Simple Parametric Models for Generating Stable and Efficient Margin Requirements for Derivatives

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Outline

▶ **Margining Process:**
Players, challenges, regulations and SPAN

▶ **Margin Model:**
Risk metric (MTL) and parameter-based margin rules

▶ **Econometric Methodology:**
Calibration, backtesting, margin model selection

▶ **Empirical Results:**
On WTI and comparison with SPAN
Players in the Futures Market

- Regulators
- Central Counter Parties (CCP)
- Central Banks
- Speculators
- Clearing Members
- Hedgers
- Smaller Clients

Recommendations

Law

Margin (+)
Margin (-)
Margin (-)
Margin (?)

Supervision

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Institutions Registered with CCP

CCP receives margins from three types of registered counterparties

▶ **Clearing Members:**
  - Members receive net positions from clients (small speculators, hedgers, brokers)
  - Margin required from clients is typically higher than margin paid to CCP
  - The whole margining process is supervised by the CCP

▶ **Large Hedgers:**
  - Large institutional investors

▶ **Large Speculators:**
  - Higher margins
Role of Central Counter Party (CCP)

- Buyers and sellers deposit *initial margin* on entering trade agreement
- Portfolios MtM daily and price evolution tracked
- Margin call initiated when maintenance margin falls below bound given by daily *maintenance margin* calculation
- Default on call $\Rightarrow$ CCP takes financial obligation of portfolio
- CCP has recourse to additional capital via *default waterfall*
Default Waterfall

- After default on maintenance margin call, CCP utilises capital in this order:

1. Initial margin
2. Default fund contributions from defaulting clearing member
3. A tranche of the CCP’s own capital
4. Default fund contributions from surviving clearing members
5. Unfunded default fund contributions
6. Additional CCP capital
Regulators Views on CCP Margins

- Are CCPs now ‘’too big to fail’’

- Pro-cyclicality $\Rightarrow$ Fear of tax-payer bailouts
  $\Rightarrow$ Focus on stability of margin requirements

- Are margins sufficiently prudent? And is the default waterfall adequate?

- $\Rightarrow$ CCPs required to integrate margin model within enterprise-wide risk management system
New Margin Regulations

- **Dodd-Frank Act (2010)**
  - Requirements for OTC trades to move to CCPs
  - Strict requirements on margins for some derivatives
  - e.g. Margins for un-cleared swaps must cover the 10-day 99% VaR

- **EMIR (2013)**
  - European Market Infrastructure Regulations
  - Strict requirements on *all* OTC derivatives:
    - Portfolio margining, liquidity/concentration adjustments by capital type, stress testing, backtesting, default fund contributions, etc.
  - e.g. Exchange-traded derivatives margins must cover the 2-day 99% VaR
Standard Portfolio Analysis of Risk Software (SPAN)

- CME (1988). Now used by largest exchanges, e.g. ICE
- Lacks firm econometric foundation: hundreds of parameters require re-setting daily
- Margin requirement = worst case loss over 16 scenarios
- Technical documents difficult to assess. Also, historical series of SPAN margins is difficult to recreate exactly - [Kupiec and White, 1996]
- Historical data on parameters:
  - https://www.theice.com/clear_europe_span.jhtml for ICE products and
Obtaining SPAN Margins

- Some historical movements on CME SPAN:

- ICE SPAN software free download and twice-daily parameter files here:
  https://www.theice.com/clear_europe_span.jhtml

- End-of-day historical parameter files downloaded January 2009 to December 2014 ⇒ daily time series of margin movements for any product (WTI crude oil futures in this case)
SPAN Margins: WTI Crude Synthetic 30-day

Daily P&L on WTI 30-day Contracts (grey)
ICE (blue) and CME (green) SPAN margin movements Jan 2009 – Dec 2014.
## Exchange Clearing Activities

