Exteme Events in Corporate Bond Spreads

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Corporate credit spreads in the United States

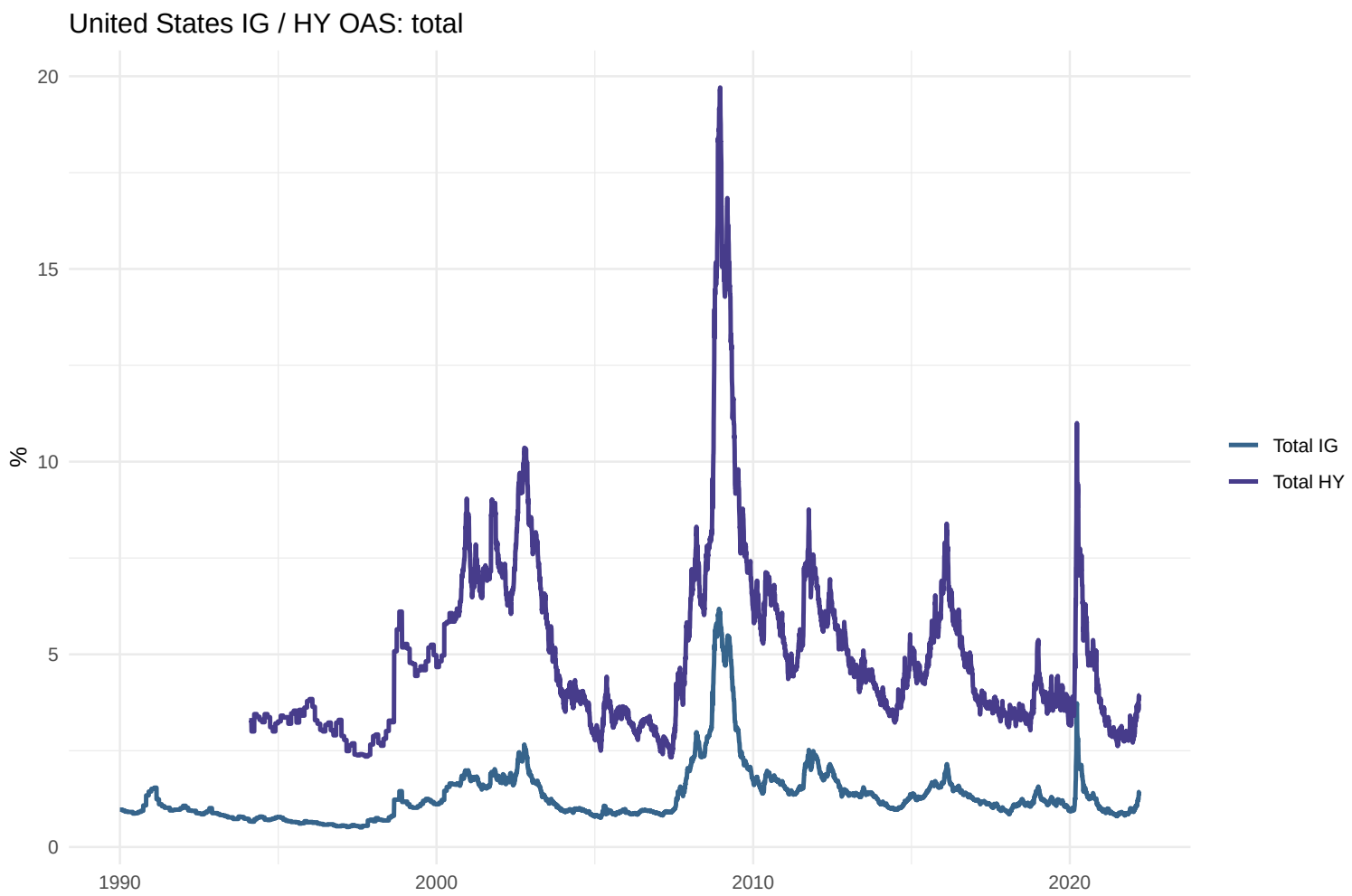

Figure 1: United States investment grade (IG) and high yield (HY) option adjusted spreads.

State of research in credit markets and extreme events

- Behavior of corporate bond markets and the impact of traded (e.g., liquidity, credit) and non-traded (e.g., systemic volatility, macroeconomic uncertainty) risk factors.

  Chen (2010), Dickerson et al. (2023), Jurado et al. (2015), Bali et al. (2021), Elkamhi et al. (2023)

- The corporate bond market is highly affected by various shocks.

  Aramonte and Avalos (2020), Chung et al. (2019)

- Most studies focusing on extreme events consider the stock market.

  McNeil and Frey (2000), Chavez-Demoulin and McGill (2012), James et al. (2023)

Hypotheses tested

1. What features are exhibited during extreme events in credit markets?
2. Is there cross-country and cross-market dependence?
3. How do financial and macroeconomic variables affect extreme events?

Presentation outline

1. Data
2. Modelling
3. Results
4. Further research
5. Conclusion

Data

Data description

Independent variables

- Options-adjusted spreads for the United States and the Euro Area
- Daily data. US: Jan. 1990 to March 2022. Euro Area: from Jan. 1999
- Different rating segments:
  - Investment Grade (IG). Disaggregation by sector: financials, industrials, utilities.
  - High yield (HY)

Explanatory variables

- Daily financial variables: volatilty (VIX, V2X)
- Daily macroeconomic variables: reference / short-term interest rates, inflation (5Y breakeven), economic activity / uncertainty index

Spreads are highly persistent in time

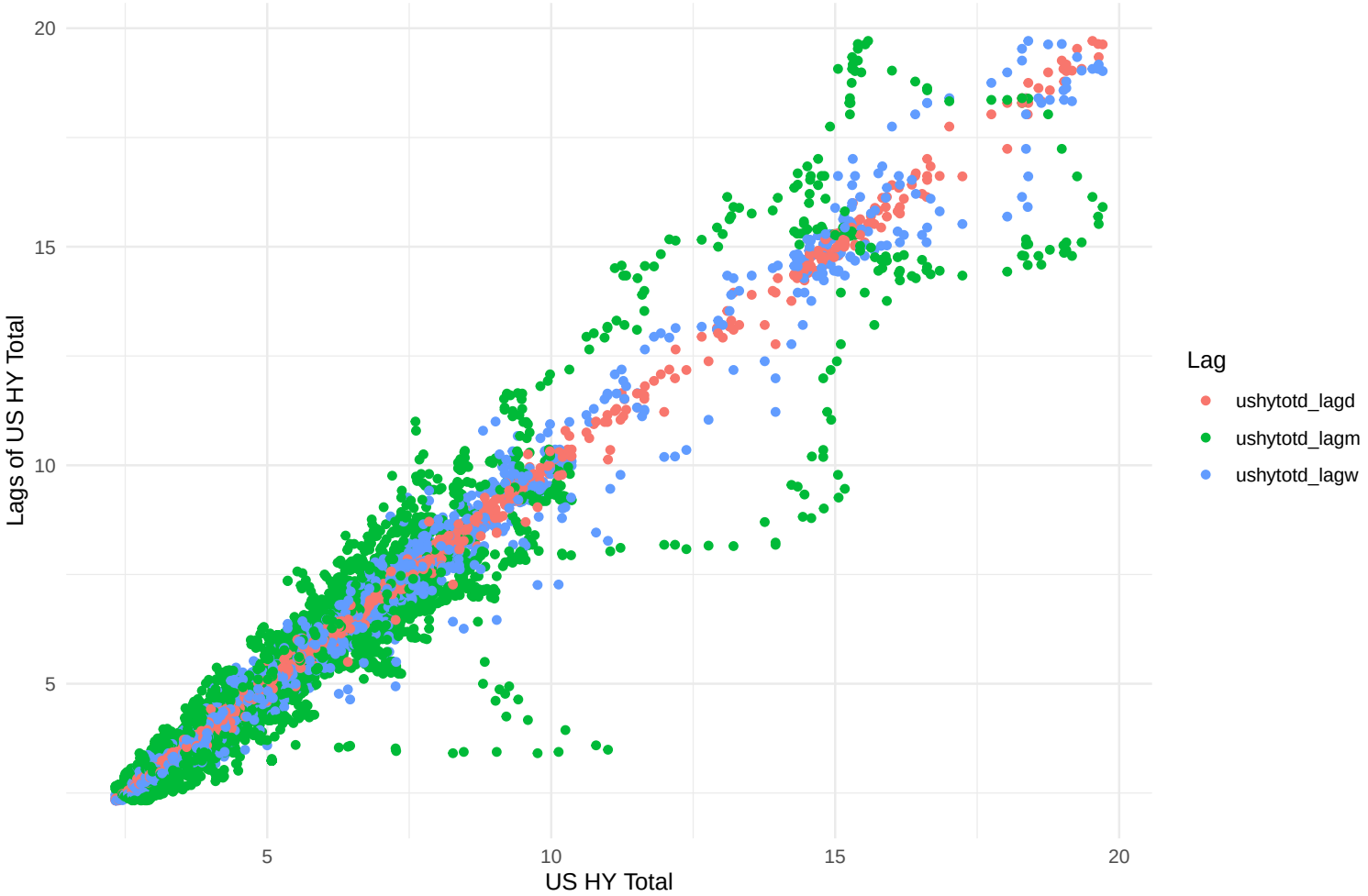

Figure 2: United States HY OAS scatterplot with one day, one week and one month lags.

