



Explaining individual firm credit default swap spreads with equity volatility and jump risks

By

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Motivation and introduction

- Structural models (Merton 1974, and follow-ups) explain credit spreads with: asset volatility (jump), macro-financial indicators, balance sheet figures.
- Performance of structural models is not very good (Huang & Huang 2003, Collin-Dufresne et al 2001, Eom et al 2004).
- Small literature on volatility and jumps, limited findings (Campbell and Taksler 2003, Collin-Dufresne et al 2003, Cremers et al 2004a, 2004b).



Contributions of this paper

- Focus on **high-frequency** equity data
- Include **intra-day** equity volatility: proxy for the time variation in equity volatility.
- **Decompose** realised volatility into continuous and jump components.
- Characterise **jump risk**:
jump size, jump mean and jump variance



Results in a nutshell

- Stronger volatility effect ($R^2=50\%$) and jump effect ($R^2=19\%$) with correct signs and economically meaningful magnitudes.
Totally 77% if combined with other structural factors.
- The impact of volatility and jump measures increases with credit risk
- The volatility and jump effects exhibit strong nonlinearity.



Outline of remaining talk

- Motivation
- Method to define the jump risk
- Data
- Empirical findings
- Conclusions



I. A stylized model with testable hypotheses

- A model with stochastic volatility and jump (JDSV)

Asset

$$\frac{dA_t}{A_t} = (\mu - \delta - \lambda\mu_J)dt + \sqrt{V_t}dW_{1t} + J_t dq_t$$

Asset vol.

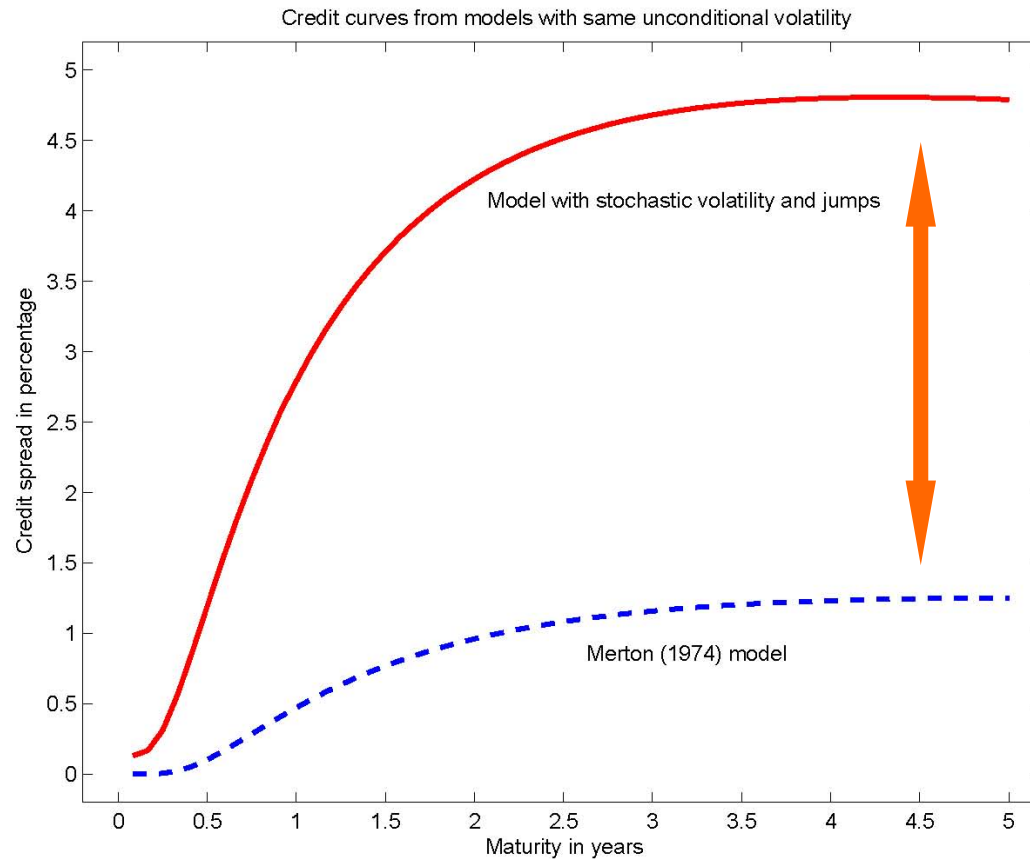
$$dV_t = \kappa(\theta - V_t)dt + \sigma\sqrt{V_t}dW_{2t}$$

$$\text{corr}(dW_{1t}, dW_{2t}) = \rho$$

(Asset , Asset vol.)



