		(1.44)	(1.85)		(1.90)
coK	0.37***		0.16**	0.75***		0.38***
	(15.90)		(1.97)	(4.68)		(2.60)
Level		0.12***	0.12***		0.91***	0.96***
		(5.93)	(4.44)		(5.28)	(6.92)
Slope		0.08***	0.07***		0.44***	0.42***
		(4.51)	(3.33)		(3.63)	(4.05)
VIX		0.01***	0.01**		0.08***	0.05***
		(3.17)	(2.09)		(3.44)	(3.12)
S&P		0.54*	0.47		3.70*	2.06
		(1.86)	(1.29)		(1.87)	(1.20)
Adj. R^2	31.60	71.85	74.67	12.68	73.26	77.43

- Coefficients in percentages.
- Newey-West $t-$statistics in parentheses.

	μ^{SYS} Utilities					
	2Y			30Y		
	(1)	(2)	(3)	(1)	(2)	(3)
Const.	0.36***	-0.80***	-0.64***	1.91***	-3.73***	-3.47***
	(8.56)	(-4.16)	(-4.78)	(7.72)	(-4.33)	(-4.95)
coV*	3.71***		1.96***	2.23		0.68
	(3.61)		(3.77)	(1.61)		(0.81)
coS*	1.77*		1.16***	2.35***		1.77***
	(1.94)		(2.72)	(3.50)		(2.64)
coK	0.48***		0.15	0.76***		0.26**
	(7.34)		(1.37)	(7.78)		(2.32)
Level		0.14***	0.12***		0.72***	0.75***
		(3.45)	(3.67)		(3.69)	(4.66)
Slope		0.11***	0.09***		0.52***	0.50***
		(2.59)	(2.79)		(2.92)	(3.56)
VIX		0.02***	0.02**		0.08***	0.06***
		(3.96)	(2.46)		(3.89)	(3.23)
S&P		0.68	0.45		2.94	1.60
		(1.62)	(0.82)		(1.50)	(0.81)
Adj. R^2	32.84	59.27	65.50	22.01	62.86	66.75

- Coefficients in percentages.
- Newey-West $t-$statistics in parentheses.

	R^{NET} Financials					
		2Y			30Y	
	(1)	(2)	(3)	(1)	(2)	(3)
Const.	2.50**	0.36	-0.65	4.62	21.11	12.71
	(2.43)	(0.05)	(-0.18)	(1.17)	(1.07)	(0.76)
coV*	26.78		15.65	-7.46		-29.03
	(1.51)		(0.61)	(-0.26)		(-0.75)
coS*	12.13***		10.94	31.70		23.48
	(2.71)		(1.58)	(0.36)		(0.26)
coK	-3.06***		-3.89***	-10.66***		-11.96***
	(-12.54)		(-8.10)	(-3.07)		(-2.65)
Level		-0.39	-0.59		-2.92	-3.00
		(-0.36)	(-0.85)		(-0.54)	(-0.81)
Slope		1.65	1.48**		1.59	2.52
		(1.54)	(2.11)		(0.32)	(0.71)
VIX		0.02	0.14		-0.39	0.02
		(0.07)	(1.47)		(-0.33)	(0.04)
S&P		9.83	7.10		-12.07	-20.53
		(0.46)	(0.58)		(-0.09)	(-0.29)
Adj.R^2	9.96	11.55	23.57	11.09	5.66	16.99

- Coefficients in percentages.
- Newey-West $t-$statistics in parentheses.

	R^{NET} Industrials					
		2Y			30Y	
	(1)	(2)	(3)	(1)	(2)	(3)
Const.	1.62**	-0.87	-3.46	1.85	13.31	9.24
	(2.09)	(-0.24)	(-1.08)	(0.79)	(0.82)	(0.73)
coV*	20.73		-13.40	23.32		5.06
	(0.59)		(-0.40)	(0.99)		(0.23)
coS*	63.18***		48.01***	52.34**		43.11
	(3.37)		(5.22)	(2.42)		(1.29)
coK	-7.77***		-13.09***	-9.13***		-12.43***
	(-8.10)		(-3.75)	(-3.93)		(-2.88)
Level		-0.35	-0.24		-3.34	-3.17
		(-0.35)	(-0.23)		(-0.98)	(-1.02)
Slope		1.01	1.11		0.35	0.39
		(1.27)	(1.25)		(0.11)	(0.14)
VIX		0.09	0.19		0.03	0.26
		(0.26)	(1.01)		(0.03)	(0.47)
S&P		-0.40	1.80		1.75	11.75
		(-0.03)	(0.22)		(0.04)	(0.24)
Adj.R^2	13.17	11.88	28.96	14.81	4.78	18.88

- Coefficients in percentages.
- Newey-West $t-$statistics in parentheses.