Behavior of the spreads with the market volatility

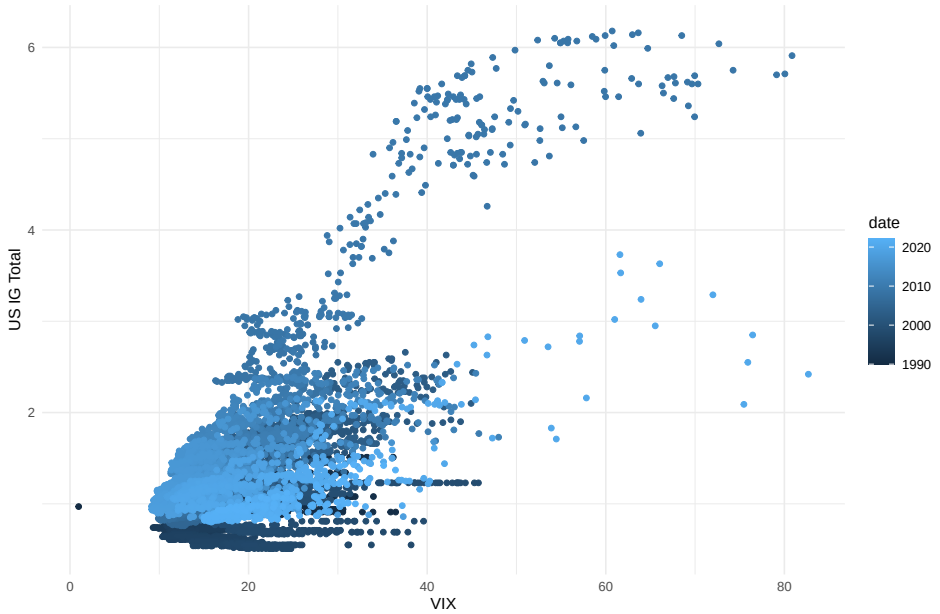

Figure 3: United States: IG total and VIX.

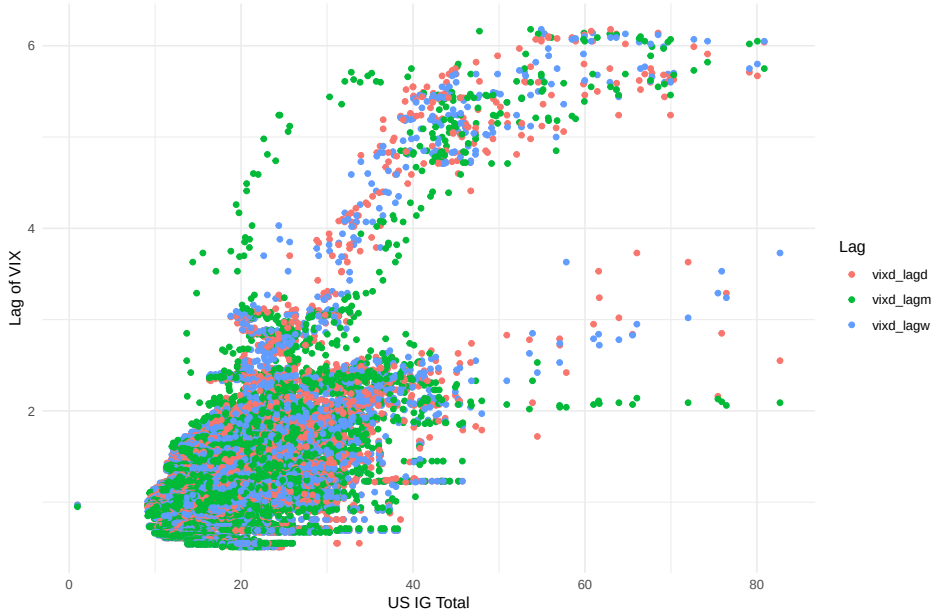

Figure 4: United States: IG total and lags of VIX.

Spreads with the T-bill rate and 5Y breakeven inflation

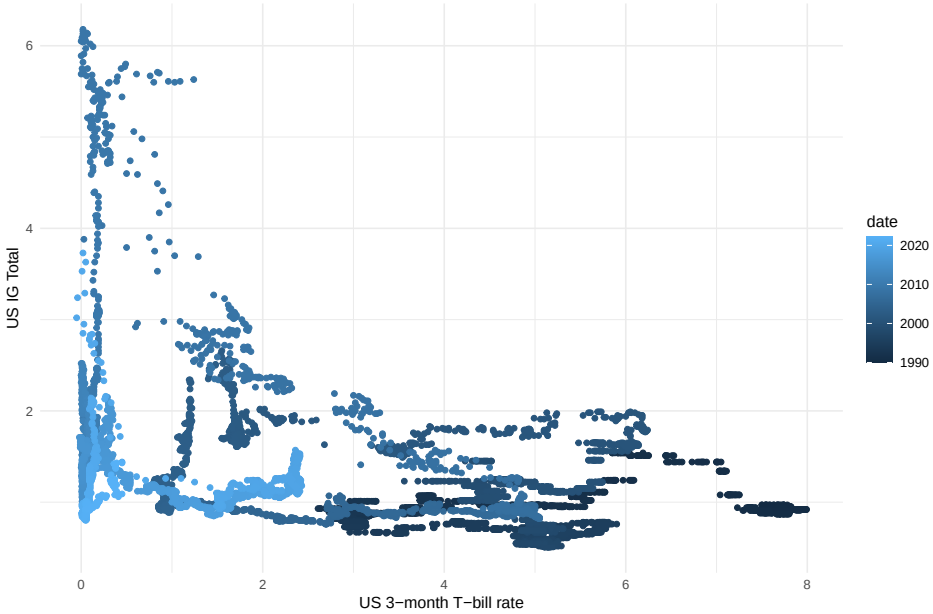

Figure 5: United States: IG total and 3-month T-bill rate.

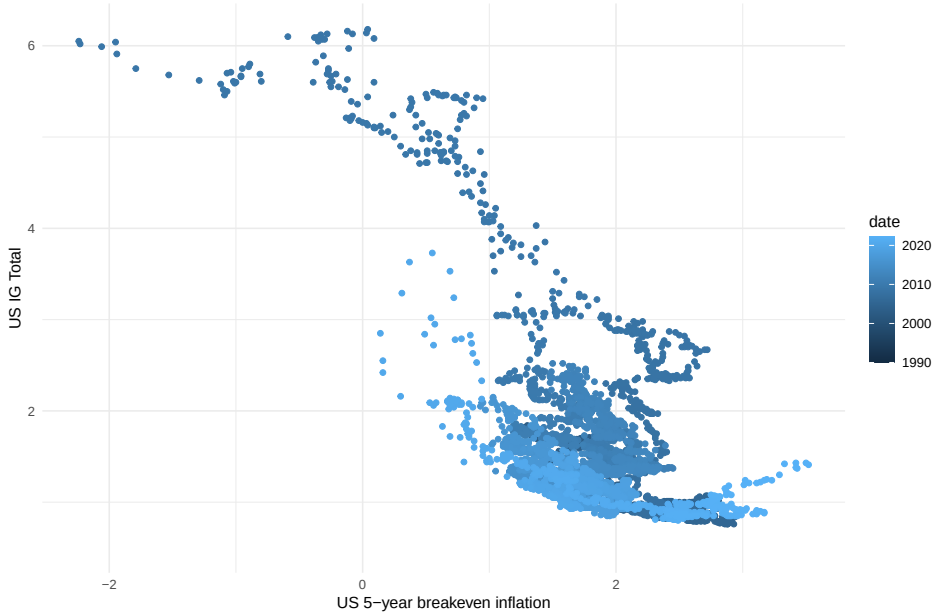

Figure 6: United States: IG total and 5-year breakeven inflation.

Correlation analysis across market segments

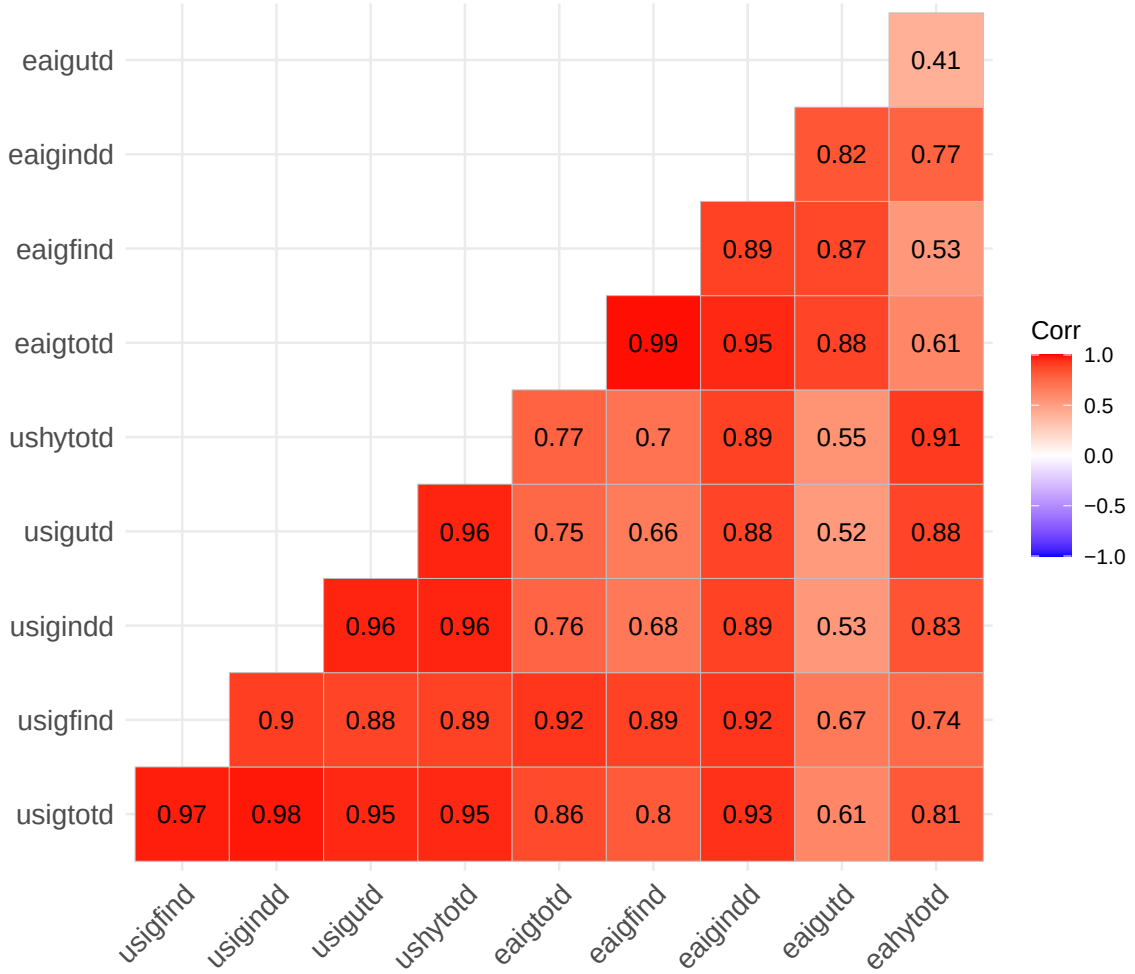

Figure 7: US and EA spread: correlation analysis

Modelling

Incremental modelling strategy

- Extreme value theory (EVT) marginal fits
- Extremal dependence analysis using χ and $\bar{\chi}$
- Time-series EVT: AR(1)-GARCH(1,1) and GPD

Definition of χ and $\bar{\chi}$

We focus on the extremal behaviour of option adjusted spreads using dual measures of extremal dependence, namely χ and $\bar{\chi}$ (Coles et al., 1999).