JDSV model is more flexible than Merton



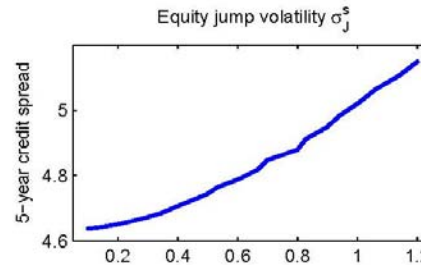
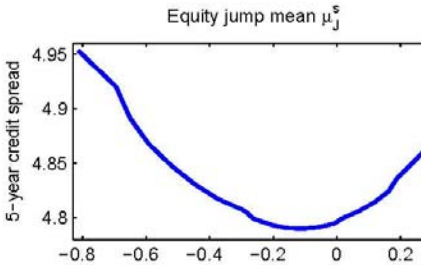
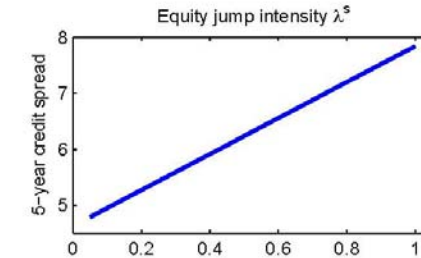
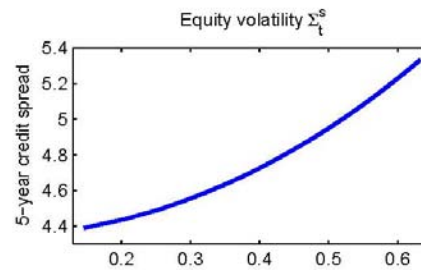
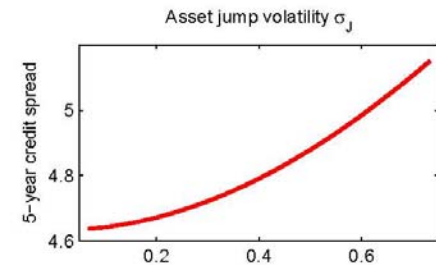
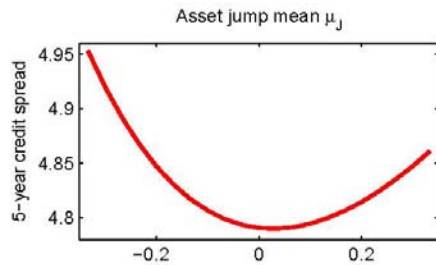
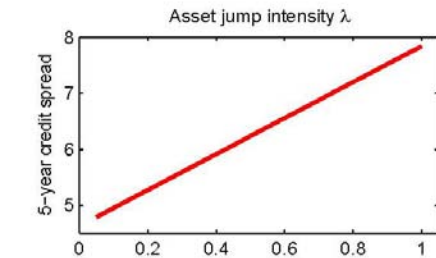
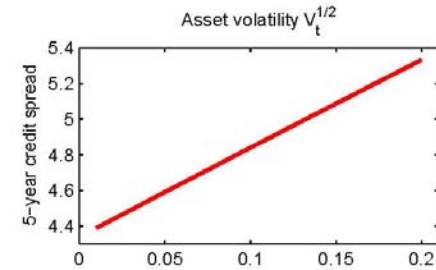


