XII Annual Seminar on
Risk, Financial Stability and Banking

Measuring systemic risk under monetary policy shocks: a network approach

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Motivations

- Financial crises → contagion and amplification: highlight the importance of several contagion channels and relevant risks such as counterparty risk and funding risk (BCBS, 2016)

- Missing a framework that allows to measure systemic risk that addresses these channels and risks (Battiston et al., 2016; Glasserman & Young, 2016)

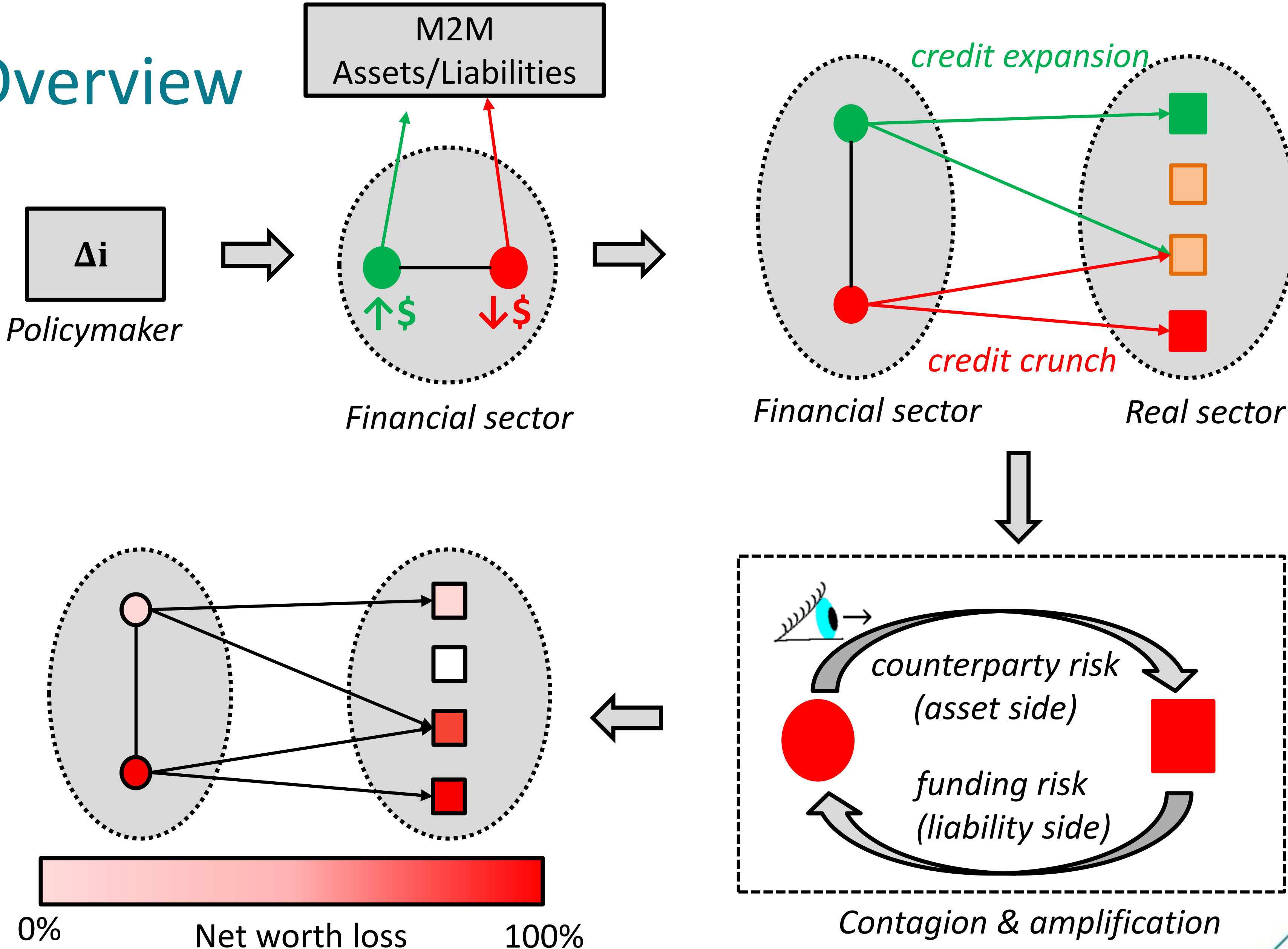
- Little understanding on the relationship between monetary policy and financial fragility → role of interconnectedness?

- What are the channels through which monetary policy may impact the financial system and financial stability?

Contributions

- Multilayer network model to quantify the short-term impact of monetary policy shocks on the net worth of banks and firms
- Empirical evidence of the importance of monetary policy in financial stability using Brazilian supervisory data
- Insights to:
  - Which sectors are more susceptible to monetary policy shocks?
  - Are there heterogeneity in the way sectors absorb monetary policy shocks?
  - Linear & non-linear relation between MP shocks and financial fragility
- Wide applicability
  - useful for the USA & countries with prolonged periods of low interest rate
  - also useful for Brazil & countries with historically high periods of high interest rate

Overview


M2M
Assets/Liabilities
Δi
Policymaker
↑$
↓$
Financial sector
credit expansion
credit crunch
Financial sector
Real sector
counterparty risk
(asset side)
funding risk
(liability side)
Contagion & amplification
0%
Net worth loss
100%

Step 1: MP shocks and bank capital changes

- Changes in interest rate immediately affect banks' trading books
- Banks recognize losses/profits in view of these fluctuations and thus bank capital changes as well
- Basel III limits ability of banks to move instruments between trading and banking books to by-pass capital requirements (BCBS, 2015)
- If trading book is mainly composed of instruments attached to the interest rate, then there could be large variations of bank capital and bank lending would be affected
- Thus, trading book variations are an important transmission channel of monetary policy to the real sector via bank credit

