

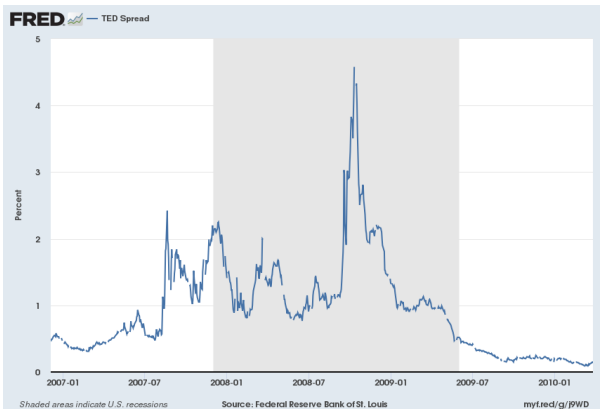
Interbank Market Turmoils and the Macroeconomy¹

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¹The views presented in this paper are those of the author, and should not be attributed to Narodowy Bank Polski.

Intro 1: LIBOR / T-bill spread



This paper: contributions

- **Macroeconomic perspective on interbank market disruptions**
- A tractable DSGE model where conventional (unconventional) monetary policy is implemented through banking sector (where NK is a special case)
- The macro consequences of non-conventional policy tools: interbank market guarantees

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- The macro consequences of non-conventional policy tools: interbank market guarantees

Literature

- Interbank market crises: Flannery (1996), Freixas and Jorge (2008), Freixas et al. (2011), Acharya and Skeie (2011), Heider et al. (2015), Afonso et al. (2011)
- Macro models with interbank market: Gertler and Kiyotaki (2010), Bianchi and Bigio (2014)
- Models using the “big family trick”: Lucas (1990), Shi (2015), Cui and Radde (2016), Negro et al. (2017)

Roadmap

- ① Model without counterparty risk
- ② Relationship to the NK framework
- ③ Model with counterparty risk
- ④ Interbank market guarantees

The model

- Building blocks:

- ▶ Real sector: New Keynesian framework, households - depositors, firms - loan takers
- ▶ Banking sector: a modified version of the model by Bianchi and Bigio (2014) (R&R ECMA) - reserves traded in a frictional interbank market as in Afonso and Lagos (2015)

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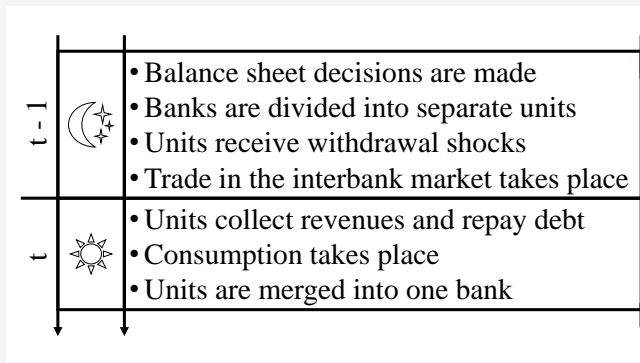
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Banking sector: no counterparty risk

- Timeline:



Banks: no counterparty risk

$$V(e_{t-1}, A_{t-1}) = \max_{\{c_t(\delta)\}, l_{t-1}, m_{t-1}, d_{t-1}, e_t} \left\{ \int_{-1}^{+\infty} u(c_t(\delta)) d\mu(\delta) + \beta_B \cdot \mathbb{E}V(e_t, A_t) \right\}$$

$$\left\{ \begin{array}{l} l_{t-1} + m_{t-1} = e_{t-1} + d_{t-1} \\ \forall \delta : c_t(\delta) + e_t + \Phi_E(e_t, \bar{e}_t) \leq \\ \frac{1+i_{L,t-1}}{\Pi_t} \cdot l_{t-1} + \frac{1+i_{ER,t-1}}{\Pi_t} \cdot m_{t-1} - \frac{1+i_{D,t-1}}{\Pi_t} \cdot d_{t-1} \\ + \left(\mathbb{I}_{\{\delta < \delta_{t-1}^*\}} \cdot \chi_t^- + \mathbb{I}_{\{\delta \geq \delta_{t-1}^*\}} \cdot \chi_t^+ \right) \cdot \mathcal{M}(m_{t-1}, d_{t-1} | i_{D,t-1}, i_{L,t-1}, \delta) \end{array} \right.$$