<table>
<thead>
<tr>
<th>Rank</th>
<th>Exchange</th>
<th>Jan-Dec 2013</th>
<th>Jan-Dec 2014</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CME Group</td>
<td>3,161,476,638</td>
<td>3,442,766,942</td>
<td>8.90%</td>
</tr>
<tr>
<td>2</td>
<td>Intercontinental Exchange</td>
<td>2,558,489,589</td>
<td>2,276,171,019</td>
<td>-11.0%</td>
</tr>
<tr>
<td>3</td>
<td>Eurex</td>
<td>2,190,727,275</td>
<td>2,097,974,756</td>
<td>-4.20%</td>
</tr>
<tr>
<td>4</td>
<td>National Stock Exchange of India</td>
<td>2,127,151,585</td>
<td>1,880,362,513</td>
<td>-11.60%</td>
</tr>
<tr>
<td>5</td>
<td>BM&amp;FBovespa</td>
<td>1,603,706,918</td>
<td>1,417,925,815</td>
<td>-11.60%</td>
</tr>
<tr>
<td>6</td>
<td>Moscow Exchange</td>
<td>1,134,477,258</td>
<td>1,413,222,196</td>
<td>24.60%</td>
</tr>
<tr>
<td>7</td>
<td>CBOE Holdings</td>
<td>1,187,642,669</td>
<td>1,325,391,523</td>
<td>11.60%</td>
</tr>
<tr>
<td>8</td>
<td>Nasdaq OMX</td>
<td>1,142,955,206</td>
<td>1,127,130,071</td>
<td>-1.40%</td>
</tr>
<tr>
<td>9</td>
<td>Shanghai Futures Exchange</td>
<td>642,473,980</td>
<td>842,294,223</td>
<td>31.10%</td>
</tr>
<tr>
<td>10</td>
<td>Dalian Commodity Exchange</td>
<td>700,500,777</td>
<td>769,637,041</td>
<td>9.90%</td>
</tr>
</tbody>
</table>

The ten largest exchanges clearing futures and options contracts.
Summary of Challenges for Exchanges

- Competitive Environment
  - How to fund large-scale risk management system?
  - Conflicts between EURO and US recommendations?

- Unclear recommendations
  - Some EMIR (2013) articles still under debate

- SPAN requires updating .... Or replacing?
  - How to build a parsimonious margin model that is:
    - Based on sound econometric principles? What principles?
    - Yields prudent and stable and competitive margin re-sets
    - Integrated within the enterprise-wide risk management system
Margin Requirement Literature

- **Prudential Margin Requirements**: Should cover all possible price movements
  [Figlewski, 1984], [Booth et al., 1997], [Cotter and Dowd, 2006]

- **Efficient Contract Design**: Setting margins and price limits simultaneously
  [Brennan, 1986], [Fenn and Kupiec, 1993], [Shanker and Balakrishnan, 2005]

- **Rules-Based Models**: Risk metrics used as bounds for margin re-sets
  [Chiu et al., 2006], [Lam et al., 2010]
Research Questions for our Parsimonious Margin Model

- What’s the best risk measure for a rules-based margin model?
- How can the model incorporate challenges for exchanges?
- How to formulate a **calibration procedure** which produces an **optimally stable margin** which balances two aims:

  (a) small and frequent margin re-sets are operationally costly for investors and exchanges, but they avoid pro-cyclicality in financial markets, vs

  (b) fewer, larger re-sets can produce stable margins over time, but they are highly risky in this competitive environment
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Two-Stage Margin Model

**Stage 1: Risk Metric (MTL) Estimation**
Based on calibration to portfolio returns

**At set-up**, a selection of competing risk models for estimating MTL are **calibrated** and **back-tested** and the ‘best’ model selected (e.g. Student-t EGARCH).

**Stage 2: Margin Rule Parameters Calibrated**
Based on historical series of ‘best’ MTL estimates

**At set-up**, a selection of parsimonious rules-based ‘models’ are **calibrated** and **back-tested** and the ‘best’ model selected
Margins Based on VaR

- [Dowd and Blake, 2006] - Volatility, Value-at-Risk (VaR), Expected Tail Loss (ETL), Median Tail Loss (MTL), partial moments, etc.

- Margins based on VaR; estimated via EVT [Figlewski, 1984], [Booth et al., 1997], [Broussard and Booth, 1998], [Longin, 1999], [Broussard, 2001], [Cotter, 2001]

- $\alpha\%$ $h$-day VaR is $\alpha$-quantile of $h$-day returns distribution

- Literature review [Abad et al., 2014]
Margins Based on VaR

- VaR is *elicitable* [Gneiting, 2011]

- But is VaR *coherent*?
  - Not always, [Acerbi and Tasche, 2002]
  - Parametric VaR with no numerical error is typically coherent [Daníelsson et al., 2013]

- However, VaR does not represent the extent of losses, should VaR be exceed ⇒ **VaR not suited to margin model**
Why Median Tail Loss (MTL)?