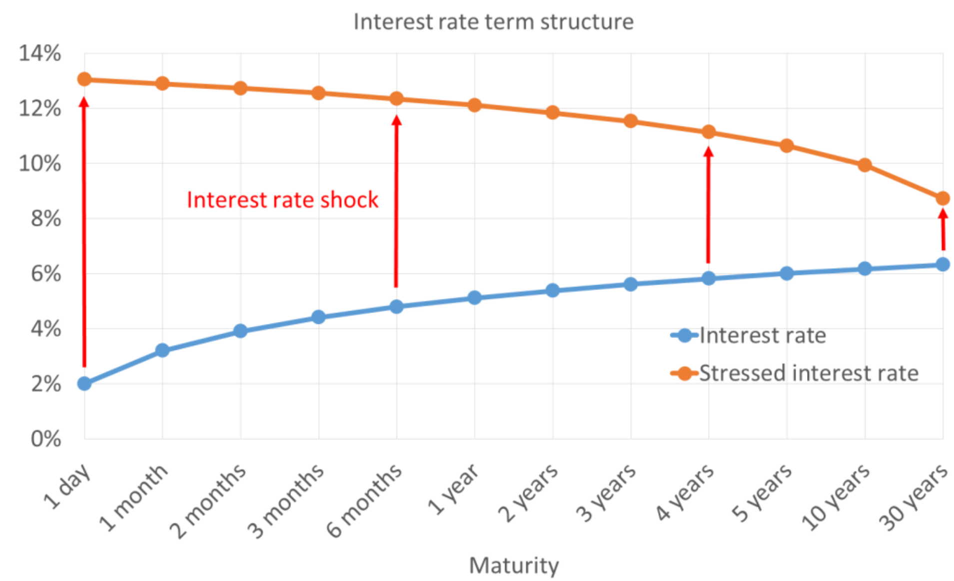
Bank net worth sensitiveness to Δi

- Monetary policy shock shifts the term structure of the interest rate
- Net exposures in 12 vertices of the interest rate term structure, ranging from 1 day to 30 years
- For each bank i and vertex v, the stressed net exposure $r_i^{\text{stressed}}(v)$ is:

$$r_i^{\text{stressed}}(v) = r_i^{\text{original}}(v) \left[\frac{1 + i_{\text{original}}}{1 + i_{\text{stressed}}}\right]^v$$

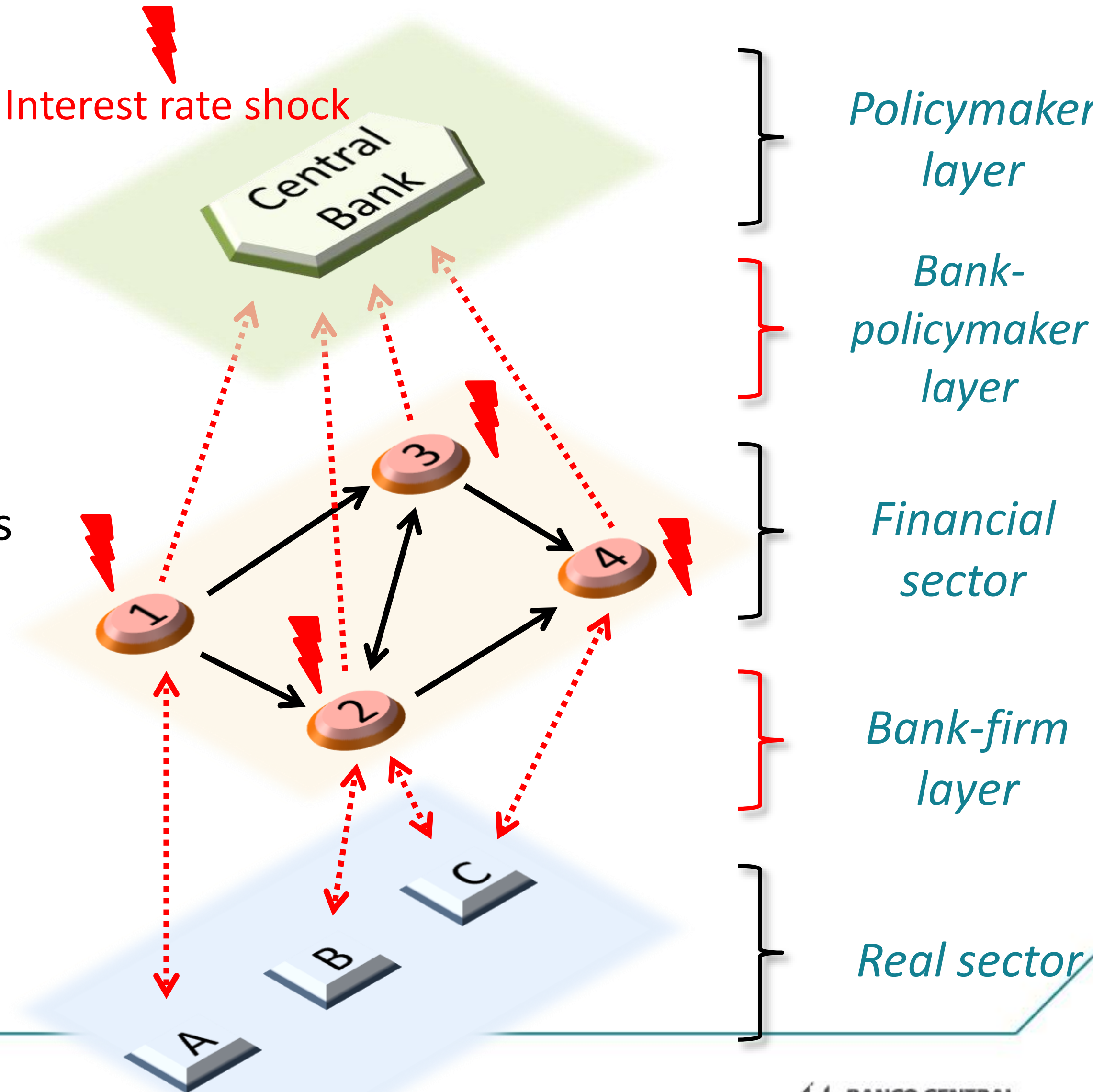
- Total loss/gain Δr_i is evaluated by summing over all vertices:

$$\Delta r_i = \sum_v r_i^{\text{original}}(v) \left(\left[\frac{1 + i_{\text{original}}}{1 + i_{\text{stressed}}}\right]^v - 1 \right)$$