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Interbank market: no counterparty risk

- Surplus (deficit) of reserves:

$$\mathcal{M}(m_{t-1}, d_{t-1} | i_{D,t-1}, i_{L,t-1}, \delta) \equiv m_{t-1} + \frac{1 + i_{D,t-1}}{1 + i_{ER,t-1}} \cdot \delta \cdot d_{t-1} - \psi \cdot (1 + \delta) \cdot d_{t-1}$$

- Critical value δ^* satisfies:

$$m_{t-1} + \frac{1 + i_{D,t-1}}{1 + i_{ER,t-1}} \cdot \delta^* \cdot d_{t-1} - \psi \cdot (1 + \delta^*) \cdot d_{t-1} = 0$$

- Aggregate deficit and surplus of reserves:

$$\mathcal{D}_t \equiv \left| \int_{-1}^{\delta_t^*} \left(m_t + \frac{1 + i_{D,t}}{1 + i_{ER,t}} \cdot \delta \cdot d_t - \psi \cdot (1 + \delta) \cdot d_t \right) d\mu(\delta) \right|$$

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- Interbank market tightness:

$$\theta_{FF,t} = \frac{\mathcal{D}_t}{\mathcal{S}_t}$$

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Interbank market: no counterparty risk

- Fed funds rate (results from the Nash bargaining problem):

$$i_{FF,t} = \frac{i_{ER,t} + i_{DW,t}}{2}$$

- Effective rates on loans in the market:

$$\chi_t^- = \psi_{t-1}^- \cdot \frac{i_{FF,t-1} - i_{ER,t-1}}{\Pi_t} + (1 - \psi_{t-1}^-) \cdot \frac{i_{DW,t-1} - i_{ER,t-1}}{\Pi_t}$$

$$\chi_t^+ = \psi_{t-1}^+ \cdot \frac{i_{FF,t-1} - i_{ER,t-1}}{\Pi_t}$$

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$$i_{L,t-1} - i_{D,t-1} = \Pi_t \cdot \frac{\mathbb{P}(\delta < \delta_{t-1}^*) \cdot \mathbb{E}_\delta \left(u'(c_t(\delta)) \cdot [\tilde{\delta}_{t-1} + \psi \cdot (1 - \delta)] \mid \delta < \delta_{t-1}^* \right) \cdot \chi_t^-}{\mathbb{E}_\delta (u'(c_t(\delta)))} \\ + \Pi_t \cdot \frac{\mathbb{P}(\delta \geq \delta_{t-1}^*) \cdot \mathbb{E}_\delta \left(u'(c_t(\delta)) \cdot [-\tilde{\delta}_{t-1} + \psi \cdot (1 + \delta)] \mid \delta \geq \delta_{t-1}^* \right) \cdot \chi_t^+}{\mathbb{E}_\delta (u'(c_t(\delta)))}$$

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Households: no counterparty risk

- Bellman equation for household $j \in [0, 1]$:

$$W\left(\tilde{d}_{j,t-1}, A_t\right) = \max_{c_{j,t}, \tilde{d}_{j,t}} \left\{ u(c_{j,t}) - v(n_{j,t}) + \beta_H \cdot \mathbb{E} W\left(\tilde{d}_{j,t}, A_{t+1}\right) \right\}$$

subject to :

$$\begin{cases} c_{j,t} + \tilde{d}_{j,t} + \tau_t + \frac{\phi_w}{2} \left(\frac{w_{j,t}}{w_{j,t-1}} - 1 \right)^2 \cdot n_t \leq \\ \frac{1+i_{D,t-1}}{\Pi_t} \cdot \tilde{d}_{j,t-1} + \frac{w_{j,t}}{p_t} \cdot n_{j,t} + \pi_t \\ n_{j,t} = \left(\frac{w_{j,t}}{w_t} \right)^{-\gamma_w} \cdot n_t \end{cases}$$