1. $\chi \in (0, 1]$ indicates asymptotic dependence, with its exact value giving a measure of the degree of extremal dependence, whereas $\chi = 0$ indicates asymptotic independence.

$$\chi = \lim_{z \to z^*} \Pr(Y > z | X > z)$$

2. If $\chi = 0$, $\bar{\chi} \in [-1, 1)$ provides a measure of the degree of extremal dependence in the class of asymptotic independent random variables, and $\bar{\chi} = 1$ indicates asymptotic dependence.

$$\bar{\chi} = \frac{2 \log \Pr(U > u)}{\log \Pr(U > u, V > u)} - 1$$

Time series EVT

- Two-stage approach to model extremes of a non-stationary time series
  - Capture varying volatility using a AR-GARCH model with external regressors
  - Model residuals exceeding a high threshold using a peaks-over-threshold method (McNeil and Frey 2000)
- Maximise a pseudo-likelihood; good properties of parameter estimates

$$y_t = \mu + \sum_{s=1}^{r} a_s y_{t-s} + \sum_{i=1}^{m} b_i x_{i,t-h} + \varepsilon_t$$

$$\varepsilon_t = \sigma_t z_t, \quad z_t \sim F_Z$$

$$\sigma_t^2 = \omega + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-j}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2$$

- Fit a Generalised Pareto Distribution (GPD) to large residuals

$$z_t \mid z_t > u \sim GPD_u(\xi, \psi)$$

Results

US: distribution of IG and HY credit OAS and marginal fits

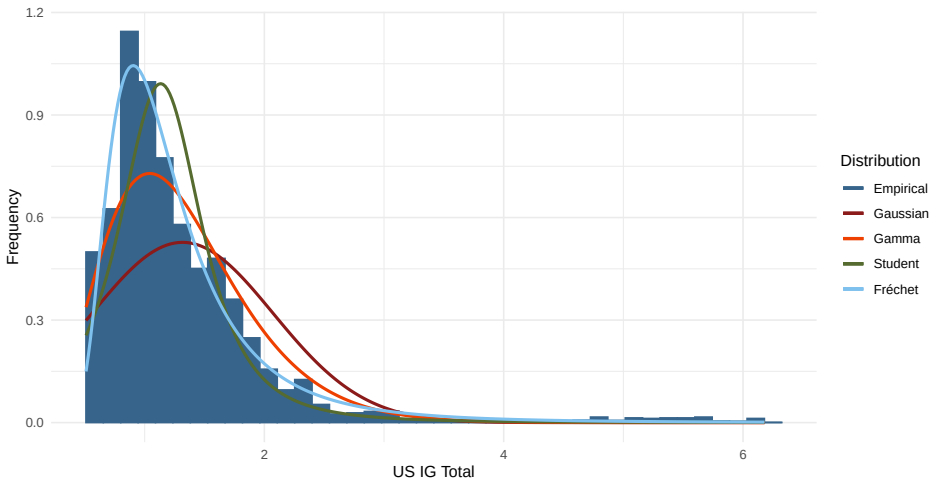

Figure 8: United States IG OAS distribution and marginal fits.

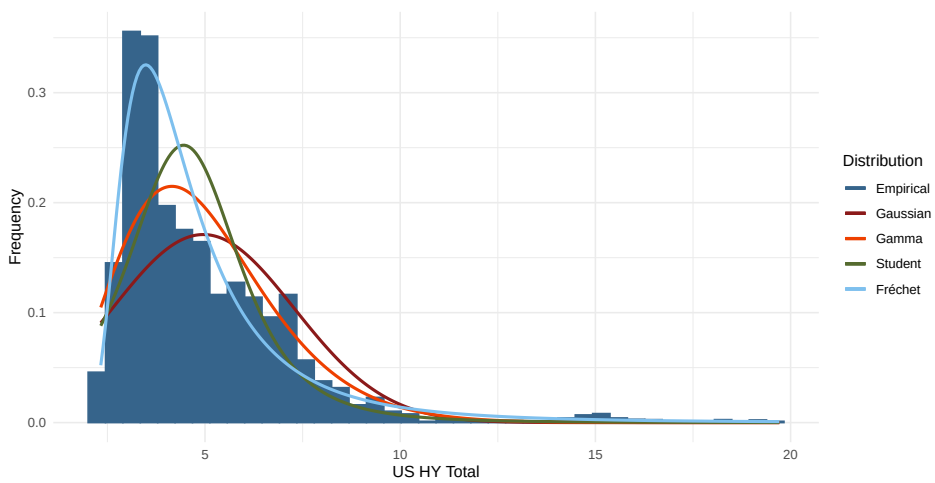

Figure 9: United States HY OAS distribution and marginal fits.

Tail prob. at:	10%	5%	2%
Gaussian	19%	7.8%	0.018%
Gamma	13%	5.6%	0.087%
Student	6.1%	2.8%	0.42%
Fréchet	12%	6.6%	1.1%

Tail prob. at:	10%	5%	2%
Gaussian	14%	5.7%	0.097%
Gamma	11%	4.9%	0.3%
Student	6.3%	2.8%	0.5%
Fréchet	11%	7.1%	2.5%

Euro Area: distribution of IG and HY credit OAS and marginal fits

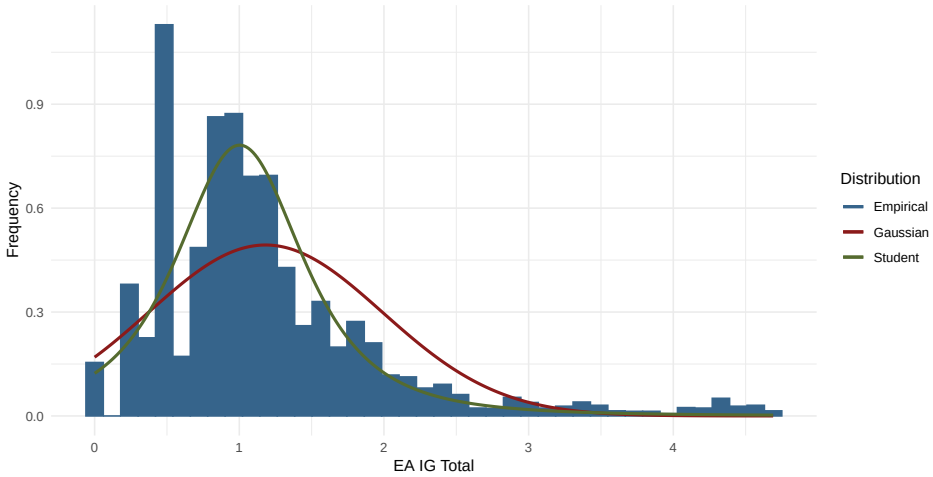

Figure 10: Euro Area IG OAS distribution and marginal fits.

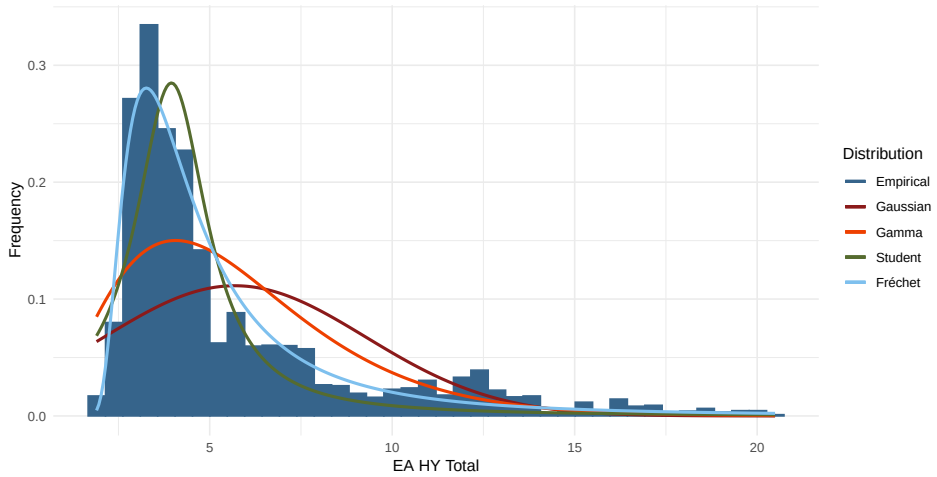

Figure 11: Euro Area HY OAS distribution and marginal fits.

