Measuring and testing for the systemically important financial institutions

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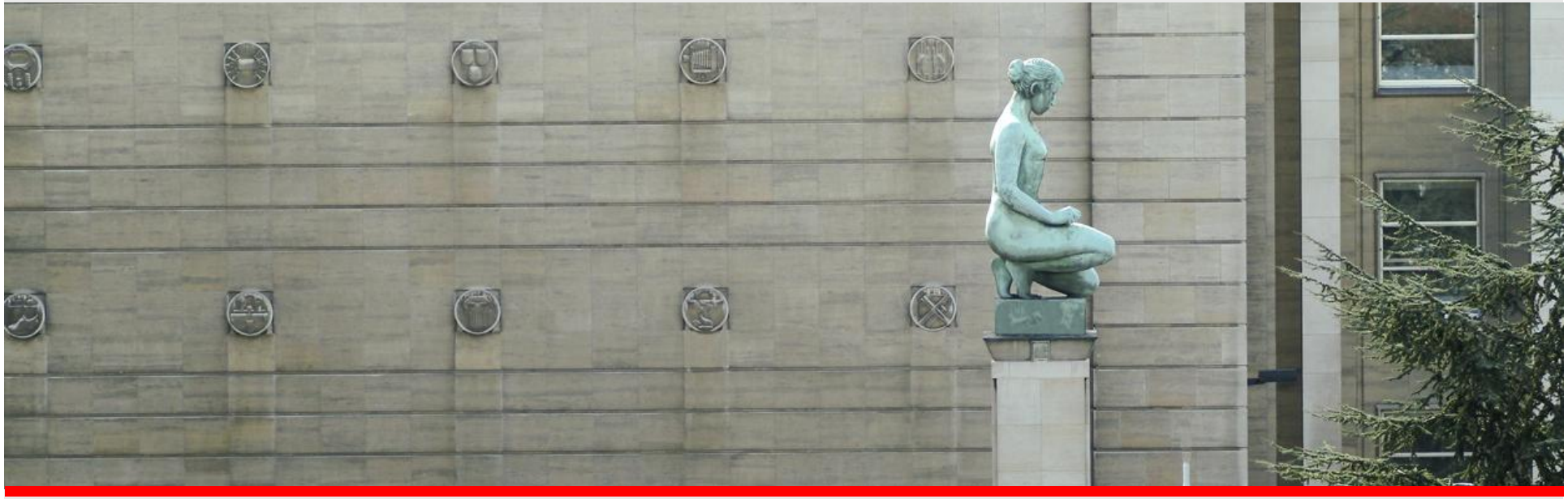

National Bank OF BELGIUM

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Introduction: systemic importance and *ΔCoVaR*

- Regulation of systemically important financial institutions (SIFIs) because of *"their potential to have a large negative impact on the financial system and the real economy"* (IMF/BIS/FSB) and monitoring of interconnectedness.
  - Co-risk measures have attracted considerable attention in both academic and policy research.
  - Adrian and Brunnermeier (2008, 2010): *ΔCoVaR* compares *VaR* of the financial system conditional on FI in distress (*CoVaR*) to unconditional *VaR* of the financial system <2008> or conditional on FI in normal times <2010>.
- Numerous applications of *ΔCoVaR*, but no statistical inference on the estimated systemic risk measures.

Introduction: purpose of the paper

- But statistical testing is of paramount importance for drawing credible policy conclusions:
  - When applying a bucketing approach for ranking and regulating SIFIs, the systemic risk contribution of FIs in higher buckets should actually be larger than FIs in lower buckets should be considered.
  - When monitoring the network of interconnections between FIs, only the significant links should be considered.
- Our contribution: testing whether
  - the systemic risk contribution, as measured by $\Delta CoVaR$, of different FIs is statistically significant;
  - the systemic risk contributions of different FIs statistically differ from each other.
- General message also applies to other market-based systemic risk measures.