Volatility

Jump intensity

Jump mean

Jump volatility



Positive non-linear

Positive linear

Asymmetric non-linear

Positive non-linear

Equity



II. Method to define the jump risk

- Underlying jump-diffusion log price process continuous and jump components (jump intensity, mean, variance)

$$ds_t = \mu_t^s dt + \sigma_t^s dW_t + J_t^s dq_t$$

$$r_{t,i}^s \equiv S_{t,i \cdot \Delta} - S_{t,(i-1) \cdot \Delta} \quad \text{One-day return, 5min intervals}$$

- RV and BV (Barndorff-Nielsen and Shephard 2003a, 2003b, 2004)

$$RV_t \equiv \sum_{i=1}^{1/\Delta} (r_{t,i}^s)^2 \rightarrow \int_{t-1}^t \sigma_s^2 ds + \sum_{i=1}^{1/\Delta} (J_{t,i}^s)^2 \quad \text{Continuous + jump}$$

$$BV_t \equiv \frac{\pi}{2} \sum_{i=2}^{1/\Delta} |r_{t,i}^s| \cdot |r_{t,i-1}^s| \rightarrow \int_{t-1}^t \sigma_s^2 ds \quad \text{Continuous}$$



- Detect jump timing and jump contribution to variance (Barndorff-Nielsen and Shephard 2004, Andersen et al 2004, Huang and Tauchen 2005).

On / Off

$$RJ_t \equiv \frac{RV_t(\Delta) - BV_t(\Delta)}{RV_t(\Delta)} \rightarrow \text{Normal}(0, A\text{Var}(RJ_t))$$

- Intuitive identification of jump patterns:
 - (1) jumps are rare (at most one jump per day)
 - (2) jumps are large (dominating jump day's return):

Measurement

$$J_t = \text{sign}(r_t) \times \sqrt{RV_t(\Delta) - BV_t(\Delta)} \times (\text{jump} - \text{indicator})_t$$

- Additionally: estimate jump frequency, jump mean (positive and negative jumps) and jump variance.

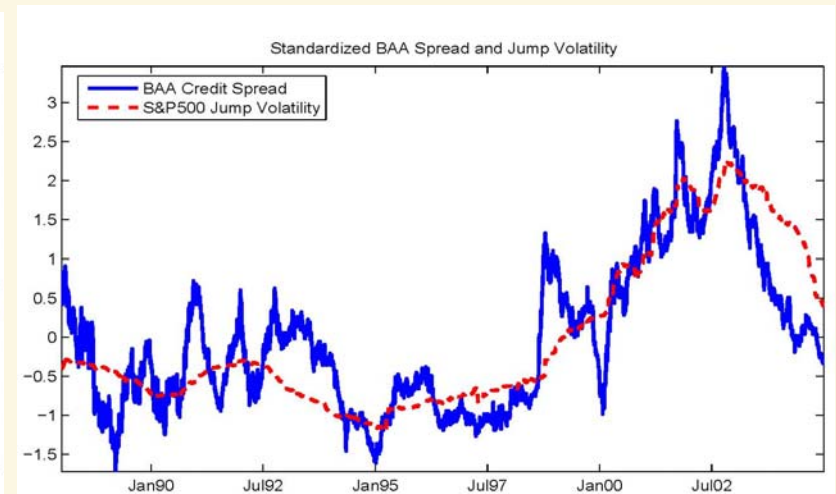
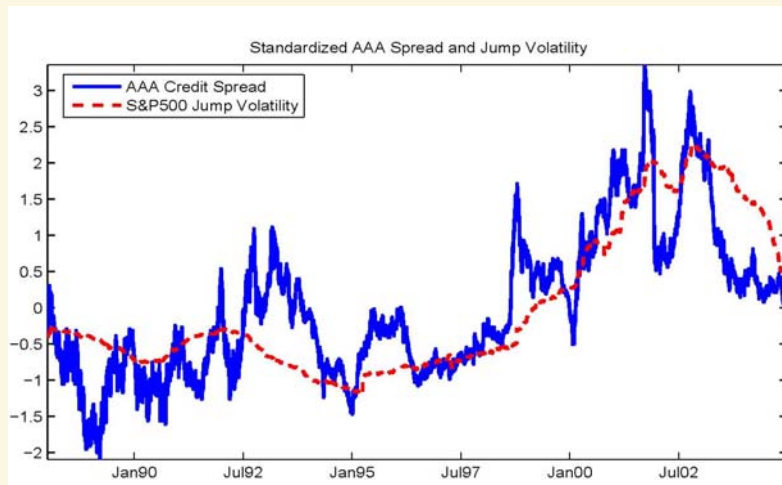


