VALUATION OF COLLATERAL IN SECURITIES SETTLEMENT SYSTEMS FOR EXTREME MARKET EVENTS

Alejandro Garcia and Ramo Gençay

Frankfurt, 3 April 2006

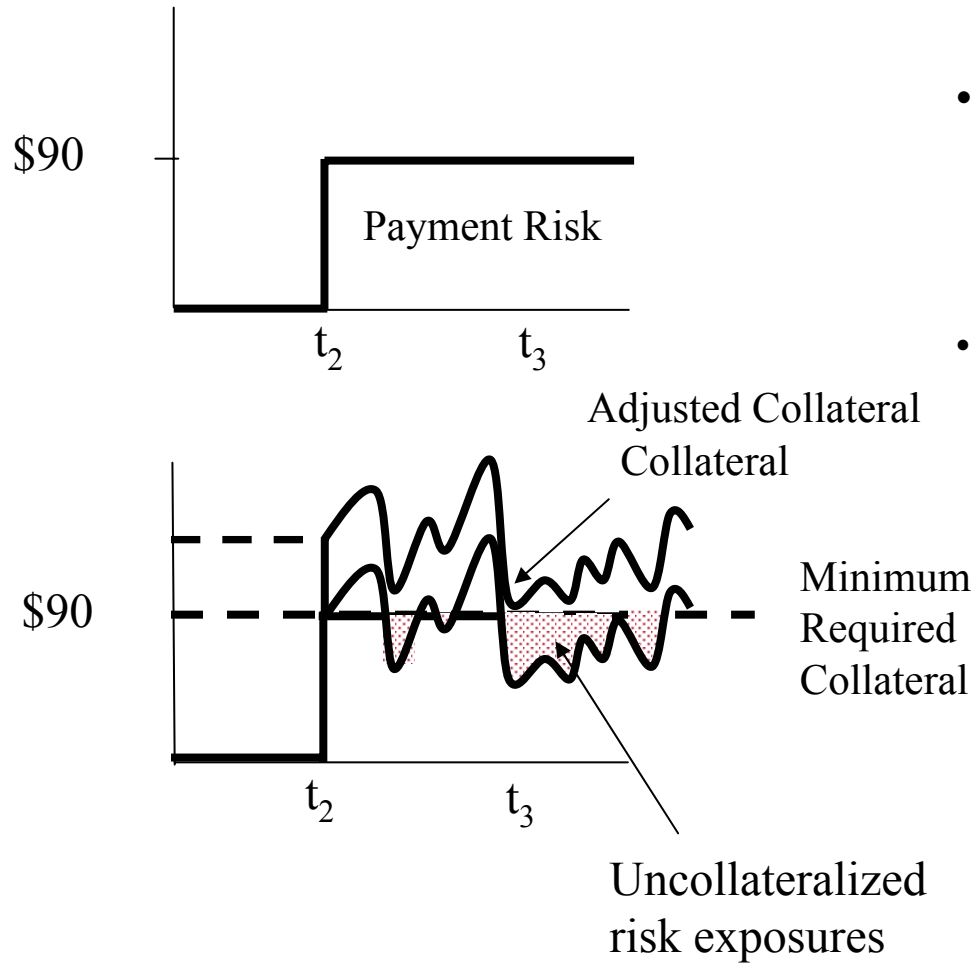
Issues Related to Central Counterparty Clearing

Invited Session II

Agenda

- ► *Motivation and Research Questions*
- Framework to Address Questions
- Case Study and Results
- Conclusions and Future Work

Risk is managed with collateral but collateral value fluctuates



- **Payment Risk**: Is the risk that a participant in a defaults on its funds obligation

- **Research Questions**:
  1. How do we value collateral (calculate haircuts) for securities that are subject to large fluctuations in their market prices?
  2. What framework can we use to compare the different methodologies to calculate haircuts?
  3. What are the desired properties that a methodology should have?