Step 2: Financial contagion component

- Takes as input the bank capital loss/gain due to the monetary policy shock
- The financial contagion and amplification model consists of a single-period economy
- Network is exogenous → useful for short-term implications of shocks



Microfoundations of the model

Economic agent $i's$ balance sheet

Assets	Liabilities
$A_i^{(\text{in})}(t)$	$L_i^{(\text{in-st})}(t)$
$A_i^{(\text{out})}(t)$	$L_i^{(\text{in-lt})}(t)$
	$L_i^{(\text{out})}(t)$
	Net worth
	$E_i(t)$

Fundamental dynamics

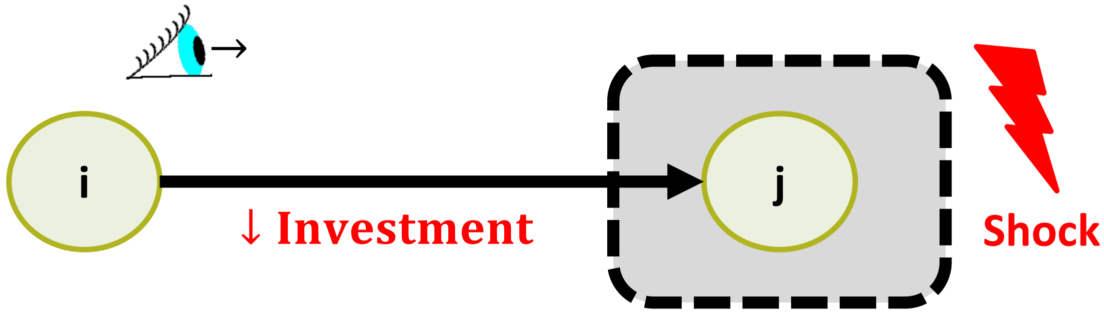
$$\Delta \mathbf{E}_i(t) = \Delta \mathbf{A}_i(t) - \Delta \mathbf{L}_i(t)$$
$$= \left[\Delta \mathbf{A}_i^{(\text{in})}(t) + \Delta \mathbf{A}_i^{(\text{out})}(t)\right] - \Delta \mathbf{L}_i(t)$$
$$= \Delta \mathbf{A}_i^{(\text{in})}(t) + \left[\Delta \mathbf{A}_i^{(\text{out})}(t) - \Delta \mathbf{L}_i(t)\right]$$
$$= \Delta \mathbf{E}_i^{(\text{ct})} + \Delta \mathbf{E}_i^{(\text{f})}$$

Counterparty risk ($\Delta \mathbf{E}_i^{(\text{ct})}$) **Funding risk** ($\Delta \mathbf{E}_i^{(\text{f})}$)

Counterparty risk: can materialize through losses of inside-network assets

Funding risk: can materialize through firesales of outside-network illiquid assets

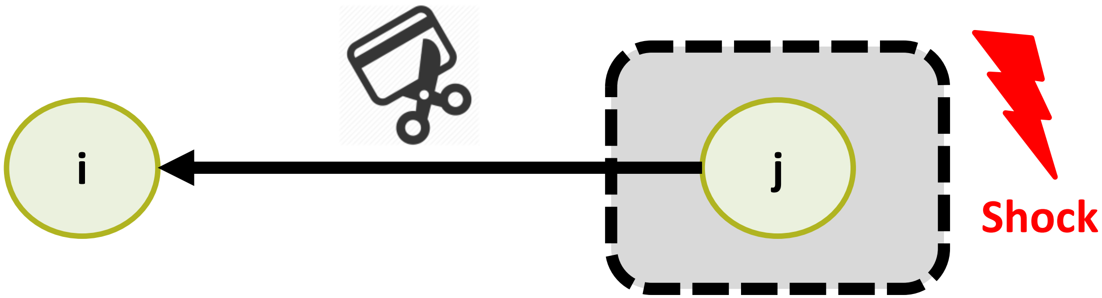
Counterparty risk: $\Delta E_i^{(ct)} = \Delta A_i^{(\text{in})}$



- **Intuition**: creditors monitor debtors’ creditworthiness and reprice down their investments as a <u>function of their net worth</u> (Bardoscia et al., 2015)
  - Only assumes local knowledge of the network topology
- BCBS (2011): “roughly two-thirds of losses attributed to counterparty risk were due to CVA losses and only about one-third was due to actual defaults”
- **Assumption**: repricing occurs in a linear fashion with respect to the debtor’s net worth

$$\mathbf{A}_{ij}^{(\text{in})}(t+1) = \begin{cases} \mathbf{A}_{ij}^{(\text{in})}(t)\frac{\mathbf{E}_j(t)}{\mathbf{E}_j(t-1)}, \text{if } j \in \mathscr{A}(t) \\ 0, \text{if } j \notin \mathscr{A}(t) \end{cases}$$

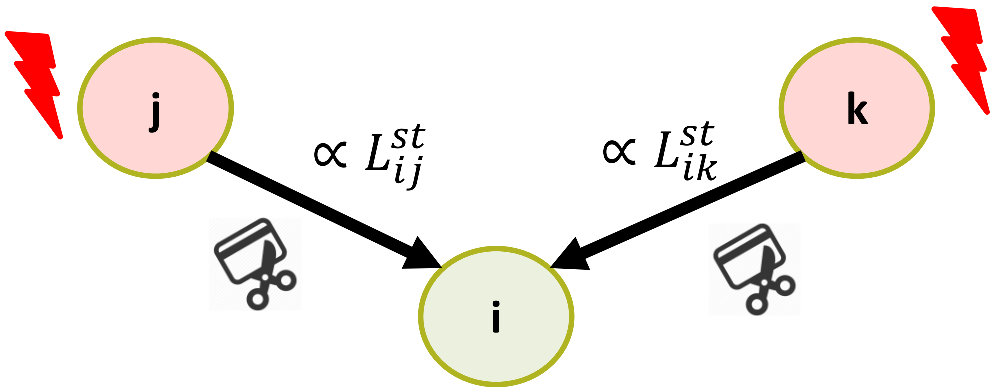
Funding risk: $\Delta E_i^{(f)} = \Delta A_i^{(\text{out-illiq})}$



