Booms and Banking Crises

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The views expressed in this presentation are our own and do not necessarily reflect those of the European Central Bank or the Eurosystem.
Motivation/Objective

- Better understand the dynamics of financial and real business cycles
- A few features are common to financial recessions (i.e. recessions concomitant with banking crises):
  - Fact #1: They are rare events
  - Fact #2: They are deeper and last longer
  - Fact #3: Unlike other types of recessions, financial recessions follow credit booms
## Motivation/Objective

### Financial recession statistics

<table>
<thead>
<tr>
<th></th>
<th>Financial</th>
<th>Other</th>
<th>Severe</th>
<th>Mild</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency (%)</strong></td>
<td>2.36</td>
<td>8.93</td>
<td>4.05</td>
<td>4.05</td>
</tr>
<tr>
<td><strong>Duration (years)</strong></td>
<td>2.32***</td>
<td>1.65</td>
<td>2.46***</td>
<td>1.25</td>
</tr>
<tr>
<td><strong>Magnitude (%)</strong></td>
<td>-6.84***</td>
<td>-3.75</td>
<td>-9.28***</td>
<td>-0.89</td>
</tr>
</tbody>
</table>

### Credit Boom

- % credit growth 2 years before peak (a) | 4.56*** | 0.01 | 1.33 | 0.40 |

### Credit Crunch

- % credit growth 2 years after peak (a) | -3.59*  | -1.24 | -1.69 | -2.44 |

Source: Schularik et al. (2011), data for 14 OECD countries, 1870-2008. Crises defined as in Laeven and Valencia (2008); *,**,***: the difference is statistically significant at 10%, 5%, 1%; (a) HP–filtered credit.
In most DSGE models financial recessions are big negative shocks amplified
Can explain Facts #1 & #2
**Cannot explain Key Fact #3** ← crises are not random
Our Framework

- Textbook stochastic optimal growth model (RBC)
- Heterogenous banks with intermediation and storage technologies
- Interbank market subject to MH and AI
- A banking crisis is an interbank market freeze
- Spill-over and feedback effects between the interbank market, the retail corporate loan market, and the real economy
Main Results

1. Normal times feature productivity–driven business cycles with a small financial accelerator; a crisis every 42 years.
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2. The typical banking crisis follows an unusually long sequence of small, positive, transitory productivity shocks — No need for a large negative financial shock.
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3. High productivity generates a credit boom and a ballooning banking sector
Main Results

1. Normal times feature productivity–driven business cycles with a small financial accelerator; a crisis every 42 years.

2. The **typical banking crisis follows an unusually long sequence of small, positive, transitory productivity shocks** — No need for a large negative financial shock.

3. High productivity generates a credit boom and a ballooning banking sector.

4. As productivity gains peter out, excess savings arise ("saving glut") and interest rates fall; counterparty fears rise in the interbank market, which may lead to a freeze and banking crisis.
Main Results

1. Normal times feature productivity–driven business cycles with a small financial accelerator; a crisis every 42 years.

2. The typical banking crisis follows an unusually long sequence of small, positive, transitory productivity shocks — No need for a large negative financial shock.

3. High productivity generates a credit boom and a ballooning banking sector.

4. As productivity gains peter out, excess savings arise ("saving glut") and interest rates fall; counterparty fears rise in the interbank market, which may lead to a freeze and banking crisis.

5. The subsequent financial recession is deep and long because of a credit crunch; credit–to–GDP ratio predicts financial recessions.
Related literature

  - Full equilibrium non-linearities, such as sudden bank runs

- Bianchi (2009), Bianchi-Mendoza (2010):
  - Endogenous interest rates play a key role

- Brunnermeier-Sannikov (2012), He-Krishnamurthy (2012):
  - Typical crisis follows a rare, long sequence of positive TFP shocks
  - Typical crisis identified as a bank run, not as a binding borrowing constraint

- Gertler-Kiyotaki (2012)
  - Bank run is market based and rationally expected
Model setup

Overview

- Bank deposits/equity $a_t$
- Return on savings $r_t a_t$
- Intermediation cost
- Corporate Loans $k_t$
- Loan payments $p_t k_t$
Firm: \[ \max \{k_t, h_t\} \pi_t = F(k_t, h_t; z_t) + (1 - \delta)k_t - R_t k_t - w_t h_t \]

Household:

\[
\max_{\{a_{t+\tau+1}, c_{t+\tau}, h_{t+\tau}\}_{\tau=0}^{\infty}} \mathbb{E}_t \sum_{\tau=0}^{\infty} \beta^{\tau} u(c_{t+\tau}, h_{t+\tau})
\]

subject to budget constraint

\[ c_t + a_{t+1} = r_t a_t + w_t h_t + \pi_t + \chi_t \]

- Notice that \( r_t \leq R_t \) (spread) and \( k_t \leq a_t \) (credit crunch)
Banks are atomistic, competitive, and price takers.