Firms: no counterparty risk

- Bellman equation for firm $i \in [0, 1]$:

$$F_i(p_{i,t-1}, \tilde{l}_{i,t-1}, S_t, A_t) = \max_{p_{i,t}, l_{i,t}, n_{i,t}, y_{i,t}} \left\{ \frac{p_{i,t}}{p_t} \cdot y_{i,t} - \frac{1 + i_{L,t-1}}{\Pi_t} \cdot \tilde{l}_{i,t-1} - \frac{\phi}{2} \left(\frac{p_{i,t} - p_{i,t-1}}{p_{i,t-1}} \right)^2 \cdot y_t + \mathbb{E} \Lambda_t \cdot F_i(p_{i,t}, \tilde{l}_{i,t}, S_{t+1}, A_{t+1}) \right\}$$

subject to :

$$\begin{cases} \tilde{l}_{i,t} = w_t \cdot n_{i,t} \\ y_{i,t} = n_{i,t} \\ y_{i,t} = \left(\frac{p_{i,t}}{p_t} \right)^{-\gamma} \cdot y_t \end{cases}$$

Government: no counterparty risk

- Government chooses: rates i_{FF} , i_{DW} , i_{FF} , supply of reserves \tilde{m} and tax τ
- Budget constraint of consolidated government:

$$\frac{1 + i_{ER,t-1}}{\Pi_t} \cdot \tilde{m}_{t-1} = \tilde{m}_t + \tau_t + \Phi_E(e_t, \bar{e}_t) + (1 - \psi_{t-1}^-) \cdot \frac{i_{DW,t-1} - i_{ER,t-1}}{\Pi_t} \cdot \left| \int_{-1}^{\delta_{t-1}^*} \mathcal{M}(\delta) d\mu(\delta) \right|$$

- Monetary policy rule:

$$\log(1 + i_{FF,t}) = (1 - \rho_m) \cdot \log(1 + i_{FF}^{SS}) + \rho_m \cdot \log(1 + i_{FF,t-1}) + (1 - \rho_m) \cdot [v_\pi \cdot (\Pi_t - \Pi^{SS}) + v_y \cdot (\log y_t - \log y^{SS})] + \varepsilon_m$$

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Relationship to the standard NK model

Proposition

Equilibrium prices and quantities converge to those associated with the standard New Keynesian model with price/wage adjustment costs as in Rotemberg (1982) and the cost channel as in Ravenna and Walsh (2006) if:

- 1) Bank units get risk neutral: $\rho \rightarrow 0$*
- 2) Matching frictions in the interbank market decay: $\alpha_{FF} \rightarrow +\infty$*
- 3) Policy requirements concerning reserves and bank equity are eliminated: $\psi, \xi \rightarrow 0$*

Model with counterparty risk

- Proportion $1 - S_{t-1}$ of bank units with deficit reserves suffers from defaults on corporate loans l_{t-1} in period t
- Banks learn the value of shock S_{t-1} before entering the interbank market in period $t - 1$
- Banks know the value of S_{t-1} but they do not know which bank units will be affected by the shock
- $1 - S_{t-1}$ bank units default on interbank loans and deposits in period t
- Liquidation procedure:
 - ▶ government guarantees deposit repayment (FDIC)
 - ▶ government confiscates equity and guarantees dividends \underline{c} to affected units
 - ▶ liquidated units are provided with a fresh start (no reputational concerns)
- Interbank loans are not secured so lending banks generate losses

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Model with counterparty risk

