Lending Standards, Credit Booms, and Monetary Policy

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Motivation and Question

- monetary policy and credit booms (Taylor, 2007; Adrian and Shin, 2010): 'too low for too long'
  - risk on the liability side of financial intermediaries (Angeloni et al., 2013; Gertler and Karadi, 2011; Gertler et al., 2012)
  - risk on the asset side: fewer studies
- this paper’s focus: lending standard decisions of banks
- step 1: Is there empirical (macro) evidence supporting asset-side risk channel in response to MP shocks?
- step 2: Formulate a microfoundation (contract) for bank’s lending standard decision
- step 3: Study the implications of this contract in a monetary GE model
Empirical Strategy: Data

- previous literature:
  - strong evidence in favor of (ex ante) asset risk channel at the micro level (e.g., Jimenez et al., 2014; Bonfim and Soares, 2014)
  - mixed evidence at the macro level (e.g., Angeloni et al., 2013; Buch et al., 2014), limited data availability

- this paper: lending standards from SLOOS of the Fed
  - coverage: large domestic and foreign banks
  - 19 measures: type of measure (collateral requirements, loan covenants etc.), type of the bank, type of the loan and type of the borrower

▶ Figure
IRFs to a Monetary Easing in a small VAR: the Choice of Measures and the Omitted Variable Bias (I)

\[ Y_t = [EMPL_t, CPI_t, LS_t, FFR_t], \text{ lag } = 2, \text{ 2 std bands, sample 1991Q2 - 2008Q4, Cholesky ID} \]
IRFs to a Monetary Easing in a small VAR: the Choice of Measures and the Omitted Variable Bias (II)

\[ Y_t = [GDP_t, CPI_t, LS_t, FFR_t], \text{ lag } = 2, \text{ 2 std bands, sample } 1991Q2 - 2008Q4, \text{ Cholesky ID} \]
Empirical Strategy: Econometric Methodology

- econometric model: FAVAR
  \[ X_t = \Lambda^f F_t + \Lambda^y Y_t + e_t, \]  
  \[ \begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + \nu_t, \]

- \( F_t \) are extracted factors, \( Y_t \) are observables, \( X_t \) is the informational data set
- data: 138 macro and financial time series, including 19 SLOOS lending standards
- Bayesian estimation
- recursive identification along the lines of Bernanke et al. (2005): FFR ordered last in the transition equation (2)
- baseline: sample 1991Q1-2008Q2, lag order = 2, FFR as observable, 3 latent factors
Baseline FAVAR: IRFs in Response to a Monetary Loosening (25bp), 68% and 90% bands
Robustness of Empirical Results

- number of factors:
  - statistical criteria point to 3-5 factors (Onatski, 2009; Alessi et al. 2010; Bai and Ng, 2007; Stock and Watson, 2005)
  - robust under more factors: 4, 5, 6 and 7
  - consistent with the scree plot
  - the variables of interest are well explained by the model

- lag order

- observable variables (FFR and CPI)

- estimation methodology: principal components

- subsamples 1997Q1 - 2008Q2, 1994Q1 - 2008Q2

- including Greenbook projections into the informational data set

Microfoundation: A CSV Contract

- starting point: costly state verification (Townsend, 1979; Gale and Hellwig, 1985) contract between risk-neutral bank and risk-neutral entrepreneur
- two dimensions of credit expansion: loan volume relative to collateral and loan quality (default threshold $\bar{\omega}$)
- problem: banks are passive and do not take risks (BGG, 1999)
- contract modification: 'reversed roles’, i.e. bank decides on the quantity and quality of credit
- bank has market power and makes 'take-it-or-leave-it’ offer to the borrower
The Contract Setup

- At the end of period $t$, entrepreneur $i$ finances capital purchases $Q_t K_t^i$ using its net worth, $N_t^i$, and borrowing the rest, $B_t^i$, from the bank.