Continuum of heterogeneous 1–period banks $p$, with cdf $\mu(p)$ over $(0, 1)$.

Bank $p$’s net return per unit of corporate loan is $pR_t$.

It is beneficial to relocate funds, but relocation is impaired due to:

- Asymmetric information: $p$ is private information.
- Moral hazard: bank $p$ may borrow $\phi_t$ and walk away (“diversion”).
Banks are atomistic, competitive, and price takers

Continuum of heterogeneous 1-period banks $p$, with $cdf \mu(p)$ over $(0, 1)$

Bank $p$’s net return per unit of corporate loan is $pR_t$

It is beneficial to relocate funds, but relocation is impaired due to:

- **Asymmetric information**: $p$ is private information
The Banking Sector

- Banks are atomistic, competitive, and price takers
- Continuum of heterogeneous 1–period banks \( p \), with \( cdf \ \mu(p) \) over \((0, 1)\)

\[
\begin{align*}
& \text{Collect Deposits } \ a_t \\
& \text{Draw skill } \ p \in (0, 1) \\
& \text{Die}
\end{align*}
\]

- Bank \( p \)'s net return per unit of corporate loan is \( pR_t \)
- It is beneficial to relocate funds, but relocation is impaired due to:
  - **Asymmetric information**: \( p \) is private information
  - **Moral hazard**: bank \( p \) may borrow \( \phi_t \) and walk away ("diversion")
Bank $p$ has 4 options:

1. Lend to other banks on the interbank market $\rightarrow \rho_t$
2. Store goods $\rightarrow \gamma$
3. Raise funds $\phi_t$ from interbank market and lend to firm $\rightarrow pR_t (1 + \phi_t) - \rho_t \phi_t$
4. Raise funds $\phi_t$ from interbank market and walk away $\rightarrow \gamma (1 + \theta \phi_t)$

**Incentives to divert depend on the corporate loan rate:** the lower $R_t$, the higher these incentives, and the more counterparty fears on the interbank market.
The Borrowing Bank’s Problem

- Borrowing bank \( p \) solves:
  \[
  \max_{\phi_t} r_t(p) \equiv pR_t(1 + \phi_t) - \rho_t \phi_t
  \]

  \begin{align*}
  PC : & \quad pR_t(1 + \phi_t) - \rho_t \phi_t \geq \rho_t \quad \Rightarrow \quad p \geq \bar{p}_t \equiv \rho_t / R_t \\
  IC : & \quad \gamma (1 + \theta \phi_t) \leq \rho_t \quad \Rightarrow \quad \phi_t = (\rho_t - \gamma) / \theta \gamma
  \end{align*}

- Profits are fully distributed to household: 
  \[
  r_t \equiv \int_0^1 r_t(p) \, d\mu(p)
  \]
Interbank Market Equilibrium

Interbank market clearing condition

Supply \((+)\)

\[
\mu(\bar{p}_t) = \frac{(1 - \mu(\bar{p}_t)) \times \phi_t}{\phi_t}
\]

"extensive margin" \((-\)}

"intensive margin" \((+)\)

Demand bends backward \((+ or -)\)

with \(\bar{p}_t \equiv \rho_t / R_t\) and \(\phi_t = (\rho_t - \gamma) / \theta \gamma\)

Two opposite effects on aggregate demand of a decrease in \(\rho_t\)
Interbank Market Equilibrium

The interbank market freezes when the retail corporate loan rate is below a threshold.
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Interbank Market Equilibrium
The interbank market freezes when the retail corporate loan rate is below a threshold.
Absorption Capacity and Market Freeze

- **Proposition (Interbank loan market freeze):** The interbank loan market is at work if and only if \( a_t \leq \bar{a}_t \equiv f_k^{-1}(\bar{R} + \delta - 1; z_t) \), and freezes otherwise.