Introduction: outline of the paper

- The co-risk measure *ΔCoVaR*
- Testing hypotheses and test statistic
- Empirical applications to sample of 26 large European banks:
  - Ranking of SIFIs: very few banks can actually be ranked according to *ΔCoVaR*
  - Mapping interconnectedness: the subset of linkages that have to be analysed is substantially narrowed down.
- Concluding remarks

The co-risk measure *ΔCoVaR*

- Systemic risk contribution:

$$\Delta CoVaR^{index|i}(\tau) = CoVaR_{X^{index}|X^{i}}(\tau) - VaR_{X^{index}}(\tau)$$
$$= Q_{X^{index}|X^{i}}(\tau) - Q_{X^{index}}(\tau)$$

- Estimation: linear QR framework

$$\hat{Q}_{X^{index}|X^{i}}(\tau) = \hat{\gamma}_0^i(\tau) + \hat{\gamma}_1^i(\tau) X^i$$

  - Since we are interested in tail dependence, τ is large (e.g., the range [0.90,0.99]).
  - Evaluate $X^i = \tilde{X}^i$, with $\tilde{X}^i$ an extreme quantile (e.g., 0.99) of the distribution of X^i to get *CoVaR.*

Testing hypotheses and test statistic (1/2)

- Kolmogorov-Smirnov (KS)-type of test statistics in the general linear testing framework.
- Significance

$$H_0 : \Delta CoVaR^{index|i} = 0$$
$$: Q_{X^{index}|X^i}(\tau) - Q_{X^{index}}(\tau) = 0$$

- Dominance

$$H_0 : CoVaR_{X^{index}|X^i} \geq CoVaR_{X^{index}|X^j}$$
$$: Q_{X^{index}|X^i}(\tau) - Q_{X^{index}|X^j}(\tau) \geq 0$$

Testing hypotheses and test statistic (2/2)

- General linear testing framework ($\hat{Q}_{Y|X}(\tau) = X\hat{\beta}(\tau)$):
  - Null hypothesis $H_0 : R\beta(\tau) = r(\tau), \tau \in \Gamma$
  - Test statistic $$v_T(\tau) = \frac{\sqrt{T}(R\Omega(\tau)R')^{-1/2}(R\hat{\beta}(\tau) - r(\tau))}{\sqrt{\tau(1-\tau)}}$$
- KS-type test statistic:

Significance	Dominance
$R = [1, \tilde{X}^i, -1]$ $\beta = [\hat{\gamma}_0^i(\tau), \hat{\gamma}_1^i(\tau), \hat{Q}_{X^{index}}(\tau)]'$ $r(\tau) = 0$	$R = [1, \tilde{X}^i, -1, -\tilde{X}^j]$ $\beta = [\hat{\gamma}_0^i(\tau), \hat{\gamma}_1^i(\tau), \hat{\gamma}_0^j(\tau), \hat{\gamma}_1^j(\tau)]'$ $r(\tau) = 0$
$\sup_{\tau \in \Gamma} \lVert v_T(\tau) \rVert$	$\sup_{\tau \in \Gamma} (v_T(\tau))$

Empirical applications: data and methodology

- Data:
  - 4594 daily observations (26/10/1993 - 13/3/2012) on weekly stock returns for 26 large European banks.
  - Market index: STOXX Europe 600 Financials index.
- Methodology:
  - First stage: regress individual bank (negative) returns on set of (lagged) common factors (weekly return on STOXX Europe 600 Basic Materials index, weekly return on STOXX Europe 600 Industrials index, weekly change of VIX index).
  - Second stage: QR using residuals of first-stage regressions for $\Delta CoVaR$ analysis.

