Monetary policy and endogenous financial crises

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Monetary policy sometimes blamed (e.g. for sowing the seeds of the GFC), sometimes praised (e.g. for containing financial risks during Covid–19) for its effects on financial stability.

New–Keynesian (NK) model with micro–founded endogenous financial crises to discipline the discussion over what a central bank should/should not do.

Patterns of a typical financial crisis in the model match key stylized facts in the data:

- follows credit/investment boom (e.g. Schularick and Taylor (2012))
- leads to resource mis–allocation and inefficiently low output (e.g. Campello, Graham, Harvey (2010), Foster, Grim, Haltiwanger (2016) for the GFC)
1. NK model with micro-founded endogenous crises

2. Typical path to crises

3. How does monetary policy affect financial stability?
NK model with micro–founded endogenous crises
1. **Capital accumulation** allows for gradual build-up of financial imbalances via savings

2. **Financial frictions** affect production and occasionally entail "crises"

3. **Model solved globally** to analyze dynamics far from steady-state
1. **Central bank** sets nominal rate in response to inflation and output fluctuations

2. **Households** work, consume, save in a safe bond ($i_t$) and firm equity ($\rightarrow$ MPK)

3. **Monopolistic retailers** sell differentiated final goods and set (sticky) prices

4. **Competitive intermediate goods firms** invest in capital, hire labor, sell goods to retailers
Agents

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4. **Competitive intermediate goods firms** invest in capital, hire labor, sell goods to retailers
   - \(\text{Ex post idiosyncratic productivity shocks}\) → firms may adjust capital stock up/down by borrowing/lending in a loan market
   - Loan market subject to frictions (MH+AI)
   - Loan market may collapse \(\equiv\) crisis → no capital adjustment/reallocation

Note: The equilibrium of the model may also be obtained with a story told in terms of financial intermediation via a banking sector
Agents — Intermediate goods firms

- Firms live one period, from the end of period $t-1$ until the end of period $t$
- At the end of $t-1$, they are identical, issue equity and purchase capital $K_t$
- At the beginning of $t$, they learn their technology $q \in \{0, 1\}$, adjust/resize their capital stock from $K_t$ to $K_t(q)$, take their hiring decision $N_t(q)$

$$Y_t(q) = A_t(qK_t(q))^{\alpha}N_t(q)^{1-\alpha}, \text{ where } q = 0 \text{ or } 1 \text{ with probability } \mu \text{ and } 1 - \mu$$
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\[
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\]

- Reshuffling of capital stock may be done via an intra–period loan market – if functions well:

  - Mass $\mu$ of unproductive firms (with $q = 0$) lend $K_t$ capital goods at rate $r_t^\ell$
  - Mass $1 - \mu$ of productive firms (with $q = 1$) borrow $K_t(1) - K_t$ capital goods at $r_t^\ell$
Firm $q = 1$ maximizes its real return on equity w.r.t. $K_t(1)$ and $N_t(1)$:

$$\max_{K_t(1), N_t(1)} \frac{p_t}{P_t} A_t K_t(1)^\alpha N_t(1)^{1-\alpha} - \omega_t N_t(1) + (1 - \delta) K_t(1) - (1 + r^\ell_t)(K_t(1) - K_t)$$

Firm $q = 1$ borrows and resizes its capital from $K_t$ to $K_t(1) \geq K_t$ only if the aggregate $MPK_t$ (net of capital depreciation) covers the loan rate, i.e.:

$$MPK_t \equiv \frac{\alpha}{M_t} \frac{Y_t(1)}{K_t(1)} \geq r^\ell_t + \delta \quad (PC)$$
Loan market — Frictionless benchmark

- Productive firms break even:

\[
\frac{\alpha}{M_t} \frac{Y_t(1)}{K_t(1)} = r_t^\ell + \delta
\]

- Capital $K_t$ is perfectly reallocated toward the firms with $q = 1$

\[
\mu K_t = (1 - \mu)(K_t(1) - K_t)
\]

- Aggregate output is the same as in the standard NK model (i.e. case with $\mu = 0$)

\[
Y_t = A_t K_t^\alpha N_t^{1-\alpha}
\]
MH: Firms may keep capital $K_t(q)$ idle, abscond, sell $(1 - \delta)K_t(q)$ at the end of the period, and earn $P_t(1 - \delta)K_t(q)$