- The entrepreneur’s return on capital in period $t+1$ is $\omega_{t+1}^i R_{t+1}^k Q_t K_t^i$, where
  - $R_{t+1}^k$ is the aggregate return on capital,
  - $\omega_{t+1}^i \in [0, \infty)$ is an idiosyncratic component that is i.i.d. across $i$ and $t$, with cdf $F(\omega)$ and $E(\omega) = 1$.

- Ex post default threshold is defined as:
  $$\bar{\omega}_{t+1}^i \equiv \frac{Z_t B_t^i}{R_{t+1}^k Q_t K_t^i}.$$

  - No default: $\omega_{t+1}^i \geq \bar{\omega}_{t+1}^i$, the entrepreneur pays the bank the fixed amount $Z_t B_t^i$ and keeps the residual $(\omega_{t+1}^i - \bar{\omega}_{t+1}^i) R_{t+1}^k Q_t K_t^i$.
  - Default: $\omega_{t+1}^i < \bar{\omega}_{t+1}^i$, the bank monitors the entrepreneur, incurs a CSV cost $\mu \omega_{t+1}^i R_{t+1}^k Q_t K_t^i$ and extracts the remainder.
The Contract: Bank’s Decision Problem

- Bank’s problem without aggregate risk:

\[
\max_{K_t, \bar{\omega}_{t+1}} \left[ \Gamma(\bar{\omega}_{t+1}) - \mu G(\bar{\omega}_{t+1}) \right] R_{t+1}^k Q_t K_t^i - R_t^n (Q_t K_t^i - N_t^i) \\
\text{s.t.} \quad \left[ 1 - \Gamma(\bar{\omega}_{t+1}) \right] R_{t+1}^k Q_t K_t^i \geq R_{t+1}^k N_t^i [\lambda_t^i]
\]

- Denote \( k_t^i \equiv \frac{Q_t K_t^i}{N_t^i} \) and get FOCs:

\[
k_t^i : \quad \left[ \Gamma(\bar{\omega}_{t+1}) - \mu G(\bar{\omega}_{t+1}) \right] R_{t+1}^k + \lambda_t^i \left[ 1 - \Gamma(\bar{\omega}_{t+1}) \right] R_{t+1}^k = R_t^n,
\]

\[
\bar{\omega}_{t+1}^i : \quad \left[ \Gamma'(\bar{\omega}_{t+1}) - \mu G'(\bar{\omega}_{t+1}) \right] + \lambda_t^i \Gamma'(\bar{\omega}_{t+1}) = 0,
\]

\[
\lambda_t^i : \quad \left[ 1 - \Gamma(\bar{\omega}_{t+1}) \right] k_t^i - 1 = 0.
\]

- positive relation between borrower’s leverage and EFP (cf. BGG, 1999)
Partial Equilibrium (No Aggregate Risk): the Effect of $R_n \downarrow$

Note: $k_{IPC} = \frac{\pi^b - 1 - n}{\Gamma(\bar{\omega}) - \mu G(\bar{\omega})} s - 1$ and $k_{PC} = \frac{1}{1 - \Gamma(\bar{\omega})}$, where $s \equiv R^k / R^n$, $k \equiv QK / N$
DSGE: Agents and Main Assumptions

- Agents
  - a representative household
  - a representative capital goods producer,
  - a continuum of competitive entrepreneurs,
  - a continuum of monopolistically competitive retailers,
  - a monopolistic bank,
  - a monetary authority (Taylor rule).

- Assumptions
  - nominal price rigidity as in Calvo (1983),
  - investment adjustment costs.

→ model structure very similar to BGG (1999), a different contract
DSGE: IRFs to a 25bp Monetary Policy Shock

Note: IRFs are plotted in terms of percentage deviations from steady state.