- **Intuition**: banks perform precautionary liquidity hoarding as they approach insolvency
  - Gai et al. (2011) and Acharya & Skie (2011): "*banks hoard as a way to control their uncertainty over their ability to roll over their own debt or even to survive*"
- **Assumption**: hoarding linearly relates to the distance to insolvency

Estimating losses due to funding risk

- Losses due to funding risk are hard to quantify
- Potential losses are a function of the short-term liabilities L^{st}



- The more stressed i's creditors are, the more they will hoard and the larger will be the credit crunch on i
- To honor short-term liabilities that cannot be rolled over, i may have to firesell assets

Estimating losses due to liquidity exposures

- If $L_{ij}^{(\mathrm{st})}$ is the short−term liability of firm i to bank j, then losses that can arise due to this liquidity exposure are in $[0, L_{ij}^{(\mathrm{short-term})}]$, i.e., $\alpha_{ij}\, L_{ij}^{(st)}, \alpha_{ij} \in [0,1]$

- The term α_{ij} modulates the impact of j's credit crunch on i's net worth:

$$\alpha_{ij} = \phi_i\left[1 - \rho_{ij}\right]$$

- ϕ_i: level of illiquidity of i: $\phi_i = \max\left[0, \frac{\mathrm{liabilities}_{\mathrm{i}}^{\mathrm{st}}}{\mathrm{assets}_{\mathrm{i}}^{st}} - 1\right]$

- ρ_{ij}: ability to replace bank i for another bank j (bank substitutability)

How to estimate bank substitutability?

- $\boldsymbol{\rho_{ij}} \in [\mathbf{0}, \mathbf{1}]$: firm i's ability to substitute bank j with another bank financer

$$\boldsymbol{\rho}_{ij} = [1 - \boldsymbol{\lambda}_i]\,[1 - \boldsymbol{RL}_{ij}]$$

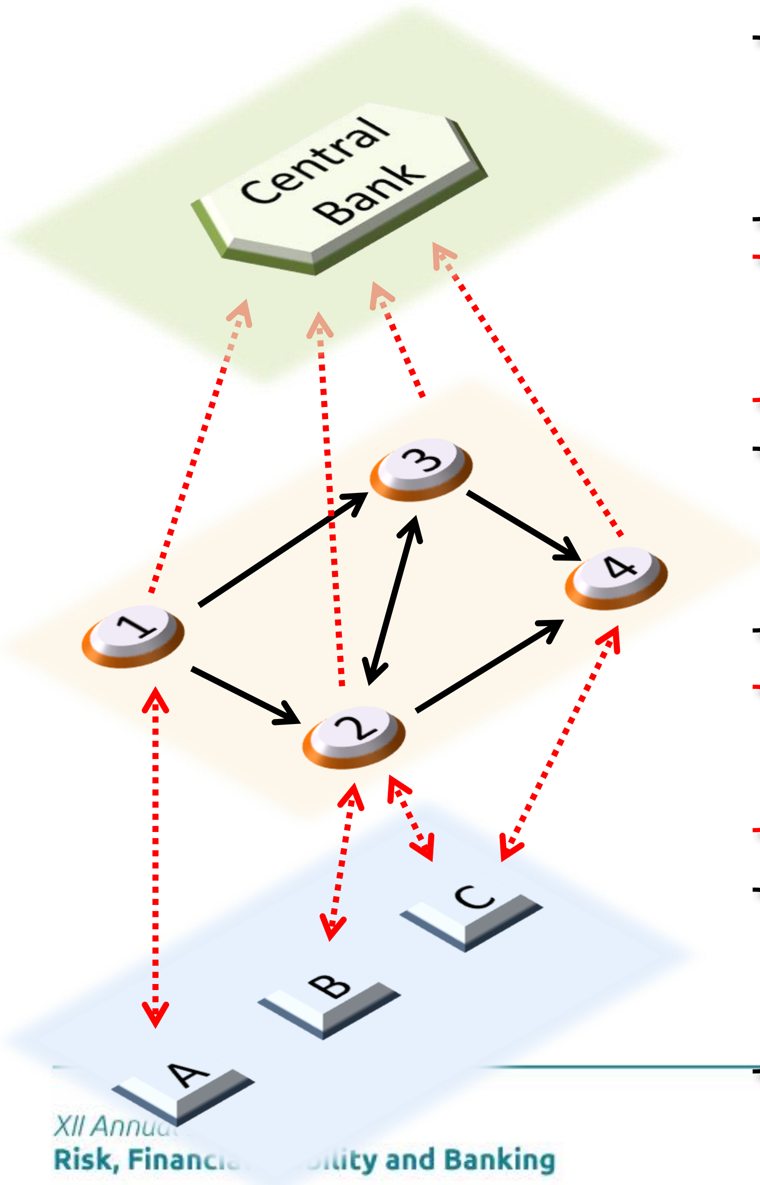
- $\boldsymbol{\lambda_i} \in [\mathbf{0}, \mathbf{1}]$: firm i's dependency on bank financing

$$\boldsymbol{\lambda}_i = \frac{\text{bank}}{\text{debt+equity}}$$

- $\boldsymbol{RL_{ij}} \in [\mathbf{0}, \mathbf{1}]$: relationship lending between i and j

$$\boldsymbol{RL}_{ij} = \frac{\sum_t e^{-t} \boldsymbol{A}_{ji}^{(\text{bank}-\text{firm})}(t)}{\sum_{u,t} e^{-t} \boldsymbol{A}_{ui}^{(\text{bank}-\text{firm})}(t)}$$