Empirical application 1: ranking SIFIs (1/4)

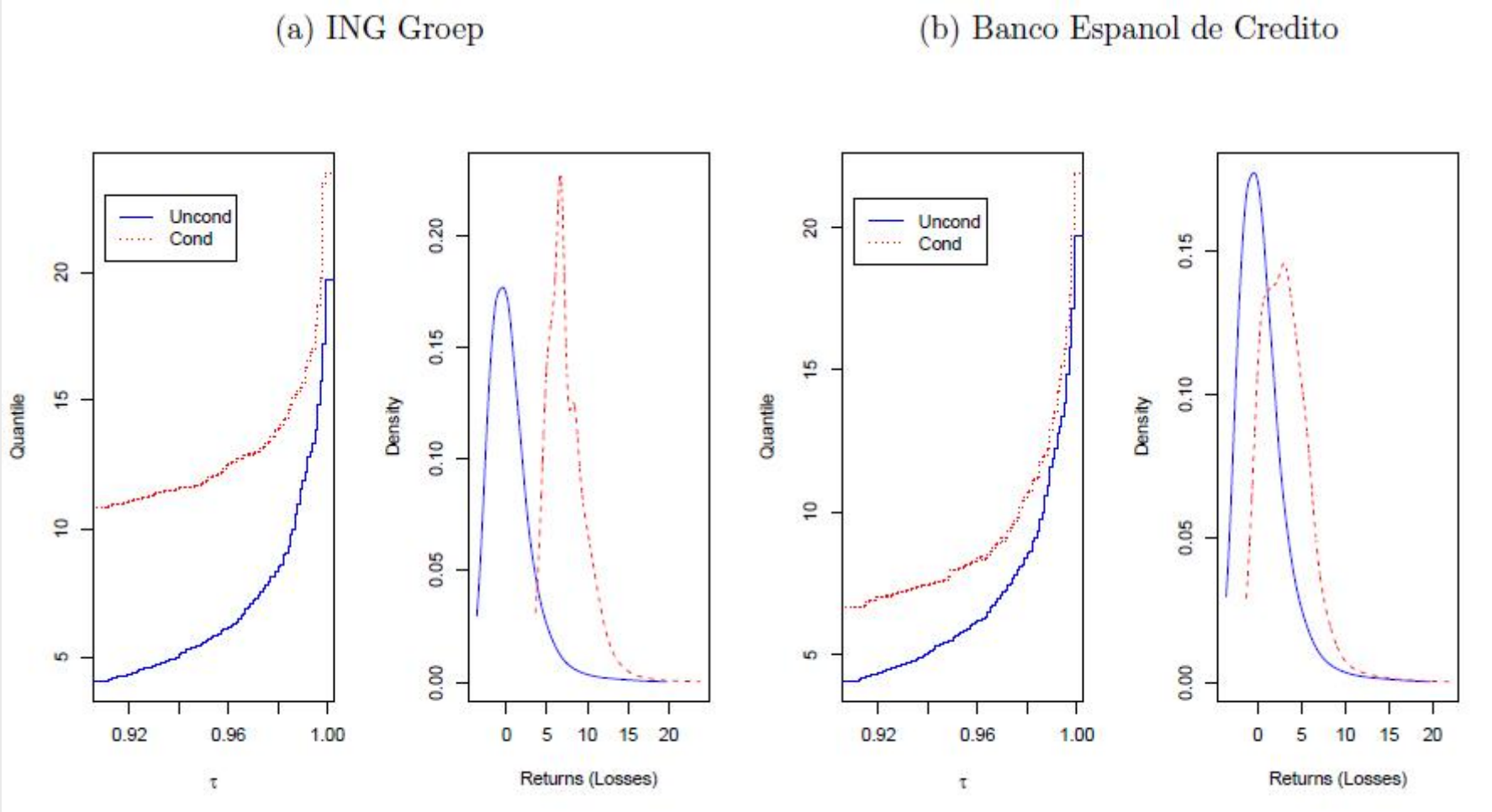
- Significance/Dominance

Table 4: Ranking of banks in terms of their impact on the market

	bank	$\Delta CoVaR$	dom		bank	$\Delta CoVaR$	dom
1	ING Groep	6.25*	13	14	Standard Chartered	4.21	0
2	Banco Santander	5.83*	1	15	Banco Popular Espanol	4.14	0
3	Credit Suisse Group	5.64*	2	16	Danske Bank	4.06	0
4	Société Générale	5.54	1	17	Bank of Ireland	3.89	0
5	HSBC Holding	5.51*	1	18	Svenska Handelsbanken	3.84	0
6	Deutsche Bank	5.46*	1	19	Royal Bank of Scotland Group	3.79*	1