Student Version of MATLAB

Elena Afanasyeva (Frankfurt University)
Our Contract vs BGG, Same Model Calibration

- **Policy Rate**
  - Our contract
  - BGG contract

- **Loan Rate**

- **Bank Lending**

- **Default Threshold**

- **Default Rate**

- **Expected EFP**

- **Net Worth**

- **Bank Net Worth**

- **Leverage Ratio**
'Too Low for Too Long'

\[ \hat{i}_t = \rho \hat{i}_{t-1} + \phi_y \hat{y}_t + \phi_\pi \hat{\pi}_t + \epsilon_t \]
Robustness of the GE Result

'Switching off/on’ the DSGE frictions:

- habit formation in consumption
- trend inflation
- presence of price indexation
- monetary policy rule specification (forward-looking vs. outcome-based rules)
- investment adjustment cost matters: higher $\phi$ dampens positive response of EFP to monetary easing
The Role of Investment Adjustment Costs ($\phi$)

- Policy Rate
- Inflation
- Output
- Lending Rate
- Leverage
- Default Threshold

- $\phi = 0.1$
- $\phi = 0.3$
Concluding Remarks

- We find empirical evidence in favor of *ex ante* asset side risk channel (measured by lending standards) for large U.S. banks in response to MP shocks.
- We reformulate the CSV contract from the bank’s perspective.
- It is optimal for the bank to loosen its lending standard in response to monetary easing (consistently with the data).
- More to explore: role of bank default and limited liability (externalities), equity decision of the bank.
monopolistic bank

\[
\max_{K_t^i, \tilde{\omega}_{t+1}^i} \quad E_t \left\{ \left[ \Gamma \left( \tilde{\omega}_{t+1}^i \right) - \mu G \left( \tilde{\omega}_{t+1}^i \right) \right] R_{t+1}^k Q_t K_t^i - \frac{R_t^n}{\pi_{t+1}} \left( Q_t K_t^i - N_t^i - N_{t,1}^{b,i} \right) \right\}
\]

subject to

\[
E_t \left\{ [1 - \Gamma (\tilde{\omega}_{t+1})] R_{t+1}^k \right\} Q_t K_t = E_t \left\{ R_{t+1}^k \right\} N_t.
\]

Bank’s aggregate expected profits:

\[
E_t V_{t+1}^b = E_t \left\{ \left[ \Gamma \left( \tilde{\omega}_{t+1} \right) - \mu G \left( \tilde{\omega}_{t+1} \right) \right] R_{t+1}^k Q_t K_t - \frac{R_t^n}{\pi_{t+1}} \left( Q_t K_t - N_t - N_t^b \right) \right\}
\]

Bank’s net worth:

\[
N_t^b = \gamma^b V_t^b.
\]

Balance sheet identity:

\[
B_t = N_t^b + D_t
\]
competitive entrepreneurs

Participation constraint:

\[ E_t \left\{ [1 - \Gamma (\bar{\omega}_{t+1})] R_{t+1}^k \right\} Q_t K_t = E_t \left\{ R_{t+1}^k \right\} N_t \]

Net worth:

\[ N_t = \gamma^e [1 - \Gamma(\bar{\omega}_t)] R_t^k Q_{t-1} K_{t-1} \]

The aggregate real rate of return per unit of capital:

\[ R_t^k = \frac{r_t^k + (1 - \delta) Q_t}{Q_{t-1}} \]
DSGE: Household and Retailer

- **household**

\[
\max_{C_t, H_t, D_t} E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{H_t^{1+\frac{1}{\eta}}}{1 + \frac{1}{\eta}} \right\},
\]

s. t. \( C_t + D_t \leq W_t H_t + \frac{R^n_{t-1}}{\pi_t} D_{t-1} \),

- **monopolistically competitive retailers**

\[
\max_{P_t^*} E_t \left\{ \sum_{s=0}^{\infty} \theta^s \Lambda_{t+t+s} \Pi_{t,s} \right\},
\]

s.t. \( Y_{t+s}(i) = \frac{P_{t,s}}{P_{t+s}}^{-\epsilon} Y_{t+s} \)

where \( \Lambda_{t,t+s} \equiv \beta^s E_t \left[ \frac{U'(C_{t+s})P_t}{U'(C_t)P_{t+s}} \right] \) and \( \Pi_{t,s} \equiv (P_{t,s} - MC_{t,s}) \left[ \frac{P_{t,s}}{P_{t+s}} \right]^{-\epsilon} Y_{t+s} \),