Tail prob. at:	10%	5%	2%
Gaussian	13%	1.7%	0.017%
Student	5.7%	1.8%	0.57%

Tail prob. at:	10%	5%	2%
Gaussian	5.1%	1.5%	0.12%
Gamma	4.8%	2%	0.49%
Student	3.6%	2.8%	2%
Fréchet	7.2%	5.2%	3.4%

Extremal dependence across market segments

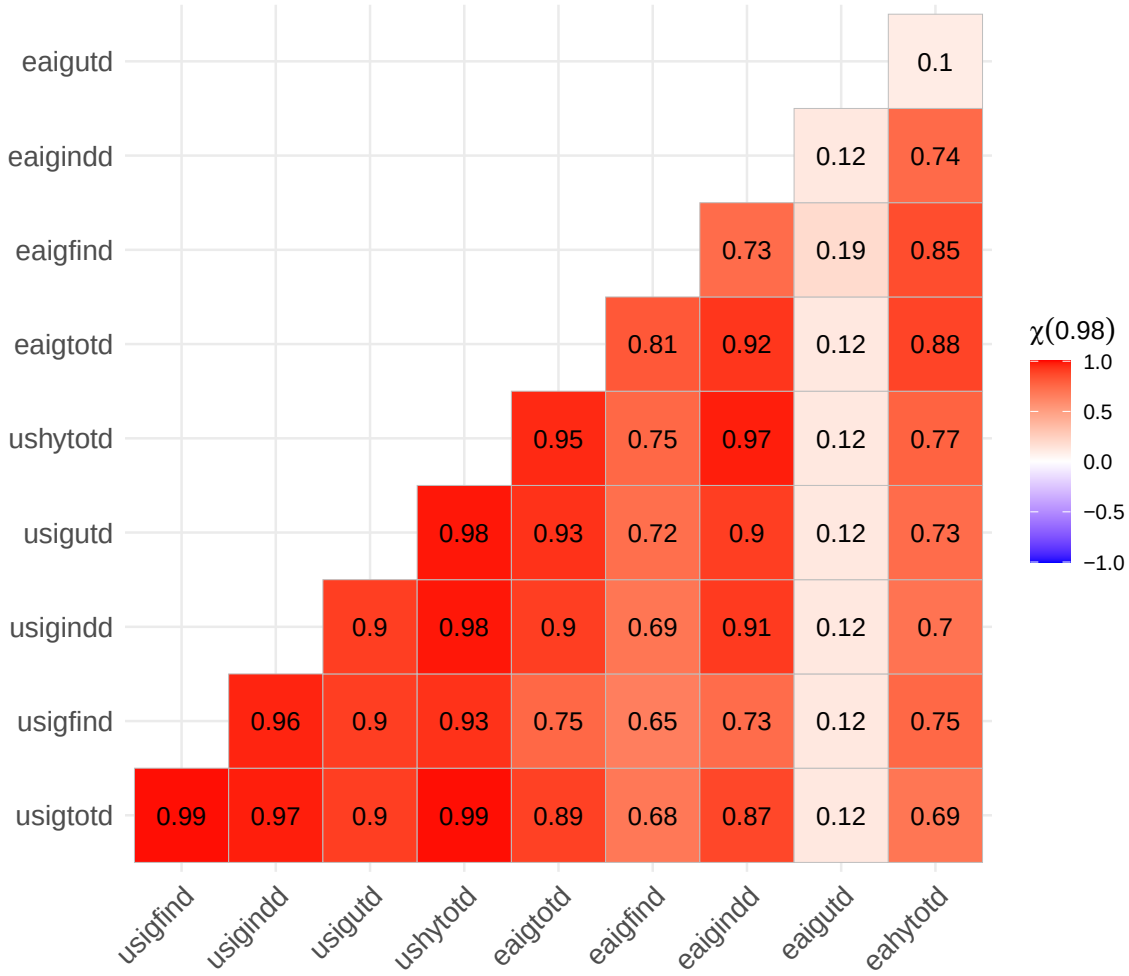

Figure 12: US and EA spreads: matrix of extremal analysis ($\chi(98\%)$)

US: IG versus HY extremal dependence

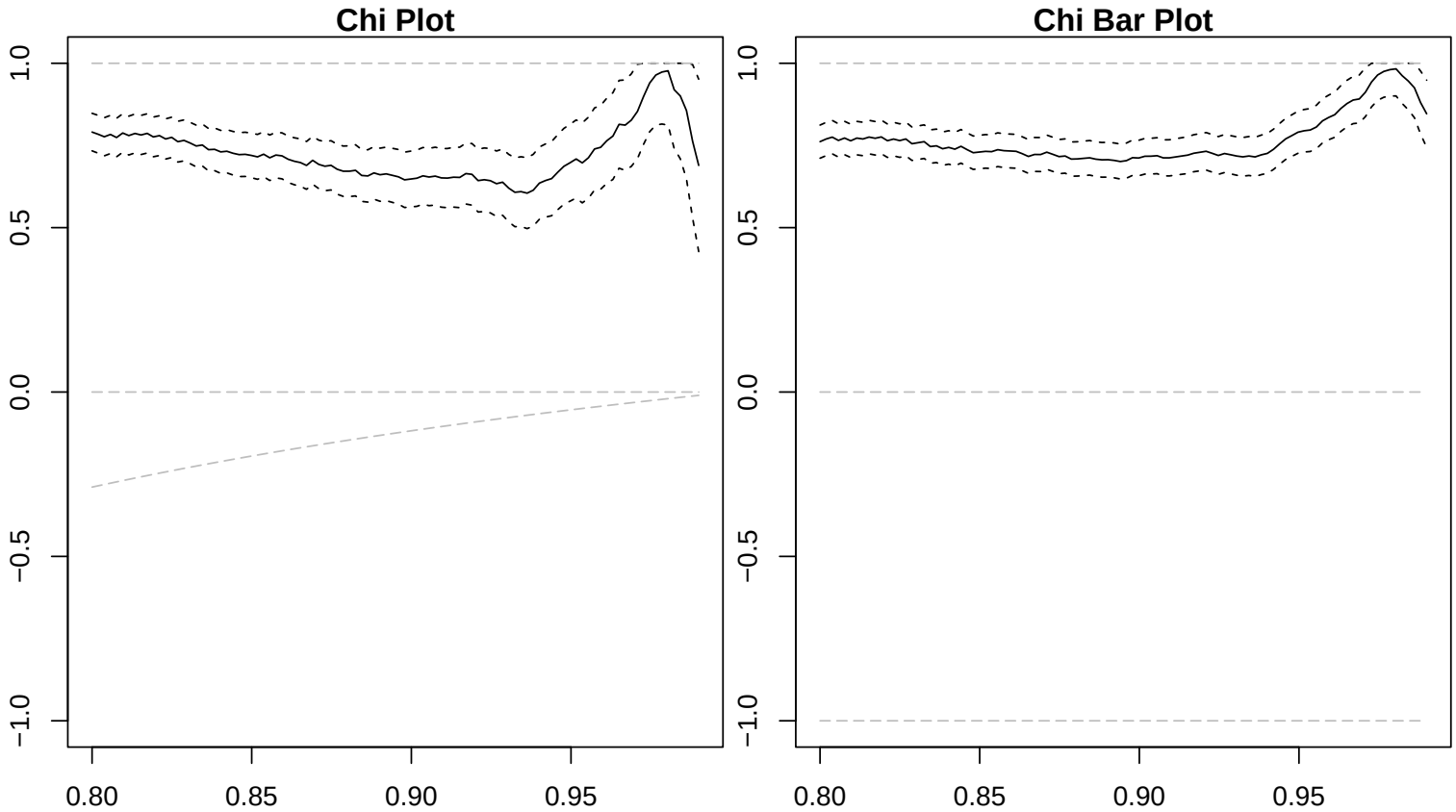

Figure 13: US IG vs HY extremal dependence.