7	BBVA	5.35*	1	20	National Bank of Greece	3.63*	0
8	BNP Paribas	5.24*	1	21	Barclays	3.53*	1
9	Unicredit	4.99	1	22	Natixis	3.46	0
10	UBS	4.97*	2	23	BCP-Millennium	3.23	0
11	KBC Groep	4.85*	0	24	Landesbank Berlin-LBB Holding	2.79	0
12	Intesa Sanpaolo	4.75	0	25	Allied Irish Banks	2.55	0
13	Commerzbank	4.61	1	26	Banco Espanol de Crédito	2.40	0

Empirical application 1: ranking SIFIs (2/4)

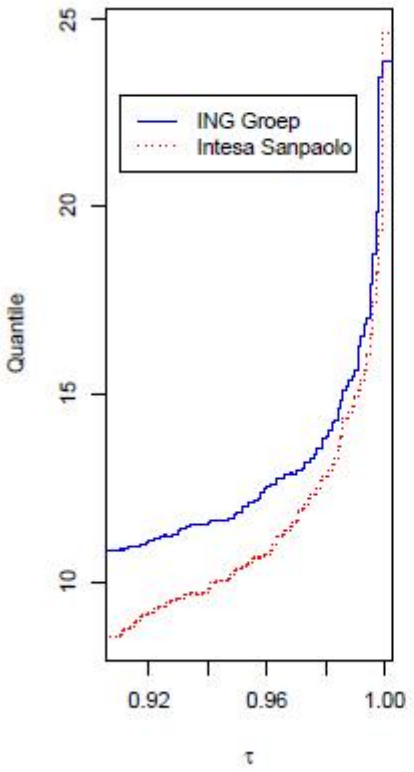
- Significance

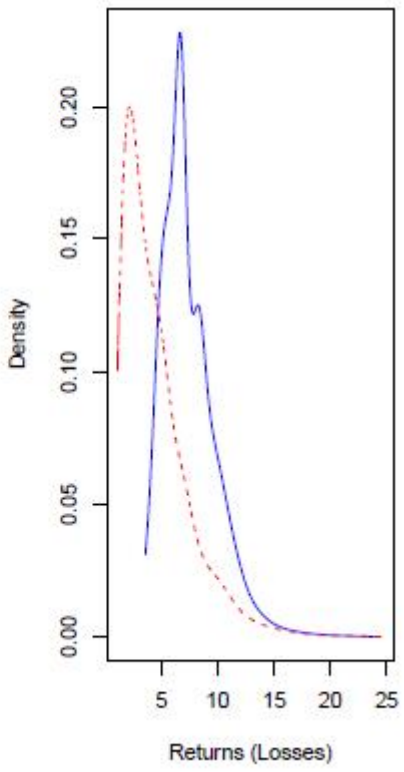


Empirical application 1: ranking SIFIs (3/4)

