Impacts of Financial Factors on Business Cycle Fluctuations

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I. Overview of the paper

- Focus: balance sheet channel of monetary policy transmission
- Key features
  - Double financial accelerator: firms and banks
  - Integrated view of balance sheet channel: credit demand and supply
What this paper does cover

<table>
<thead>
<tr>
<th>Model features</th>
<th>BGG (1999)</th>
<th>Sunirand (2003)</th>
<th>This paper</th>
</tr>
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<tbody>
<tr>
<td>Standard monetary DSGE</td>
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<tr>
<td>Financial accelerator</td>
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<tr>
<td>Firms’ balance sheet</td>
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<tr>
<td>Banks’ balance sheet</td>
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<td>Open economy</td>
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<tr>
<td>Trade</td>
<td>x</td>
<td>x</td>
<td>✓</td>
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<tr>
<td>Exchange rate</td>
<td>x</td>
<td>x</td>
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</tbody>
</table>
What this paper does not cover

- Multiple financial accelerators
  - Bernanke (2007): firms, households, banks, nonbanks
- Disruption of financial intermediation & unconventional monetary policy
  - Gertler and Karadi (2009), Gertler and Kiyotaki (2010)
II. Model

Double financial accelerator
Key equations

- Firm’s balance sheet

\[ Q_t K_t^D = B_t^D + N_t^D \]

- External finance premium

\[ R_t^D - R_t = \left( \frac{Q_t K_t^D}{N_t^D + N_t^{BD}} \right)^\nu \]

\( Q_t \) = price of capital (firm’s assets)

\( K_t^D \) = domestic firm’s capital

\( B_t^D \) = nominal debt

\( N_t^D \) = firm’s net worth

\( N_t^{BD} \) = bank’s capital that implicitly supports lending to the domestic firm
Determination of external finance premium

Double financial accelerator

Three cases

1. $QK^D < N^D$
   - No need to seek external finance

Sunirand (2003)
Determination of external finance premium
Double financial accelerator

Three cases

1. $QK^D < N^D$
   - No need to seek external finance

2. $N^D < QK^D < N^D + N^{BD}$
   - Bank can satisfy firm’s demand for loans with own internal funds (BGG, 1999)

Sunirand (2003)
Three cases

1. $QK^D < N^D$
   No need to seek external finance

2. $N^D < QK^D < N^D + N^{BD}$
   Bank can satisfy firm’s demand for loans with own internal funds (BGG, 1999)

3. $QK^D > N^D + N^{BD}$

Sunirand (2003)
Endogenous firm’s net worth

- Instead of net worth being a fixed proportion of firm’s balance sheet
  \[ N_t^D = \vartheta Q_t K_t^D \]

- Net worth depends on real developments that determine value of firm
  \[
  N_t^D = \phi_v V_t^D \\
  V_t^D = (1 - \delta) Q_t K_{t-1}^D + \left( Q_t^D Y_t^D - W_t L_t^D - P_t^M M_t^D \right) \\
  - \left( 1 + R_{t-1}^D \right) B_{t-1}^D
  
  Q_t^D = \text{competitive price of the domestic good} \\
  L_t^D, M_t^D = \text{labor and imported inputs} \]
Banks

- Balance sheet
  \[ B_t = B_t^B + N_t^B \]

- External finance premium
  \[ R_t^B - R_t = \left( \frac{B_t}{N_t^B} \right)^{\nu^B} \]

- Endogenous bank capital
  \[ N_t^B = \phi_v^B V_t^B \]
  \[ V_t^B = \left[ \left( 1 + R_{t-1}^D \right) B_{t-1}^D + \left( 1 + R_{t-1}^X \right) B_{t-1}^X \right] - \left( 1 + R_{t-1}^B \right) B_{t-1}^B \]

\[ B_t = B_t^D + B_t^X = \text{bank's assets} \]
\[ B_t^B = \text{bank's external funds} \]
\[ N_t^B = N_t^{BD} + N_t^{BX} = \text{bank capital} \]
III. Simulation results

Interest rate shock

An increase in policy rate reduces firm’s net worth, raises external finance premium, and amplifies investment’s fall and makes it more persistent.
A negative shock to firm’s net worth raises external finance premium and amplifies investment’s fall and makes it more persistent.
A negative shock to bank’s capital raises its external finance premium. Having borrowed from bank, firms in turn are required to pay higher premium, further amplifying and propagating a fall in investment.
IV. Reflections on recent crisis