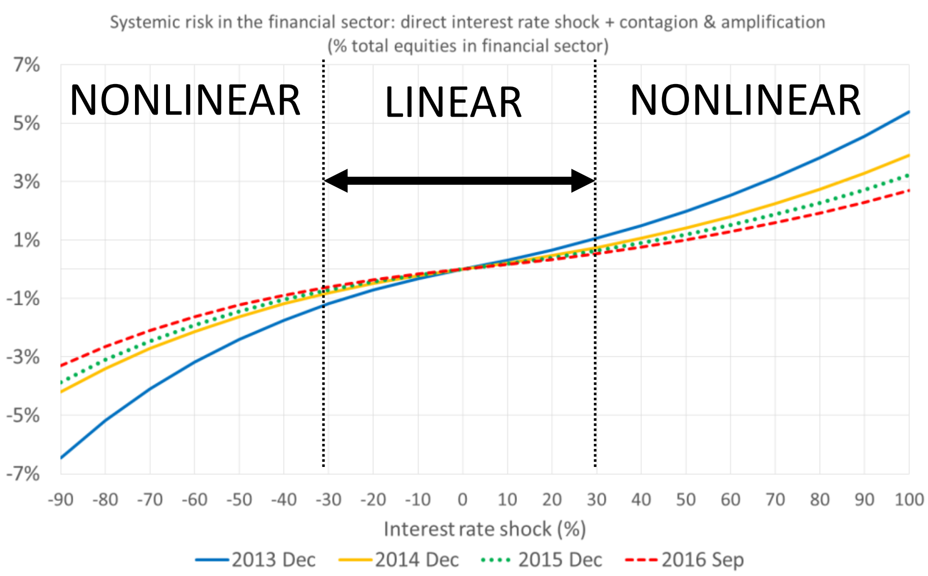
Data



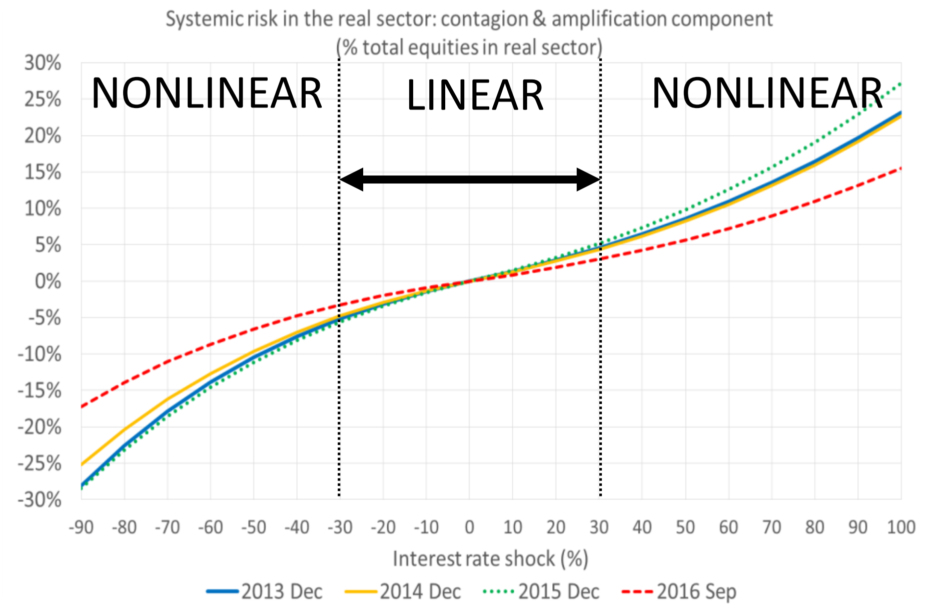
Policymaker layer	
Bank-policymaker layer	• Supervisory data
Financial sector	• All banks • Unsecured financial assets (Cetip, BMF&Bovespa, ...)
Bank-firm layer	• Only firms listed in stock exchanges • Brazilian credit register
Real sector	• Do NOT have the corporate trade network