- The interbank market improves efficiency but freezes when \( R_t < \bar{R} \)
- In general equilibrium, \( R_t \) is driven by savings \( (a_t) \) and technology \( (z_t) \). Hence the interbank market freezes when \( a_t > \bar{a}(z_t) \)
- **Threshold** \( \bar{a}(z_t) \) is the banking sector's "absorption capacity"
Calibration of the real side is standard

Financial sector \((\gamma, \theta, \mu(.))\) is calibrated so that:

- Crisis probability is 2.3%
- Average interest rate spread is 1.7%
- Average corporate loan rate of 4.4%

The model is solved numerically by a collocation method
Quantitative Analysis
Optimal savings rule: exogenous versus endogenous crises

Variety of crises: shock–driven (S) and credit boom–driven (U)

History suggests that credit–boom driven crises prevail

Note: Dashed line: 45° line where $a_{t+1} = a_t$. 
Quantitative Analysis

Typical path to crisis

- Dynamics in normal times,
- Dynamics during a crisis,
- Dynamics of $\bar{a}_t$,
- Average across simulations,
- 66% Confidence band around typical path,
- Underlying TFP innovations ($\varepsilon_t$).
Quantitative Analysis

Typical path to crisis

- Corporate Loan Rate
- Return on Deposits
- Credit/Output
Quantitative Analysis

Typical path to crisis

Output

Consumption

1-step ahead Proba.
At the beginning, a positive shock brings TFP above its mean

- Credit demand rises. Return on savings goes up. The household accumulates assets for *consumption smoothing*

TFP goes down back to mean but remains above it for a long time

- Credit demand decreases, while the household keeps on accumulating savings; interest rates go down

As the probability of a crisis increases, the household maintains savings to hedge against a more likely loss of revenue, which works to reduce interest rates and to raise the likelihood of a crisis even further — *saving glut externality*

A crisis breaks out as the corporate loan $R_t$ rate crosses threshold $\bar{R}$
# Quantitative Assessment

## Financial recession statistics

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<th>Severe</th>
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<tr>
<td>Frequency (%)</td>
<td>2.35</td>
<td>8.94</td>
<td>3.76</td>
<td>3.76</td>
</tr>
<tr>
<td>Duration (years)</td>
<td>2.08</td>
<td>1.39</td>
<td>2.22</td>
<td>1.04</td>
</tr>
<tr>
<td>Magnitude (%)</td>
<td>-12.60</td>
<td>-4.98</td>
<td>-11.32</td>
<td>-3.28</td>
</tr>
</tbody>
</table>

### Credit Boom

- % credit growth 2 years before peak (a)  
  - Financial: 3.81  
  - Other: 0.11  
  - Severe: 2.33  
  - Mild: 0.06

### Credit Crunch

- % credit growth 2 years after peak (a)  
  - Financial: -5.09  
  - Other: 0.09  
  - Severe: -2.97  
  - Mild: 0.02

(a) HP–filtered credit.
## Welfare

%-Loss in permanent consumption

<table>
<thead>
<tr>
<th>Financial frictions</th>
<th>Deficient institutions</th>
<th>Externalities</th>
<th>Fin. under-development</th>
</tr>
</thead>
<tbody>
<tr>
<td>FBA – DEA</td>
<td>FBA – CEA</td>
<td>CEA – DEA</td>
<td>DEA – NIM</td>
</tr>
<tr>
<td>2.20</td>
<td>1.53</td>
<td>0.61</td>
<td>4.61</td>
</tr>
</tbody>
</table>

FBA: Fist Best Allocation; DEA: Decentralized Equilibrium Allocation
CEA: Constrained Efficient Allocation; NIM: No Interbank Market
Concluding Remarks

- Develop a simple quantitative macro-model with banking crises, where crises are not caused by large, negative, financial shocks but rather by long sequences of small, positive, productivity shocks
- Credit booms are conducive to crises
- Highlight the role of consumption smoothing and saving glut externalities
- From a policy making perspective:
  - Framework for both crisis management and crisis prevention
  - DSGE-based probability of a crisis
THANK YOU
Return on Deposits and Corporate Loan Supply