A preview of our answers

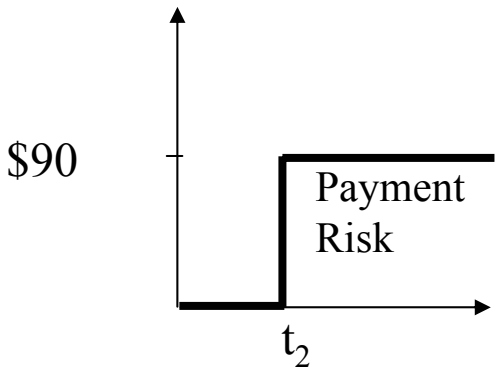
1. How do we calculate haircuts for securities that are subject to large fluctuations in their market prices?
   - **Estimate risk measures (haircuts) with extreme value methods**

2. What framework can we use to compare the different methodologies to calculate haircuts?
   - **We propose to create a risk-cost frontier**

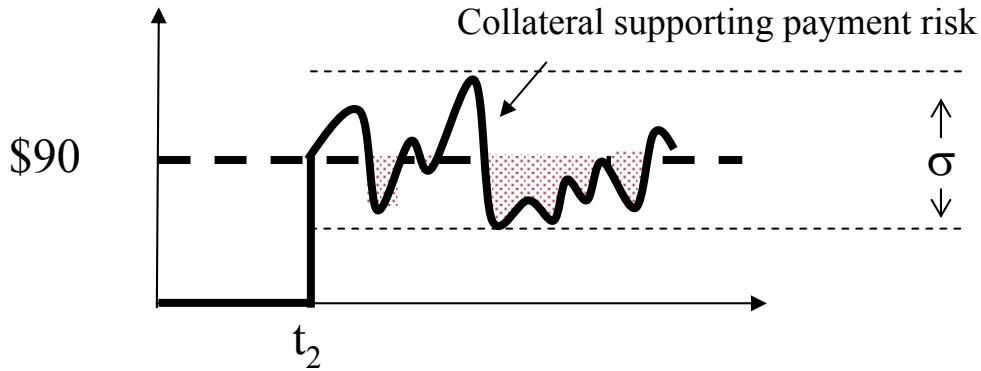
3. What are the desired properties that a methodology to value collateral should have?
   - **Coherent, accurate, and efficient**

How are haircuts calculated?

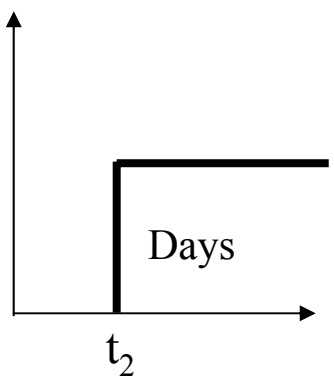
1. Calculate risk exposure



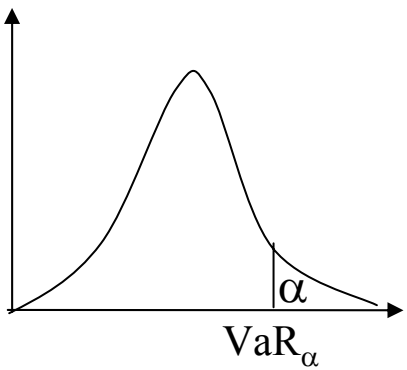
2. Measure variability of risk factor



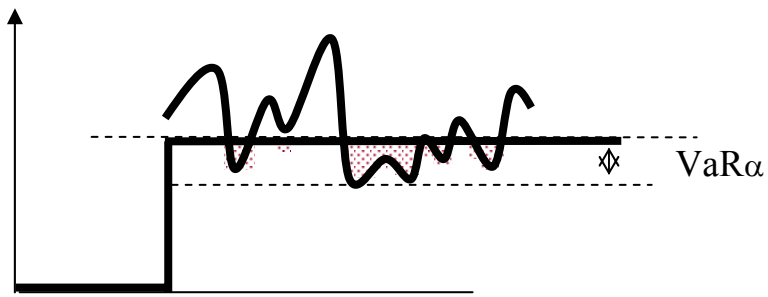
3. Set time horizon



4. Set confidence interval and calculate VaR_α



5. Increase collateral required. Report potential losses when collateral is insufficient.



In summary, we need to choose 2 aspects

1. A parametric assumption
   - Normal
   - Student *t*
   - Generalized Pareto
   - etc ..
2. A risk measure
   - Value-at-Risk
   - Expected Shortfall

