More or less aggressive? Robust monetary policy in a New Keynesian model with financial distress

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The views expressed in this paper are those of the authors and do not represent those of the Deutsche Bundesbank, the National Bank of Belgium or the Eurosystem.
“Central banks generally recognise the need to cut the interbank rate in response to widespread financial distress.”

Marvin Goodfriend and Bennett T. McCallum (2007, p. 1503)

- **Question 1: How to react to financial distress?**
  - looking at theoretical foundation
  - financial distress associated with model uncertainty

- **Question 2: More or less aggressive policy response?**
  - less aggressive: Brainard (1967), Blinder (1998)
  - more aggressive: Craine (1979), Söderström (2002)
    - results refer mostly to cost-push shock
    - here: evidence for shock to collateral
Outline

1) **Goodfriend / McCallum (2007) model as decentralised economy**
   - Central bank may be misled when not differentiating between policy rate and other short-term rates

2) **Model uncertainty**
   - Robust control approach

3) **Cost-push shock**
   - Be more aggressive → confirms literature

4) **Shock to collateral (financial distress)**
   - Be more aggressive → our contribution

5) **Sensitivity analysis**
   - Varying weight on interest rate smoothing in the loss function
Decentralised economy with three agents and two sectors:

- **Households maximise utility**
  - budget constraint
  - transaction constraint $\Rightarrow$ demand for deposits (loan demand)

- **Firms maximise profits under monopolistic competition**
  - goods are produced with capital & labour

- **Banks maximise profits under perfect competition**
  - bank’s balance sheet
  - loans produced with collateral & labour (monitoring) $\Rightarrow$ loan supply
    - bonds & capital
Households maximise utility

\[ E_0 \sum_{t=0}^{\infty} \beta^t \left[ \phi \log(c_t^A) + (1-\phi) \log(1-n_t^s - m_t^s) \right] \]

subject to a budget constraint

\[ c_t^A + tax_t + \frac{B_{t+1}}{P_t^A \left(1 + R_t^B \right)} + \frac{H_t}{P_t^A} + \frac{R_t^T L_t}{P_t^A} + q_t I_t \]

\[ = w_t \left(n_t^s + m_t^s\right) + \frac{B_t}{P_t^A} + \frac{H_{t-1}}{P_t^A} + \frac{R_t^D D_t}{P_t^A} \]

\[ + \frac{\tilde{R}_t^B B_{t+1}}{P_t^A \left(1 + R_t^B \right)} + \tilde{q}_t q_t K_{t+1} + \tilde{q}_t q_t K_t + \Psi_t \]

payments for collateral from bank

rent on capital from firm
Further constraints

- **law of motion**

\[ I_t = K_{t+1} - (1 - \delta) K_t \]

- **transaction constraint**

\[ D_t = \frac{P_t^A}{V} c_t^A \]

Households face a liquidity constraint that requires to pay for (aggregate) consumption during period \( t \) with deposits held in that period

- similar to a cash-in-advance constraint
- constraint always binds
Firms maximise real profits

\[ \Psi_t = \frac{\text{profit}_t}{P_t^A} = \frac{P_t}{P_t^A} c_t - w_t n_t - \tilde{q}_t q_t K_t \]

subject to

- production function (goods supply)

\[ c_t = K_t^n \left( A1_t n_t \right)^{1-n} \]

- goods demand

\[ c_t = \left( \frac{P_t}{P_t^A} \right)^{-\theta} c_t^A \]
The Bank

Banks maximise real profits

\[
\frac{\text{bankprofit}_t}{P_t^A} = \frac{R_t^T L_t}{P_t^A} + \frac{S_t}{P_t^A} - \frac{R_t^D D_t}{P_t^A} - w_i m_t - \frac{S_{i+1}}{P_t^A (1 + R_t^T)} - \frac{\tilde{q}_t q_i K_{t+1}}{P_t^A (1 + R_t^B)}
\]

subject to

- bank’s balance sheet & chosen reserve ratio by banks
  \[H_t + L_t = D_t\]
  \[rr = \frac{H_t}{D_t}\]
  with \(H_t\) = base money (equal to bank reserves)

- loan production function
  \[\frac{L_t}{P_t^A} = \mathcal{F} \left( \frac{B_{i+1}}{P_t^A (1 + R_t^B)} + A3_t k q_i K_{t+1} \right)^\alpha \frac{(A2, m_t)^{1-\alpha}}{\text{collateral monitoring}}\]
  with \(0 < k < 1\)
Different Interest Rates

<table>
<thead>
<tr>
<th>Fictitious security (no collateral)</th>
<th>Government bonds (collateral service)</th>
<th>Interbank market rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^T$</td>
<td>$R^B$</td>
<td>$R^{IB}$</td>
</tr>
</tbody>
</table>

- Euler equations give $R^T$ and $R^B$
  - Recognise bonds provide **liquidity service** in loan production
  - $R^T = R^B + LSY$
- Central bank sets policy rate $R^{IB}$
  - Recognise loan production is costly (collateral & monitoring)
  - Costs give rise to **external finance premium**
  - $R^T = R^{IB} + EFP$
Dynamic Analysis

- **Log-linearisation with New Keynesian Phillips curve**
  \[ \Delta \hat{p}_t = \beta E_t \Delta \hat{p}_{t+1} + \kappa m c_t + u_t \]