- Return on deposits:

\[
R_t \left\{ \begin{array}{ll}
R_t \int_0^1 p \frac{d\mu(p)}{1-\mu(p)} & , \text{if an equilibrium with trade exists} \\
R_t \left( \frac{\gamma}{R_t} \mu \left( \frac{\gamma}{R_t} \right) + \int_0^{\frac{\gamma}{R_t}} p \, d\mu(p) \right) & , \text{otherwise.}
\end{array} \right.
\]

- Corporate loan supply

\[
k_t^s = \left\{ \begin{array}{ll}
a_t & , \text{if an equilibrium with trade exists} \\
\left(1 - \mu \left( \frac{\gamma}{R_t} \right) \right) a_t & , \text{otherwise}
\end{array} \right.
\]
Interest Rates
Endogenous and exogenous sources of instability

(a) Assets \( (a_t) \) as endogenous source of crisis

(b) Productivity \( (z_t) \) as exogenous source of crisis
Optimal Decision Rules
Typical paths to crisis without smoothing or externality

- Baseline;
- No saving glut externality;
- Constant saving rate.
Quantitative Assessment
Dynamics of output and credit gaps around recessions

(a) Financial Recessions

Output (% deviation about trend)

Credit (% deviation about trend)

Model, Data; 66% Confidence band (model)
Quantitative Assessment
Dynamics of output and credit gaps around recessions

(b) Normal Recessions

Output
(% deviation about trend)

Credit
(% deviation about trend)

Model, Data; 66% Confidence band (model)
### Crisis Prediction

Type–I and Type–II errors

<table>
<thead>
<tr>
<th>Model Probability (benchmark)</th>
<th>Probability regressions</th>
<th>Logit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td>$z$</td>
<td>$a$</td>
</tr>
<tr>
<td>$R^2$</td>
<td>—</td>
<td>0.03</td>
</tr>
<tr>
<td>F-Test</td>
<td>—</td>
<td>0.00</td>
</tr>
<tr>
<td>Type-I errors (%)</td>
<td>31.43</td>
<td>100.00</td>
</tr>
<tr>
<td>Type-II errors (%)</td>
<td>4.85</td>
<td>0.00</td>
</tr>
<tr>
<td>N. warnings</td>
<td>30,215</td>
<td>0</td>
</tr>
<tr>
<td>N. crises</td>
<td>11,739</td>
<td>11,739</td>
</tr>
<tr>
<td>N. obs (simul.)</td>
<td>468,769</td>
<td>468,769</td>
</tr>
</tbody>
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Booms and Banking Crises
## Sensitivity Analysis

### Financial recession statistics

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>$\sigma$</th>
<th>$\nu$</th>
<th>$\theta$</th>
<th>$\lambda$</th>
<th>$\sigma_z$</th>
<th>$\rho_z$</th>
<th>Altern.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>0.25</td>
<td>0.15</td>
<td>20</td>
<td>0.025</td>
<td>0.70</td>
<td>TFP</td>
</tr>
<tr>
<td>Frequency (%)</td>
<td>2.35</td>
<td>4.74</td>
<td>3.45</td>
<td>5.87</td>
<td>5.73</td>
<td>4.56</td>
<td>4.34</td>
<td>2.32</td>
</tr>
<tr>
<td>Duration (years)</td>
<td>2.08</td>
<td>1.75</td>
<td>2.31</td>
<td>1.72</td>
<td>1.84</td>
<td>2.09</td>
<td>2.22</td>
<td>1.99</td>
</tr>
<tr>
<td>Magnitude (%)</td>
<td>-12.60</td>
<td>-10.61</td>
<td>-16.33</td>
<td>-9.29</td>
<td>-12.05</td>
<td>-15.40</td>
<td>-17.82</td>
<td>-10.86</td>
</tr>
</tbody>
</table>
Endogenous Cycles
Two deterministic versions of the model (constant TFP)

(b) Asymptotic dynamics

\[ \theta = 0.26 \]

\[ \theta = 0.27 \]

Dynamics of aggregates, \( \tilde{\omega}_t \).
Model With Both TFP and Financial Shocks

Typical path to crisis

- Dynamics in normal times,
- Dynamics in a systemic banking crisis,
- Dynamics of $\overline{a}_t$,
- long-run average,
- Dynamics in the constrained efficient Central Planner Allocation,
- 66% Confidence Band.