Our selection is based on a framework

Our Framework:

1. Proposes a way to select the distribution
   - Use **extreme value theory** to determine the tail behavior of collateral returns

2. Proposes three criteria for the selection of the risk measure
   - Coherence
   - Efficiency
   - Accuracy

3. Evaluates different alternatives using the **risk-cost frontier**

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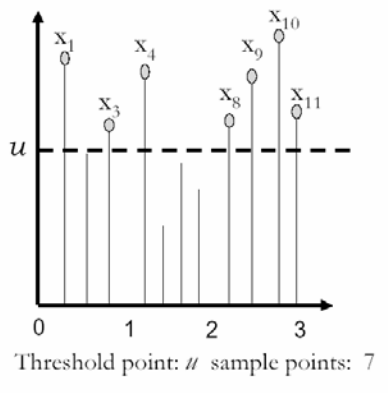
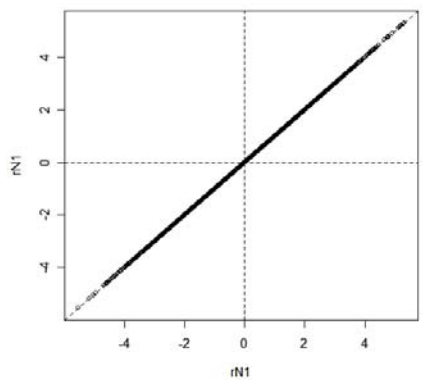
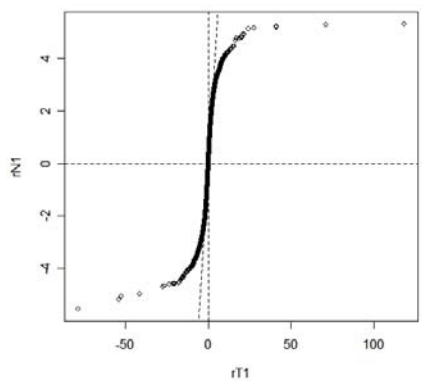
How to select the distribution?

- One approach is extreme value theory
  - **Distribution of exceedances over a Threshold**: GPD is the limiting distribution of the exceedances



- Diagnostics to determine the tail type
  - QQ-plots
  - Mean excess function
  - Hill estimator
  - Risk-cost frontier



