Climate Stress-test of the Financial System

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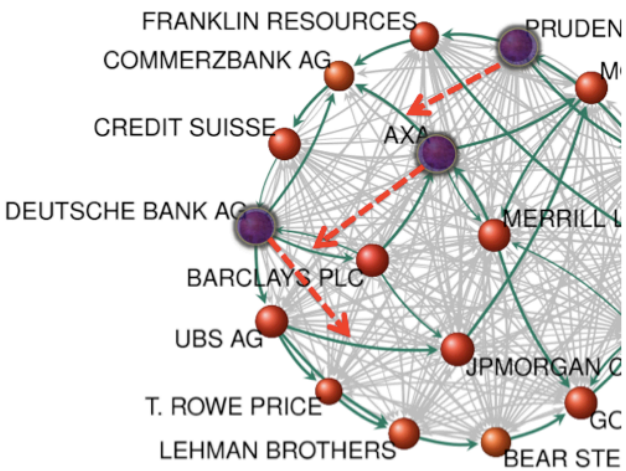


Acknowledgments

- SNF Professorship at Dpt. Banking and Finance, UZH: Financial Networks and Systemic risk FNSNF Swiss National Science Foundation
- EU-GSS **DOLFINS** 2015-2018, 14 partners
  - Financial Stability and Sustainable Investments; design incentives to sustainable investing, policy evaluation, civic engagement.
- EU-GSS **SIMPOL** 2013-2016 Simpol project
  `www.simpolproject.eu`: crowdsourcing Policy Network Maps
  - Financial Systems and Policy Modeling: collaborations with central banks, ECB, DG-FISMA; complex derivatives, climate-finance, big-data, crowdsourcing policy maps.
- ISIGROWTH, SEIMETRICS, BIGDATAFINANCE
- INET - Financial Stability Program directed by J. Stiglitz (WG on Financial Networks, co-chaired by A. Haldane)

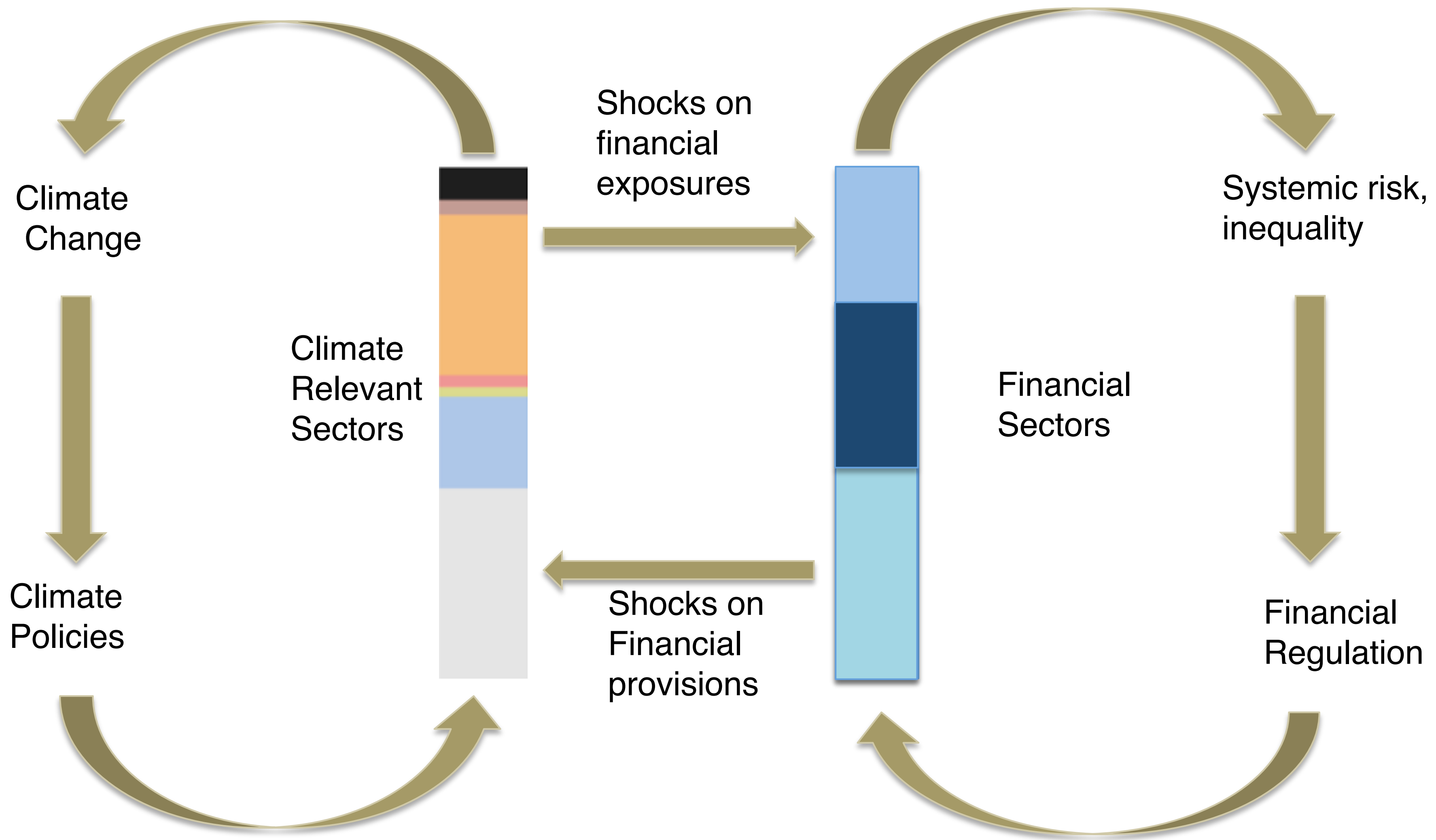
University of Zurich

Outline

- Network analysis of direct and indirect exposures
- Disclosure of climate-relevant financial information is key to improve risk estimations and create the right incentives for investors. However, better disclosure may not be sufficient.
- The timing and credibility of the implementation of climate policies matter.
  - Early and stable policy framework: smooth carbon-asset values adjustments
  - a late and abrupt implementation: adverse systemic consequences for the financial system.

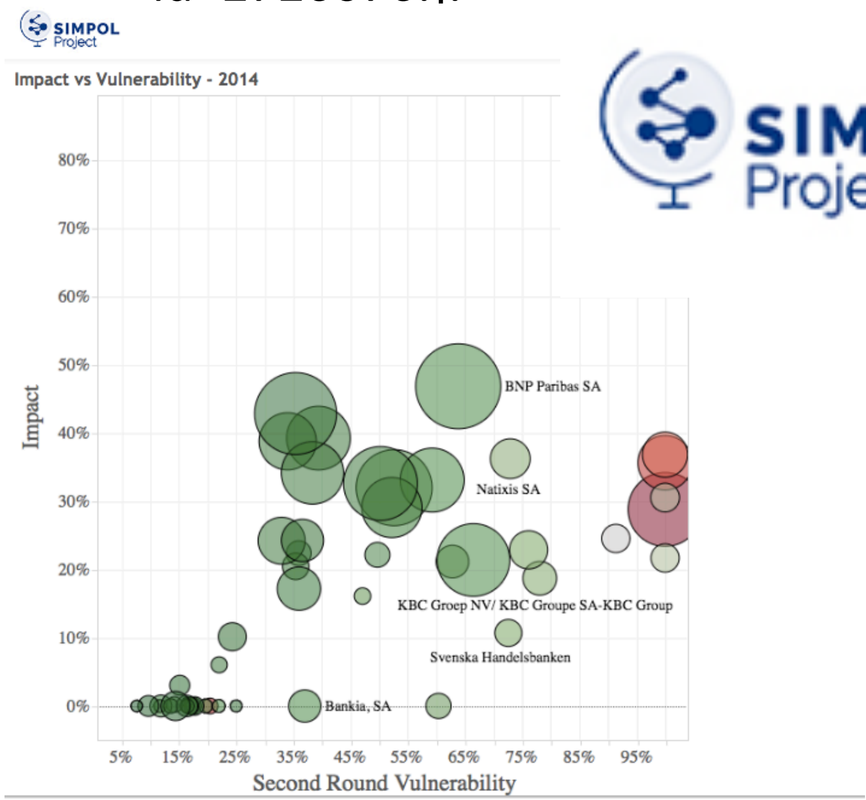
(1) Battiston, S., Mandel, Antoine, Monasterolo, I., Schuetze, F., Visentin, G.: A Climate stress-test of the EU financial system. Available SSRN id=2726076. (2016).