Euro Area: IG vs HY extremal dependence

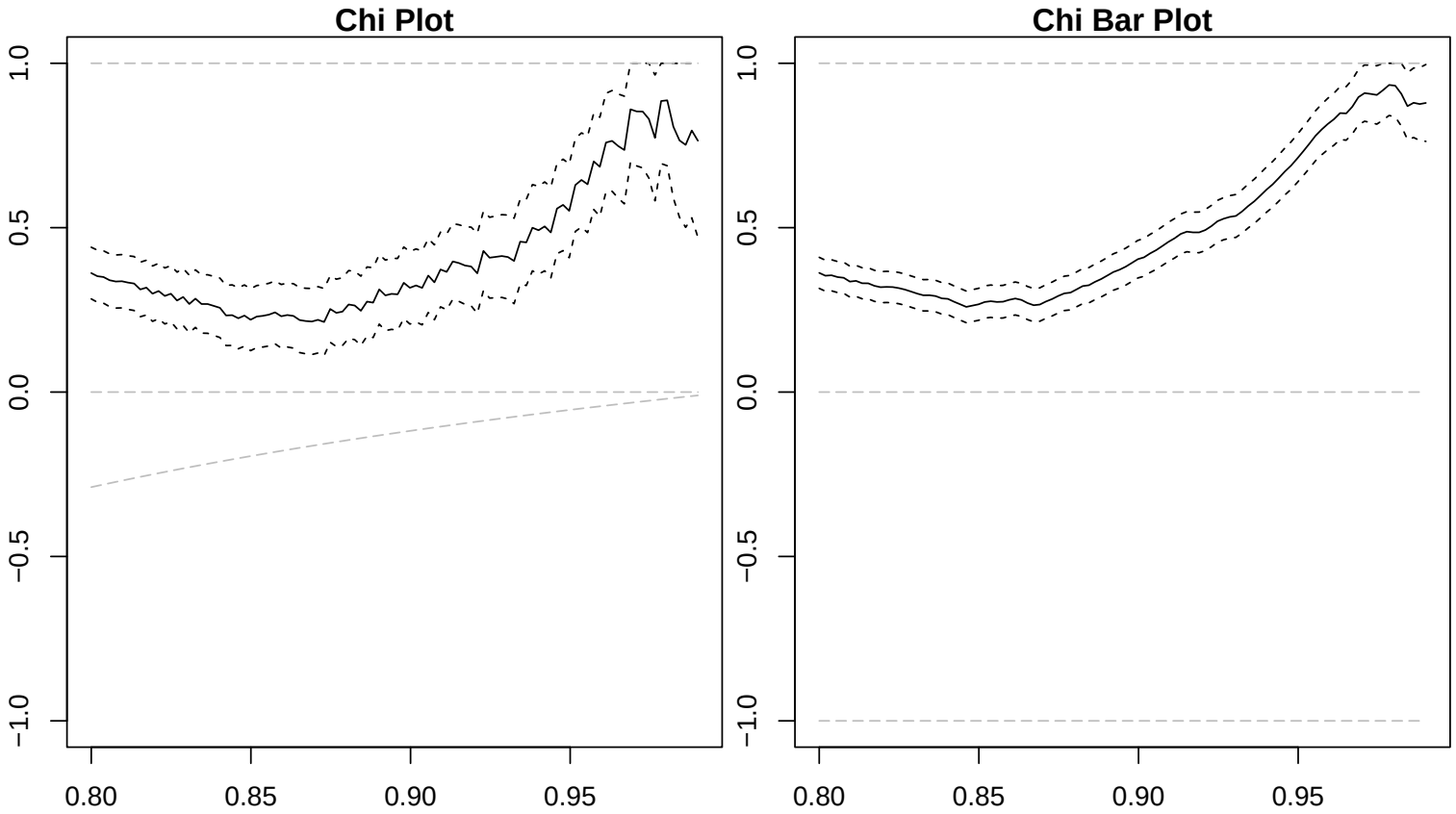

Figure 14: EA IG vs HY extremal dependence

Euro Area: IG financials vs IG industrials extremal dependence

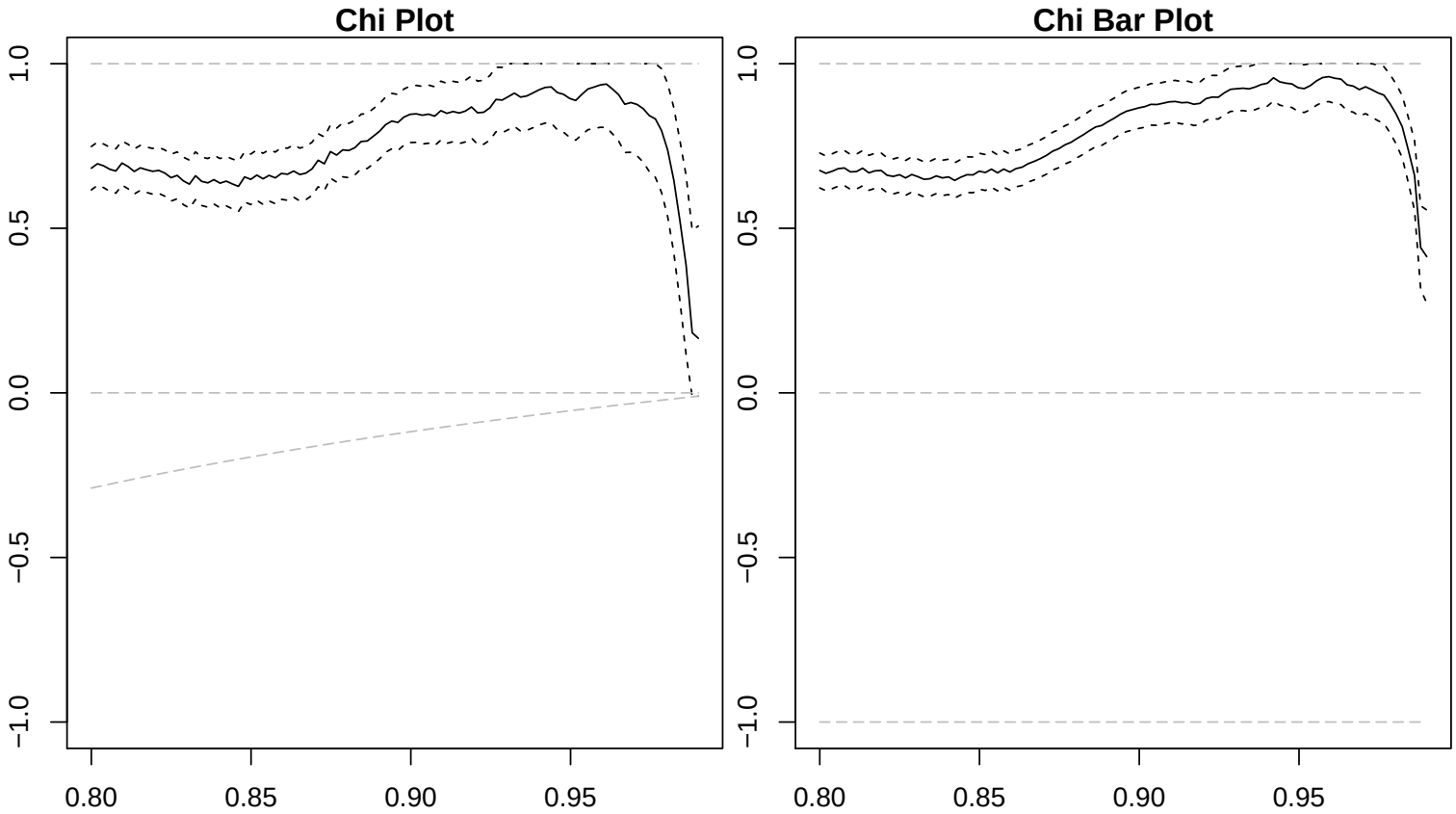

Figure 15: EA IG financials vs IG industrials extremal dependence.

United States: Estimation results from AR(1)-GARCH(1,1)

Table 1: Estimation results from the AR(1)-GARCH(1,1) and GPD model.

Parameter	Investment Grade Total	Financials	Industrials	Utilities	High Yield Total
	United States				
AR(1)					
μ	−0.0088	−0.00093	−0.0062	−0.015	−0.031
t	(−0.99)	(−0.12)	(−0.63)	(−1.7)	(−0.72)
a	0.97*	0.97*	0.97*	0.97*	0.97*
t	(280)	(270)	(260)	(250)	(230)
External regressors					
b_1 (VIX)	−0.0013*	−0.0011*	−0.0012*	−0.00072*	−0.0084*
t	(−8.70)	(−7.4)	(−7.4)	(−5.7)	(−11)
b_2 (3M T-bill)	−0.014*	−0.014*	0.0039	−0.0049	0.12*
t	(−2.1)	(−2.1)	(0.53)	(−0.77)	(3.8)
b_3 (5Y inf. break.)	0.016*	0.010*	0.010*	0.0016	0.077*
t	(3.2)	(2.0)	(1.9)	(0.31)	(2.8)
GARCH(1,1)					
ω	0.0000068*	0.0000059*	0.0000081*	0.0000049*	0.00014*
t	(3.6)	(3.7)	(4.1)	(3.7)	(4.8)
α	0.13*	0.14*	0.12*	0.087*	0.092*
t	(16)	(18)	(15)	(15)	(12)
β	0.86*	0.86*	0.88*	0.91*	0.91*
t	(100)	(110)	(140)	(170)	(130)
GPD					
ψ (scale)	0.65	0.69	0.63*	0.64*	0.68*
t	(1.4)	(1.4)	(13)	(8.8)	(13)
ξ (shape)	0.12*	0.15*	0.14*	0.24*	0.051
t	(2.5)	(3.0)	(2.5)	(2.6)	(0.94)
u (threshold)	1.18 (90%)	1.18 (90%)	1.16 (90%)	1.61 (95%)	1.17 (90%)
No. exceedances	419	419	419	210	419

Euro Area: Estimation results from AR(1)-GARCH(1,1)

Table 2: Estimation results from the AR(1)-GARCH(1,1) and GPD model.

Parameter	Investment Grade Total Euro Area	Financials	Industrials	Utilities	High Yield Total
AR(1)					
μ	0.024	0.0037	0.071	−0.0046	−0.077
t	(1.5)	(0.30)	(0.36)	(−0.65)	(−1.6)
a	0.98*	0.98*	0.99*	0.97*	0.98*
t	(280)	(310)	(44)	(280)	(330)
External regressors					
b_1 (V2X)	−0.0011*	−0.0014*	−0.00087*	−0.00086*	−0.0076*
t	(−8.8)	(−10)	(−6.9)	(−7.0)	(−12)
b_2 (3M-sov.yield)	−0.0028	0.0013	0.0066	0.0049	−0.017
t	(−0.78)	(0.34)	(1.8)	(1.4)	(−0.91)
GARCH(1,1)					
ω	0.0000044*	0.0000057*	0.0000045*	0.0000024*	0.000060*
t	(3.4)	(4.8)	(3.6)	(2.2)	(4.7)
α	0.11*	0.11*	0.095*	0.081*	0.066*
t	(16)	(18)	(15)	(14)	(15)
β	0.89*	0.89*	0.90*	0.92*	0.93*
t	(130)	(160)	(160)	(160)	(230)
GPD					
ψ (scale)	0.55*	0.61*	0.55*	0.53*	0.70*
t	(15)	(16)	(10)	(10)	(16)
ξ (shape)	0.19*	0.18*	0.30*	0.28*	0.047
t	(3.7)	(3.75)	(3.8)	(3.5)	(1.0)
u (threshold)	1.2 (90%)	1.2 (90%)	1.6 (95%)	1.7 (95%)	1.2 (90%)
No. exceedances	533	533	267	267	527

Note: t statistics are shown in parentheses. The symbol * indicates significance of the estimated coefficient at 5%. The dependent variables are constructed as the first difference of the OAS over a given month. All external regressors are also transformed to monthly first differences and taken with a lag of one month.