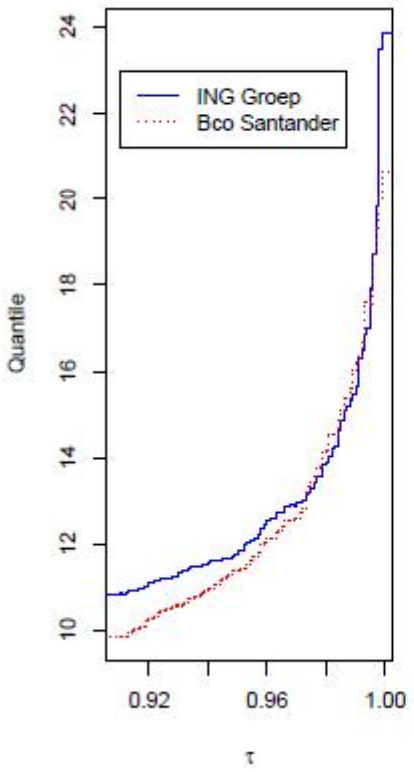
- Dominance

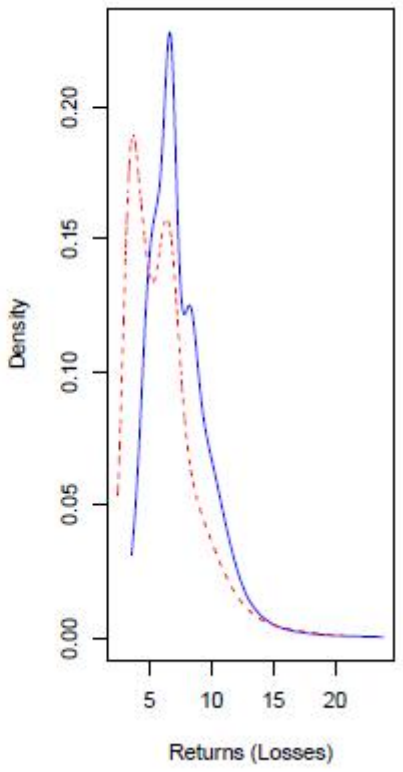
(a) ING Groep vs Intesa Sanpaolo





(b) ING Groep vs. Banco Santander





Empirical application 1: ranking SIFIs (4/4)

- Dominance

Table 5: Dominance test results

variable	bank pairs with dominance	total bank pairs
total	27	325
significant dominates significant	4	55
significant dominates insignificant	20	165
insignificant dominates significant	0	
insignificant dominates insignificant	3	105

- Conclusion: very few banks can actually be ranked according to *ΔCoVaR.*
  - Linear functional form in QR approach may be too restrictive.
- Implications for (ranking and) regulating SIFIs.

Empirical application 2: mapping interconnectedness

- Pairwise *ΔCoVaR*: similar ranking

Table 7: Ranking of banks in terms of their impact on the other banks in the sample: significance-adjusted

	bank	average $\Delta CoVaR$	sign. impact		bank	average $\Delta CoVaR$	sign. impact
1	ING Groep	3.22	12	14	Bank of Ireland	0.91	4
2	KBC Groep	2.74	13	15	Intesa Sanpaolo	0.89	5
3	Deutsche Bank	2.60	11	16	Credit Suisse Group	0.83	4
4	Banco Santander	2.28	10	17	Banco Popular Espanol	0.68	4
5	BBVA	2.03	10	18	Svenska Handelsbanken	0.68	4
6	Commerzbank	1.92	10	19	Allied Irish Banks	0.45	1
7	Barclays	1.76	12	20	Banco Espanol de Crédito	0.41	3
8	BNP Paribas	1.74	8	21	Standard Chartered	0.36	2
9	Société Générale	1.54	7	22	Danske Bank	0.34	3
10	HSBC Holding	1.22	5	23	Natixis	0.26	2
11	UBS	1.22	5	24	BCP-Millennium	0.15	1
12	Royal Bank Scotland Group	1.14	7	25	National Bank of Greece	0.13	1
13	Unicredit	0.92	5	26	Landesbank Berlin-LBB Holding	0.09	1

- 150 out of 650 possible links are statistically relevant.