Jump measures better than skewness

- Skewness may:
 - over-detect a model with asymmetric distribution but no jumps;
 - under-detect a model with symmetric jump distributions
- Jump intensity, mean and variance measure for different aspects of the jump risk



S&P 500 jump volatility matches bond spreads (Tauchen & Zhou 2005)





III. Data: 307 US firms, monthly, 2001.01-2003.12

- **Mark-It**: 5-year CDS spreads: non-sovereign, modified-restructuring, USD denomination.
- **CRSP & TAQ**: Volatilities and jumps of individual firms.
- **S&P Ratings**
- **Compustat**: Firm balance sheet information (ROE, leverage, div payout ratio) and recovery rate.
- **Bloomberg**: Macro-financial variables (S&P 500 return / vol, 3-month Treasury rate and term spread).



Why CDS and not bond spreads?

- Traded on **standardized** terms (no noise from seniority, coupon rates, embedded options, guarantees)
- **Pure** pricing of default risk (a large proportion of bond spreads are determined by liquidity factors, Longstaff et al 2005)
- More **responsive** to changes in credit conditions (Blanco et al 2005, Zhu 2004)
- Avoid the confusion about risk-free rates



Theoretical determinants of CDS spreads

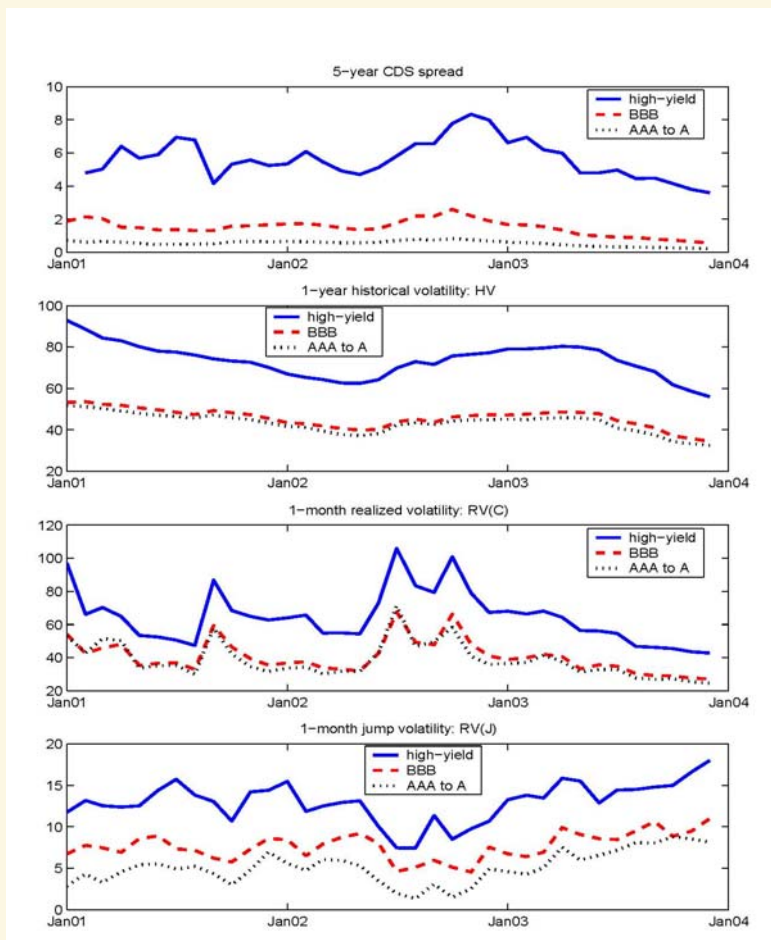
Equity return	-	Firm leverage	+
Equity volatility	+	ROE	-
Equity skewness	-	Dividend payout ratio	+
Equity kurtosis	+	General market return	-
Jump intensity	+	General market vol	+
Jump mean	-	Short-term int. rate	?
Jump variance	+	Slope of yield curve	?
		Recovery rate	-