AI: The $q$s are private information

$\Rightarrow$ Firms with $q = 0$ may mimic firms with $q = 1$, borrow capital and abscond, rather than lend their initial capital stock $K_t$ and earn $P_t(1 + r^\ell_t)K_t$
The loan contract ensures that firms with $q = 0$ lend rather than borrow/abscond

\[ P_t(1 - \delta)K_t(1) \leq P_t(1 + r^\ell_t)K_t \quad \text{(IC)} \]

\[ \Leftrightarrow \quad \frac{K_t(1) - K_t}{K_t} \leq \frac{r^\ell_t + \delta}{1 - \delta} \quad \forall q \in \{0, 1\} \]

- Firms’ borrowing limit increases in $r^\ell_t$ – unproductive firms’ opportunity cost of absconding (i.e. their “skin in the game”)
Loan market — Equilibrium

- Supply from \( q = 0 \) firms:
  \[
  \mu K_t \text{ if } -\delta < r_t^\ell \text{ and 0 otherwise}
  \]

- Demand from \( q = 1 \) firms:
  \[
  (1 - \mu) \frac{r_t^\ell + \delta}{1 - \delta} K_t \text{ if } r_t^\ell \leq \frac{\alpha}{M_t} \frac{Y_t(1)}{K_t(1)} - \delta \text{ and 0 otherwise}
  \]

- Trade takes place if and only if

\[
MPK_t \equiv \frac{\alpha}{M_t K_t} Y_t \geq \frac{(1 - \delta)\mu}{1 - \mu} \equiv \hat{r}^\ell + \delta
\]

where \( M_t \equiv \frac{P_t}{p_t} \)
Aggregate outcome — Crisis versus normal times

- **In crisis times**
  - Financial autarky $\rightarrow$ unproductive firms keep their capital idle
  - Capital mis-allocation lowers aggregate productivity

$$Y_t = A_t ((1 - \mu)K_t)\alpha N_t^{1-\alpha}$$

- **In normal times** capital is fully reallocated $\rightarrow$ the frictional economy resembles the frictionless one...

$$Y_t = A_t K_t^\alpha N_t^{1-\alpha}$$

... except that households may accumulate precautionary savings in anticipation of a crisis

$\rightarrow$ **Financial externalities:** a higher $K_t$ may precipitate the crisis
Aggregate outcome — Two polar types of crisis

Optimal capital accumulation decision rules $K_{t+1}(K_t, A_t, Z_t)$

Real return on capital may decline below the crisis threshold because of

- unusually large adverse shocks → "exogenous crisis"
- excess capital accumulation during an unusually long sequence of favorable shocks → "endogenous crisis"
Typical path to crises
Average crisis episodes — Dynamics under standard Taylor rule (STR)

- Crises occur toward the end of a boom due to long sequences of positive technology and/or demand shocks
- Crises are triggered by relatively mild adverse TFP and/or demand shocks
- TFP shocks are prevalent in the build-up of crises

- \textbf{Crises occur toward the end of a boom due to long sequences of positive technology and/or demand shocks}\
  ![](image1)

- \textbf{Crises are triggered by relatively mild adverse TFP and/or demand shocks}\
  ![](image2)

- \textbf{TFP shocks are prevalent in the build-up of crises}\
  ![](image3)

- \textbf{Techno vs demand statistics}

- Parametrisation

- Techno vs demand shocks
How does monetary policy affect financial stability?
Channels

- Probability that a crisis breaks out next period:

\[ \mathbb{E}_{t-1} \left( \mathbb{I} \left\{ \frac{\alpha Y_t}{M_t K_t} < \frac{(1 - \delta)\mu}{1 - \mu} \right\} \right) \]

- The central bank affects financial stability by the way it

  (i) stabilizes aggregate output (\(Y\)) and inflation (\(M\)) in response to contemporaneous shocks \(\rightarrow\) **short–term dimension**

  (ii) affects capital accumulation (\(CA\)) along the business cycle \(\rightarrow\) **long/medium–term dimension**
### Probability of a crisis under alternative monetary policy regimes