Q-Q plots: Innovations from AR(1)-GARCH(1,1) and GPD

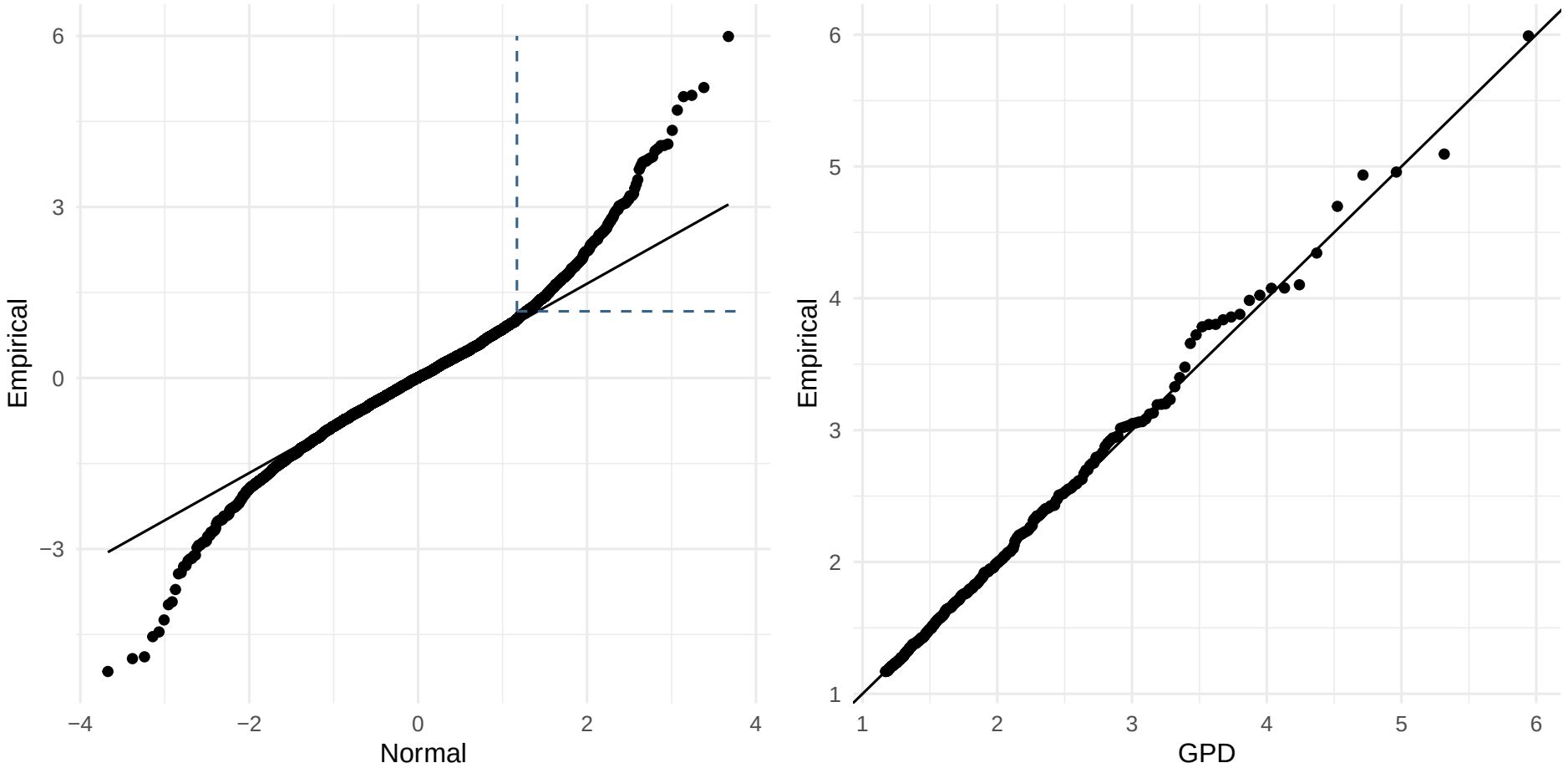

Figure 16: US HY OAS: (left) Normal Q-Q plot of AR(1)-GARCH(1,1) innovations, (right) GPD Q-Q plot of innovations exceeding a high threshold (dashed blue lines on left plot).

Further research

Further research

- Find appropriate measures of daily inflation for the Euro Area and integrate them in the model.
- Extend the data to the recent hiking cycle from central banks.
- For robustness, use various EVT approaches to model extremes in the credit market.

Conclusion

- All credit spreads considered feature extreme events.
- EVT distributions are much more suitable than standard distributions.
- Credit spreads exhibit high persistence over time and strong dependence across markets and regions, and remarkably so at extremal levels.
- The utilities sector shows the lowest correlation and extremal dependence.
- AR(1)-GARCH(1,1) and GPD results show strong evidence for heavy tails in the innovations.

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US and Euro Area IG OAS

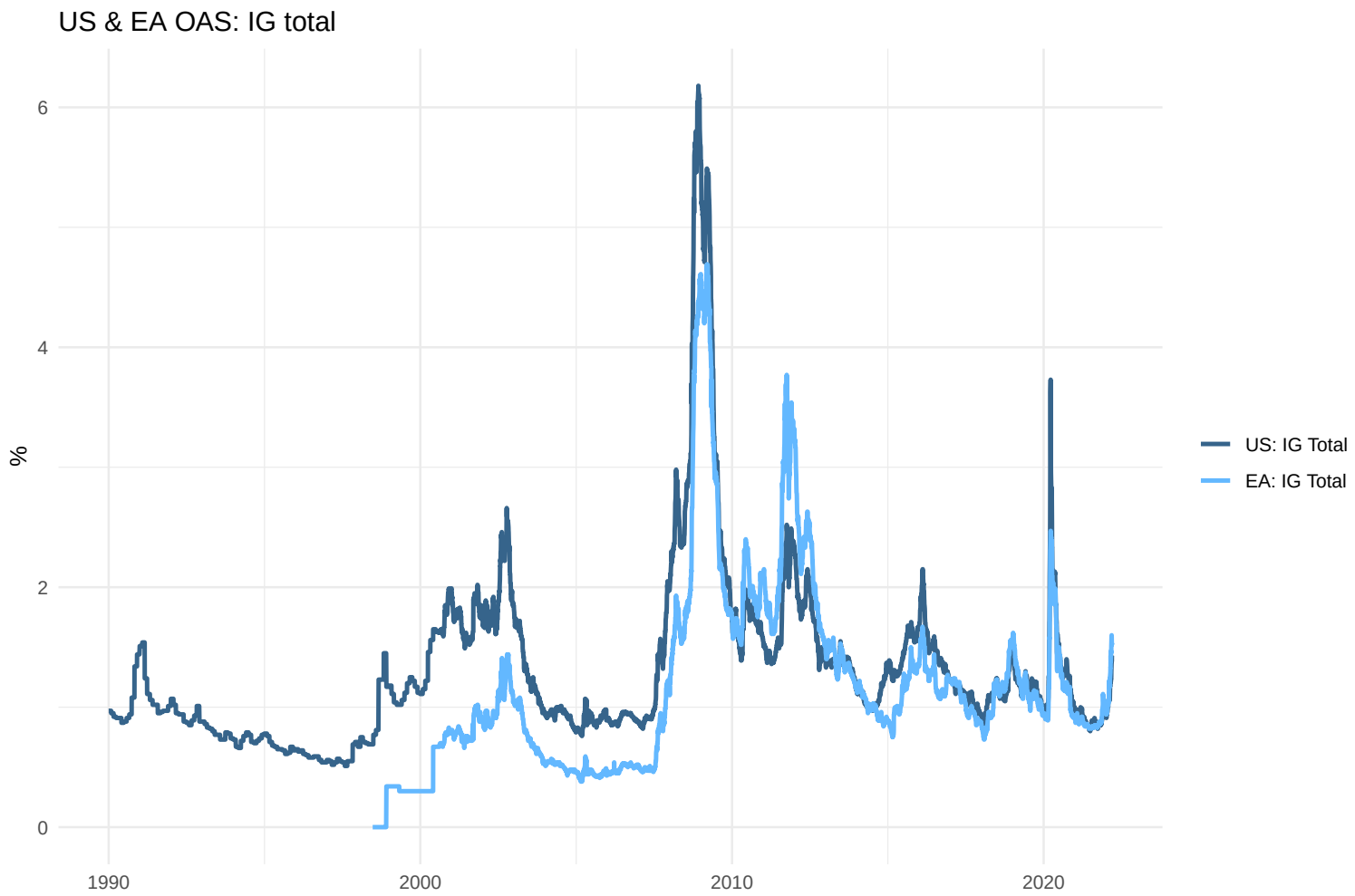

Figure 17: United States and Euro Area investment grade option adjusted spreads.

US OAS by sector: financials, industrials, utilities

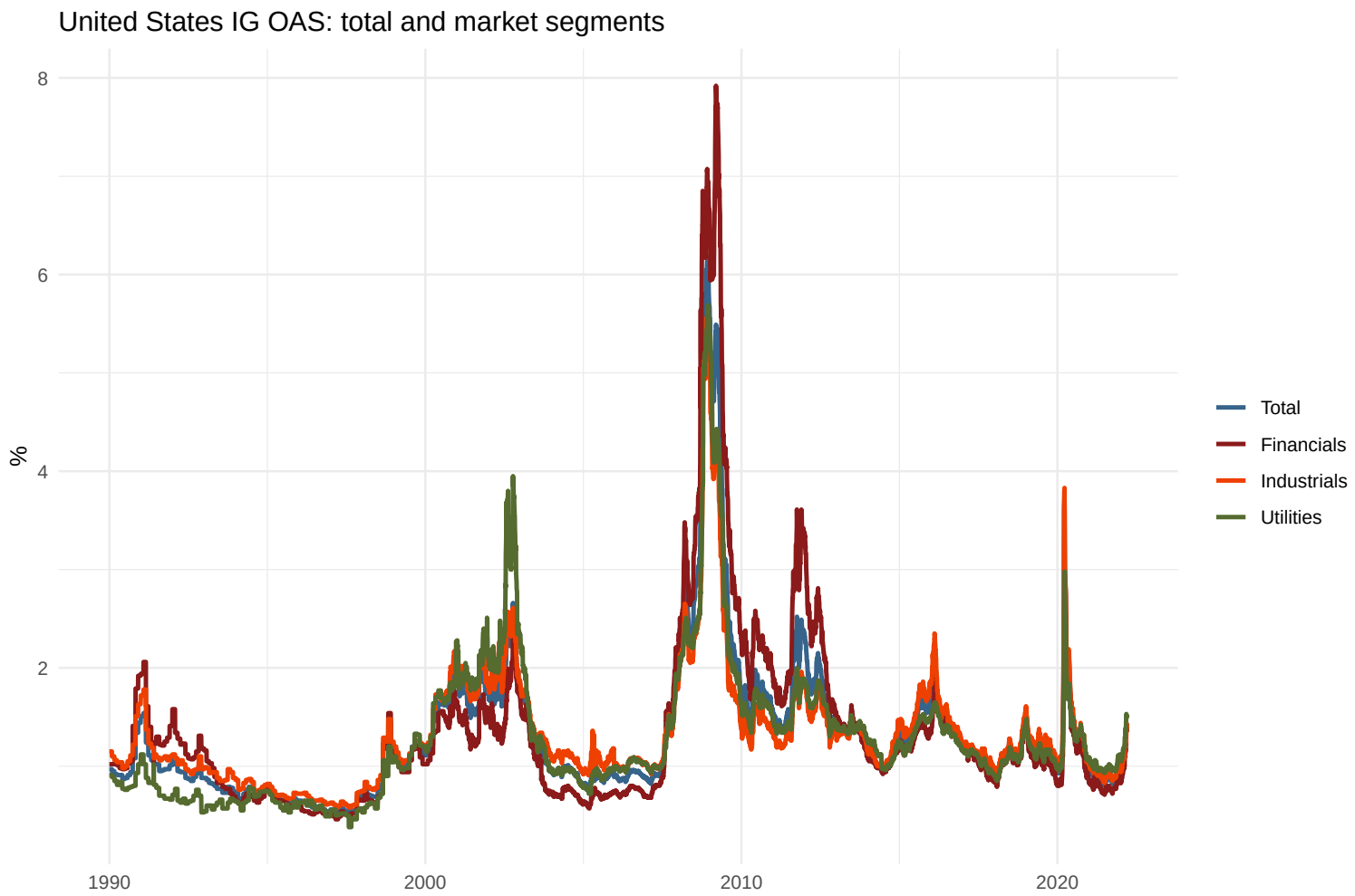

Figure 18: United States investment grade option adjusted spread by sector.