- Bellman equation becomes:

$$V(e_{t-1}, S_{t-1}, A_{t-1}) = \max_{x_t} \left\{ \int_{\delta_{t-1}^*}^{+\infty} u(c_t(\delta)) d\mu(\delta) + \frac{S_{t-1} - \mathbb{P}(\delta \geq \delta_{t-1}^*)}{\mathbb{P}(\delta < \delta_{t-1}^*)} \cdot \int_{-1}^{\delta_{t-1}^*} u(c_t(\delta)) d\mu(\delta) + (1 - S_{t-1}) \cdot u(\underline{c}) + \beta_B \cdot \mathbb{E}V(e_t, S_t, A_t) \right\}$$

$$\left\{ \begin{array}{l} l_{t-1} + m_{t-1} = S_{t-1} \cdot e_{t-1} + d_{t-1} \\ \forall \delta : c_t(\delta) + e_t + \Phi_E(e_t, \bar{e}_t) \leq \\ \frac{1+i_{L,t-1}}{\Pi_t} \cdot l_{t-1} + \frac{1+i_{ER,t-1}}{\Pi_t} \cdot m_{t-1} - \frac{1+i_{D,t-1}}{\Pi_t} \cdot d_{t-1} \\ + \left(\mathbb{I}_{\{\delta < \delta_{t-1}^*\}} \cdot \chi_t^- + \mathbb{I}_{\{\delta \geq \delta_{t-1}^*\}} \cdot \chi_t^+(S_{t-1}) \right) \cdot \mathcal{M}(m_{t-1}, d_{t-1} | i_{D,t-1}, i_{L,t-1}, \delta) \end{array} \right.$$

Model with counterparty risk

- Bellman equation becomes:

$$V(e_{t-1}, S_{t-1}, A_{t-1}) = \max_{x_t} \left\{ \int_{\delta_{t-1}^*}^{+\infty} u(c_t(\delta)) d\mu(\delta) + \frac{S_{t-1} - \mathbb{P}(\delta \geq \delta_{t-1}^*)}{\mathbb{P}(\delta < \delta_{t-1}^*)} \right. \\ \left. \cdot \int_{-1}^{\delta_{t-1}^*} u(c_t(\delta)) d\mu(\delta) + (1 - S_{t-1}) \cdot u(\underline{c}) + \beta_B \cdot \mathbb{E}V(e_t, S_t, A_t) \right\}$$

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Model with counterparty risk

- Interbank market rate becomes:

$$i_{FF,t} = \frac{i_{ER,t} + i_{DW,t} + \overbrace{\frac{1 - S_t}{S_t - \mathbb{P}(\delta \geq \delta_t^*)}}^{\text{The counterparty risk component}}}{2}$$

- Effective return on surplus reserves:

$$\begin{aligned} \chi_t^+(S_{t-1}) = & \underbrace{\frac{S_{t-1} - \mathbb{P}(\delta \geq \delta_{t-1}^*)}{\mathbb{P}(\delta < \delta_{t-1}^*)}}_{\text{Probability that counterparty is safe/solvent}} \cdot \psi_{t-1}^+ \cdot \frac{i_{FF,t-1} - i_{ER,t-1}}{\Pi_t} \\ & + \underbrace{\frac{1 - S_{t-1}}{\mathbb{P}(\delta < \delta_{t-1}^*)}}_{\text{Probability that counterparty is risky/insolvent}} \cdot \psi_{t-1}^+ \cdot \left(-1 \cdot \frac{1}{\Pi_t}\right) \end{aligned}$$