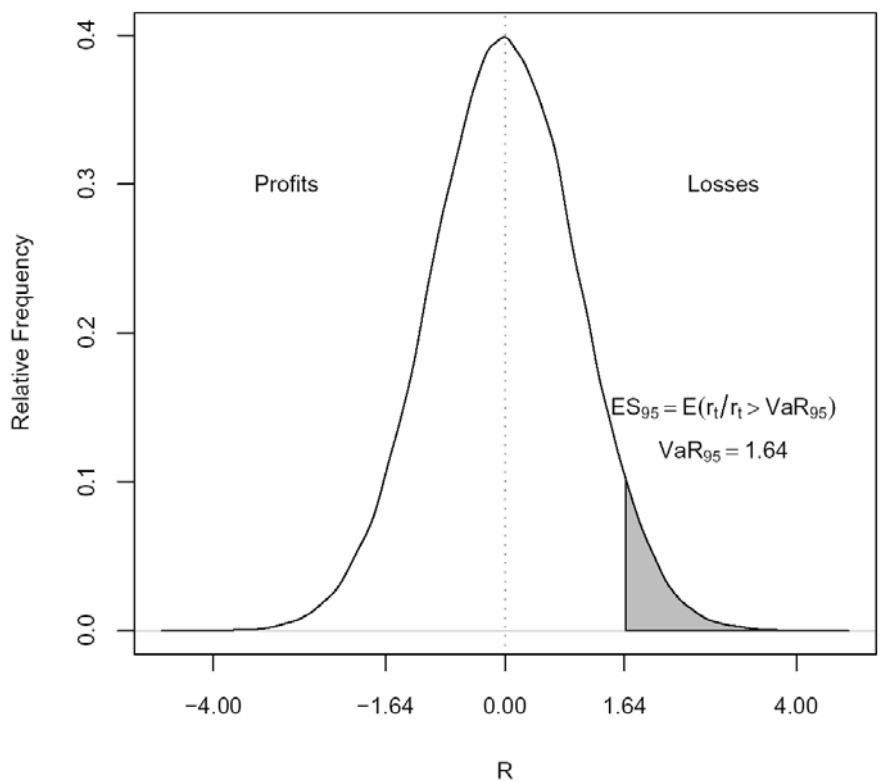


How do we select the risk measure?

1. List potential risk measures:
   - Value at Risk
     $$VaR_t(\alpha) = F_t^{-1}(\alpha)$$
   - Expected Shortfall
     $$ES_t(\alpha) = E[r_t \mid r_t > VaR_t(\alpha)]$$

2. Determine risk preferences
   - Place a weight on decision criteria
     - Coherence
     - Accuracy
     - Efficiency

3. Use the risk-cost frontier to select the desired risk measure



To select the risk measure consider: ***Axioms of Coherent Measures***

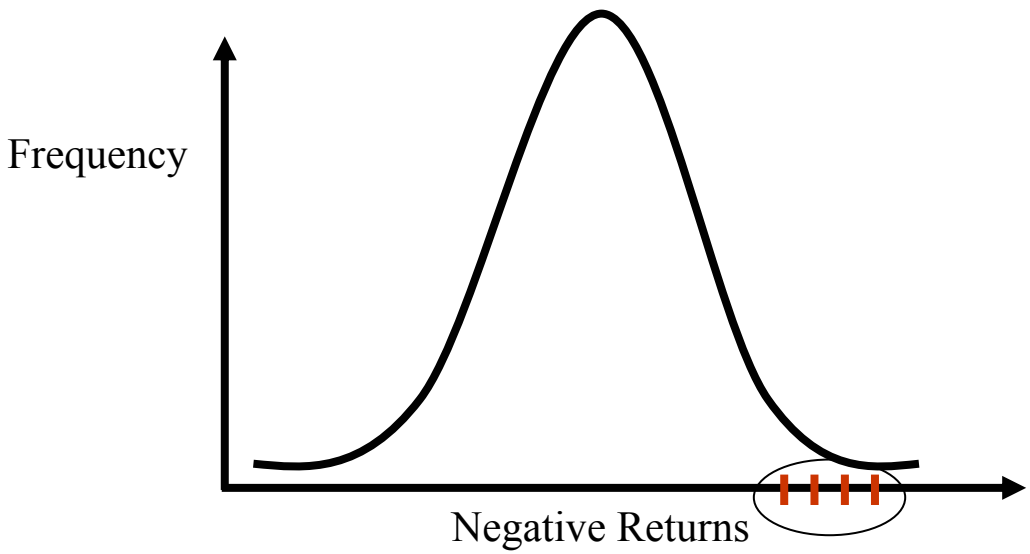
- Artzner *et al.* (1997, 1999):
  - An appropriate risk measure ≈ **Coherent** risk measure

- A coherent risk measure ,
  - Reflects **diversification effects** of a portfolio
    - Positive Homogeneity
    - Sub-additivity
  - Reflects the relation between **Risk & Return**
    - Monotonicity
  - Reflects the reduction of risk by introducing the **risk free asset** in a portfolio
    - Transitional Invariance

To select the risk measure consider: ***Accuracy***

- Our interest is on extreme events → high quantiles of the return distribution

Accurate measure of the tail of the returns distribution



To select the risk measure consider: ***Efficiency***

- Lower transaction costs allows participants to reallocate their investment portfolios to more efficient ones

Efficient collateral implies the minimum collateral portfolio to cover payment risk

To compare methodologies consider: ***risk-cost trade-offs***

- We focus on a particular risk and cost
  - **Tail risk:** The risk that fluctuations in the market price of collateral are **not** covered by the haircut
  - **Collateral cost:** The cost of pledging collateral, measured by the **added** collateral required by the haircut