- **Loss function with interest rate smoothing**
  \[ \lambda_{mc} = \frac{k}{\theta} = 0.0045, \quad \lambda_{\Delta i} = [0.1, 1.0] \]

\[ L_i = E_i \sum_{i=0}^{\infty} \beta^i \left( \Delta \hat{p}_{t+i}^2 + \lambda_{mc} \hat{m c}_{t+i}^2 + \lambda_{\Delta i} \left( \Delta R_{t+i}^{IB} \right)^2 \right) \]

- **Optimal monetary policy under discretion**
  - Central bank has no commitment device
  - Optimal rule derived numerically

- **Shocks: follow AR(1) processes**
  - Shocks introduce additive uncertainty
  - Certainty equivalence holds
- Robust Control approach
  - Uncertainty around (a single) reference model
  - Knightian uncertainty $\Rightarrow$ no ex ante probabilities known
  - Zero-sum game of two players: policymaker vs. evil agent
- Evil agent
  - … is metaphor for policymaker’s cautionary behaviour
  - Budget of evil agent (how much distortion of the reference model) corresponds to policymaker’s preference for robustness
Robust Control

- **Robust policy rule** works well in the worst case
  - **Rational expectations (RE) equilibrium**: reference model
  - **Worst-case equilibrium**: outcome of min-max strategy
    - Evil agent maximises loss
    - Policymaker minimises that loss: robust policy rule
  - **Approximating equilibrium**: “more likely outcome”
    - Policymaker uses robust policy rule
    - Evil agent not present
Cost-Push Shock

Graphs showing the response of various variables to a Cost-Push Shock, including n, w, m, q, c, λ, RIB, mc, EFP, RB, Δp, RT.
## Results

<table>
<thead>
<tr>
<th></th>
<th>$a^3_t$</th>
<th>$u_t$</th>
<th>$P_{t-1}$</th>
<th>$R_{t-1}^{IB}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE rule</td>
<td>0.27</td>
<td>2.41</td>
<td>0.00</td>
<td>0.57</td>
</tr>
<tr>
<td>Robust rule</td>
<td><strong>0.30</strong></td>
<td><strong>3.08</strong></td>
<td>0.00</td>
<td>0.53</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th></th>
<th>RE equilibrium</th>
<th>Worst-case equilibrium</th>
<th>Approximating equilibrium</th>
<th>Insurance premium in %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.62</td>
<td>5.37</td>
<td>4.61</td>
<td>56.45</td>
</tr>
</tbody>
</table>

Detection error probability = 25%

Insurance premium = \[ \frac{Loss_{Approx}^{RE} - Loss_{Worst}^{RE}}{Loss_{Worst}^{RE} - Loss_{Approx}^{RE}} \cdot 100 \]
Shock to Collateral for $\lambda_{\Delta t} = 0.1$
Questions

1. Does model uncertainty induce more aggressiveness (for both shocks)?

2. Has the policymaker to be less concerned about uncertainty surrounding the shock to collateral?
1. Absolute differences
   - Cost-push shock: aggressiveness decreases
   - Shock to collateral: aggressiveness roughly constant at 0.03
2. All three equilibriums coincide
   for shock to collateral if \( \lambda_{\Delta i} = 0 \)
3. CB penalises deviations of interest rate from st at \( (R^B_i)^2 \)
   - Results carry over
   - degree of aggressiveness (in %) remains unchanged

Absolute Change in Aggressiveness

\[
\begin{align*}
\Delta I^B_t & = R^B_t E a a - R^B_t E u u \\
\Delta^3 R^C - \Delta^3 R^E & = 0.6 \quad 0.5 \quad 0.4 \quad 0.3 \quad 0.2 \quad 0.1 \quad 0 \quad 0.2 \quad 0.4 \quad 0.6 \quad 0.8 \quad 1
\end{align*}
\]
Sensitivity Analysis: 
Shock to Collateral for $\lambda \Delta = 1$
Conclusions

**RE equilibrium**

- $R^T$ inappropriate indicator for monetary policy stance for both shocks

**Robust control**

1. Uncertainty induces more aggressive policy response to both shocks
2. Higher weight on interest rate smoothing raises degree of aggressiveness
3. Uncertainty surrounding shock to collateral less relevant
Interest Rates: $R^T - R^B$

Euler equation for fictitious securities $S_t$ (no collateral service)

\[
\frac{1}{1 + R^T_t} = \beta \frac{\lambda_{t+1}}{\lambda_t} \frac{P^A_t}{P^A_{t+1}}
\]

Euler equation for bonds $B_t$ (provide collateral service)

\[
\frac{1}{1 + R^B_t} = \beta \frac{\lambda_{t+1}}{\lambda_t} \frac{P^A_t}{P^A_{t+1}} \frac{1}{1 + R^T_t} \left(1 - \phi \frac{1}{c_i \lambda_t} - 1\right) \Omega_t
\]

It’s instructive to rewrite this as

\[
R^T_t \simeq R^B_t + \left(\phi \frac{1}{c_i \lambda_t} - 1\right) \Omega_t
\]

$LSY^B =$ liquidity service yield on bonds
• Assume there is an interbank market, where the bank can obtain funds at the rate \( R^{IB} \).

• Impose a no-arbitrage condition between loan and asset market → banks provide loans at the rate \( R^T \).

• Banks chose the cost-minimising mix of factor inputs to get real marginal cost of loan production

\[
\frac{\text{factor price}}{\text{factor's marginal product}} = \cdots = \frac{1}{(1 - \alpha)} \cdot \frac{Vm_t w_t}{(1 - rr)c_t}
\]

• Profit maximisation implies approximately

\[
R^T_t \approx R^{IB}_t + \frac{Vm_t w_t}{(1 - \alpha)(1 - rr)c_t}
\]

External Finance Premium