Historical measures						
Variables	Mean	std dev	Mean	std dev	Mean	std dev
Hist ret	3.12	154.26	1.58	87.35	-3.22	42.70
Hist vol (HV)	38.35	23.91	40.29	22.16	43.62	18.57
Hist skew (HS)	0.042	0.75	-0.061	0.93	-0.335	1.22
Hist Kurt (HK)	3.36	1.71	4.91	4.25	8.62	11.78
Realized measures						
Variables	1-month		3-month		1-year	
RV	45.83	25.98	47.51	24.60	50.76	22.49
RV(C)	44.20	25.85	45.96	24.44	49.37	22.25
RV(J)	7.85	9.59	8.60	8.88	9.03	8.27
Correlations						
Variables	1-month		3-month		1-year	
(HV, RV)	0.87		0.90		0.91	
(HV, RV(C))	0.87		0.89		0.90	
(HS, RV(J))	0.006		0.014		0.009	
(HK, RV(J))	0.040		0.025		0.011	



CDS spreads and volatility by rating groups





IV. Empirical results

- Benchmark of volatility and jump effect on credit spreads.
- Including other structural variables and robustness check.
- Regression by rating groups.
- Nonlinear jump and volatility effects.
- In all regressions, use lagged explanatory variables to avoid the simultaneity problem.



- Baseline: 5-yr CDS spreads with equity volatility and jumps

Explanatory	1	2	3	4	5	6	7	8
Constant	-207.22	-91.10	-223.11	145.35	42.05	85.66	51.93	-272.08
1-year HV	9.01		6.51					6.56
1-year HS				-10.23				
1-year HK				2.59				
1-month RV		6.04	2.78					
1-month RV(C)								2.58
1-year JI				0.55			-0.9	1.46
1-year JM				-0.21				
1-year JV				4.52			2.51	1.32
1-year JP						-0.45	-0.59	-0.63
1-year JN						1.47	1.59	0.46
Adjusted R ²	0.45	0.37	0.50	0.03	0.15	0.14	0.19	0.54
obs	6342	6353	6337	6342	6328	6328	6328	6328



- Table 5: Ratings, macro-financial, firm-specific variables and recovery rates

Regression	1	2	3	4
1-year Return		-0.87		-0.75
1-year HV		2.09		2.79
1-month RV(C)		2.14		1.60
1-year JI		0.93		0.89
1-year JV		1.29		1.58
1-year JP		-0.69		-0.63
1-year JN		0.39		0.36
Rating (AAA)	33.03	-160.81	-72.09	-342.99
Rating (AA)	36.85	-143.36	-81.66	-332.93
Rating (A)	56.62	-126.81	-68.62	-320.11
Rating (BBB)	142.06	-60.04	9.31	-258.11
Rating (BB)	436.94	158.18	294.02	-46.14
Rating (B)	744.95	376.90	556.58	127.03
Rating (CCC)	1019.17	583.74	566.83	9.31
SP 500 return			-1.21	-0.82
SP 500 vol			4.87	0.88
Short rate			13.46	15.52
Term spread			33.38	42.30
Recovery rate			-2.65	-0.59
ROE			-4.20	-0.79
Leverage ratio			0.46	0.68
Div payout ratio			12.84	21.52
Adjusted R ²	0.56	→ 0.74	0.63	→ 0.77



- Economic significance

Variable	Impact of one STD change (bp)
1-year HV	≈ 50
1-month RV	≈ 40
JI	≈ 36
JV	≈ 26
JP	≈ 59
JN	≈ 34

* Average CDS spreads: 172 bp.
std. dev.: 230 bp



Robustness check (panel): fixed (1, 2) random (3, 4)