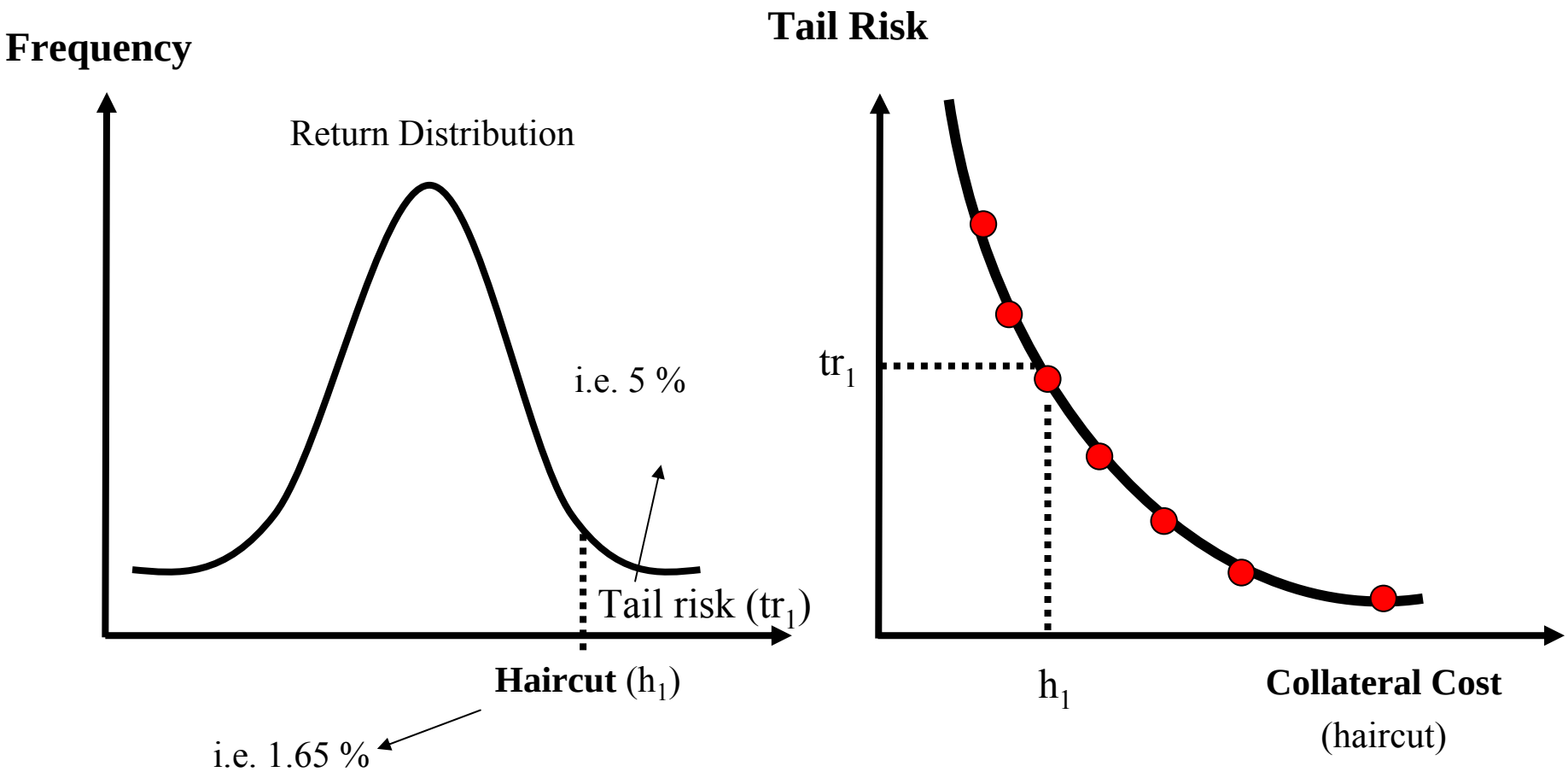
- There is a risk-cost trade-off

Higher haircuts → higher collateral cost

BUT ALSO

Higher haircuts → lower tail risk → lower settlement risk

The **Risk-Cost Frontier** captures the trade-off at high quartiles