- Elasticity of external finance premium with respect to net worth is key to understanding severity of feedback
- External finance premium is more sensitive to borrower’s financial position given an increase in
  - Probability of bankruptcy, raising expected monitoring costs
  - Subjective uncertainty—especially in crises
  - True financial positions and expected losses are not known (Levin, Natalucci, and Zakrajsek, 2004)
With a heightened sensitivity, net worth shock induces premium to rise more, causing investment to contract further.
Mishkin (2008): Policy flexibility

- Monetary policy must be at least as preemptive in responding to financial shocks
- Interest rate cuts shore up borrowers’ balance sheets, thereby dampening finance premium
- By reducing the likelihood of losses, monetary easing works to reduce uncertainty
V. Conclusions

- Framework to analyze how balance sheets of financial-constrained firms and banks amplify shocks and prolong business cycles
  - Double financial accelerator
- Useful tool to offer a deeper understanding of financial-real linkage
- Potential platform for incorporating elements of financial stability—such as firms’ leverage or bank capital—when calibrating monetary policy
Appendix 1: Model equations
Households

Consumption, saving, and labor supply decisions

\[ E_0 \sum_{t=0}^{\infty} \beta^t \left[ (1 - \chi) \log \tilde{C}_t - \varphi L_t^{1+\eta} \right] \]

subject to

\[ P_t^D C_t + B_t^B \leq \left( 1 + R_{t-1}^B \right) B_{t-1}^B + W_t L_t + \sum_j \Phi_j \]

Optimal consumption, saving, labor supply

\[ \frac{1}{\tilde{C}_t} = \lambda_t P_t^D \]

\[ \lambda_t = \beta E_t \lambda_{t+1} \left( 1 + R_t^B \right) \]

\[ \lambda_t Q_t^L = \varphi L_t^\eta \]
Households
Adjustment costs

- \( \tilde{C}_t \) is habit-adjusted consumption which depends on \( C_t \) and \( C_{t-1} \) and the parameter \( \chi \)

\[
\tilde{C}_t = \frac{C_t - \chi h_t}{1 - \chi}
\]

with \( h_t = (1 + \alpha) C_{t-1} \)

- When \( \chi = 0 \), household completely disregards past consumption
Households

Wage decision

$$
\min \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[ (W_t - W_t^*)^2 + \xi^W (\Delta W_t - \Delta \bar{W}_{t-1})^2 \right]
$$

- Optimal wage setting

$$
W_t = W_t^* + \xi^W \left[ - (\Delta W_t - \Delta \bar{W}_{t-1}) + \beta (E_t \Delta W_{t+1} - \Delta \bar{W}_t) \right]
$$
Households

Foreign-bond holding decision

\[
\max_{B^*_t} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \lambda_t S_t \left\{ B^*_t - \left[ 1 + \frac{\zeta_B^f}{2} \left( \frac{S_{t-1}B^*_{t-1}}{4Y^N_{t-1}} - \psi \right) \right] (1 + R^*_{t-1}) B^*_{t-1} \right\}
\]

- UIP condition

\[
R^B_t - R^*_t = \mathbb{E}_t dS_{t+1} + \zeta_B^f \left( \frac{B^f_t}{4Y^N_t} - \frac{\psi}{2} \right) + \nu
\]

with law of motion for \( B^f_t \)

\[
B^f_t = \left( 1 + R^B_{t-1} \right) B^f_{t-1} - \left( P^X_t X_t - P^M_t M_t \right)
\]
Domestic wholesale good producing firms

Production decision

\[ Y_t^D = \left( A_t L_t^D \right)^{\gamma_L^D} \left( M_t^D \right)^{\gamma_M^D} \left( K_{t-1}^D \right)^{1-\gamma_L^D-\gamma_M^D} \]

- Optimal demand for labor and imported intermediates

\[ W_t L_t^D = \gamma_L^D Q_t^D Y_t^D \]

\[ P_t^M M_t^D = \gamma_M^D Q_t^D Y_t^D \]

- Optimal demand for capital given financial frictions

\[ 1 + R_t^D = \frac{(1 - \gamma_L^D - \gamma_M^D) Q_{t+1}^D Y_{t+1}^D}{Q_t K_t^D} + (1 - \delta) \frac{Q_{t+1}^D}{Q_t} \]

with

\[ R_t^D - R_t = \left( \frac{Q_t K_t^D}{N_t^D + N_t^{BD}} \right)^\nu \]
Domestic wholesale good producing firms
Determination of net worth