<table>
<thead>
<tr>
<th></th>
<th>% Crisis time</th>
<th>Length</th>
<th>% Nb crises</th>
<th>Output loss</th>
<th>YMCA channels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$\sigma(Y_t)$</td>
</tr>
<tr>
<td>STR</td>
<td>10</td>
<td>1.86</td>
<td>5.48</td>
<td>-2.73</td>
<td>4.36</td>
</tr>
<tr>
<td>SIT</td>
<td>1.91</td>
<td>4.47</td>
<td>0.43</td>
<td>-5.84</td>
<td>4.49</td>
</tr>
<tr>
<td>$\alpha_y &gt; 0.5/4$</td>
<td>0.50</td>
<td>1.78</td>
<td>0.28</td>
<td>-2.27</td>
<td>3.17</td>
</tr>
</tbody>
</table>

- SIT significantly reduces the time spent in crisis relative to STR $\rightarrow$ eliminates both demand–driven and mixed crises
- A stronger response to output can eliminate even more crises relative to STR than SIT
Financial stability gains of $\phi_y > 0.5/4$ in the short and long run

(i) Improved CA channel: Households accumulate less capital during booms than under SIT or STR since:
- expected real return on investment is lower
- are better insured against negative shocks (less need for precautionary savings)

(ii) Improved Y and M channels
- Y better stabilized in response to adverse shocks
- M declines more in response to adverse TFP shocks
Policy trade–off

- No financial frictions: stabilizing inflation (SIT) is optimal

⇒ Relative to SIT, in "normal" times, variations in macro–variables in response to demand and technology shocks under $\phi_y > \frac{0.5}{4}$ are inefficient

- A benevolent central bank may choose $\phi_y > \frac{0.5}{4}$ instead of SIT only if the financial stability gains exceed the losses in the face of business cycle fluctuations in normal times
Breaking the “divine coincidence”

- No financial frictions: stabilizing inflation (SIT) is optimal
- Financial frictions: responding more strongly to output relative to STR may outperform SIT

<table>
<thead>
<tr>
<th>Policy rules</th>
<th>PCE (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STR</td>
<td>–</td>
</tr>
<tr>
<td>SIT</td>
<td>0.0560</td>
</tr>
<tr>
<td>$\alpha_y &gt; 0.5/4$</td>
<td>0.0641</td>
</tr>
</tbody>
</table>
(i) Keeping policy unexpectedly loose for a long time ("too low for too long") may feed an investment boom (in line with US’s 2003–5 ‘Great Deviation’ hypothesis)

(ii) Unexpected rate hikes toward the end of a boom may contract demand and trigger a crisis (in line with Schularick et al 2021)
Takeaways (so far)

1. “Canonical” NK model with endogenous financial crises + micro-foundations to existing reduced form models
   - Crises follow investment booms due to favorable shocks
   - Monetary policy affects financial stability through YMCA channels

2. Benevolent central bank trades off the short-term cost (deviations from first best in normal times) and medium/long-term benefits (fewer/milder financial crises)
   - With prevalent technology-driven crises, a stronger response to output than under STR may be warranted
   - Unexpectedly keep rates low for long, or unexpectedly tighten policy on the heals of booms may trigger financial crises
Backup Slides
The “Great Deviation” (John Taylor)

Note that the target funds rate predicted by the Taylor formula generally tracks the actual funds rate through 2000, though there are sizable and persistent deviations of the funds rate from the values predicted by the formula. Nevertheless several of these episodes are consistent with a systematic monetary policy. First, in 1989, the FOMC increased the target funds rate more quickly than predicted by the formula, suggesting that the Committee responded more vigorously to rising inflation than incorporated in the Taylor specification. Second, during 1990-91, the FOMC reduced the funds rate more quickly than predicted by the formula, suggesting a stronger response to the recession than incorporated in the Taylor specification. Third, between late September 1992 and February 1994, the target funds rate was held at a lower level (3 percent) than predicted by the Taylor specification. It was during this period that the FOMC expressed concern about “financial headwinds” that were restraining the recovery from the 1990-91 recession. Finally, in the fall of 1998, the FOMC lowered the funds rate when the Taylor specification predicted that the rate would be held constant. At this time, concern about financial stability figured strongly in policy deliberations in the wake of the Asian financial crisis, the Russian Default, and the collapse of Long-Term Capital Management (LTCM).

The FOMC, and certainly John Taylor himself, view the Taylor rule as a general guideline. Departures from the rule make good sense when information beyond that incorporated in the rule is available. For example, policy is forward looking, which means that from time to time the economic outlook changes sufficiently that it makes sense for the FOMC to set a funds rate target either above or below the level called for in the Taylor rule, which relies on observed recent data rather than on economic forecasts of future data. Other circumstances—an obvious example is September 11, 2001—call for a policy response. These responses can be and generally are understood by the market. Thus, such responses can be every bit as systematic as the responses specified in the Taylor rule.