\( P_{t,s} = P_t^* \left( \frac{P_{t+s-1}}{P_{t-1}} \right)^\gamma \).
DSGE: Capital Goods Producer, MP, Market Clearing

- capital goods producer

\[
\max_{l_t} \sum_{t=0}^{\infty} \beta^t \left\{ Q_t [K_t - (1 - \delta)K_{t-1}] - I_t \right\},
\]

s.t. \( K_t = (1 - \delta)K_{t-1} + \left[ 1 - S \left( \frac{l_t}{l_{t-1}} \right) \right] l_t, \)

where \( S \left( \frac{l_t}{l_{t-1}} \right) = \frac{\phi}{2} \left( \frac{l_t}{l_{t-1}} - 1 \right)^2. \)

- monetary policy and market clearing

\[
\frac{R^n_t}{R^n_{ss}} = \left( \frac{R^n_{t-1}}{R^n_{ss}} \right)^\rho \left[ \left( \frac{\pi_t}{\pi_{ss}} \right)^{\phi_\pi} \left( \frac{Y_t}{Y_{ss}} \right)^{\phi_y} \right]^{1-\rho} e^{\nu_t}
\]

\[
Y_t = C_t + C^e_t + C^b_t + I_t + \mu G(\tilde{\omega}_t) R^K_t Q_{t-1} K_{t-1}
\]
FAVAR with 5 Factors: IRFs in Response to a Monetary Loosening (25bp)
Lending Standards Measures: 1991Q1 - 2008Q4

Net Percentage of Banks

Lending Standard 1
Lending Standard 2
Lending Standard 3
Lending Standard 4
Lending Standard 5
Lending Standard 6
Lending Standard 7
Lending Standard 8
Lending Standard 9
Lending Standard 10
Lending Standard 11
Lending Standard 12
Lending Standard 13
Lending Standard 14
Lending Standard 15
Lending Standard 16
Lending Standard 17
Lending Standard 18
Lending Standard 19
FAVAR Scree Plot (Principal Components Analysis)
## Baseline Parameter Calibration: Steady State

<table>
<thead>
<tr>
<th>Steady-State Variable or Ratio</th>
<th>Computation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>capital-output ratio</td>
<td>Y / (4 · K)</td>
<td>1.9451</td>
</tr>
<tr>
<td>household consumption relative to output</td>
<td>C / Y</td>
<td>0.6963</td>
</tr>
<tr>
<td>entrepreneur consumption relative to output</td>
<td>C_e / Y</td>
<td>0.0784</td>
</tr>
<tr>
<td>bank consumption relative to output</td>
<td>C_b / Y</td>
<td>0.0251</td>
</tr>
<tr>
<td>capital investment relative to output</td>
<td>I / Y</td>
<td>0.1945</td>
</tr>
<tr>
<td>employment as a share of time endowment*</td>
<td>H</td>
<td>1/3</td>
</tr>
<tr>
<td>gross price markup of retailers*</td>
<td>ε / (ε − 1)</td>
<td>1.1111</td>
</tr>
<tr>
<td>leverage ratio of entrepreneurs*</td>
<td>QK / N</td>
<td>1.5372</td>
</tr>
<tr>
<td>default monitoring costs relative to output</td>
<td>μG (ω) R^k QK / Y</td>
<td>0.0057</td>
</tr>
<tr>
<td>annualized default rate of entrepreneurs*</td>
<td>4 · F (ω)</td>
<td>4.735%</td>
</tr>
<tr>
<td>annualized risk-free policy interest rate*</td>
<td>4 · (R^n − 1)</td>
<td>2.010%</td>
</tr>
<tr>
<td>annualized interest rate on bank loans*</td>
<td>4 · (Z − 1)</td>
<td>6.816%</td>
</tr>
<tr>
<td>annualized rate of return to capital</td>
<td>4 · (R^k − 1)</td>
<td>6.195%</td>
</tr>
<tr>
<td>annualized external finance premium</td>
<td>4 · (R^k / R^n − 1)</td>
<td>4.164%</td>
</tr>
</tbody>
</table>

