The Procyclical Effects of Basel II

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Purpose of paper

• The purpose of the risk-based capital requirements of Basel II is to improve the weighting of risks in the cross-section of loans: They are increasing functions of the probabilities of default (PDs) and losses given default (LGDs) of a bank’s exposures.

• This paper is about a side-effect concerning the time dimension:
  – Since PDs and LGDs tend to be higher during recessions, Basel II requirements may exhibit strong procyclicality.
  – Can it lead to amplification of business cycle fluctuations?
Bank capital requirements

- Consider a bank’s simplified balance sheet:

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loans ((l))</td>
<td>Deposits ((l-k))</td>
</tr>
<tr>
<td></td>
<td>Capital ((k))</td>
</tr>
</tbody>
</table>

- Equity capital comes from equity issues & retained earnings
- Capital requirements set \(k \geq \gamma l\) (in Basel I, \(\gamma = 0.08\))
- For fixed \(k\), capital requirements impose a limit on \(l\)
Bank capital amplification channel

• In downturns, PDs are higher, thus:
  – Bank capital is lower due to higher default rates
  – Basel II requirements are higher

• Under which conditions will this imply a restriction in (aggregate) loan supply?
  – Banks should find it difficult to issue equity in downturns
  – Firms should find it difficult to switch financing source
Model setup

• Two key ingredients in the model produce those conditions:
  – Banks are unable to access equity markets every period
  – Credit transactions consist of relationship lending

• Key features of the analysis
  – Endogenous capital buffers (dynamic optimization)
  – Endogenous loan rates (perfect competition ex ante)
Main results

• Banks hold capital buffers
  – Realistic size
  – Countercyclical under Basel I
  – Procyclical under Basel II

• Basel II leads to
  – *Large credit rationing if economy goes into recession*
  – Lower probabilities of bank failure
Presentation outline

• The model
• Banks’ capital decision
• Equilibrium
• Numerical results
• Concluding remarks
The model

• Discrete time $t = 0, 1, 2,…$

• Three classes of risk-neutral agents
  – Overlapping generations of entrepreneurs (measure one)
  – Large number of infinitely lived banks
  – Large number of infinitely lived investors

• Banks intermediate funds
  – from investors (deposits and capital)
  – to entrepreneurs (loans)
Entrepreneurs

- Entrepreneurs born at date $t$ have:
  - 1st period project that requires unit investment at date $t$
    \[
    \text{Return at date } t + 1 = \begin{cases} 
    1 + a & \text{with prob. } 1 - p_t \\
    1 - \lambda & \text{with prob. } p_t 
    \end{cases}
    \]
  - 2nd period project that requires unit investment at date $t + 1$
    \[
    \text{Return at date } t + 2 = \begin{cases} 
    1 + a & \text{with prob. } 1 - p_{t+1} \\
    1 - \lambda & \text{with prob. } p_{t+1} 
    \end{cases}
    \]

- Projects require relationship-based bank finance
  \[\rightarrow\] Sequence of one period loans
Project return correlation

• Returns are correlated according to **single risk factor** model

• Aggregate **failure rate** \( x_t \) of projects started at date \( t \) has cdf

\[
F_t(x_t; p_t, \rho_t) = \Phi \left( \sqrt{1 - \rho_t} \frac{\Phi^{-1}(x_t) - \Phi^{-1}(p_t)}{\sqrt{\rho_t}} \right)
\]

– We have \( p_t = E_t(x_t) = \int_0^1 x_t \, dF_t(x_t) \)

– When \( \rho_t = 0 \) we have independent returns

– When \( \rho_t = 1 \) we have perfectly correlated returns
Aggregate states

• State of the economy $s_t \in \{h, l\}$ follows a Markov chain with

$$q_h = \Pr(s_t = h|s_{t-1} = h)$$

$$q_l = \Pr(s_t = h|s_{t-1} = l)$$

• State $s_t$ determines probability of failure

$$p_t = \begin{cases} 
  p_h & \text{if } s_t = h \\
  p_l & \text{if } s_t = l 
\end{cases} \text{ with } p_h > p_l$$

• Interpretation

  – State $h$ \rightarrow high business failure (recession)