Euro Area: IG and HY OAS

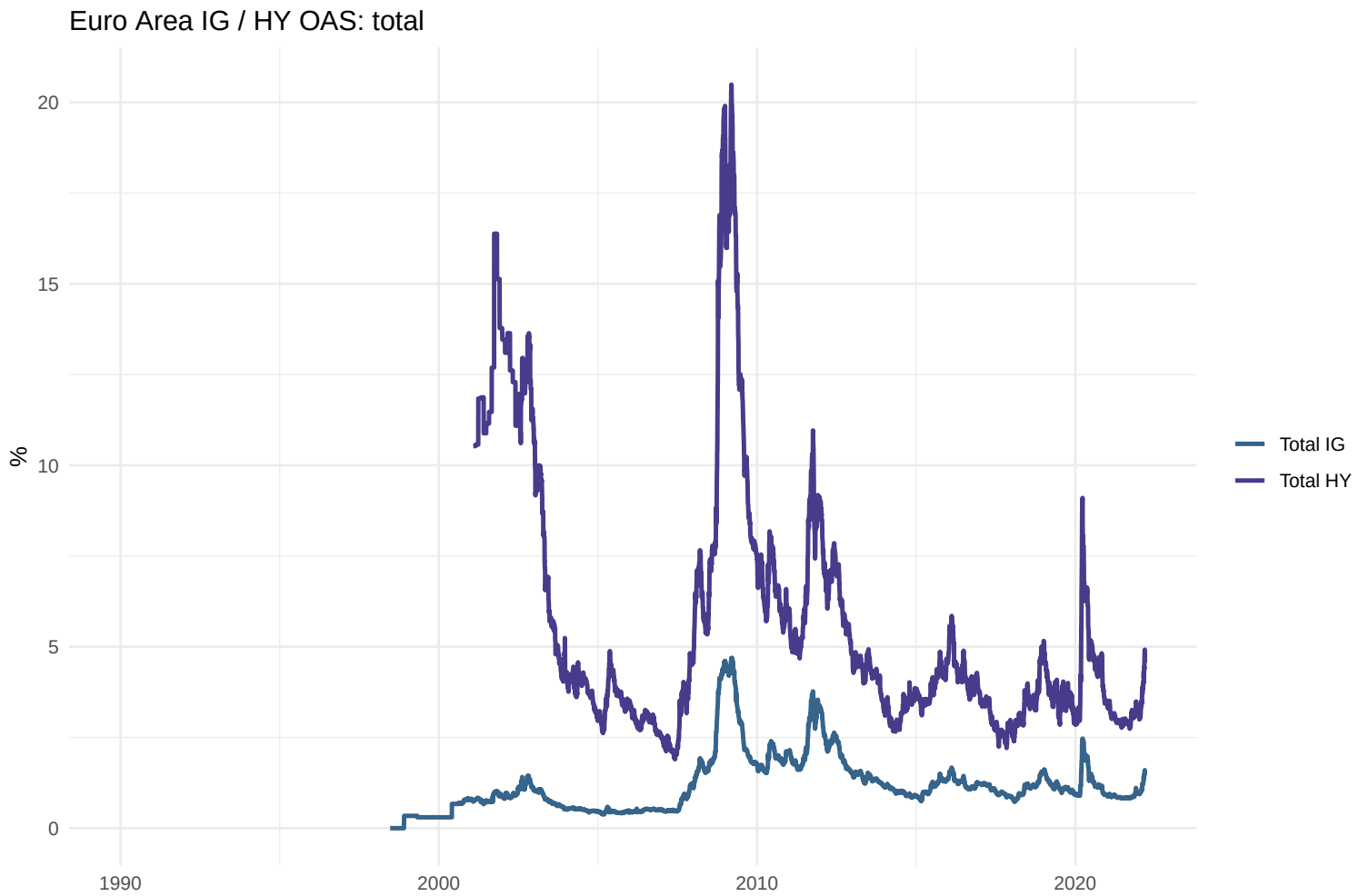

Figure 19: Euro Area investment grade (IG) and high yield (HY) option adjusted spreads.

Euro Area IG OAS by sector: financials, industrials, utilities

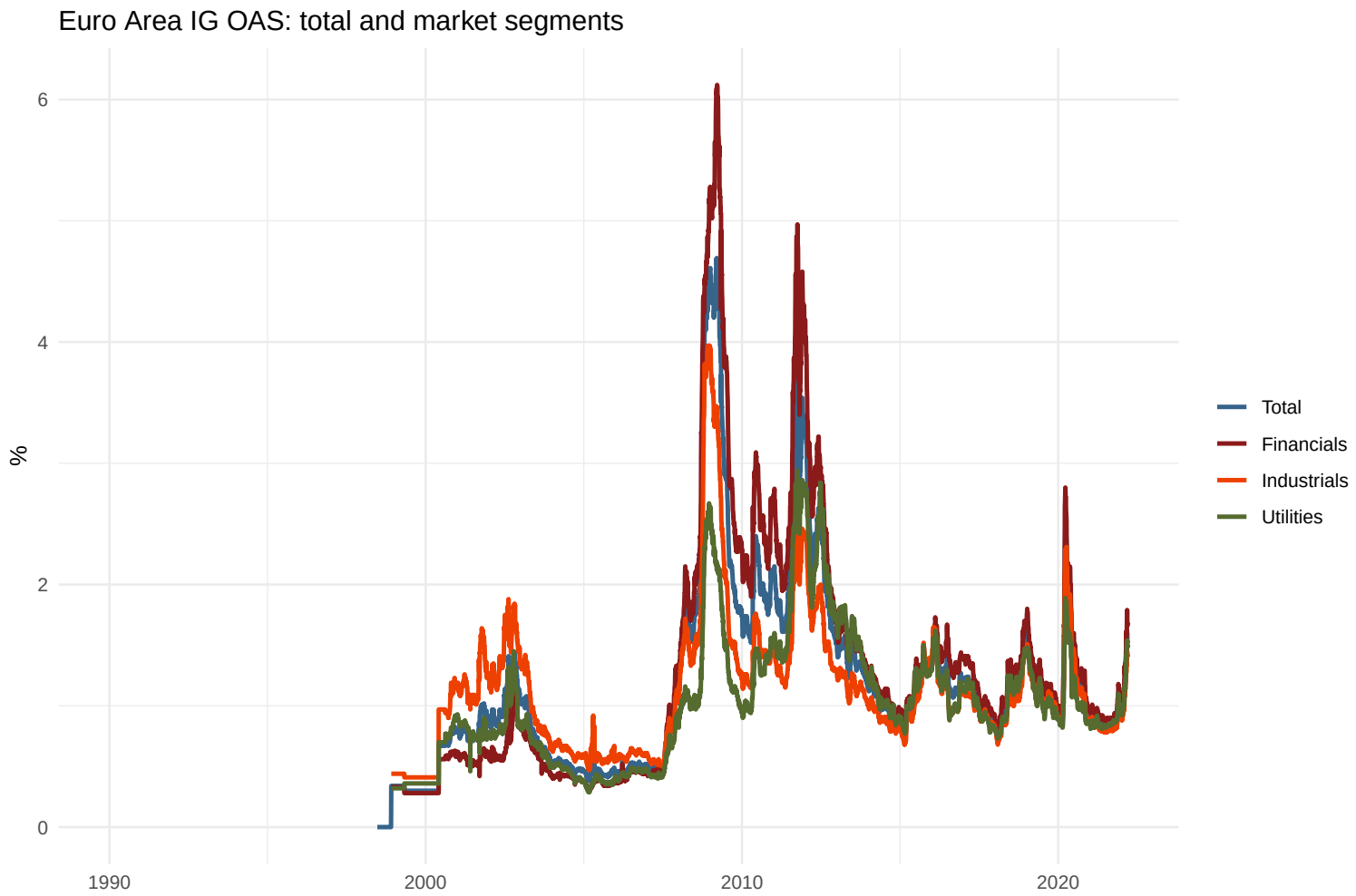

Figure 20: Euro Area investment grade option adjusted spread by sector.