Figure 1
Greenspan Years: Federal Funds Rate and Taylor Rule (CPI $p^* = 2.0$, $r^* = 2.0$) $a = 1.5$, $b = 0.5$
Monetary policy during the Covid–19 crisis

Evolution of monetary policy rates

- Forceful monetary policy boost matches fiscal largesse
- Many central banks cut policy rates to all-time lows, often to effective lower bound
- Also deployed unconventional tools on an unparalleled scale, including in many EMEs: large-scale asset purchases, special lending programmes, forward guidance, yield curve control.
- Central bank balance sheet at a historical high: largely increased holdings of government bonds

Weekly announcements of policies

- Standardised information for 39 economies, based on central banks' public announcements of monetary policy measures.
- Announcements classified into 5 types of tools: interest rate measures, reserve policies, lending operations, asset purchase programmes and foreign exchange operations.
2. **Employment**, inflation, employment, and long-term interest rates fluctuate over time in response to economic and financial disturbances. Monetary policy plays an important role in stabilizing the economy in response to these disturbances. The Committee’s primary means of adjusting the stance of monetary policy is through changes in the target range for the federal funds rate. The Committee judges that the level of the federal funds rate consistent with maximum employment and price stability over the longer run has declined relative to its historical average. Therefore, the federal funds rate is likely to be constrained by its effective lower bound more frequently than in the past. Owing in part to the proximity of interest rates to the effective lower bound, the Committee judges that downward risks to employment and inflation have increased. The Committee is prepared to use its full range of tools to achieve its maximum employment and price stability goals. Moreover, monetary policy actions tend to influence economic activity and prices with a lag. Therefore, the Committee’s policy decisions reflect its longer-run goals, its medium-term outlook, and its assessments of the balance of risks, including risks to the financial system that could impede the attainment of the Committee’s goals.

5. Monetary policy actions tend to influence economic activity, employment, and prices with a lag. In setting monetary policy, the Committee seeks over time to mitigate shortfalls of employment from the Committee’s assessment of its maximum level and deviations of inflation from its longer-run goal and deviations of employment from the Committee’s assessments of its maximum level. Moreover, sustainably achieving maximum employment and price stability depends on a stable financial system. Therefore, the Committee’s policy decisions reflect its longer-run goals, its medium-term outlook, and its assessments of the balance of risks, including risks to the financial system that could impede the attainment of the Committee’s goals.
Monetary policy rule

\[ 1 + i_t = \frac{1}{\beta} (1 + \pi_t)^{1.5} \left( \frac{Y_t}{Y} \right)^{0.125} \]

STR (Taylor (1993))
Households

\[
\mathbb{E}_0 \left[ \sum_{t=0}^{\infty} \beta^t \left( \frac{C_t^{1-\sigma}}{1-\sigma} - \nu N_t^{1+\nu} \right) \right]
\]

\[
P_t C_t + B_{t+1} + P_t K_{t+1} \leq P_t \omega_t N_t + (1 + i_{t-1}) B_t + P_t (1 + r^k_t) K_t + X_t
\]

\[
\beta \mathbb{E}_t \left[ \left( \frac{C_{t+1}}{C_t} \right)^{-\sigma} \frac{1 + i_t}{1 + \pi_{t+1}} \right] = Z_t
\]

\[
\beta \mathbb{E}_t \left[ \left( \frac{C_{t+1}}{C_t} \right)^{-\sigma} (1 + r^k_{t+1}) \right] = 1
\]

\[
\nu N_t^\nu C_t^\sigma = \omega_t
\]
\[ \mathbb{E}_0 \left[ \sum_{t=0}^{\infty} \Lambda_{0,t} \left( \frac{P_t(j)}{P_t} Y_t(j) - \frac{p_t}{P_t} Y_t(j) - \frac{\rho}{2} Y_t \left( \frac{P_t(j)}{P_{t-1}(j)} - 1 \right)^2 \right) \right] \]

\[ Y_t(j) = \left( \frac{P_t(j)}{P_t} \right)^{-\epsilon} Y_t \]

\[ (1 + \pi_t) \pi_t = \mathbb{E}_t \left( \Lambda_{t,t+1} \frac{Y_{t+1}}{Y_t} (1 + \pi_{t+1}) \pi_{t+1} \right) - \frac{\epsilon - 1}{\rho} \left( 1 - \frac{\epsilon}{\epsilon - 1} \mathcal{M}_t \right) \]

where

\[ \mathcal{M}_t \equiv \frac{P_t}{p_t} \]
\[ \max_{K_t(1), N_t(1)} \frac{p_t}{P_t} A_t K_t(1)^\alpha N_t(1)^{1-\alpha} - \omega_t N_t(1) + (1 - \delta) K_t(1) - (1 + r^\ell_t)(K_t(1) - K_t) \]