Interest rate sensitiveness analysis

Financial sector



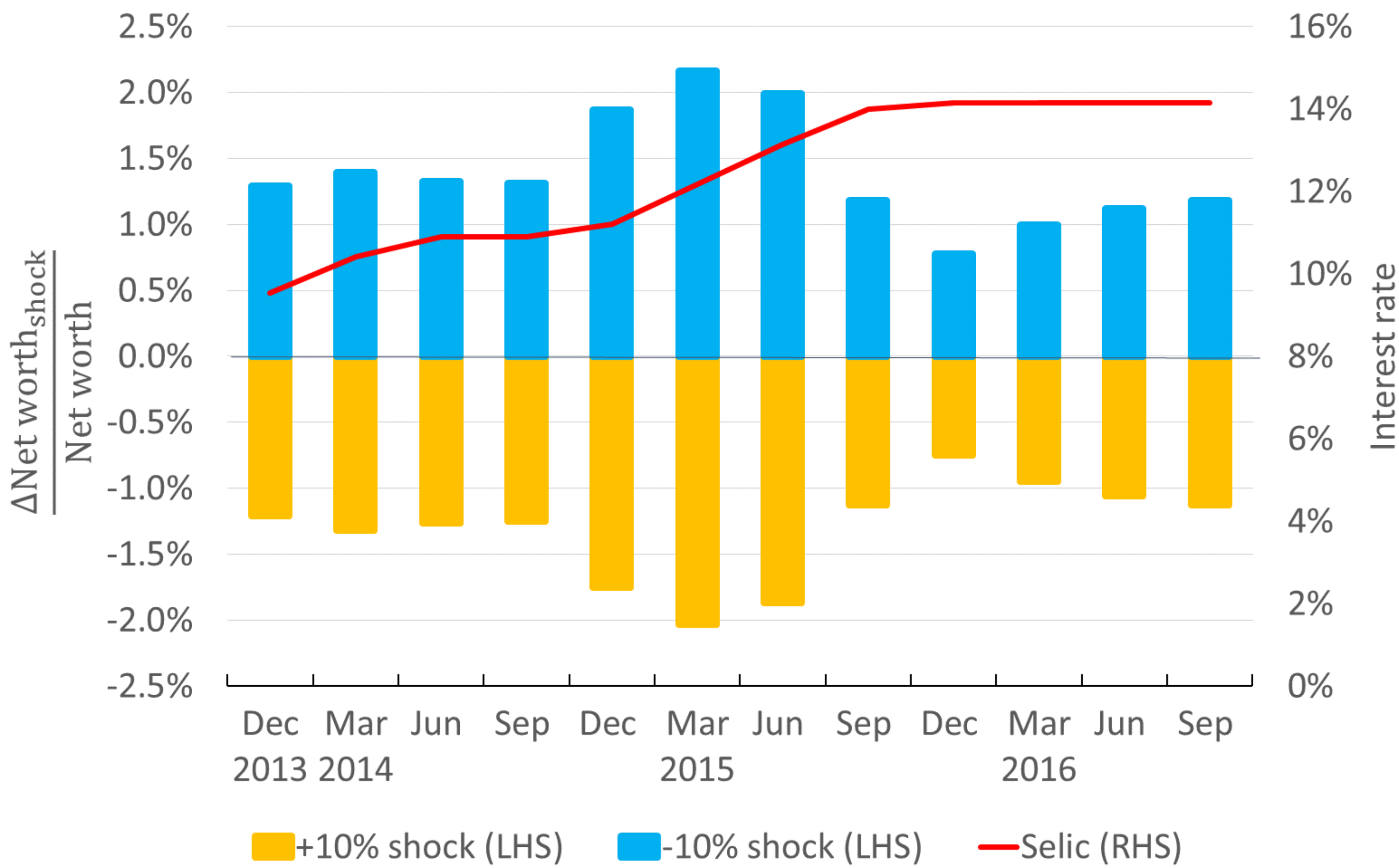
Real sector



- Short-term systemic risk consequences are:
  - LINEAR (shock up to 30%), if the monetary policy shock is small
  - NONLINEAR (shock larger than 30%), if the monetary policy shock is large

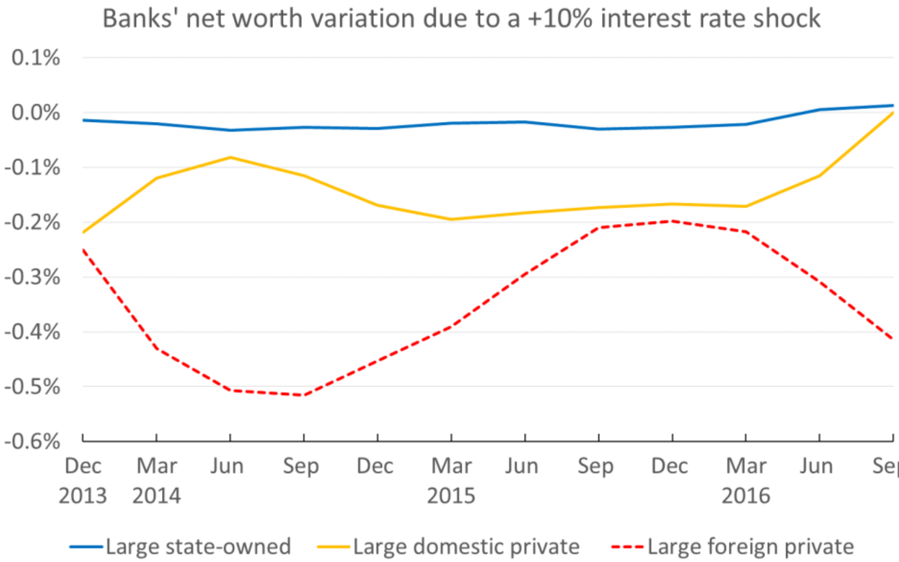
- **Big swings might cause undesirable nonlinear consequences on the financial fragility**
  - Minimize with: interest rate persistence, management of market expectations