Regression	1	2	3	4
1-year Return		-0.85		-0.83
1-year HV	3.09	1.58	3.54	1.88
1-month RV(C)	2.74	1.58	2.74	1.60
1-year JI	0.21	0.15	0.43	0.35
1-year JV	1.06	1.35	1.01	1.35
1-year JP	-0.69	-0.55	-0.65	-0.53
1-year JN	0.46	0.34	0.54	0.40
Rating (AAA)		-203.65		-375.58
Rating (AA)		-230.48		-393.30
Rating (A)		-165.49		-330.47
Rating (BBB)		-133.47		-281.13
Rating (BB)		-110.64		-207.16
Rating (B)				-62.38
Rating (CCC)				-40.67
SP 500 return		-0.80		-0.81
SP 500 vol		0.44		0.63
Short rate		16.31		17.80
Term spread		40.78		41.90
Recovery rate		-0.13		-0.21
ROE		0.02		-0.09
Leverage ratio		2.52		2.23
Div payout ratio		45.23		42.89
Adjusted R ²	0.81	0.87		



Table 7: By rating class

Regression	AAA-A	BBB	High-yield
Constant	-109.87	-347.00	-351.10
1-year Return	-0.12	-0.61	-0.76
1-year HV	0.75	3.81	3.25
1-month RV(C)	0.36	1.38	2.17
1-year JI	0.24	0.30	1.52
1-year JV	-0.03	0.06	3.55
1-year JP	-0.13	-0.31	-1.10
1-year JN	0.13	0.60	0.52
SP 500 return	-0.41	-1.29	-1.69
SP 500 vol	0.54	0.31	6.46
Short rate	9.95	14.48	-12.12
Term spread	19.03	48.02	59.10
Recovery rate	0.61	1.11	-5.32
ROE	-1.19	-1.85	1.23
Leverage ratio	0.20	0.54	5.19
Div payout ratio	16.45	24.17	59.83
Adjusted R ²	0.41	0.54	0.65
Obs	1881	2311	760



- High-yield entities have higher volatility and jump risks

Regression	AAA-A		BBB		High-yield	
	Mean	std	Mean	std	Mean	std
1-year HV	36.38	11.28	40.07	13.40	62.41	25.97
1-month RV(C)	38.08	17.56	39.05	18.73	62.47	37.78
1-year JI	20.97	25.94	39.80	45.89	45.09	43.42
1-year JV	20.63	12.39	24.51	13.50	35.60	22.81
1-year JP	64.00	51.97	99.39	80.10	156.90	128.11
1-year JN	61.54	51.86	91.34	73.78	162.77	132.35