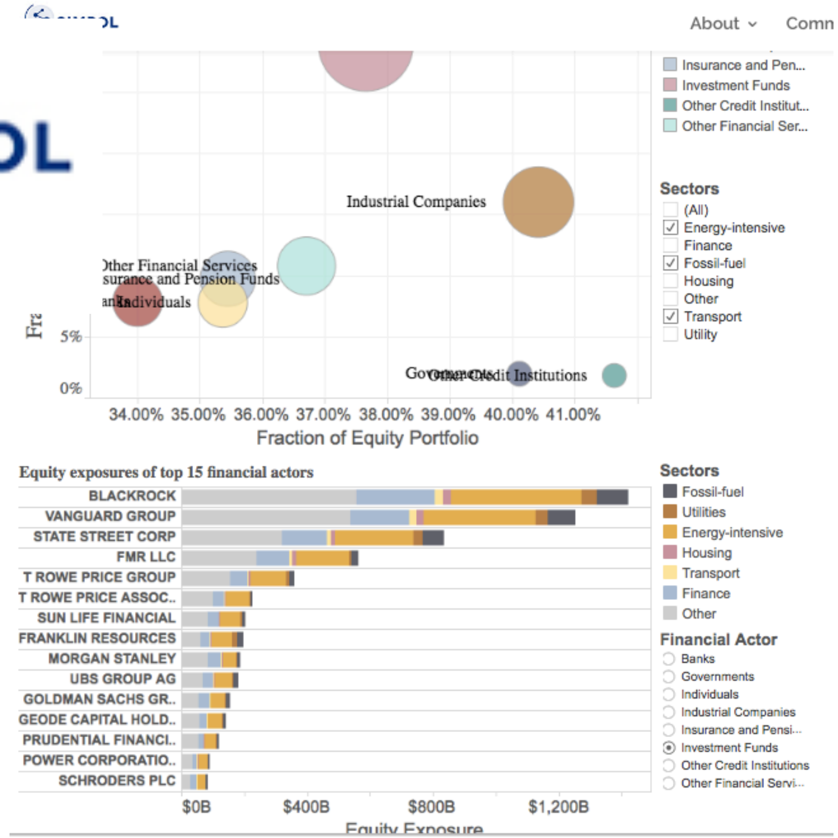
The Source of Complexity in the Climate – Finance nexus



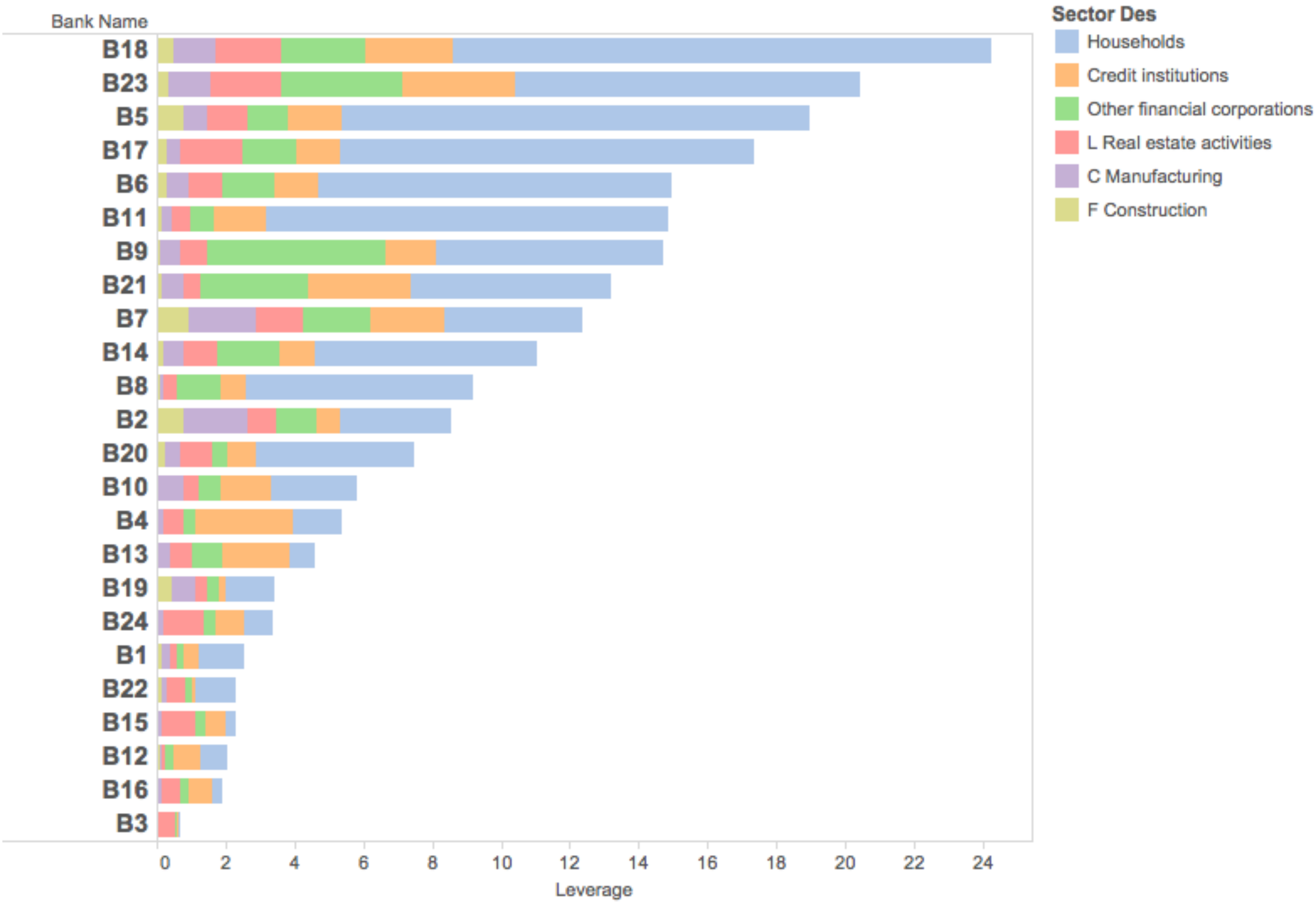
Dashboards

- Dashboard on EuroArea network-based stress-test https://simpolproject.eu/2016/06/09/debtrank-2/ [Battiston et al 2016, *Leveraging the network.* Statistics and Risk Modeling, 1–33].
- Dashboard Climate Stress-test financial https://simpolproject.eu/2016/06/10/climate-stress-test/ [Battiston et al. 2016, A Climate stress-test of the financial system. Available at SSRN id=2726076.].