- Balance sheet
  \[ Q_t K_t^D = B_t^D + N_t^D \]

- Endogenous net worth
  \[ N_t^D = \phi_v V_t^D \]

with

\[ V_t^D = (1 - \delta) Q_t K_{t-1}^D + Q_t^D Y_t^D - \left[ W_t L_t^D + P_t^M M_t^D \right] \]

\[ - \left( 1 + R_{t-1}^D \right) B_{t-1}^D \]

\[ = \left( 1 + R_{t-1}^D \right) N_{t-1}^D \]
Export firms
Production decision

\[ Y_t^X = \left( A_t L_t^X \right)^{\gamma_L^X} \left( M_t^X \right)^{\gamma_M^X} \left( K_{t-1}^X \right)^{1-\gamma_L^X-\gamma_M^X} \]

- Optimality conditions for export firms are similar to those for domestic firms
Capital producers

Setup

\[
\max_{l_t} E_0 \sum_{t=0}^{\infty} \beta^t \lambda_t \left\{ Q_t \left[ (1 - \delta)K_t + F(l_t, l_{t-1}) - K_{t+1} \right] - P_t^D l_t \right\}
\]

- Rent capital from firms after used in production, \((1 - \delta)K_t\)
- Combine with the investment good, \(l_t\), it has purchased from retailer of final good to produce new capital
- Return \(K_{t+1}\) to the firms to be used in later production
Capital producers

Adjustment costs

\[ F(I_t, I_{t-1}) = \left\{ 1 - \frac{\zeta^l}{2} \left[ \frac{I_t}{I_{t-1}} - (1 + \alpha) \right]^2 \right\} I_t \]

- \( \zeta^l \) is investment adjustment cost parameter
- When \( \zeta^l = 0 \), \( F(I_t, I_{t-1}) = I_t \)
- For \( \zeta^l > 0 \), there will be real costs incurred
  - \( F > 0 \) when (gross) growth rate of investment, \( \frac{I_t}{I_{t-1}} \), is different from balanced growth rate, \( 1 + \alpha \)
Capital producers

First-order condition

\[
\frac{Q_t}{P_t^D} = \left[ F_1(l_t, l_{t-1}) \right]^{-1} \left[ 1 - \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \frac{Q_{t+1}}{P_t^D} F_2(l_{t+1}, l_t) \right]
\]

\[
= \left[ 1 - \tilde{\zeta}' \frac{l_t}{l_{t-1}} \left( \frac{l_t}{l_{t-1}} - (1 + \alpha) \right) - \frac{\tilde{\zeta}'}{2} \left( \frac{l_t}{l_{t-1}} - (1 + \alpha) \right)^2 \right]^{-1} \times \left[ 1 - \tilde{\zeta}' \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \frac{Q_{t+1}}{P_t^D} \left( \frac{l_{t+1}}{l_t} \right)^2 \left( \frac{l_{t+1}}{l_t} - (1 + \alpha) \right) \right].
\]

- The left hand side is Tobin's \( q \)
Banks

- **Balance sheet**
  \[ B_t^D + B_t^X = B_t = B_t^B + N_t^B \]

- **External finance premium**
  \[ R_t^B - R_t = \left( \frac{B_t}{N_t^B} \right)^{\nu^B} \]

- **Endogenous bank capital**
  \[ N_t^B = \phi^B V_t^B \]
  \[ V_t^B = \left[ \left( 1 + R_{t-1}^D \right) B_{t-1}^D + \left( 1 + R_{t-1}^X \right) B_{t-1}^X \right] - \left( 1 + R_{t-1}^B \right) B_{t-1}^B \]

- **Loans to domestic and export firms**
  \[ \frac{B_t^D}{N_t^{BD}} = \frac{B_t^X}{N_t^{BX}} \]
Retailers of final goods

Domestic good: monopolistically competitive price setting

\[ \min_{P^D_t} E_0 \sum_{t=0}^{\infty} \beta^t \left[ (P^D_t - P^D_{t*})^2 + \zeta^D (\Delta P^D_t - \Delta \bar{P}^D_{t-1})^2 \right] \]