Substituting the FOC w.r.t. \( N_t(1) \) into the firm’s profits yields

\[ \max_{K_t(1)} \frac{\alpha}{\mathcal{M}_t} \frac{Y_t(1)}{K_t(1)} K_t(1) + (1 - \delta) K_t - (r^\ell_t + \delta)(K_t(1) - K_t) \]

Since \( Y_t = (1 - \mu) Y_t(1) \), \( K_t = (1 - \mu) K_t(1) \) and \( \frac{Y_t(1)}{K_t(1)} = A_t^{\frac{1}{\alpha}} \left( \frac{1}{\mathcal{M}_t \omega_t} \right)^{\frac{1-\alpha}{\alpha}} = \frac{Y_t}{K_t} \), one gets:

\[ \max_{K_t(1)} \left( \frac{\alpha}{\mathcal{M}_t} \frac{Y_t}{K_t} - (r^\ell_t + \delta) \right) K_t(1) \]

\[ \Rightarrow \text{The firm will resize its capital stock to } K_t(1) \geq K_t \text{ if } \text{MPK} \equiv \frac{\alpha}{\mathcal{M}_t} \frac{Y_t}{K_t} \geq r^\ell + \delta \]
Frictionless case
Loan market equilibrium

\[ r^\ell \equiv \frac{(1-\delta)\mu}{1-\mu} - \delta \]

Frictional case
The fall in MPK reduces borrowers' ability to pay the loan rate required to preserve unproductive firms' incentives. $r_t^\ell$ must be above $\hat{r}^\ell$ to entice unproductive firms to lend rather than borrow and abscond.
Loan market equilibrium

- Financial autarky
- When $\frac{\alpha Y_t}{M_tK_t} < \hat{r}^\ell + \delta$ productive firms cannot afford the required loan rate $\rightarrow E$ not sustainable
1. \( Z_t = E_t \left\{ \Lambda_{t,t+1}(1 + r_{t+1}) \right\} \)

2. \( 1 = E_t \left\{ \Lambda_{t,t+1}(1 + r_{t+1}^k) \right\} \)

3. \( \omega_t = \vartheta N_t^\nu C_t^\sigma \)

4. \( Y_t = A_t \left( (1 + \phi_t)(1 - \mu)K_t \right)^\alpha N_t^{1-\alpha} \)

5. \( \omega_t = (1 - \alpha) \frac{Y_t}{M_t N_t} \)

6. \( r_t^k + \delta = \alpha \frac{Y_t}{M_t K_t} \)

7. \( (1 + \pi_t)\pi_t = E_t \left( \frac{\Lambda_{t,t+1}}{Y_t} \frac{Y_{t+1}}{(1 + \pi_{t+1})\pi_{t+1}} \right) - \frac{\epsilon - 1}{\theta} \left( 1 - \frac{\epsilon}{\epsilon - 1} \cdot \frac{1}{M_t} \right) \)

8. \( 1 + i_t = \frac{1}{\beta} (1 + \pi_t)^{\alpha \pi} \left( \frac{Y_t}{\bar{Y}} \right)^{\alpha y} \)

9. \( Y_t = C_t + K_{t+1} - (1 - \delta)K_t \)

10. \( \phi_t = \begin{cases} \frac{\mu}{1 - \mu}, & \text{if } r_t^k + \delta \geq \frac{(1 - \delta)\mu}{1 - \mu} \\ 0, & \text{otherwise} \end{cases} \)

11. \( \Lambda_{t,t+1} \equiv \beta \frac{C_{t+1}^{\sigma-\sigma}}{C_t^{\sigma-\sigma}} \)

12. \( 1 + r_t \equiv \frac{1 + i_{t-1}}{1 + \pi_t} \)
The return on equity and the more resilient the loan market in the face of adverse shocks (i.e., the weaker the CA–channel). Intuitively, smoothing the business cycle helps the central bank address the savings glut externality. This is akin to providing the household with an insurance against future aggregate shocks that helps them smooth consumption and reduces their need for accumulating savings during booms. For this reason, and as we show later, monetary rules that are more aggressive toward variations in output are more effective in lowering the crisis probability.