* Steady state values targeted in benchmark calibration
## Baseline Parameter Calibration

<table>
<thead>
<tr>
<th>Household and production sector</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>coefficient of relative risk aversion</td>
<td>$\sigma$</td>
<td>2</td>
</tr>
<tr>
<td>Frisch elasticity of labor supply</td>
<td>$\eta$</td>
<td>3</td>
</tr>
<tr>
<td>relative weight of labor in the utility function</td>
<td>$\chi$</td>
<td>5.19</td>
</tr>
<tr>
<td>quarterly discount factor of households</td>
<td>$\beta$</td>
<td>0.995</td>
</tr>
<tr>
<td>elasticity of substitution between retailer varieties</td>
<td>$\epsilon$</td>
<td>10</td>
</tr>
<tr>
<td>quarterly depreciation rate of physical capital</td>
<td>$\delta$</td>
<td>0.025</td>
</tr>
<tr>
<td>coefficient of quadratic investment adjustment costs</td>
<td>$\phi$</td>
<td>0.1</td>
</tr>
<tr>
<td>elasticity of output with respect to capital</td>
<td>$\alpha$</td>
<td>0.35</td>
</tr>
<tr>
<td>Calvo probability of quarterly price adjustments</td>
<td>$\theta$</td>
<td>0.75</td>
</tr>
<tr>
<td>automatic price indexation to past inflation</td>
<td>$\gamma$</td>
<td>0.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monetary policy</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>interest-rate persistence in the monetary policy rule</td>
<td>$\rho$</td>
<td>0.9</td>
</tr>
<tr>
<td>responsiveness of monetary policy to inflation deviations</td>
<td>$\phi_\pi$</td>
<td>1.5</td>
</tr>
<tr>
<td>responsiveness of monetary policy to output deviations</td>
<td>$\phi_y$</td>
<td>0.5</td>
</tr>
<tr>
<td>standard deviation of unsystematic monetary policy shocks</td>
<td>$\sigma_\nu$</td>
<td>0.25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Optimal financial contract</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>exogenous consumption rate of entrepreneurial net worth</td>
<td>$\gamma^e$</td>
<td>0.985</td>
</tr>
<tr>
<td>exogenous consumption rate of bank net worth</td>
<td>$\gamma^b$</td>
<td>0.95</td>
</tr>
<tr>
<td>monitoring cost as a fraction of total return on capital</td>
<td>$\mu$</td>
<td>0.20</td>
</tr>
<tr>
<td>variance of idiosyncratic productivity draws</td>
<td>$\sigma^2_\omega$</td>
<td>0.18</td>
</tr>
<tr>
<td>steady-state default threshold of entrepreneurs</td>
<td>$\bar{\omega}$</td>
<td>0.35</td>
</tr>
</tbody>
</table>
Extended Set of IRFs to a Monetary Policy Shock (25bp), Baseline I
Extended Set of IRFs to a Monetary Policy Shock (25bp), Baseline II
IRFs to a Monetary Policy Shock (25bp) under BGG Rule

\[ \hat{i}_t = \rho \hat{i}_{t-1} + \phi_\pi \hat{\pi}_{t-1} + \epsilon_t \]