Direct impact of interest rate shock on the financial sector capitalization

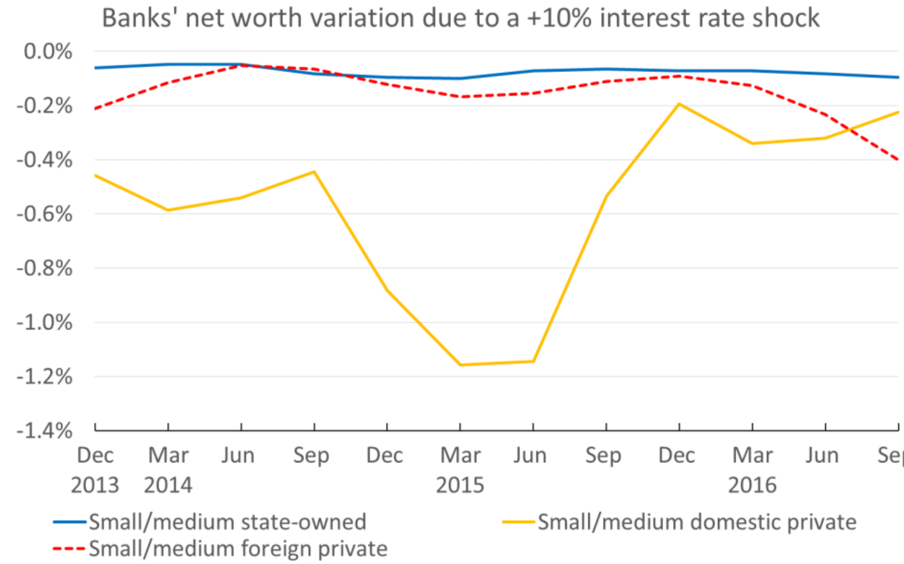


Direct impact of interest shock on the financial sector

Large banks



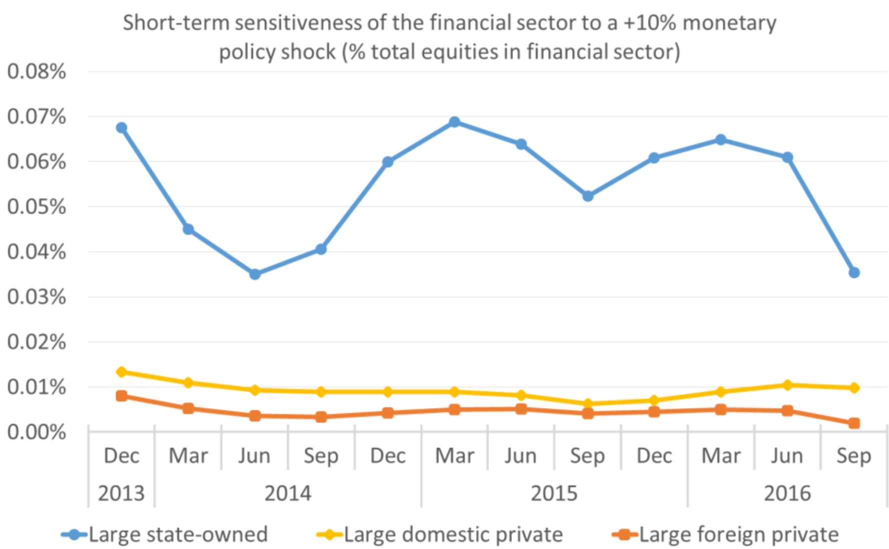
Small/medium banks



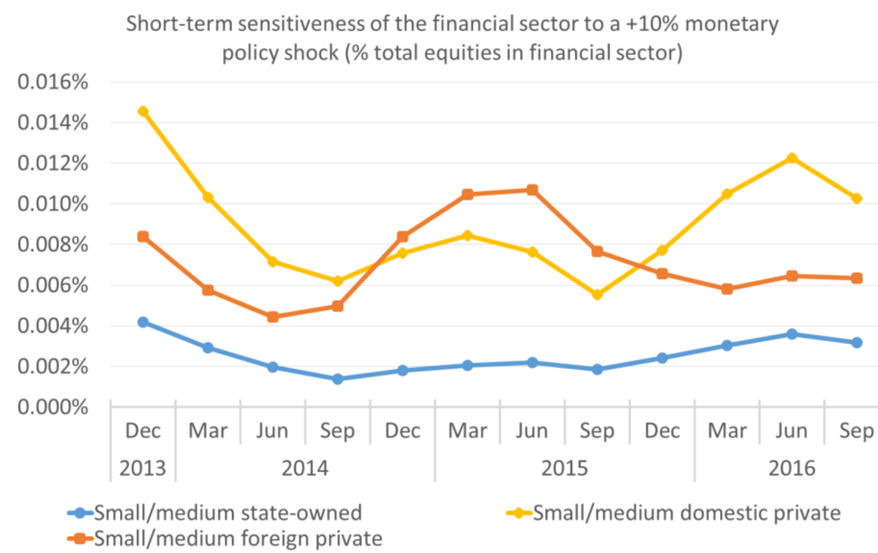
- State-owned banks have small sensitiveness regardless of size
- Most sensitive banks are small/medium domestic private, particularly investment banks
- Among large banks, foreign private banks are the most sensitive