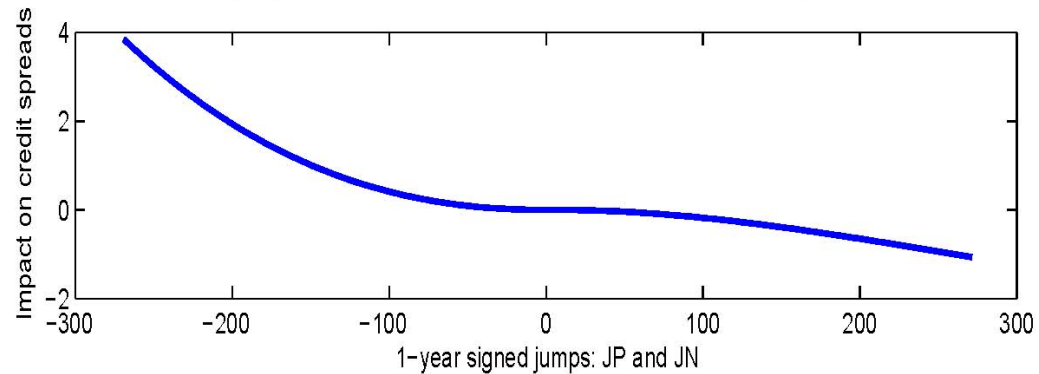
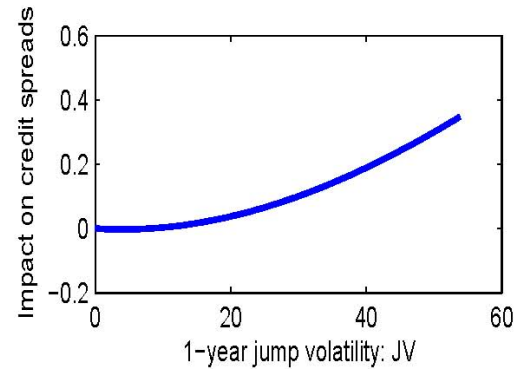
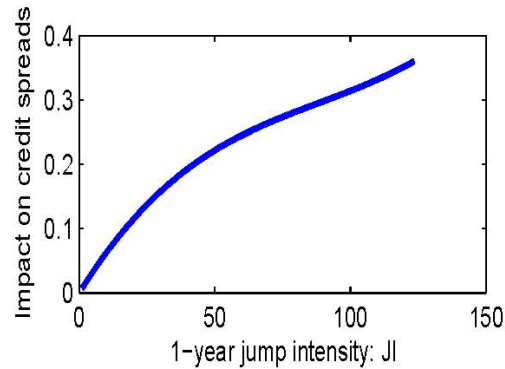
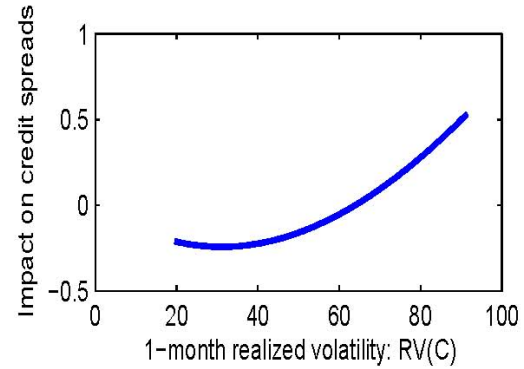
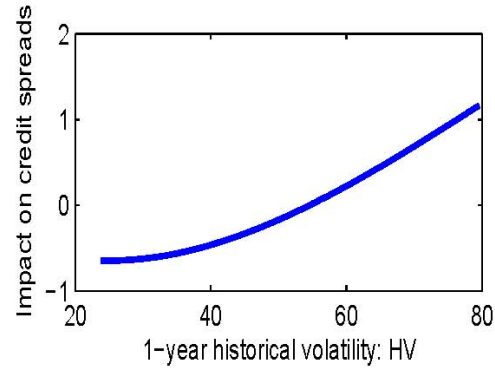
- Table 8: Nonlinear effects

YES: HV, RV(Continuous),
J Vol, J (+), J(-)

NO: J Int.