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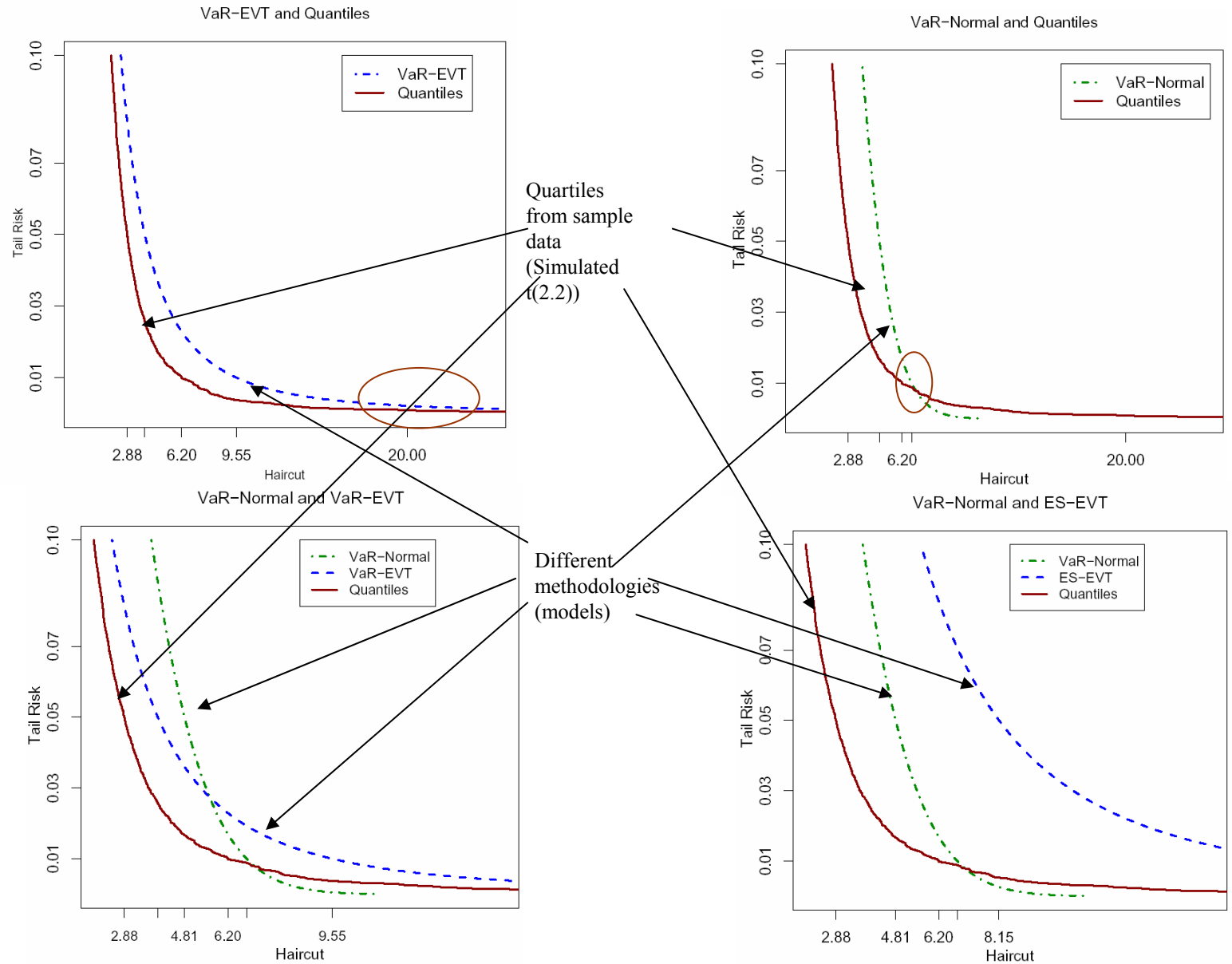
Comparison of methodologies using simulated data



Considerations to select a risk measure for extreme events

	Coherent	Accurate	Efficient
VaR Normal	?	✗	✓
VaR EVT	?	✓	✓
ES EVT	✓	✓	?