Empirical application 2: mapping interconnectedness

Figure 3: Network of significant impact of top 3 banks

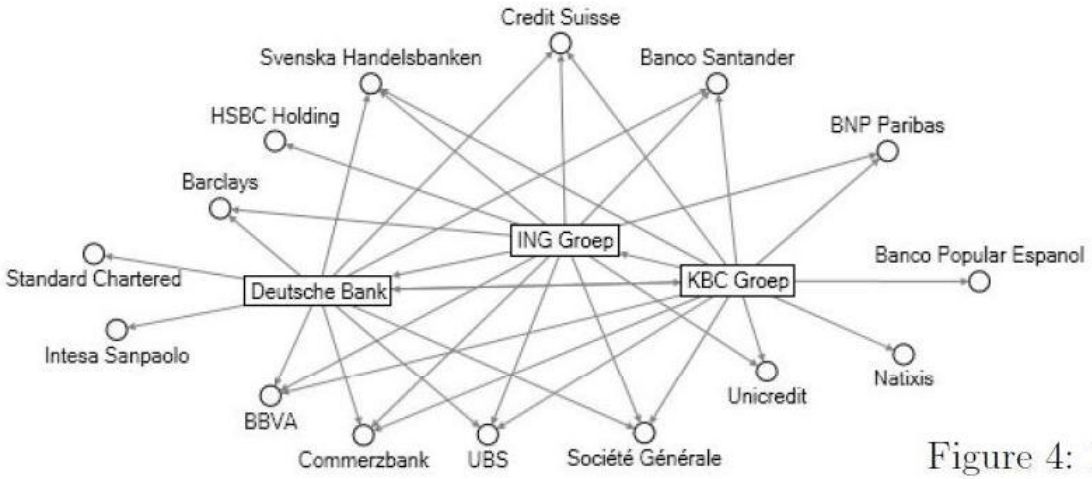
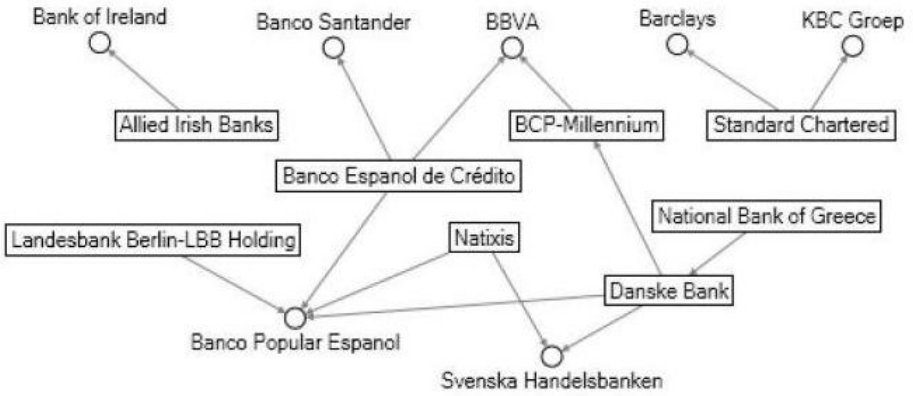


Figure 4: Network of significant impact of bottom 8 banks

- Top 3: relatively dense
- Bottom 8: relatively sparse



Concluding remarks

- *ΔCoVaR* is interesting tool for measuring SI, but statistical testing is required before interpreting results:
  - When applying a bucketing approach for ranking and regulating SIFIs: to test whether banks in higher buckets actually have a larger systemic risk contribution than banks in lower buckets.
  - When monitoring interconnectedness: to test which links are significant.
- We develop such tests in linear QR framework:
  - Very few banks can actually be ranked according to *ΔCoVaR.*
  - The subset of linkages that have to be analysed is substantially narrowed down.
- Future research:
  - Asymptotics of the extremal regression quantiles ($\tau \to 1$).
  - Test for stochastic dominance at the extremum for a general class of conditional and unconditional quantile functions.