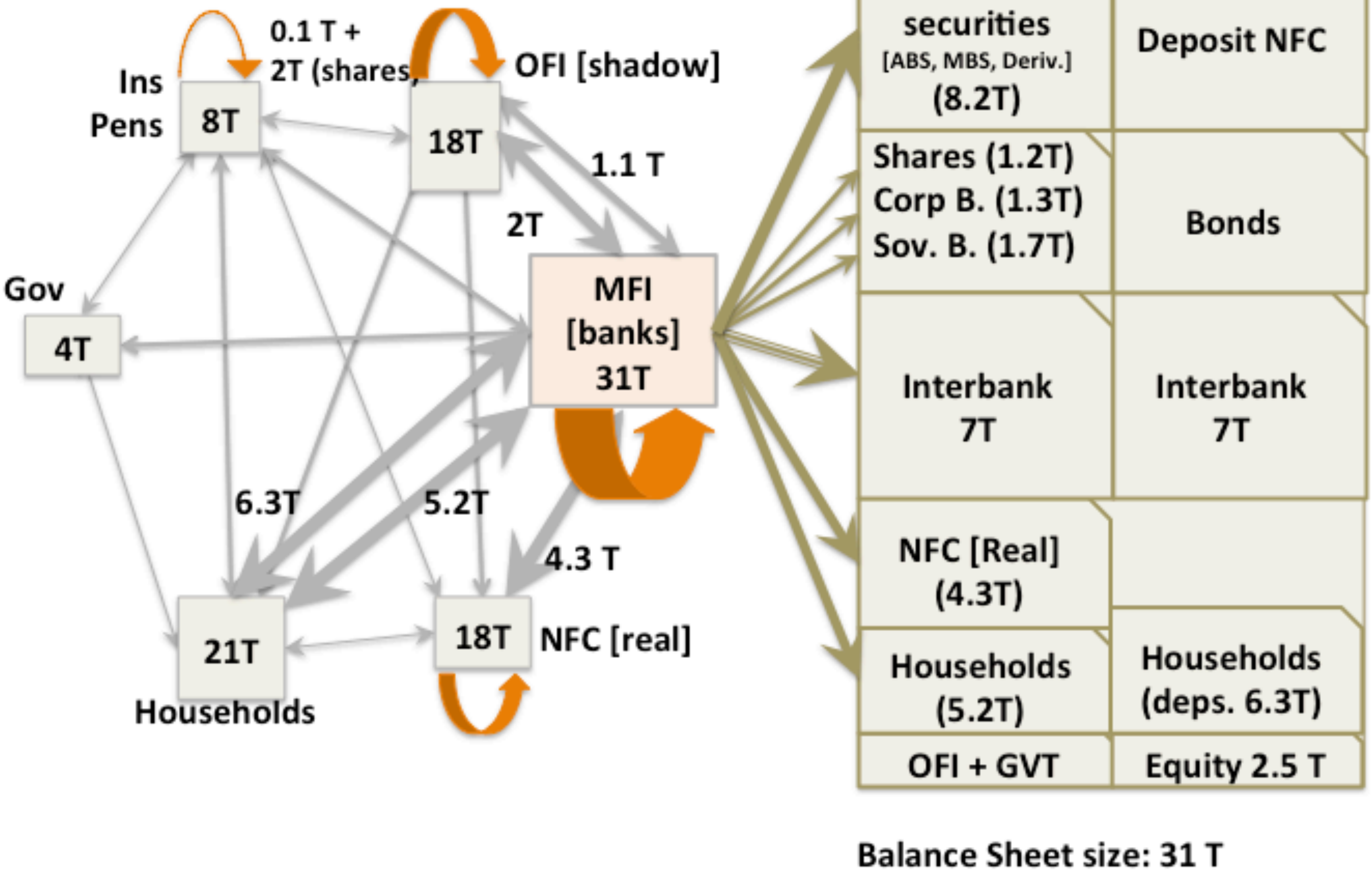




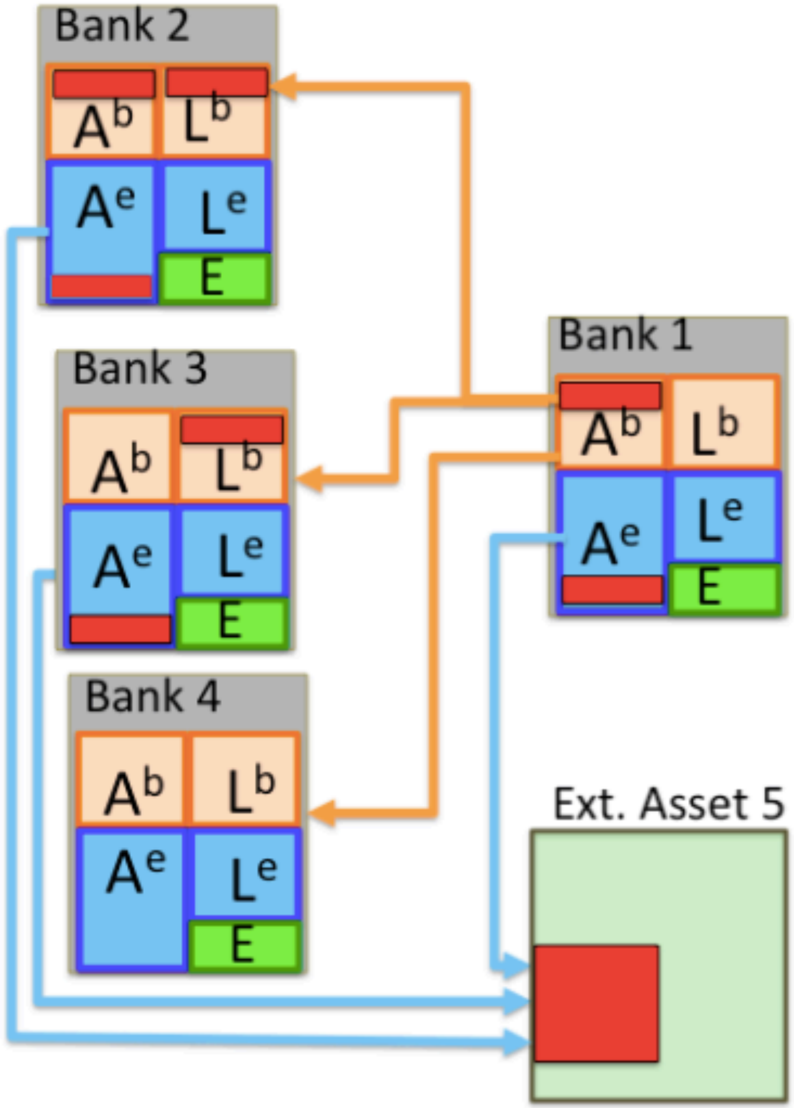
Loan Portfolios of Major Euro Area Banks – Leverage across sectors



Macro financial system
Euro area | 2014 Q1
Assets: deposits + short & long term loans
Source: ECB Data Warehouse



Example



Bank 1 lending to Bank 2,3; all investing in external asset 5

- $h_1(0) = \varepsilon_{15}\frac{\Delta p_5}{p_5}; h_2(0) = \varepsilon_{25}\frac{\Delta p_5}{p_5}; \ldots$
- $h_1(1) = \varepsilon_{15}\frac{\Delta p_5}{p_5} + \beta_{12}h_2(0) + \beta_{13}h_3(0)$
  $= \varepsilon_{15}\frac{\Delta p_5}{p_5} + \beta_{12}\varepsilon_{25}\frac{\Delta p_5}{p_5} + \beta_{13}\varepsilon_{35}\frac{\Delta p_5}{p_5}$
  $\approx \varepsilon\frac{\Delta p_5}{p_5} + \beta\varepsilon\frac{\Delta p_5}{p_5}$

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The NO-CONTAGION Paradox

Traditional systemic risk model predict little contagion, because two key assumptions rule out contagion by construction

1. **R =1** i.e. banks assets can be liquidated at any time with no loss
2. **Only default valuation**: obligation's value unaffected by losses on obligor's equity unless default.

Conservation constraint on losses in the process.

→ network structure is irrelevant for the aggregate losses.

→ Almost no banks' defaults after initial defaults

In a distress contagion accounting framework, intra-financial contagion approximated by simple and instructive formula

$$\mathbf{H = \varepsilon\ \ s + (1\text{-}R^E)\ \beta\ \varepsilon\ \ s\ = 2\ \varepsilon\ \ s}$$

where H is the relative equity loss in the banking system, b is the interbank leverage, e is the external asset leverage, and R^E is the recovery rate on external assets.

(1) Visentin et al. 2016 "Rethinking Financial Contagion",

(2) Battiston, Caldarelli, D'errico, Gurciullo, S. (2016). *Leveraging the network.* Statistics and Risk Modeling, 1–33. Battiston, S., Roukny, T., Stiglitz, J., Caldarelli, G. & May, R. The Price of Complexity in Financial Networks. PNAS (2016) www.pnas.org/content/113/36/10031.full

FINEXUS climate stress test methodology

✧ New framework based on network analysis to assess the largest exposures of financial actors to climate policy risks

✧ 3 key conceptual/methodological innovations:

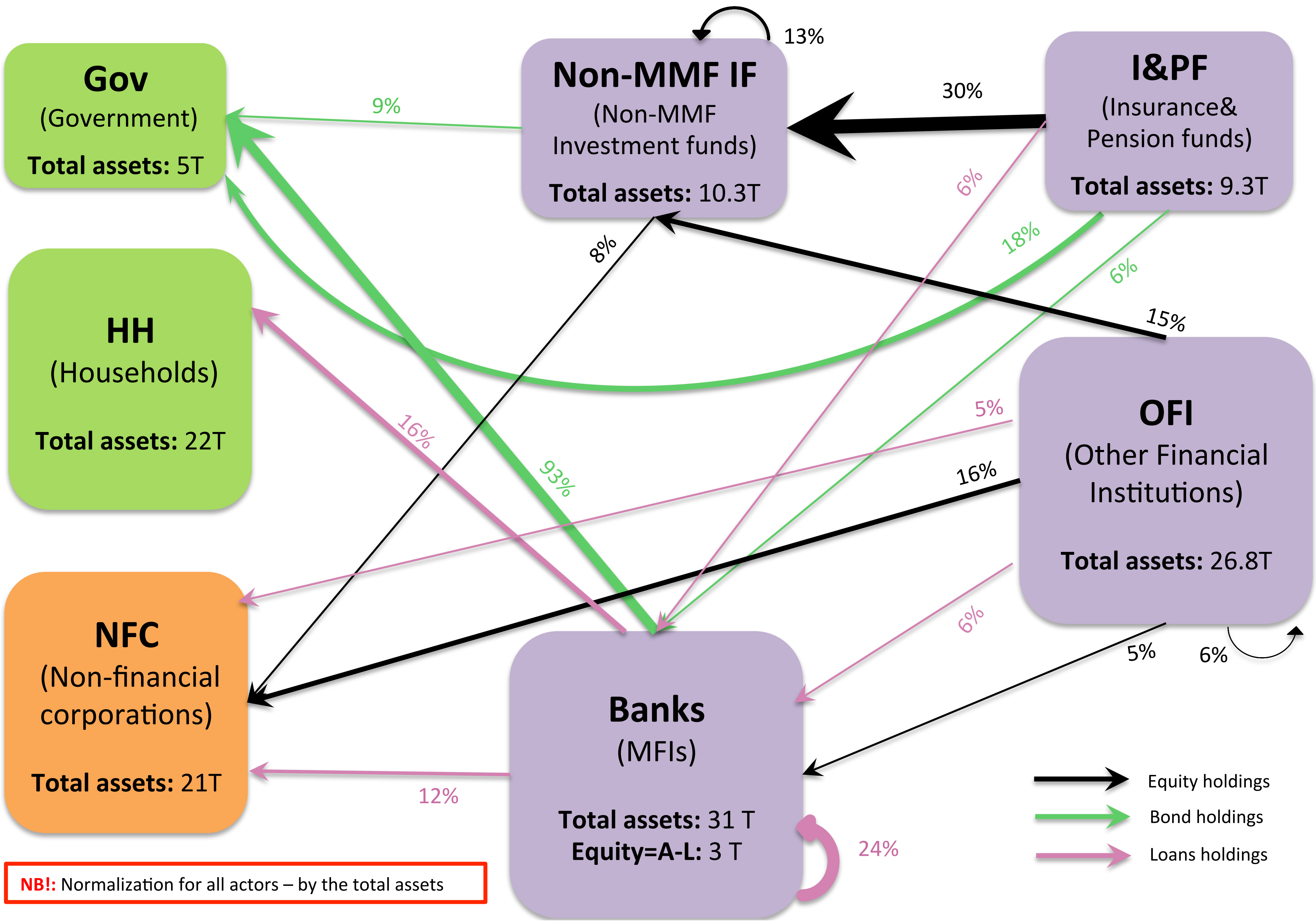
1. **Reclassification of NACERev2 sectors**
2. Quantification of **direct exposure** through external assets
3. Assessment of **indirect exposure**, including intra-financial *interlinkages*