US and Euro Area volatility measures

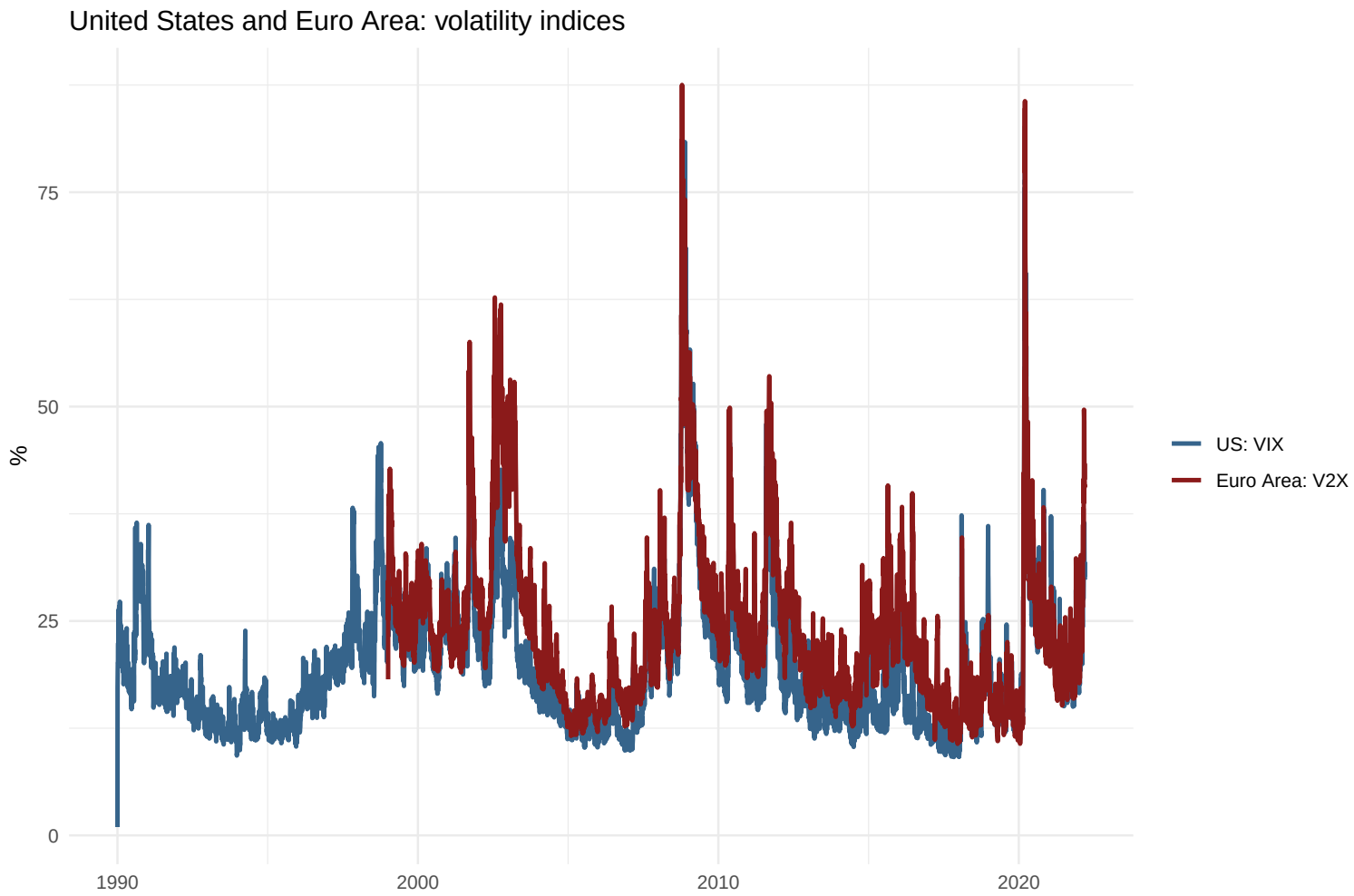

Figure 21: United States and Euro Area volatility indices.

US HY OAS: 1-day, 1-week and 1-month first differences

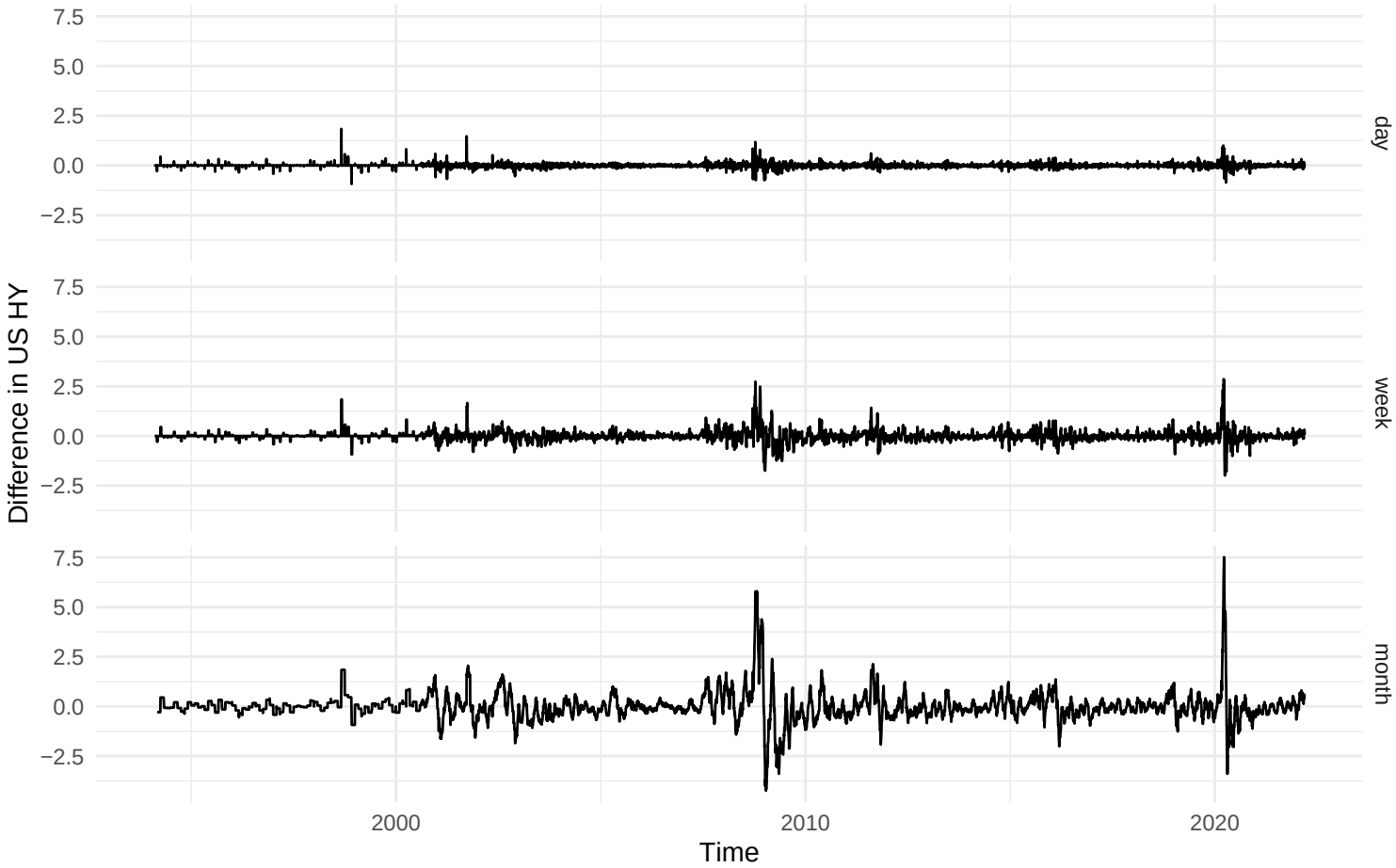

Figure 22: United States: One day, one week, one month difference in HY OAS

Euro Area HY OAS: 1-day, 1-week and 1-month first diff.

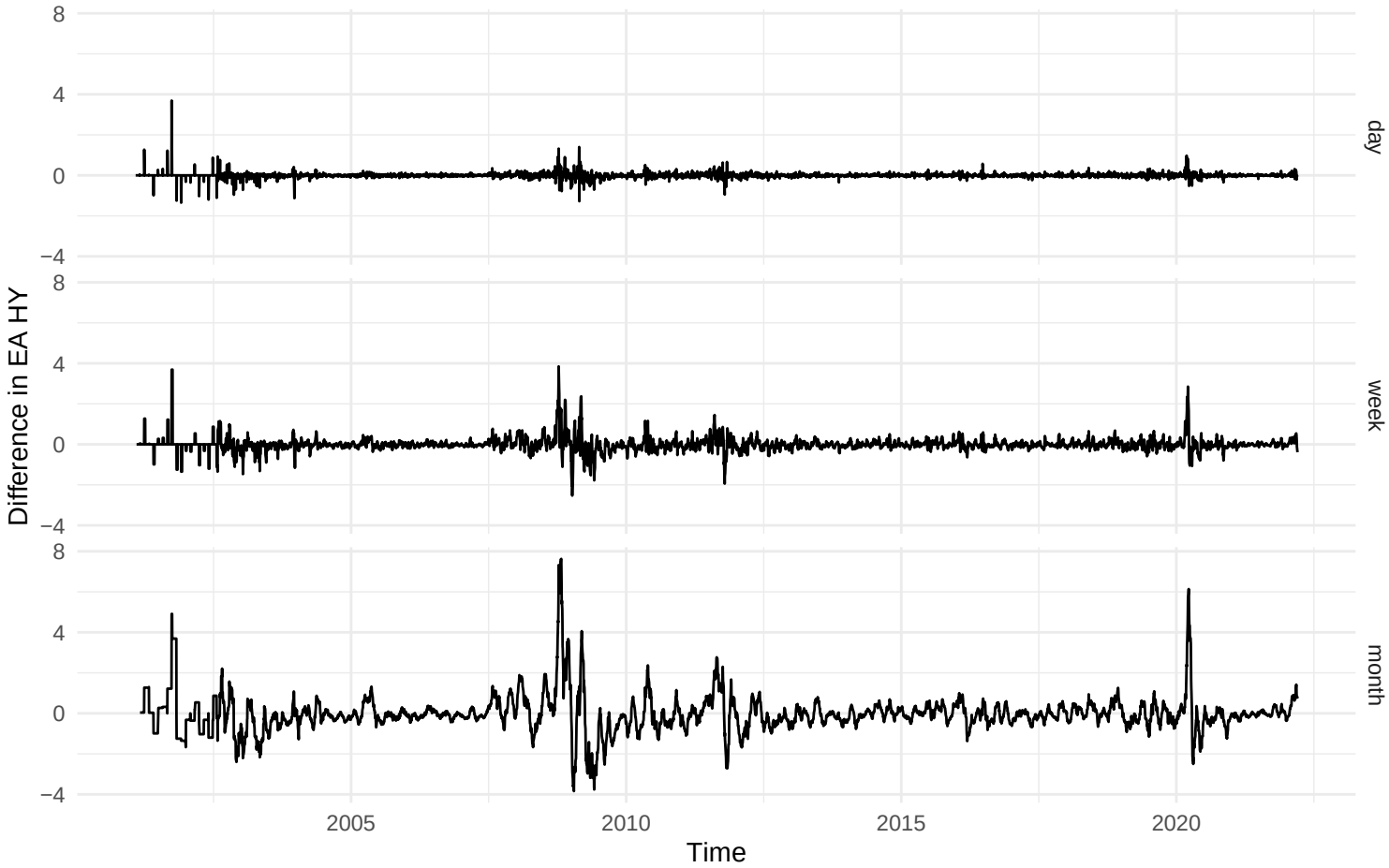

Figure 23: Euro Area: One day, one week, one month difference in HY OAS