- Expected tail loss (ETL) = expected loss, given $> \text{VaR}$

- ETL is coherent. Advocates: [Acerbi and Tasche, 2002], [Tasche, 2002], [Yamai and Yoshiba, 2005]

- But ETL is not elicitable [Gneiting, 2011]

- The $\alpha\%$ MTL is simply the $(1 + \alpha)/2$ percentile VaR

- Therefore **MTL is representative of the scale of loss, elicitable and coherent** – provided MTL parametric and estimates analytic
Stage 1: MTL Models

- **EWMA:**
  \[
  \hat{\sigma}_t^2 = \zeta \hat{\sigma}_{t-1}^2 + (1 - \zeta) \varepsilon_{t-1}^2, \quad \varepsilon_t = r_t - \bar{r}_t
  \]

- **EGARCH:** [Nelson, 1990]
  \[
  \ln \sigma_t = \beta_0 + g(\varepsilon_{t-1}) + \beta_3 \ln \sigma_{t-1}, \quad \text{with}
  \]
  \[
  g(\varepsilon_t) = \beta_1 \varepsilon_t + \beta_2 (|\varepsilon_t| - E[|\varepsilon_t|]), \quad \varepsilon_t \sim D(0, \sigma_t^2)
  \]

- **GJR-GARCH:** [Glosten et al., 1993]
  \[
  \sigma_t^2 = \beta_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 \sigma_{t-1}^2 + \beta_3 I_{\varepsilon_{t-1} < 0} \varepsilon_{t-1}^2
  \]
Stage 2: Margin Re-set Rules Based on Buffer

Margins driven by MTL evolution with periodic jumps.

EMIR (Article 28a) → Base rules on buffer of at least 25%, which may be exhausted when margins increases significantly. Graph below illustrates three possible re-set rules.
Margin Re-set Rules

Margin Rules

- All rules are based on symmetric margin band of width equal to the buffer $B$ above the MTL, i.e.

$$\text{Margin band at time } t = [M_t, (1 + B) M_t], \text{ where } M_t = \text{MTL}_t^{0.99,1}$$

- Boundary hit $\Rightarrow$ margin reset to different level $R_t$:

<table>
<thead>
<tr>
<th>Rule Label</th>
<th>Reset Level $(R_t)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M^{(1)}$</td>
<td>1.125 $M_t$</td>
</tr>
<tr>
<td>$M^{(2)}$</td>
<td>$(1 + \beta) M_t$</td>
</tr>
</tbody>
</table>
| $M^{(3)}$  | $(1 + \beta^u) M_t$ if margin falls below $M_t$  
$(1 + \beta^d)(1 + B) M_t$ if margin exceeds $(1 + B) M_t$ |
Margin Re-set Rules

Margin Rule Calibration

- Margin resets follow a process with **correlated jump size and arrival time**

- Focus on stability $\rightarrow$ calibration parameters, e.g. $(\beta^u, \beta^d)$ based on **minimizing the variance of this process**

- A standard compound Poisson process $Y_t = \sum_{i=1}^{N_t} X_i$ has i.i.d. jumps sizes $X_i \sim X$, independent of $N_t$, $t \geq 0$

- Its total variance between time 0 and time $t$ is

$$\mathbb{V} [Y_t] = \mathbb{E} [N_t] \mathbb{E} [X^2]$$
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Summary of New Model Implementation

Stage 1:

1. Calibrate MTL models: MLE
2. Backtest MTL models: [Christoffersen, 1998]
3. Select MTL model(s): [Gneiting and Ranjan, 2011]
4. Check robustness of results: [Hansen et al., 2011]

Stage 2:

1. Use historical estimates on selected MTL model(s) to calibrate margin rule parameters
2. Backtest margin rules
Backtesting MTL

- Backtesting VaR [Kupiec, 1995], [Christoffersen, 1998], [Engle and Manganelli, 2004]

- CCPs exposed to long and short positions simultaneously ⇒ Use the lesser-known [Christoffersen, 1998] two-tailed coverage tests