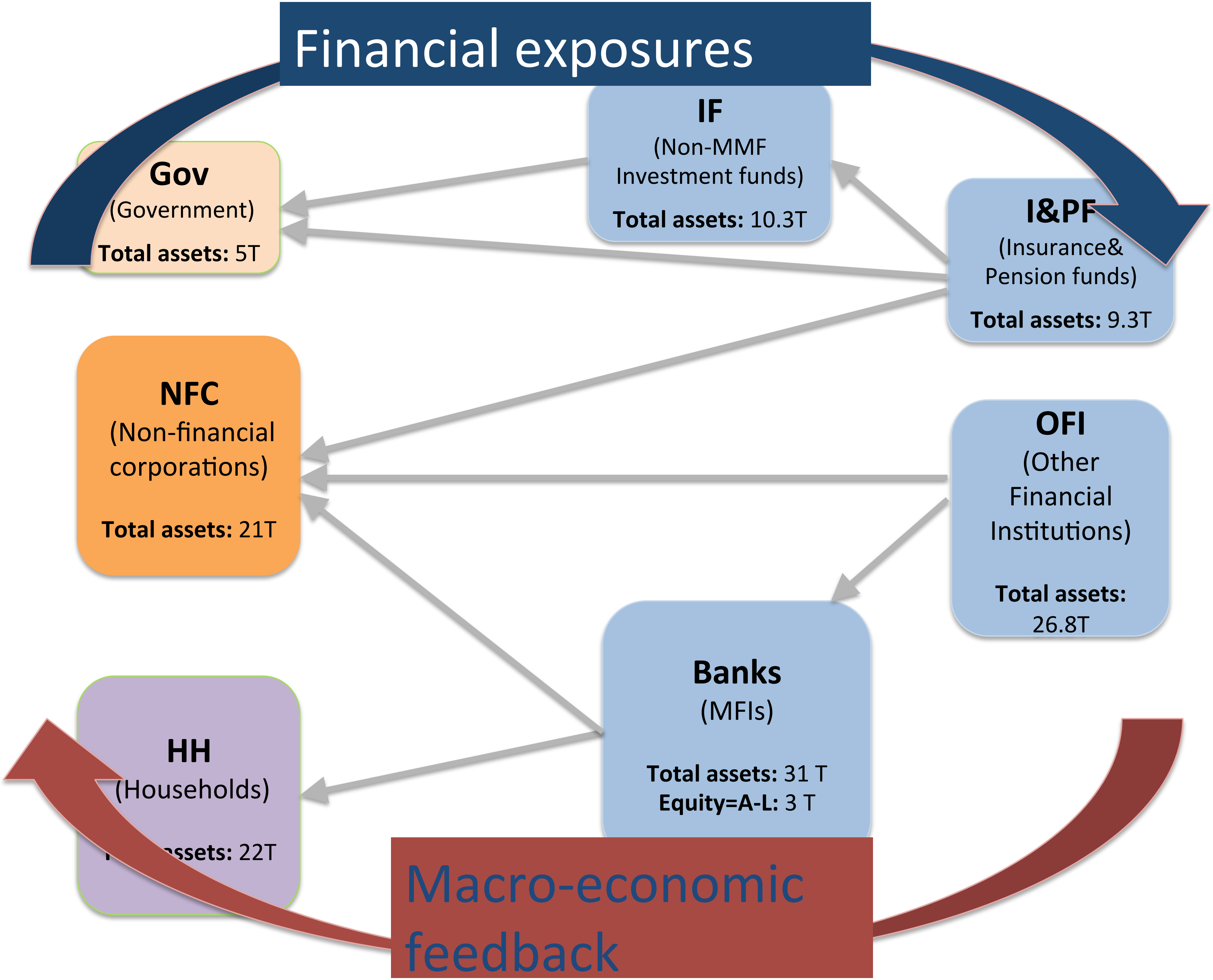
DATASETS:

- Bvd Orbis and Bankscope
- ECB Data Warehouse
- NACE code description

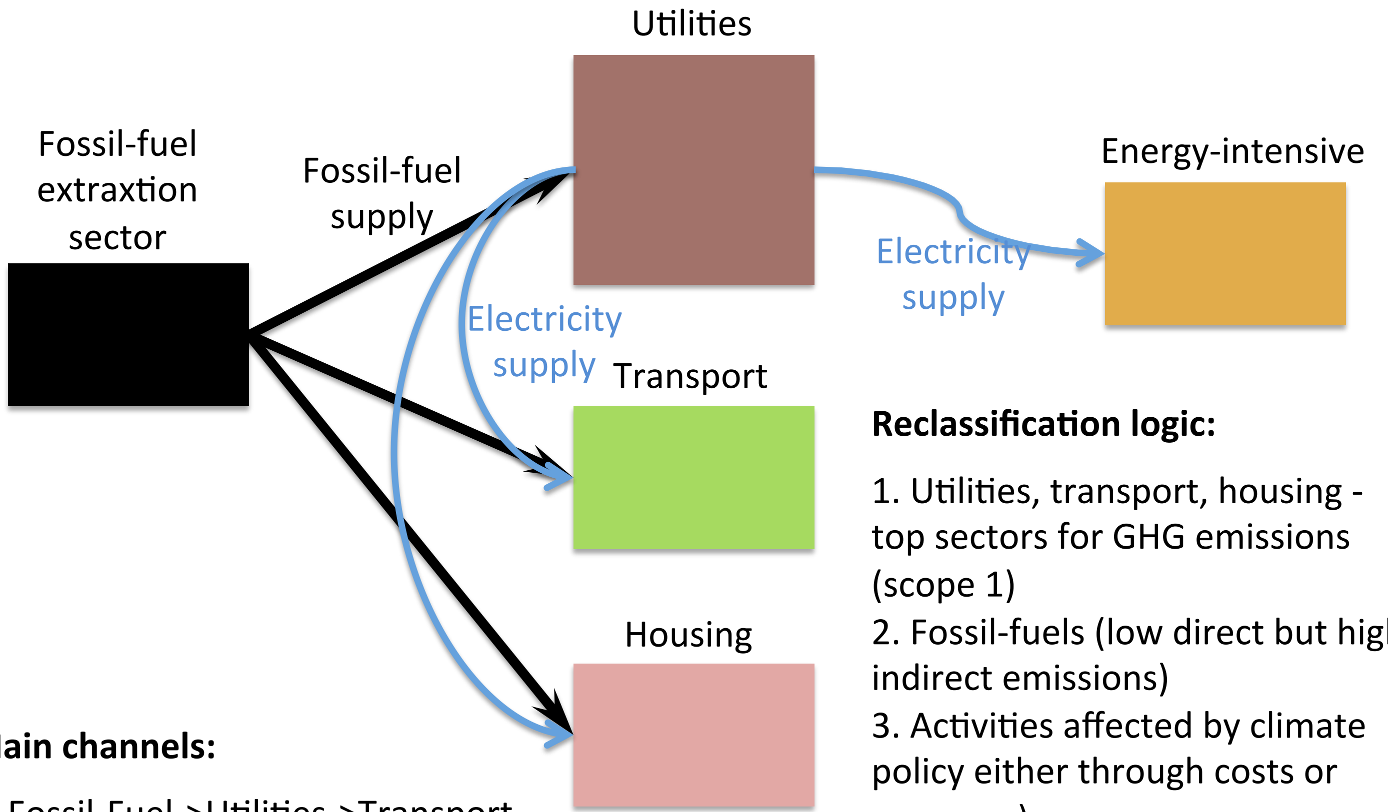
Battiston, S., *Mandel, Antoine, Monasterolo, I., Schuetze, F.,* ***Visentin, G.****: A Climate stress-test of the financial system. Available SSRN id=2726076. (2016).*

Some indirect exposures of financial sectors to the real economy




Financial exposures
IF
(Non-MMF
Investment funds)
Total assets: 10.3T
Gov
(Government)
Total assets: 5T
I&PF
(Insurance&
Pension funds)
Total assets: 9.3T
NFC
(Non-financial
corporations)
Total assets: 21T
OFI
(Other
Financial
Institutions)
Total assets:
26.8T
Banks
(MFIs)
Total assets: 31 T
Equity=A-L: 3 T
HH
(Households)
Macro-economic
feedback

Methods: identification of the climate sensitive sectors



Reclassification logic:

1. Utilities, transport, housing - top sectors for GHG emissions (scope 1)
2. Fossil-fuels (low direct but high indirect emissions)
3. Activities affected by climate policy either through costs or revenues).