Insofar as capital accumulation takes time, this channel of monetary policy only materializes itself over multiple years.

### 3.2 Parametrization of the model

We parameterize our model based on quarterly data (see Table 1) and under STR (our baseline). The model is a standard NK model with endogenous capital accumulation, except that firms differ in terms of their technology — their $q_s$. Accordingly, the only non–standard parameters in the model relate to the distribution of the idiosyncratic productivity shocks $\mu(q)$. For the sake of parsimony, we assume that $\mu(q)$ takes the following simple form:

$$\mu(q) = \mu + (1 - \mu)q^\lambda$$

As parameters $\lambda$ and $\mu$ govern the dispersion of firm productivity shocks, they also determine the degree of asymmetric information and, therefore, the size of financial frictions in the economy.

### Table 1: Parametrization

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Target Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preferences</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta$</td>
<td>4% annual real interest rate</td>
<td>0.989</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Logarithmic utility on consumption</td>
<td>1.000</td>
</tr>
<tr>
<td>$\nu$</td>
<td>Inverse Frish elasticity equals 2</td>
<td>0.500</td>
</tr>
<tr>
<td>$\vartheta$</td>
<td>Steady state hours equal 1</td>
<td>0.757</td>
</tr>
<tr>
<td><strong>Technology and price setting</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha$</td>
<td>64% labor share</td>
<td>0.289</td>
</tr>
<tr>
<td>$\delta$</td>
<td>6% annual capital depreciation rate</td>
<td>0.015</td>
</tr>
<tr>
<td>$\varphi$</td>
<td>Same slope of the Phillips curve as with Calvo price setting</td>
<td>105.000</td>
</tr>
<tr>
<td>$\epsilon$</td>
<td>11% markup rate</td>
<td>10.000</td>
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<tr>
<td><strong>Aggregate shocks</strong></td>
<td></td>
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<tr>
<td>$\rho_a$</td>
<td>Persistence of TFP</td>
<td>0.950</td>
</tr>
<tr>
<td>$\sigma_a$</td>
<td>Standard deviation of TFP innovation (in %)</td>
<td>0.700</td>
</tr>
<tr>
<td>$\rho_z$</td>
<td>Persistence in Smets and Wouters (2007)</td>
<td>0.220</td>
</tr>
<tr>
<td>$\sigma_z$</td>
<td>Standard deviation of risk–premium innovation in Smets and Wouters (2007) (in %)</td>
<td>0.230</td>
</tr>
<tr>
<td><strong>Idiosyncratic productivity shocks</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\lambda$</td>
<td>2pp spread in normal times</td>
<td>23.000</td>
</tr>
<tr>
<td>$\mu$</td>
<td>The economy spends 10% of the time in a crisis</td>
<td>0.0176</td>
</tr>
</tbody>
</table>

![Cumulative distribution mu(q)](image)
Monetary policy rule

\[ 1 + i_t = \frac{1}{\beta} (1 + \pi_t)^{1.5} \left( \frac{Y_t}{Y} \right)^{\alpha_y} \]

→ We experiment with values of $\alpha_y$ higher than under STR, i.e. $\alpha_y > 0.5/4$
### Average crisis statistics under STR — Demand versus TFP shocks

<table>
<thead>
<tr>
<th>Model</th>
<th>% Crisis time</th>
<th>Length</th>
<th>% Nb crises</th>
<th>Output loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline model</td>
<td>[10.00]</td>
<td>1.86</td>
<td>5.48</td>
<td>−2.73</td>
</tr>
<tr>
<td>Model with TFP shocks only</td>
<td>5.53</td>
<td>7.67</td>
<td>0.72</td>
<td>−5.39</td>
</tr>
<tr>
<td>Model with demand shocks only</td>
<td>1.25</td>
<td>1.05</td>
<td>1.19</td>
<td>−2.65</td>
</tr>
</tbody>
</table>

- Technology–driven crises last longer and, therefore, are deeper
  - Because technology shocks are more persistent than demand shocks
- The economy spends more time in technology–driven crises, even though they are less frequent than demand–driven ones
The loan market is more fragile toward the end of a boom