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Conclusions

Findings

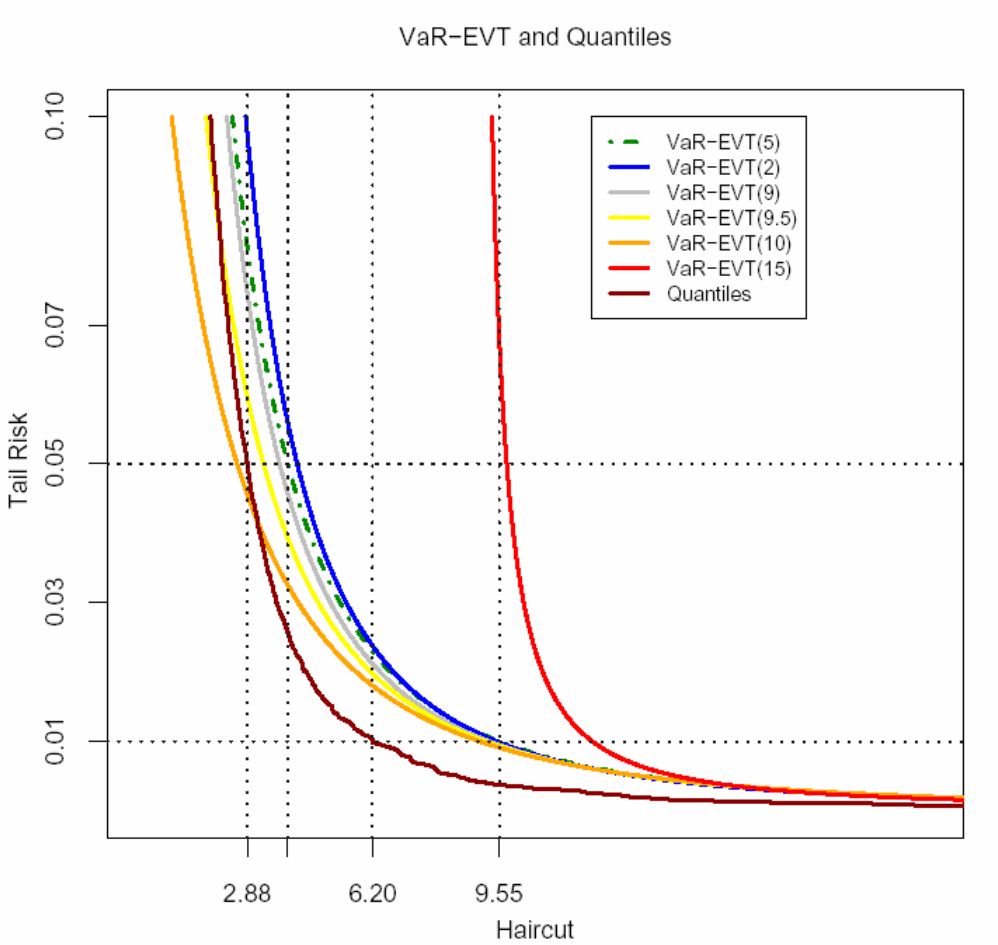
1. Propose a framework to characterise and rank risk measures
2. Find VaR with EVT to be an adequate risk measure
3. Risk-cost frontier useful as diagnostic tool for selection of a risk measure.

Future Research (Using market data)

1. Extend framework analysis to portfolios of collateral
2. Study valuation of debt instruments for extreme events
3. Consider the effect of liquidity shortages on collateral value during extreme events

Thank you!

Annex


VaR−EVT and Quantiles
Tail Risk
0.10
0.07
0.05
0.03
0.01
VaR−EVT(5)
VaR−EVT(2)
VaR−EVT(9)
VaR−EVT(9.5)
VaR−EVT(10)
VaR−EVT(15)
Quantiles
2.88
6.20
9.55
Haircut