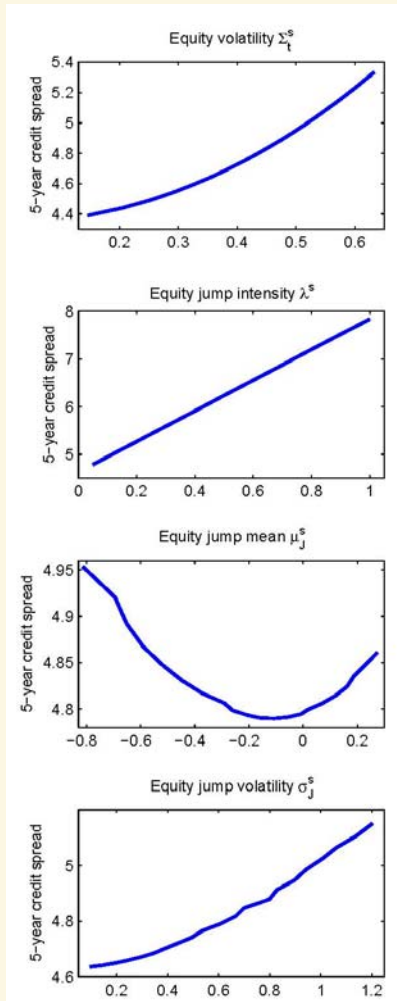
→ Consistent with predictions

1-year Return	-0.73
HV	→ -5.47
HV ²	→ 2.04
HV ³	→ -0.13
RV(C)	→ -1.60
RV(C) ²	→ 0.44
RV(C) ³	→ -0.01
Jl	0.68
Jl ²	-0.09
Jl ³	0.006
JV	-0.14
JV ²	→ 0.27
JV ³	→ -0.01
JP	0.02
JP ²	→ -0.04
JP ³	→ 0.0007
JN	0.02
JN ²	→ 0.06
JN ³	→ -0.0002
Ratings, Macro-financial, Firm-specific	Omitted, see paper
Adjusted R ²	0.80

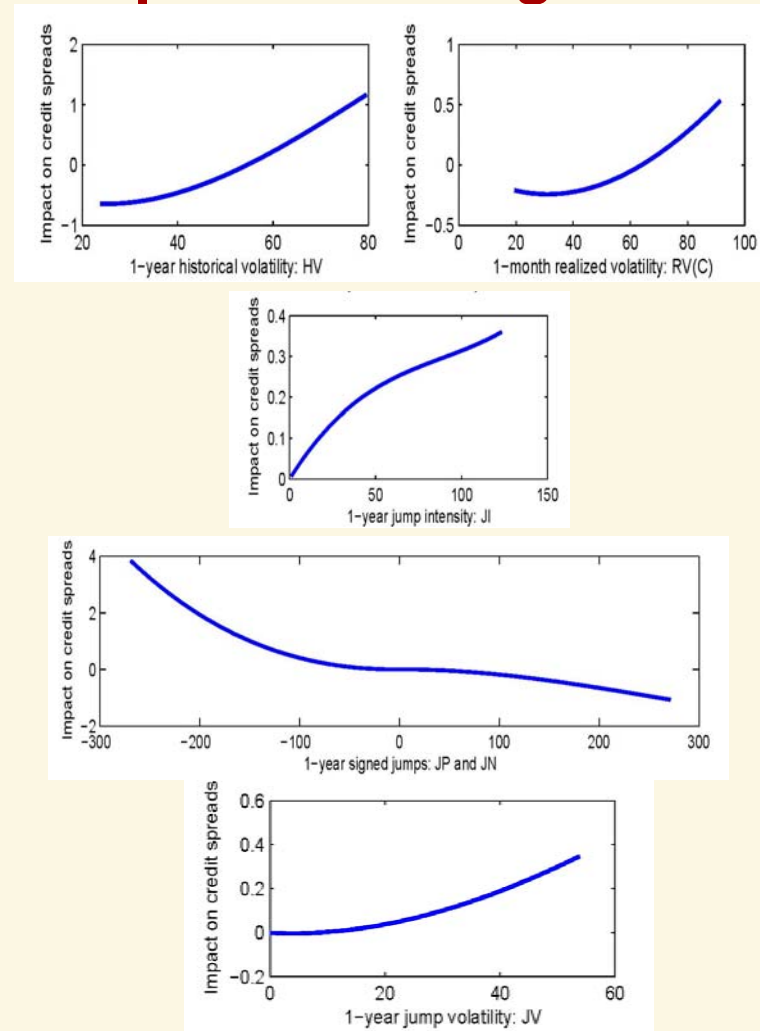




Predictions:



Empirical findings:





Implications of non-linearity

- Ignoring it may cause substantial bias:
Jensen inequality problem $f[E(x)] \neq E[f(x)]$
- Pricing errors due to the nonlinear effect is not trivial, based on sample data and model estimates
 - HV: - 13 bps BV(C): - 12 bps
 - JV: - 3 bps JP: + 7 bps JN: - 4.5 bps
 - Total: underestimate by 25 bps
- A promising direction to enhance the empirical performance of structural models?



Concluding remarks

- Volatility and jump matters. Should be treated more seriously.
- More significant than ratings, macro-financials, firm-specific variables.
- Volatility and jump impacts are related to firms' credit standings.
- Nonlinear effect.



Thank you for bearing with me



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