Generalized IRF – Negative TFP shock

Generalized IRF — Negative demand shock

$K_0$ is 2% below $\bar{K}$

$K_0$ is 2% above $\bar{K}$

$K_0$ is 6% above $\bar{K}$

$K_0$ is 1% above $\bar{K}$

$K_0$ is 3% above $\bar{K}$

$K_0$ is 5% above $\bar{K}$
Economies with either technology or demand shocks

- Investment booms are caused by long sequence of favorable technology shocks
- Demand–driven booms are not accompanied with productivity gains and positive demand shocks are short–lived → crises tend to break out before capital builds up
Next, we compare LAW with STR. LAW stabilizes the loan market mainly through the Y- and CA-channels. Table 5 indeed shows that output and capital are less volatile ($\sigma(Y_t)$ and $\sigma(K_t - 1)$ are lower) under LAW, which reduces the probability that the return on capital falls below the crisis threshold. These lower volatilities are both due to the central bank’s stronger stabilization of output in the face of adverse (demand and technology) shocks (see Figure 4) and to a slower capital accumulation during booms (see Figure 5, panel (c)). As the central bank commits itself to reining booms more aggressively under LAW than under STR, the household indeed expects lower equity.
Crisis statistics: technology– and demand–driven crises

<table>
<thead>
<tr>
<th></th>
<th>% Crisis time</th>
<th>Length</th>
<th>% Nb crises</th>
<th>Output loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crisis due to TFP shocks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STR</td>
<td>5.45</td>
<td>7.58</td>
<td>0.72</td>
<td>−5.39</td>
</tr>
<tr>
<td>SIT</td>
<td>1.91</td>
<td>4.48</td>
<td>0.43</td>
<td>−5.84</td>
</tr>
<tr>
<td>LAW–φ</td>
<td>0.86</td>
<td>5.43</td>
<td>0.16</td>
<td>−4.13</td>
</tr>
<tr>
<td>LAW–y⁽L⁾</td>
<td>1.06</td>
<td>3.07</td>
<td>0.35</td>
<td>−3.80</td>
</tr>
<tr>
<td>LAW–y⁽M⁾</td>
<td>0.67</td>
<td>3.52</td>
<td>0.19</td>
<td>−3.43</td>
</tr>
<tr>
<td>LAW–y⁽H⁾</td>
<td>0.34</td>
<td>3.16</td>
<td>0.11</td>
<td>−3.39</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crisis due to demand shocks</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>STR</td>
<td>1.24</td>
<td>1.05</td>
<td>1.18</td>
<td>−2.65</td>
</tr>
<tr>
<td>SIT</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>LAW–φ</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
<td>−2.84</td>
</tr>
<tr>
<td>LAW–y⁽L⁾</td>
<td>0.00</td>
<td>0.00</td>
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<td>0.00</td>
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<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Note:** The subset of crises specifically due to technology (resp. demand) shocks correspond to the crises that would have broken out even in the absence of demand (resp. technology) shocks.
Current US monetary policy stance

Sources: Wu-Xia Shadow Federal Funds Rate - Federal Reserve Bank of Atlanta [atlantafed.org] and Simple Monetary Policy Rules: Archives [clevelandfed.org]
Related literature

- **Monetary policy and financial stability**
  

- **Quantitative non-linear DGSE models with endogenous financial crises**
  
  Boissay, Collard, Smets (2016), Gertler, Kiyotaki, Prestipino (2020)

- **Capital mis-allocation during financial crises**
  
During a boom, the policy rate may be lower under LAW than under STR.

Permanent income effects are smaller under LAW than under STR.

Aggregate demand increases by less during technology-driven booms.

Productivity gains are more deflationary under LAW than under STR and call for a lower rate.

The rate cut due to lower inflation more than offsets the rate hike due to the higher coefficient on output in the LAW rule.
Discussion – Cleaning also helps to curb booms

\[
1 + i_t = \frac{1}{\beta} (1 + \pi_t)^{1.5} \left( \frac{Y_t}{Y} \right)^{0.125} - \frac{0.0083}{4} \times \mathbb{1} \left\{ \frac{\alpha Y_t}{M_t K_t} < \frac{(1 - \delta)\mu}{1 - \mu} \right\}
\]

- Commitment to additional policy rate cuts during crises ("CLEAN") affects anticipations and precautionary savings
- CLEAN addresses the savings glut externalities and curbs the boom ahead of the crisis