	R^{NET} Utilities					
	2Y			30Y		
	(1)	(2)	(3)	(1)	(2)	(3)
Const.	2.22**	0.29	-4.68	2.32	26.53	14.52
	(1.96)	(0.04)	(-0.76)	(0.74)	(1.31)	(1.00)
coV*	-26.07**		-41.07***	-6.82		-25.73
	(-2.38)		(-2.70)	(-0.19)		(-0.93)
coS*	45.82***		31.14***	30.69		19.30
	(3.52)		(2.78)	(1.21)		(0.77)
coK	-7.37***		-12.62***	-11.39***		-15.47***
	(-8.81)		(-3.11)	(-3.59)		(-3.17)
Level		-0.61	-0.17		-5.17	-5.04
		(-0.45)	(-0.13)		(-1.31)	(-1.34)
Slope		1.33	1.70		-0.53	0.54
		(0.81)	(1.20)		(-0.12)	(0.15)
VIX		0.08	0.21		-0.15	0.39
		(0.25)	(1.08)		(-0.15)	(0.56)
S&P		7.43	13.65		24.23	71.74
		(0.42)	(1.15)		(0.51)	(1.35)
Adj.R^2	8.81	13.15	26.81	10.19	6.50	18.59

- Coefficients in percentages.
- Newey-West $t-$statistics in parentheses.

Summary of findings

- Comoment factors are, in a vast majority of cases, highly significant.
  - Cokurtosis (significant 47/48 specifications),
  - Covariance (22/48),
  - Coskewness (27/48).
- All comoments affect the systematic default risk premium *positively*.
  - For even moments, consistent with standard preferences.
  - Evidence that bond investors prefer *negative* skewness:
    - Behavioral bias as in Kahneman and Tversky (1979),
    - Prefer running the risk of "blowup" rather than "bleed" (Taleb, 2004).
- Cokurtosis impacts on net excess returns negatively.
  - When risk materializes, high cokurtosis entails more negative returns.

Summary of findings (cont'd)

- Goodness-of-fit
  - μ^{SYS}: Model with controls is marginally improved with comoments.
  - R^{NET}: Comoments substantially increase adjusted R^2 (from 10% to 25%). Explanatory power of controls decays with maturity while that of comoments does not.
- Level of coefficients with maturity
  - Covariance $\downarrow$ while higher moments $\uparrow$ (especially for μ^{SYS}).
  - Substitution effect in the price of risk: downgrading risk more prevalent for shorter bonds, whereas outright default risk (i.e. tail risk) matters more for longer bonds.

Robustness checks

- Alternative ways to compute realized returns:
  - Smoothed weekly realized returns (with MA or EWMA),
  - Realized returns with annual horizon.
- Comoment window calculation: 10, 30, 45, 60 days.
- Pooled regressions.
- Adding funding liquidity (Fontaine, Garcia and Gungor, 2015).

Credit cycle effects

- Explanatory power of credit spread determinants improve when credit cycle effects are taken into account (Maalaoui Chun, Dionne and François, 2014).
- A two-state Gaussian Markov chain regime switching model is estimated on the weekly 30-year Composite bond index yields.
- High state: mean $= 6.16\%$, vol $= 1.00\%$. Low state: mean $= 1.17\%$, vol $= 1.21\%$.
- Periods of high state
  - Jan 3, 1997 - Dec 3, 1997,
  - Apr 28, 1999 - Jan 22, 2003,
  - Sep 10, 2008 - Jun 24, 2009.

Credit cycle effects (cont'd)

- Pooled regressions on high and low states.
- Substantial increase in goodness-of-fit.
- μ^{SYS}: Strong pickup of even comoments in the high state, while positive effect of coskewness fades away in the high credit cycle.
  $\Rightarrow$ Consistent with disaster myopia (Guttentag and Herring, 1986).
- R^{NET}: Covariance and coskewness robust to credit cycle effects, but stronger impact in the low state. Again, consistent with the "business-as-usual" interpretation during quiet credit markets.

- Decomposition of corporate bond default excess returns into the sum of
  - A systematic default risk premium: Model-dependent, ex ante reward for default risk exposure,
  - A net excess return: Ex post market correction.
- Comoment factor analysis of these two components.
  - Bond investors, similarly to equity investors, demand a compensation for exposure to even moments,
  - Bond investors, unlike equity investors, seem to exhibit a preference for negative skewness (behavioral explanation?).
  - Maturity effect: Longer bonds are more sensitive to tail risk (kurtosis), while shorter bonds are more exposed to covariance risk (interpreted as "business-as-usual" risk, or downgrading risk).
- Our empirical contribution is an additional motivation to reconcile bonds with general equilibrium asset pricing models with preferences for higher moments.