- $LR^{uc} \sim \chi^2_3$, $LR^{in} \sim \chi^2_4$ and $LR^{cc} \sim \chi^2_6$ respectively
MTL Model Selection

The perfect forecast
The actual forecast

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Continuous Ranked Probability Score (CRPS) [Gneiting and Ranjan, 2011]

Figure 1: Continuous Ranked Probability Score (CRPS) is equal to the sum of the squared shaded areas.
Continuous Ranked Probability Score (CRPS)
[Gneiting and Ranjan, 2011]

Figure 2: (Weighted) relative CRPS ⇒ negative value indicates first model better
Robustness Check: Model Confidence Set (MCS) [Hansen et al., 2011]

▶ Extension of Hansen’s SPA in absence of benchmark model

▶ Corrects for data-snooping bias when testing out-performance

▶ Like SPA, MCS uses pair-wise comparison of distribution of 10,000+ performance metrics (CRPS) each based on very large bootstrapped samples

▶ But MCS more computationally intensive, e.g. with 10 models no. pairwise comparisons is about 100,000, each taking 10,000+ repetitions of the bootstrap

▶ Testing down yields a set of superior models which are statistically indistinguishable from each other at a user-specified level of confidence
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## Energy Futures

<table>
<thead>
<tr>
<th>Rank</th>
<th>Contract</th>
<th>Jan-Dec 2013</th>
<th>Jan-Dec 2014</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Brent Crude (ICE)</td>
<td>159,102,103</td>
<td>160,425,461</td>
<td>0.8%</td>
</tr>
<tr>
<td>2</td>
<td>LS Crude, WTI (CME)</td>
<td>147,690,593</td>
<td>145,147,334</td>
<td>-1.7%</td>
</tr>
<tr>
<td>3</td>
<td>HH NG (CME)</td>
<td>84,282,495</td>
<td>74,206,602</td>
<td>-12.0%</td>
</tr>
<tr>
<td>4</td>
<td>Coke (DCE)</td>
<td>115,306,637</td>
<td>63,688,294</td>
<td>-44.8%</td>
</tr>
<tr>
<td>5</td>
<td>Coking Coal (DCE)</td>
<td>34,259,550</td>
<td>57,605,436</td>
<td>68.1%</td>
</tr>
<tr>
<td>6</td>
<td>Gasoil (ICE)</td>
<td>64,000,861</td>
<td>52,800,084</td>
<td>-17.5%</td>
</tr>
<tr>
<td>7</td>
<td>NYH RBOB (CME)</td>
<td>34,470,288</td>
<td>34,421,866</td>
<td>-0.1%</td>
</tr>
<tr>
<td>8</td>
<td>HO No.2 (CME)</td>
<td>32,749,553</td>
<td>33,946,420</td>
<td>3.7%</td>
</tr>
<tr>
<td>9</td>
<td>WTI Crude (ICE)</td>
<td>36,111,163</td>
<td>31,600,959</td>
<td>-12.5%</td>
</tr>
</tbody>
</table>

Top ten traded energy futures by contracts traded:


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WTI Crude Oil Futures

30-day synthetic WTI crude oil futures daily returns
Nov 1989 – Dec 2014
Stage 1

- Calibrate GARCH parameters for the first sample period (In our case, Jan 1990 - Dec 1995)
- Roll the sample forward daily, re-estimating all parameters to generate a series of 1-day 99% MTL forecasts for the risk model out-of-sample period (In our case, Jan 1995 - Dec 2008)
- Backtesting, Selection, Robustness
Backtesting: Coverage Results

<table>
<thead>
<tr>
<th>Code</th>
<th>Volatility</th>
<th>Error</th>
<th>UC</th>
<th>IND</th>
<th>CC</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>GARCH</td>
<td>Student t</td>
<td>0.270</td>
<td>7.645</td>
<td>7.915</td>
</tr>
<tr>
<td>II</td>
<td>GARCH</td>
<td>normal</td>
<td>9.574</td>
<td>12.970</td>
<td>22.544</td>
</tr>
<tr>
<td>III</td>
<td>EGARCH</td>
<td>Student t</td>
<td>0.526</td>
<td>4.000</td>
<td>4.526</td>
</tr>
<tr>
<td>IV</td>
<td>EGARCH</td>
<td>normal</td>
<td>7.082</td>
<td>10.543</td>
<td>17.625</td>
</tr>
<tr>
<td>V</td>
<td>GJR</td>
<td>Student t</td>
<td>0.526</td>
<td>4.000</td>
<td>4.526</td>
</tr>
<tr>
<td>VI</td>
<td>GJR</td>
<td>normal</td>
<td>8.044</td>
<td>10.283</td>
<td>18.327</td>
</tr>
</tbody>
</table>