Main channels:

1. Fossil-Fuel->Utilities->Transport
2. Fossil-Fuel->Transport
3. Utilities->Housing
4.Utilities->Energy-intensive

Figure 1. Diagram illustrating the reclassification of sectors from NACE Rev2 codes into climate relevant sectors.

Methods: identification of direct&indirect exposures to the the climate sensitive sectors

Direct exposures: through assets of the market player

$$A_i = \left(\sum_{S \in S} \sum_{j \in S} \alpha_{ij}^{Equity} + \alpha_{ij}^{Bonds} + \alpha_{ij}^{Loans} \right) + R_i$$

S - Set of climate-relevant sectors

A_i - Total assets of the financial actor *i*

α_{ij} - Monetary value of exposure of *i* to *j*

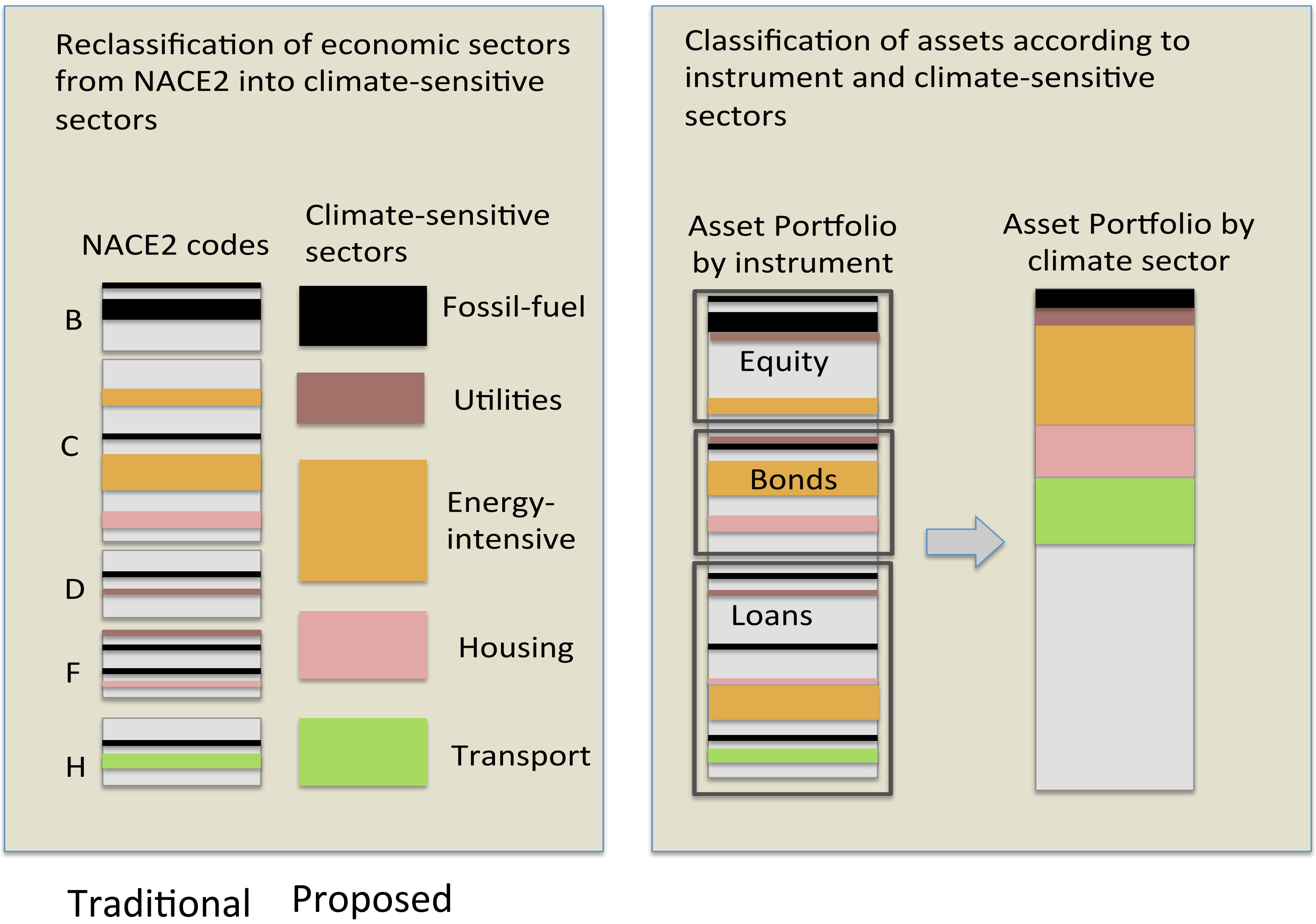
$A_{FS} = \sum_{i \in F} \alpha_{iS}$ - Exposure of institution *F* to a given climate sector

Indirect exposures: through interlinckages of the market player with its couterparties

$$A_i = \left(\sum_{j \in F} \alpha_{ij}^{Equity}(A_j) + \alpha_{ij}^{Bonds}(A_j) + \alpha_{ij}^{Loans}(A_j) \right) + \left(\sum_{k \in A/F} \alpha_{ik}^{Equity} + \alpha_{ik}^{Bonds} + \alpha_{ik}^{Loans} \right) + R_i$$

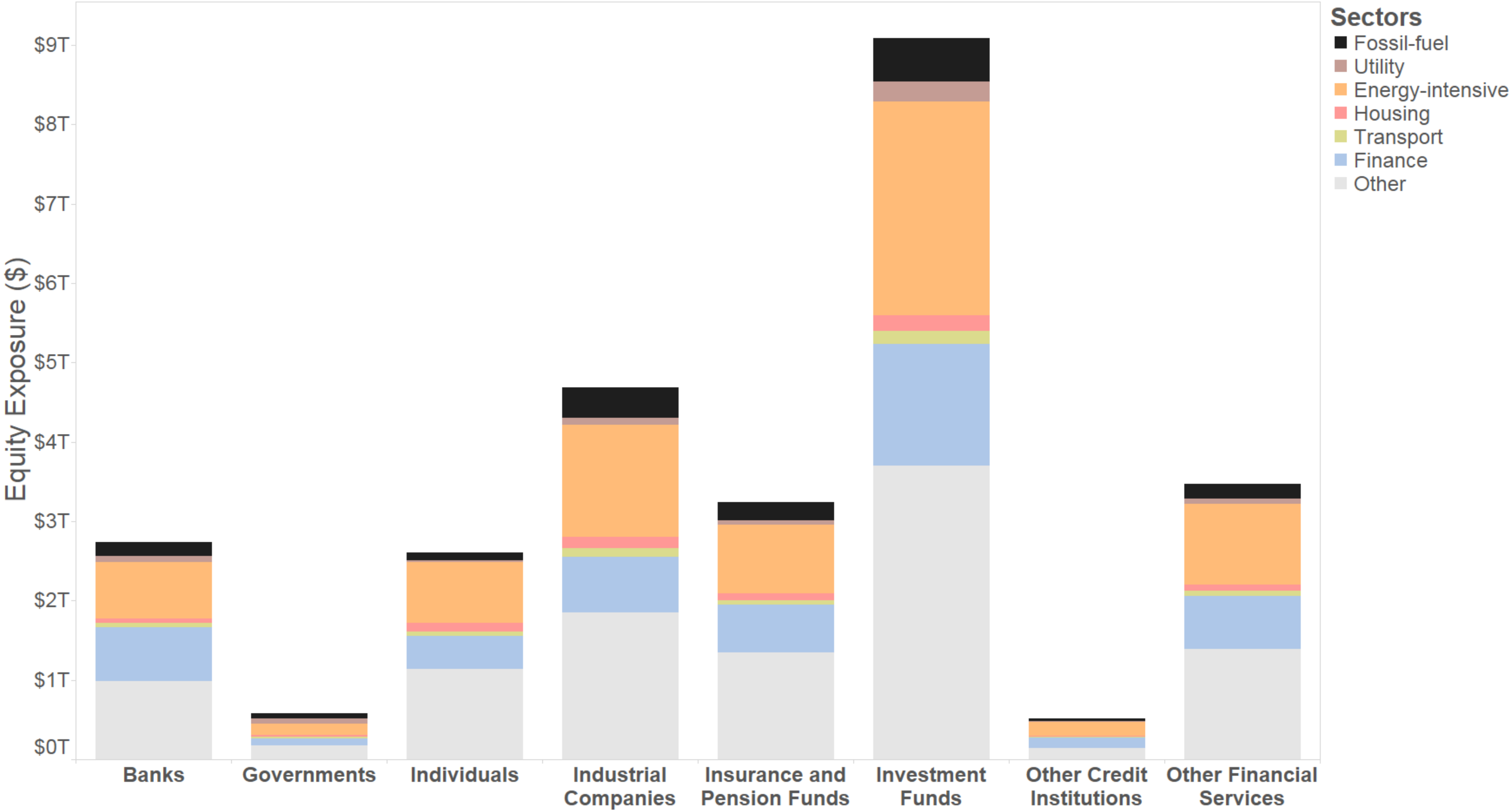
$\alpha_{ij}^{0} \cdot \alpha_{jk}^{0}$ - Product of exposures along the chain

Methods: identification of the climate sensitive sectors



***Battiston, S.**, Mandel, Antoine, Monasterolo, I., Schuetze, F., **Visentin, G.**: A Climate stress-test of the EU financial system. Available SSRN id=2726076. (2016).*