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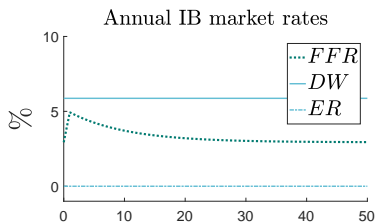
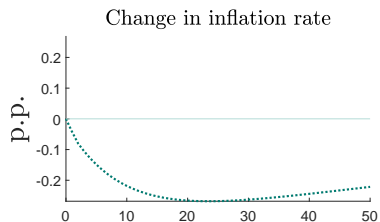
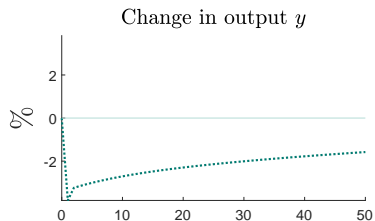
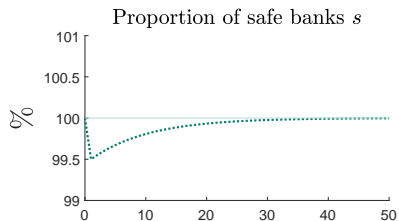
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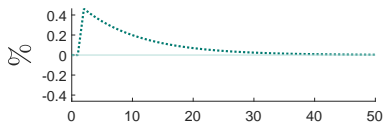
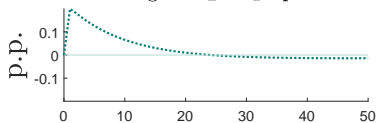
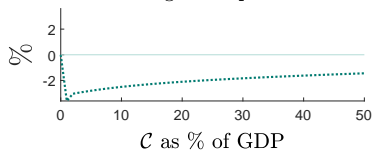
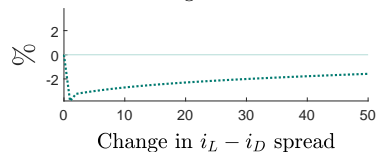
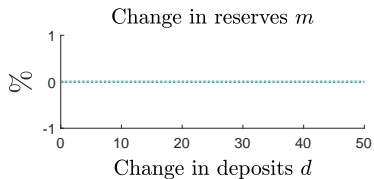
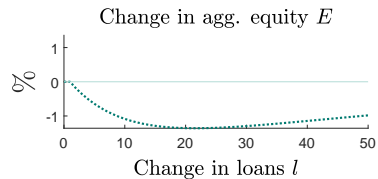
Calibration

Parameter	Description	Value	Target
α	Parameter of matching technology M	68.9	Probabilities ψ^+ and ψ^- equal to 0.99
i_{DW}	Discount window rate	0.0147	Annual discount window rate in 2006
i_{ER}	Interest on reserves	0	Annual rate on excess reserves in 2006
ξ	Capital requirement ratio	0.04	Assets to equity ratio of 4%
ψ	Reserve requirement	0.1	Reserve requirement equal to 10%
δ	Std. error of withdrawal shock	0.05	Evidence by Bianchi and Bigio (2014)
\bar{m}	Supply of reserves	0.032	Value of tightness $\theta_{FF} = 1$

Simulation: a decrease in S



Simulation: a decrease in S



Interbank market guarantees

- $\mathcal{P} \in (0, 1)$ denotes the proportion of non-performing interbank loans that are guaranteed by government
- I choose $\mathcal{P} = 0.5$
- Interbank market rate becomes:

$$i_{FF,t}(\mathcal{P}) = \frac{i_{ER,t} + i_{DW,t} + \frac{(1-\mathcal{P}) \cdot (1-S_t)}{S_t + \mathcal{P} \cdot (1-S_t) - \mathbb{P}(\delta \geq \delta_t^*)}}{2}$$

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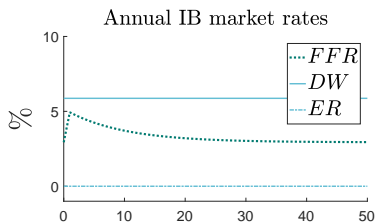
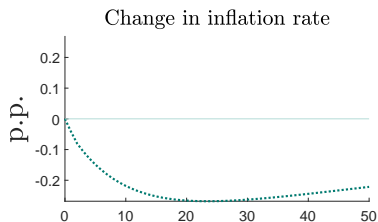
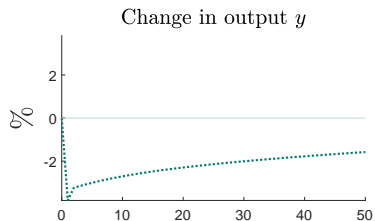
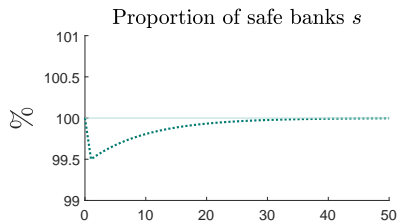
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Interbank market guarantees