Rejection at 95% (99%) level indicated by red (dark red)

EWMA smoothing constants $\neq 0.96$ reject nulls with even greater confidence
## Selection: CRPS Results

**Symmetric: CRPS weights ($\phi, 1 - \phi$)**

<table>
<thead>
<tr>
<th>No Weight</th>
<th>Volatility</th>
<th>Error</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>GARCH</td>
<td>Student $t$</td>
<td>$-$</td>
<td>-3.08</td>
<td>0.14</td>
<td>-1.72</td>
<td>1.25</td>
<td>-2.08</td>
</tr>
<tr>
<td>II</td>
<td>GARCH</td>
<td>normal</td>
<td>3.08</td>
<td>$-$</td>
<td>2.63</td>
<td>1.16</td>
<td>3.39</td>
<td>0.81</td>
</tr>
<tr>
<td>III</td>
<td>EGARCH</td>
<td>Student $t$</td>
<td>-0.14</td>
<td>-2.63</td>
<td>$-$</td>
<td>-2.35</td>
<td>1.12</td>
<td>-2.26</td>
</tr>
<tr>
<td>IV</td>
<td>EGARCH</td>
<td>normal</td>
<td>1.72</td>
<td>-1.16</td>
<td>2.35</td>
<td>$-$</td>
<td>2.65</td>
<td>-0.75</td>
</tr>
<tr>
<td>V</td>
<td>GJR</td>
<td>Student $t$</td>
<td>-1.25</td>
<td>-3.39</td>
<td>-1.12</td>
<td>-2.65</td>
<td>$-$</td>
<td>-3.16</td>
</tr>
<tr>
<td>VI</td>
<td>GJR</td>
<td>normal</td>
<td>2.08</td>
<td>-0.81</td>
<td>2.26</td>
<td>0.75</td>
<td>3.16</td>
<td>$-$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Both Tails</th>
<th>Volatility</th>
<th>Error</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>GARCH</td>
<td>Student $t$</td>
<td>$-$</td>
<td>-2.94</td>
<td>0.11</td>
<td>-1.29</td>
<td>1.27</td>
<td>-1.73</td>
</tr>
<tr>
<td>II</td>
<td>GARCH</td>
<td>normal</td>
<td>2.94</td>
<td>$-$</td>
<td>2.36</td>
<td>1.22</td>
<td>3.20</td>
<td>0.89</td>
</tr>
<tr>
<td>III</td>
<td>EGARCH</td>
<td>Student $t$</td>
<td>-0.11</td>
<td>-2.36</td>
<td>$-$</td>
<td>-1.97</td>
<td>1.18</td>
<td>-1.93</td>
</tr>
<tr>
<td>VI</td>
<td>EGARCH</td>
<td>normal</td>
<td>1.29</td>
<td>-1.22</td>
<td>1.97</td>
<td>$-$</td>
<td>2.30</td>
<td>-0.74</td>
</tr>
<tr>
<td>V</td>
<td>GJR</td>
<td>Student $t$</td>
<td>-1.27</td>
<td>-3.20</td>
<td>-1.18</td>
<td>-2.30</td>
<td>$-$</td>
<td>-3.00</td>
</tr>
<tr>
<td>VI</td>
<td>GJR</td>
<td>normal</td>
<td>1.73</td>
<td>-0.89</td>
<td>1.93</td>
<td>0.74</td>
<td>3.00</td>
<td>$-$</td>
</tr>
</tbody>
</table>
## Selection: CRPS Results