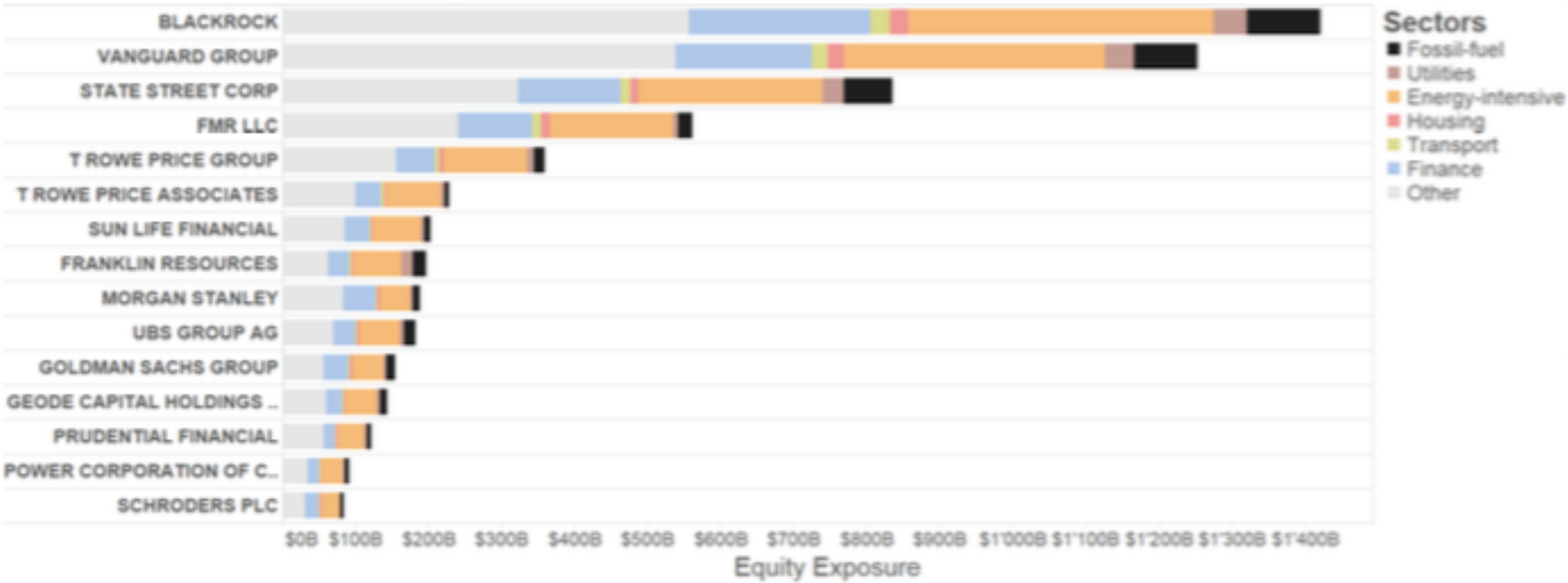
Results: Exposure to climate sensitive sectors



Equity holdings in EU and US listed companies. Sector composition of aggregate institutional sectors world-wide according to BvD data 2015.

***Battiston, S.**, Mandel, Antoine, Monasterolo, I., Schuetze, F., **Visentin, G.**: A Climate stress-test of the EU financial system. Available SSRN id=2726076. (2016).*

Portfolio composition of top world-wide Investment Funds: climate-sensitive sectors exposure



- This micro-level approach allows us to understand heterogeneity of investors' exposure and portfolio allocation.

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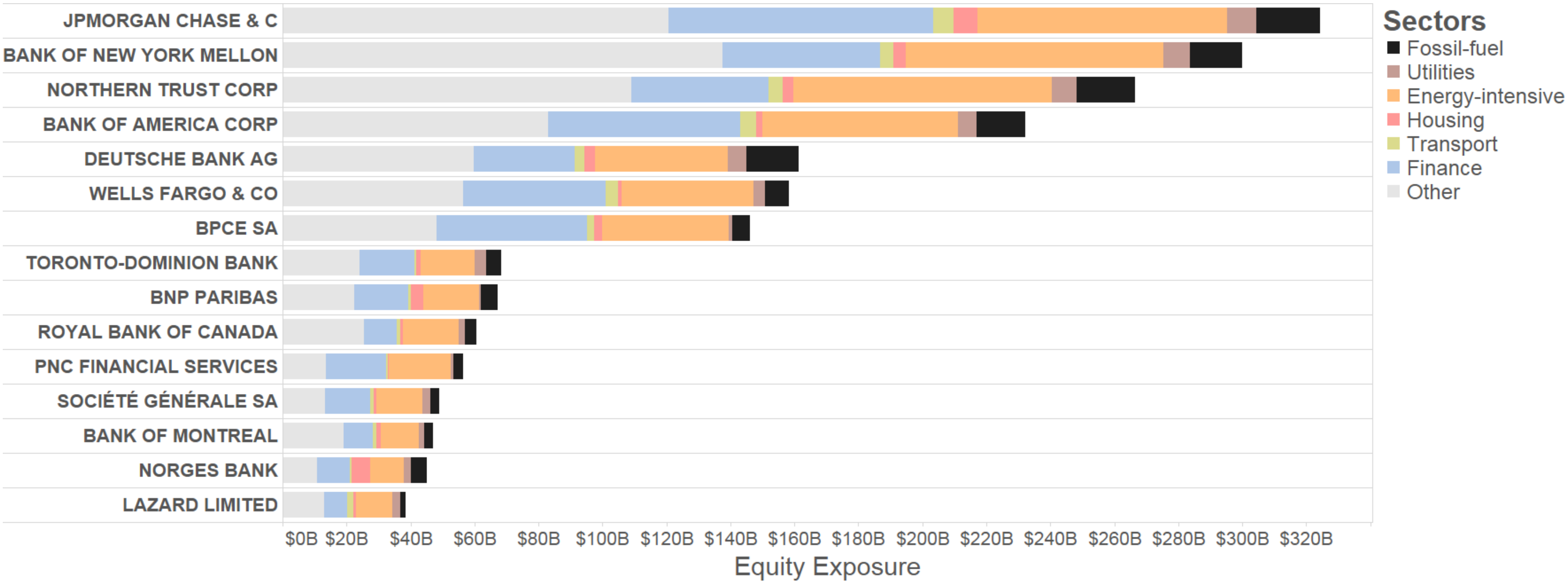
Portfolio composition of top world-wide Banks: climate-sensitive sectors exposure



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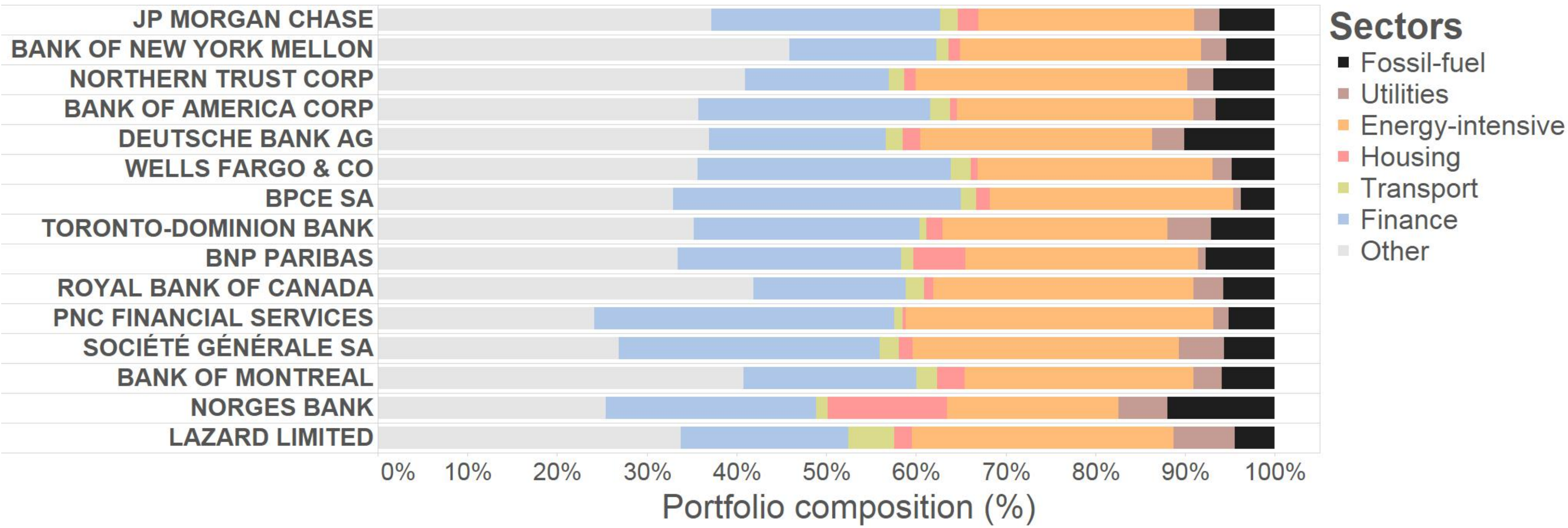
Relative portfolio composition of top world-wide Banks: climate-sensitive sectors exposure