Indirect impact (contagion) on the financial sector

Large banks

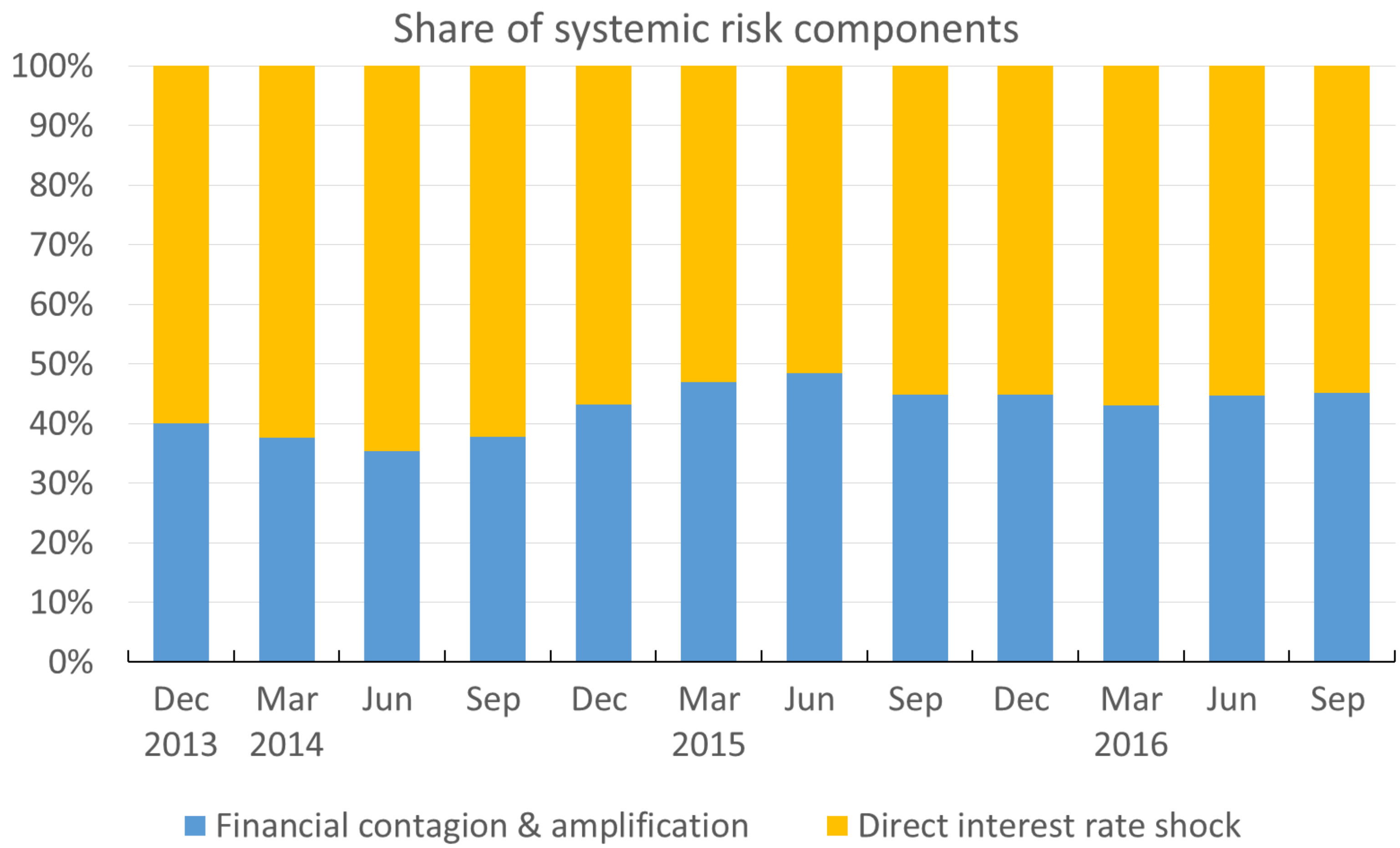


Small/medium banks

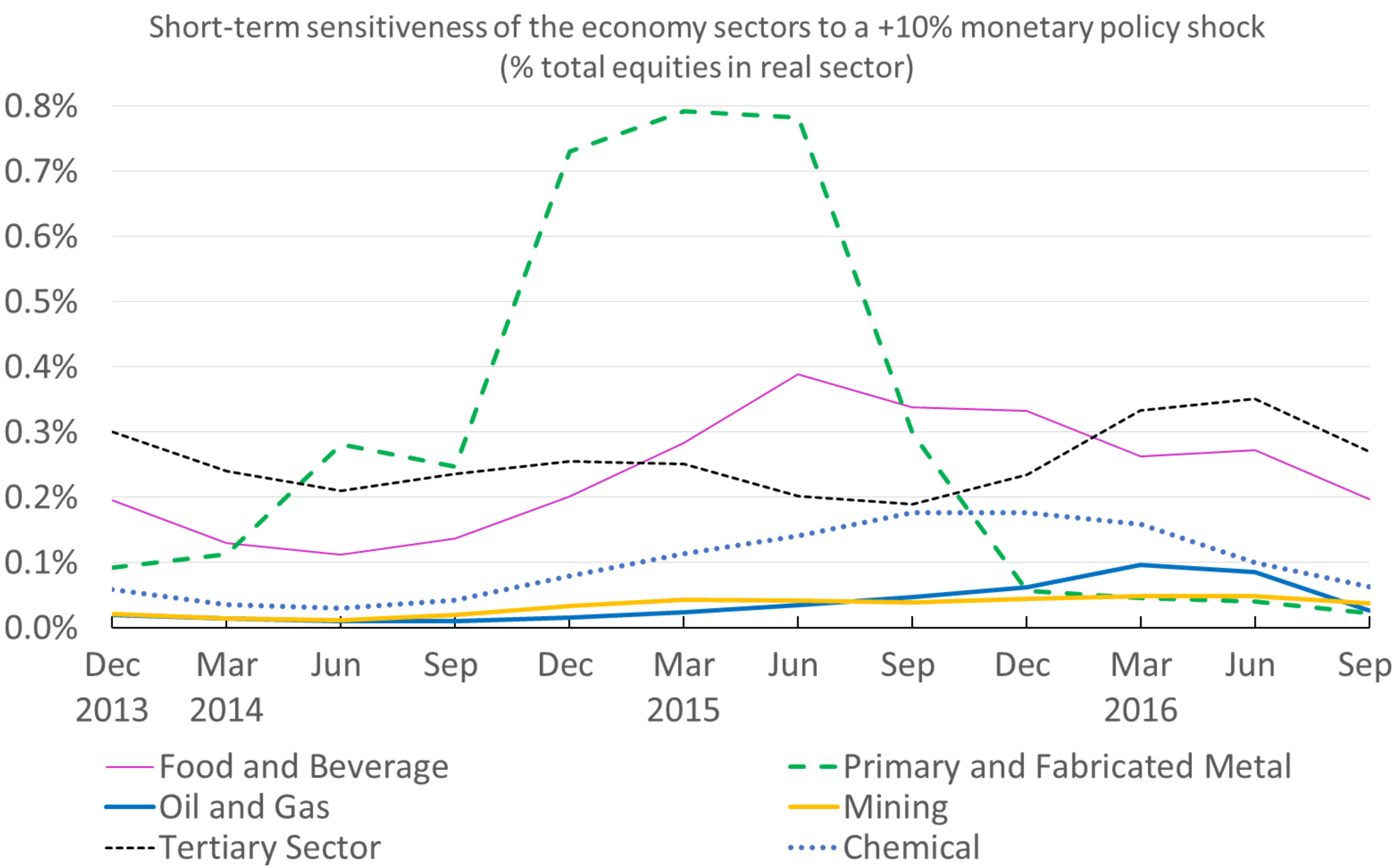


- Although large state-owned banks are the least affected to direct impacts of monetary policy shocks, they turn out to be the most affected in terms of indirect impacts via financial contagion
  - Core banks
  - High centrality

Comparison of direct impact + indirect impact (contagion) in the financial sector



Indirect impact (contagion) on the real sector



Takeaways

- Model quantifies how monetary policy affects bank lending to real sector and the increased firms' funding cost, while also treating interconnectedness
- Using Brazilian supervisory data, the short-term effect of monetary policy on financial fragility is an important source of systemic risk
- Insights to how macroprudential policy can be used to mitigate the systemic-risk effects of monetary policy in the real and financial sectors
- Future work:
  - endogenous network formation, long-term effects
  - add new contagion channels

QUESTIONS
&
SUGGESTIONS

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