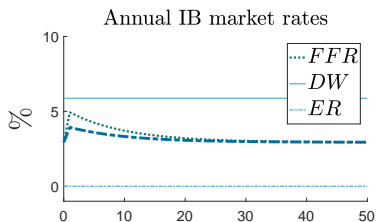
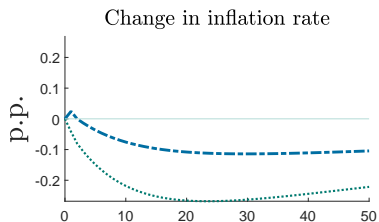
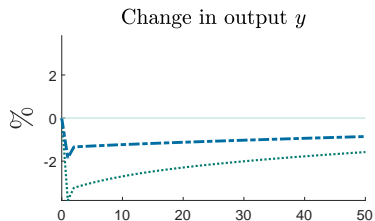
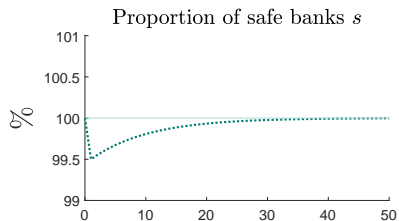
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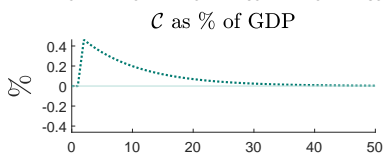
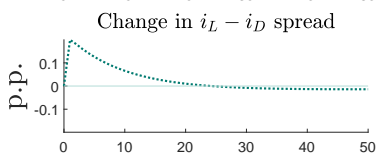
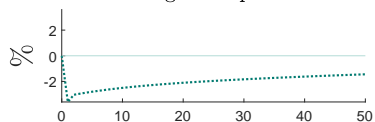
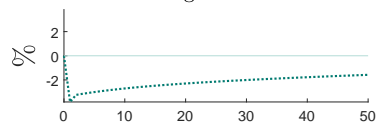
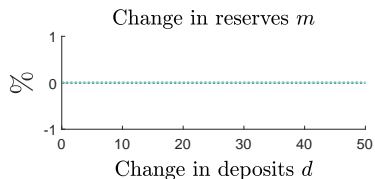
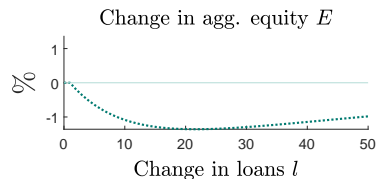
Simulation: interbank market guarantees



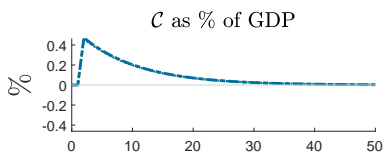
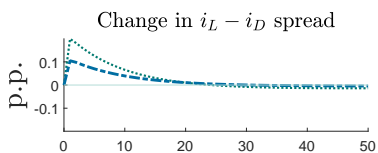
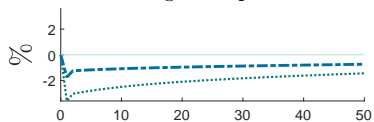
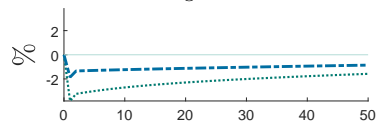
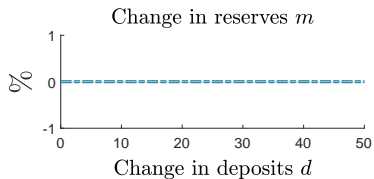
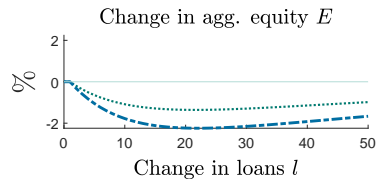
Simulation: interbank market guarantees



Simulation: interbank market guarantees



Simulation: interbank market guarantees



Conclusions

- Technical contributions:
 - ▶ a dynamic model of banking industry with interbank market
 - ▶ conventional (unconventional) monetary policy can be studied
 - ▶ model nests the standard NK framework
- Simulation and policy experiment:
 - ▶ interbank market crisis caused by higher counterparty risk
 - ▶ the role of interbank market guarantees
- Future research:
 - ▶ other types of policy interventions
 - ▶ diabolic loops between sovereign debt and banking sector

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The End

Thanks for your attention!