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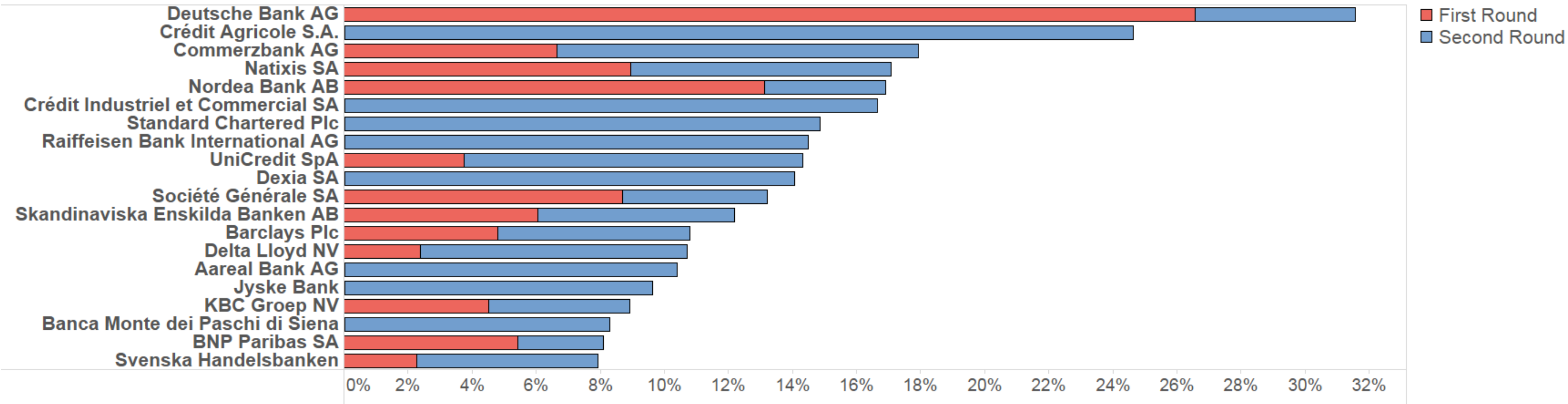
Exercise 1. Upper bound of Euro Area banks' loss: 100% shock on Fossil-Fuel+Utilities sector



Impact on the top 50 listed EU banks of a 100% shock in the market capitalization of the climate-sensitive sectors in different, progressive aggregations.

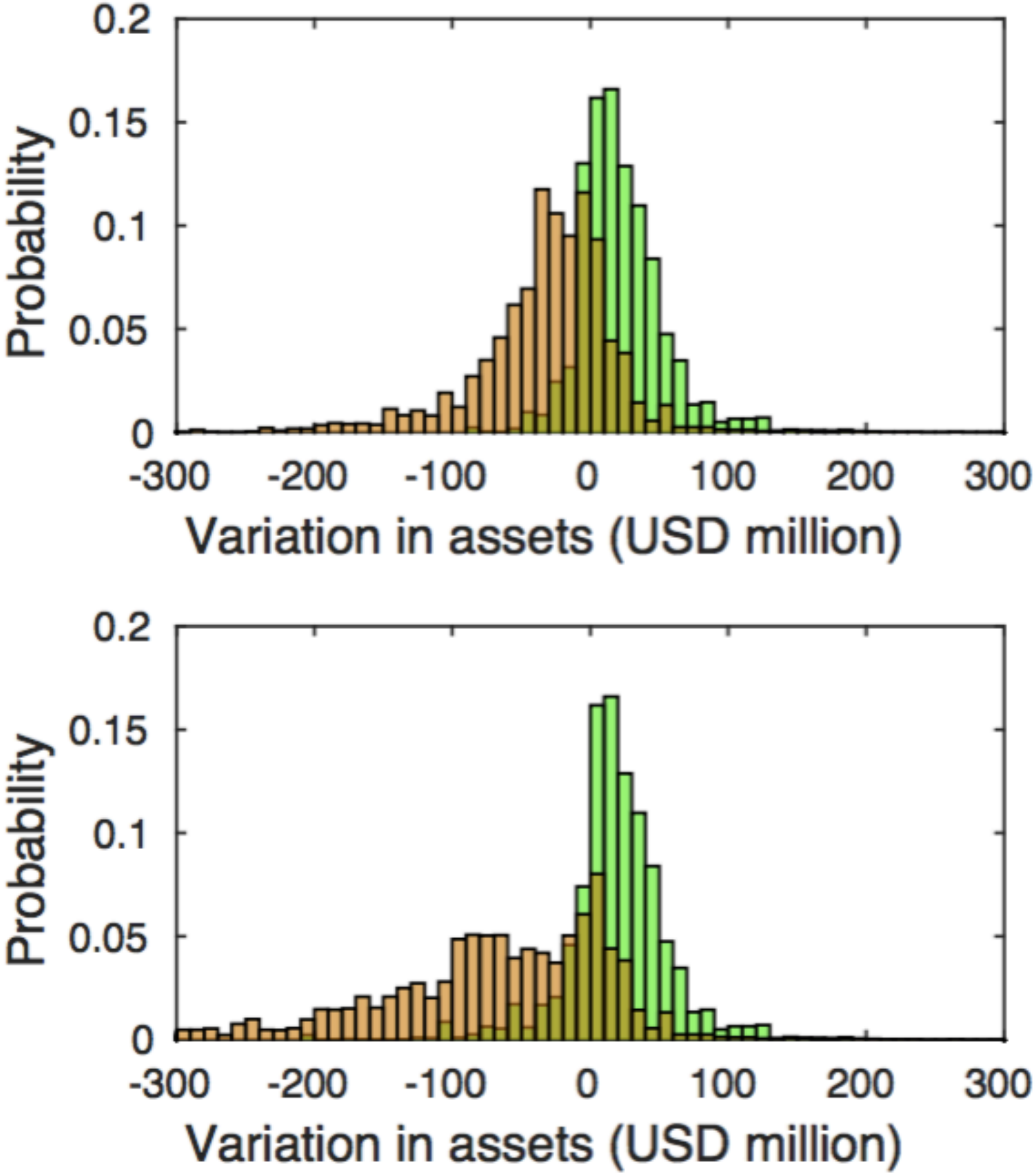
- Equity loss of EU banks from a fossil-fuel sector shock only is 2.55%, and increases to 6.08% when including indirect effects.
- Losses increase to 13.18% (direct effect) and 27.91% (direct and indirect effect) when including utilities and energy-intensive industries on equity shares (1.2 T).

Exercise 2. Shocks obtained from LIMITS IAM database

Scenario	Round	Mean	Median	VaR(5%)	Max
Fossil-fuel	1st	0.08 %	0.05 %	0.26 %	2.25 %
	1st+2nd	0.18 %	0.11 %	0.63 %	5.34 %
Fossil-fuel + Fossil-fuel Utilities **(Brown banks)**	1st	0.12 %	0.08 %	0.41 %	2.84 %
	1st+2nd	0.29 %	0.19 %	0.96 %	6.73 %
Fossil-fuel + Renewable Utilities	1st	0.05 %	0.006 %	0.19 %	2.00 %
	1st+2nd	0.11 %	0.016 %	0.47 %	4.78 %
Renewable Utilities **(Green banks)**	1st	0.008 %	0.00 %	0.06 %	0.26 %
	1st+2nd	0.019 %	0.00 %	0.13 %	0.62 %

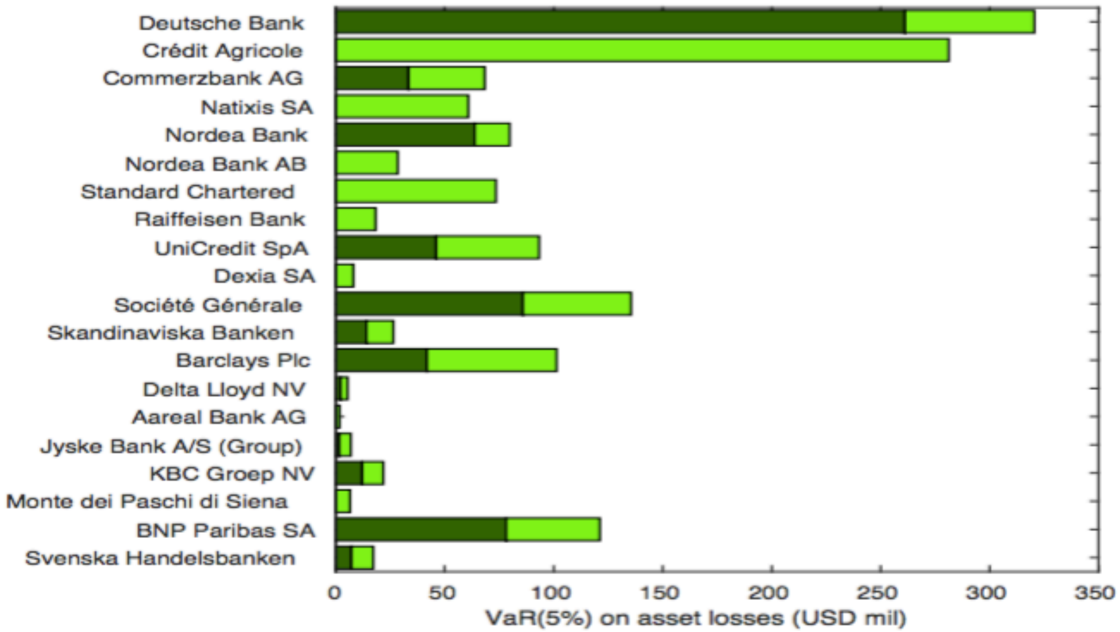
Table 2: Stress-test results for four shock scenarios. Shock distributions obtained from LIMITS project. Statistical measures refer to the median global vulnerability of the system (total banks' equity loss) at the end of the first and second rounds, over an ensemble to 1,000 estimated interbank networks.