- Optimal price setting

\[ P^D_t = P^D_{t*} + \zeta^D \left[ - (\Delta P^D_t - \Delta \bar{P}^D_{t-1}) + \beta \left( E_t \Delta P^D_{t+1} - \Delta \bar{P}^D_t \right) \right] \]

with

\[ P^D_{t*} = \mu^D Q^D_t \]
Retailers of final goods

Export good: perfectly competitive price setting

- Optimal price setting

\[ Q_t^X = P_t^X \]

with

\[ P_t^X = S_t P_t^{Xf} \]
Fiscal and monetary authorities

Government

Fiscal rule

\[ P_t^D G_t = \rho^G \left( P_{t-1}^D G_{t-1} \right) + \left( 1 - \rho^G \right) \left( \sigma Y_t^N \right) \]
Monetary policy rule

\[ R_t = \rho^R R_{t-1} + \left(1 - \rho^R\right) \left[ R^{ss} + \kappa \left( dP^D_{t+1} - \pi \right) \right] \]
Exogenous processes

\[
\begin{align*}
A_t &= A_{t-1} + \alpha + \varepsilon_t^A \\
T_t &= \rho^T T_{t-1} + \varepsilon_t^T, \quad \text{where } T_t \equiv P_t^{X*} / P_t^{M*} \\
dP_t^{M*} &= \pi^* + \varepsilon_t^{P^{M*}} \\
R_t^* &= \rho^{R*} R_{t-1}^* + \left(1 - \rho^{R*}\right) R_{ss*}^* + \varepsilon_t^{R*}
\end{align*}
\]
Market clearing conditions

Factor inputs

\[ L_t = L^D_t + L^X_t \]
\[ M_t = M^D_t + M^X_t \]
\[ K_t = K^D_t + K^X_t \]

Domestic final good

\[ Y^D_t = C_t + I_t + G_t \]
Steady-state conditions

Steady state is defined such that macro variables grow at constant rates

- Three key parameters determining steady-state growth rates
  1. Productivity growth rate ($\alpha$)
  2. Target rate of inflation ($\pi$)
  3. Foreign inflation target ($\pi^*$)

In steady state

- Real variables grow at $\alpha$
- Price variables grow at $\pi$
- Nominal variables (including financial variables) grow at $\alpha + \pi$
- Foreign export and import prices grow at $\pi^*$
- Exchange rate depreciates at the rate of $\pi - \pi^*$
Appendix 2: Calibration of model parameters
## Steady-state parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Households</strong></td>
<td></td>
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</tr>
<tr>
<td>$\beta$</td>
<td>0.9968</td>
<td>Discount factor</td>
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<tr>
<td>$\delta$</td>
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<td>Depreciation rate (4.2% per year)</td>
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<td>$\eta$</td>
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<td>Scaling parameter for labor disutility</td>
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<td>Ratio of foreign debt to nominal GDP</td>
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<td><strong>Firms</strong></td>
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<tr>
<td>$\mu^D$</td>
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<td>Price markup, domestic firms</td>
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<td>$\gamma^D_L$</td>
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<td>Labor income share, domestic firms</td>
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<td>$\gamma^D_M$</td>
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<td>Imported input income share, domestic firms</td>
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<td>$\gamma^X_L$</td>
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<td>Labor income share, export firms</td>
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<td>$\gamma^X_M$</td>
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<td>Imported input income share, export firms</td>
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<td>$\phi_v$</td>
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<td>Probability of firms surviving into next period</td>
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<tr>
<td>$\nu$</td>
<td>0.0170</td>
<td>Elasticity of firms’ external finance premium</td>
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Steady-state parameters

<table>
<thead>
<tr>
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<tr>
<td><strong>Bank</strong></td>
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<td>$\phi^B_v$</td>
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<td>Probability of banks surviving into next period</td>
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<td>Elasticity of bank’s external finance premium to bank’s capital-to-asset ratio</td>
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<td><strong>Government</strong></td>
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<td>$\sigma$</td>
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<td>Ratio of government expenditure to nominal GDP</td>
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<td>$\pi$</td>
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<td>Inflation target (3% per year)</td>
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<td><strong>Exogenous processes</strong></td>
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<tr>
<td>$\alpha$</td>
<td>0.0059</td>
<td>Productivity growth rate (2% per year)</td>
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<tr>
<td>$\pi^*$</td>
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<td>Foreign inflation target (3% per year)</td>
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## Dynamic parameters

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<td>Persistence in government expenditure</td>
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<td><strong>Exogenous processes</strong></td>
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<tr>
<td>$\rho^{R^*}$</td>
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<td>$\rho^T$</td>
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<td>Persistence in terms of trade</td>
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