### Asymmetric: CRPS weights ($\Phi, 1 - \Phi$)

<table>
<thead>
<tr>
<th>Right Tail</th>
<th>Volatility</th>
<th>Error</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>GARCH</td>
<td>Student $t$</td>
<td>–</td>
<td>-0.94</td>
<td>1.56</td>
<td>0.76</td>
<td>1.18</td>
<td>-0.22</td>
</tr>
<tr>
<td>II</td>
<td>GARCH</td>
<td>normal</td>
<td>0.94</td>
<td>–</td>
<td>1.79</td>
<td>2.28</td>
<td>1.43</td>
<td>1.12</td>
</tr>
<tr>
<td>III</td>
<td>EGARCH</td>
<td>Student $t$</td>
<td>-1.56</td>
<td>-1.79</td>
<td>–</td>
<td>-0.23</td>
<td>-0.85</td>
<td>-1.24</td>
</tr>
<tr>
<td>IV</td>
<td>EGARCH</td>
<td>normal</td>
<td>-0.76</td>
<td>-2.28</td>
<td>0.23</td>
<td>–</td>
<td>-0.25</td>
<td>-1.95</td>
</tr>
<tr>
<td>V</td>
<td>GJR</td>
<td>Student $t$</td>
<td>-1.18</td>
<td>-1.43</td>
<td>0.85</td>
<td>0.25</td>
<td>–</td>
<td>-0.89</td>
</tr>
<tr>
<td>VI</td>
<td>GJR</td>
<td>normal</td>
<td>0.22</td>
<td>-1.12</td>
<td>1.24</td>
<td>1.95</td>
<td>0.89</td>
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</table>

<table>
<thead>
<tr>
<th>Left Tail</th>
<th>Volatility</th>
<th>Error</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>GARCH</td>
<td>Student $t$</td>
<td>–</td>
<td>-3.20</td>
<td>-1.28</td>
<td>-2.90</td>
<td>0.52</td>
<td>-2.42</td>
</tr>
<tr>
<td>II</td>
<td>GARCH</td>
<td>normal</td>
<td>3.20</td>
<td>–</td>
<td>1.58</td>
<td>-0.66</td>
<td>3.01</td>
<td>0.06</td>
</tr>
<tr>
<td>III</td>
<td>EGARCH</td>
<td>Student $t$</td>
<td>1.28</td>
<td>-1.58</td>
<td>–</td>
<td>-2.78</td>
<td>2.29</td>
<td>-1.62</td>
</tr>
<tr>
<td>IV</td>
<td>EGARCH</td>
<td>normal</td>
<td>2.90</td>
<td>0.66</td>
<td>2.78</td>
<td>–</td>
<td>3.77</td>
<td>1.00</td>
</tr>
<tr>
<td>V</td>
<td>GJR</td>
<td>Student $t$</td>
<td>-0.52</td>
<td>-3.01</td>
<td>-2.29</td>
<td>-3.77</td>
<td>–</td>
<td>-3.36</td>
</tr>
<tr>
<td>VI</td>
<td>GJR</td>
<td>normal</td>
<td>2.42</td>
<td>-0.06</td>
<td>1.62</td>
<td>-1.00</td>
<td>3.36</td>
<td>–</td>
</tr>
</tbody>
</table>
Robustness: MCS Results

Models in 25% or higher MCS should confirm CRPS results
⇒ same tail-weight combinations as in CRPS tests
Best model p-value = 1.00
All models with a p-value > 0.25 lie in the 25% MCS

<table>
<thead>
<tr>
<th>Error</th>
<th>Volatility</th>
<th>No Weight</th>
<th>Left Tail</th>
<th>Right Tail</th>
<th>Both Tails</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>t-GARCH</td>
<td>0.670</td>
<td>0.893</td>
<td>0.716</td>
<td>0.874</td>
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<tr>
<td>II</td>
<td>Normal GARCH</td>
<td>0.146</td>
<td>0.203</td>
<td>0.602</td>
<td>0.276</td>
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<tr>
<td>III</td>
<td>t-EGARCH</td>
<td>0.291</td>
<td>0.472</td>
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<td>0.596</td>
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<td>IV</td>
<td>Normal-EGARCH</td>
<td>0.155</td>
<td>0.014</td>
<td>1.00</td>
<td>0.383</td>
</tr>
<tr>
<td>V</td>
<td>t-GJR</td>
<td>1.00</td>
<td>1.00</td>
<td>0.716</td>
<td>1.00</td>
</tr>
<tr>
<td>VI</td>
<td>Normal-GJR</td>
<td>0.146</td>
<td>0.061</td>
<td>0.686</td>
<td>0.284</td>
</tr>
</tbody>
</table>