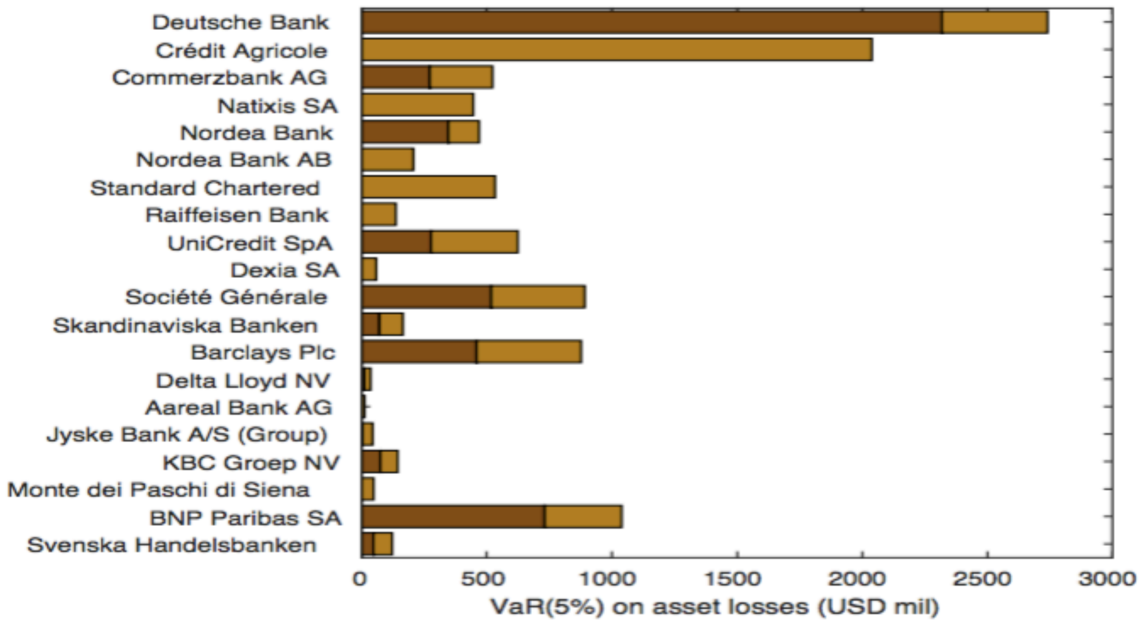
Exercise 2. Shocks obtained from LIMITS IAM database



First round losses (top) and second round losses (bottom) of a “brown” and “green” banks’ equity

Exercise 2. Shocks obtained from LIMITS IAM database

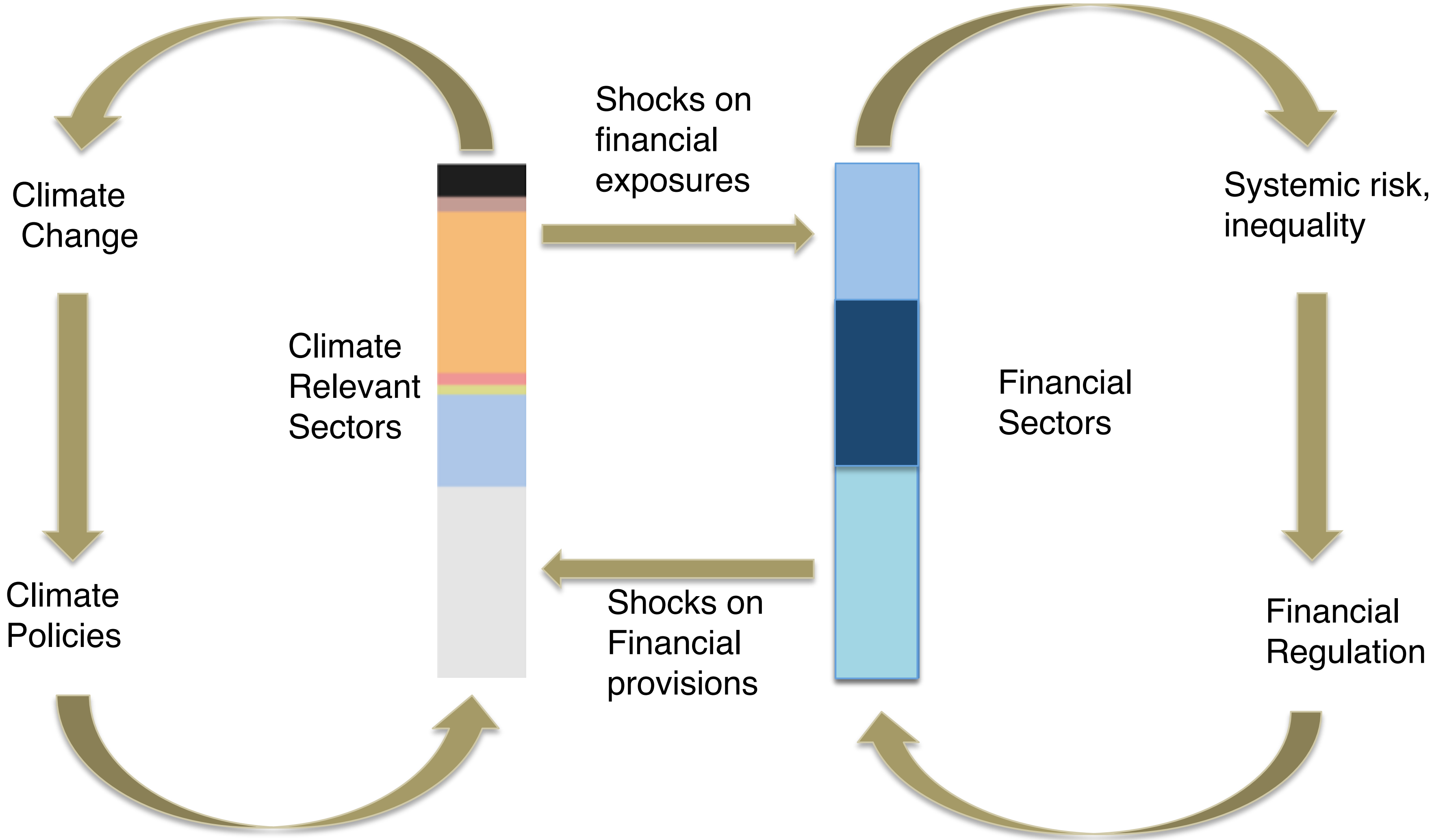




Value at Risk (5% significance) for the 20 most affected EU banks in the dataset, under the scenario of green (brown) investment strategy.

Darker colors: VaR(5%) in the distribution of first-round losses. Lighter colors: VaR(5%) in the distribution of first- and second - round losses together.

The Source of Complexity in the Climate – Finance nexus



Conclusion

- Financial interconnectedness matters for financial stability and macro-prudential policy.
  - In the presence of **uncertainty on value of assets backing** up obligations, and uncertainty on **default resolution** process, direct losses from shocks can be doubled, due to indirect losses via intra-financial complexity[1].
  - Further, inaccuracy on price of (systemic) risk increases with complexity[2].
  - Collective moral hazard: the financial system does not pay for the

(1) Battiston, S., Puliga, M., Kaushik, R., Tasca, P., & Caldarelli, G. (2012). DebtRank: Too Central to Fail? Financial Networks, the FED and Systemic Risk. *Scientific Reports*, *2*, 1–6. Battiston, Caldarelli, D'errico, Gurciullo, S. (2016). *Leveraging the network.* Statistics and Risk Modeling, 1–33.

(2) Battiston, S., Roukny, T., Stiglitz, J., Caldarelli, G. & May, R. The Price of **Complexity** in Financial Networks. PNAS (2016) www.pnas.org/content/113/36/10031.full

Conclusions

- Climate policies as potential source of (endogenous) shocks to the financial system.

- Traditional cost-benefit analyses: aggregate estimates not adequate to identify individual risks and their propagation through the financial system.

- Network analysis of financial dependencies: direct and indirect exposures to climate-policy relevant sectors represent a **large portion of investors' portfolios** – in particular for **investment funds and pension funds**.

Conclusions

Findings of our study[1] suggest that:

- **Disclosure of climate-relevant financial information is key** to improve risk estimations and create the right incentives for investors. However, better disclosure **may not be sufficient**.

- The **timing and credibility** of the implementation of climate policies matter. An early and stable policy framework would allow for smooth carbon-asset values adjustments and lead to potential net winners and losers.

- In contrast, a late and abrupt policy implementation would have adverse systemic consequences for the financial system.

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