MCS p-values. Blue belongs to 25% MCS
Stage 1: Conclusions

- [Christoffersen, 1998] Best backtests: Student $t$, EGARCH or GJR

- [Gneiting, 2011] Best CRPS: Student $t$, EGARCH or GJR

- [Gneiting and Ranjan, 2011] Models in 25% MCS: GARCH, EGARCH or GJR with Student $t$ innovations

- Models III and V taken to Stage 2
  - Student $t$ innovations
  - EGARCH and GJR conditional variance processes
Stage 2: Margin Rule Implementation Procedure

- Calibrate MTL models III and V, sample Jan 1995 - Dec 2008
- Forecast a time series for each 1-day 99% MTL
- Calibrate margin rule parameters for each MTL
- Apply the same margin parameters out-of-sample (Jan 2009 - Dec 2014) and compare margins with SPAN over this period
## Margin Model Stability

<table>
<thead>
<tr>
<th></th>
<th>CPP Variance</th>
<th>No. Exceedances</th>
<th>Average Exceedance</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Upper tail</td>
<td>Lower tail</td>
<td>Upper tail</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower tail</td>
</tr>
<tr>
<td>SPAN</td>
<td>13.622</td>
<td>13.622</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>9.763</td>
<td>9.763</td>
<td>4</td>
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<tr>
<td>Model III:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student-t</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EGARCH</td>
<td>142.938</td>
<td>142.938</td>
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<td></td>
<td>112.485</td>
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<tr>
<td></td>
<td>11.274</td>
<td>11.274</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>69.288</td>
<td>69.288</td>
<td>4</td>
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<tr>
<td>Model III:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student-t</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>GJR</td>
<td>197.546</td>
<td>197.546</td>
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<tr>
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<td>160.761</td>
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<td>23.556</td>
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<tr>
<td></td>
<td>93.342</td>
<td>93.342</td>
<td>4</td>
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</tbody>
</table>

CPP variance, number of margin exceedances and average exceedances for each margin rule according to MTL models III and IV. Out-of-sample period: Jan 2009 - Dec 2014. CPP variance in $^2$. Average exceedances denoted in $ per bbl.
Margin Evolution Out-of-Sample

Out-of-sample margins for the 30-day synthetic WTI futures (Jan 2009 - Dec 2014).
Based on Student $t$-EGARCH model

Thematic Semester, Paris
Summary

- Parsimonious two-stage margin calibration process seeks to address current challenges for CPPs and regulators.
- Parametric MTL models preferred $\leftarrow$ elicitable, sub-additive and reflect average extreme loss.
- Preliminary results $\Rightarrow$ 25% buffer can provide foundation for parsimonious model which generates margins as stable as ICE historical SPAN.
- Extension to multivariate framework: aggregated MTL should incorporate term-structure and cross-product correlations.
- Next step: calibrate margin rules based on minimizing variance of coupled CTRW.
Stage 2


Stage 2


Clearing margin system in the futures markets–applying the value-at-risk model to taiwanese data.

Evaluating interval forecasts.

Margin exceedences for european stock index futures using extreme value theory.

Extreme spectral risk measures: An application to futures clearinghouse margin requirements.

Fat tails, var and subadditivity.

After var: The theory, estimation, and insurance applications of quantile-based risk measures.

CAViaR.

Prudential margin policy in a futures-style settlement system.

Margins and market integrity: Margin setting for stock index futures and options.

On the relation between the expected value and the volatility of nominal excess return on stocks.
Stage 2


Making and evaluating point forecasts.

Comparing density forecasts using threshold-and quantile-weighted scoring rules.
*Journal of Business & Economic Statistics.*

The model confidence set.

Techniques for verifying the accuracy of risk measurement models.
*The Journal of Derivatives, 3(2).*

Regulatory competition and the efficiency of alternative derivative product margining systems.
*Journal of Futures Markets, 16(8):943–968.*

Stage 2


**Longin, F. M. (1999).**

**Nelson, D. B. (1990).**

**Shanker, L. and Balakrishnan, N. (2005).**

**Tasche, D. (2002).**

**Yamai, Y. and Yoshiba, T. (2005).**