  – State $l$ \rightarrow low business failure (expansion)
Banks

• Banks funded by
  – **Insured deposits** → deposit rate normalized to 0
  – **Equity capital** → required return $\delta \geq 0$

• Funds invested in **one period loans** (with interest rates $r_s$ & $a$)

• Capital requirements
  – Basel I: $\gamma_h = \gamma_l = 8\%$
  – Basel II: $\gamma_h > \gamma_l$

• Cost $c$ of setting up relationship with entrepreneur

• Banks can only **raise capital every other date**
Banks’ capital decision (i)

• Assume that recapitalized banks lend to new entrepreneurs
  → OLG banking industry

• Consider representative bank that can raise capital at date $t$

• Let $s$ and $s’$ denote states of the economy at dates $t$ and $t + 1$
Banks’ capital decision (ii)

• At date $t$ the bank
  – Raises $1 - k_s$ deposits and $k_s \geq \gamma_s$ capital
  – Invests in unit portfolio of initial loans at rate $r_s$

• At date $t + 1$ a random fraction $x_t$ of loans default
  – Net worth at date $t + 1$
    \[
    n_s(x_t) = (1 - x_t)(1 + r_s) + x_t(1 - \lambda) - (1 - k_s) - c
    \]
    ↑
    assets deposits

Banks’ capital decision (iii)

• Three possible cases at date $t + 1$

  • $n_s(x_t) < 0$ $\rightarrow$ Bank is closed

  • $0 < n_s(x_t) < \gamma_s$ $\rightarrow$ Bank has **insufficient lending capacity**

  • $\gamma_s < n_s(x_t)$ $\rightarrow$ Bank has **excess lending capacity**
Excess lending capacity (i)

- At date $t + 1$ the bank
  - Pays dividend $n_s(p_t) - \gamma_s'$ to shareholders
  - Raises $1 - \gamma_s'$ deposits
  - Invests in unit portfolio of continuation loans at rate $a$

- At date $t + 2$ a random fraction $x_{t+1}$ of loans default
  - Net worth at date $t + 2$
    \[
    n_s'(x_{t+1}) = (1 - x_{t+1})(1 + a) + x_t(1 - \lambda) - (1 - \gamma_s')
    \]
    \[
    \uparrow \quad \uparrow
    \]
    \[
    \text{assets} \quad \text{deposits}
    \]
Excess lending capacity (ii)

• Shareholders’ expected payoff at date $t + 1$

$$v_{ss'}(x_t) = \beta \pi_{s'} + (n_{s}(x_t) - \gamma_{s'})$$

where $\beta = \frac{1}{1 + \delta}$ and $\pi_{s'} = \int_0^1 \max \{n_{s'}(x_{t+1}), 0\} \, dF_{s'}(x_{t+1})$
Insufficient lending capacity

• At date $t + 1$ the bank
  – Rations credit to $1 - n_s(p_t)/\gamma_s$, old entrepreneurs
  – Raises $(1 - \gamma_s')n_s(p_t)/\gamma_s$, deposits
  – Invests in portfolio of $n_s(p_t)/\gamma_s$, continuation loans at rate $a$

• At date $t + 2$ a random fraction $x_{t+1}$ of loans default

• Shareholders’ expected payoff at date $t + 1$

$$
\nu_{ss'}(p_t) = \beta \pi_s n_s(x_t) / \gamma_s
$$
Banks’ initial capital decision

• Shareholders’ expected payoff at date \( t + 1 \)

\[
v_{ss'}(x_t) = \begin{cases} 
0 & \text{if } \hat{x}_s < x_t \\
\beta \pi_s, n_s(x_t) / \gamma_s, & \text{if } \tilde{x}_{ss'} < x_t \leq \hat{x}_s \\
\beta \pi_s, + (n_s(x_t) - \gamma_s,) & \text{if } x_t \leq \tilde{x}_{ss'}, 
\end{cases}
\]

• Shareholders’ net expected payoff at date \( t \)

\[
v_s(k_s, r_s) = \beta E_t(v_{ss'}(x_t)) - k_s
\]

• Banks choose \( k_s \) to maximize \( v_s(k_s, r_s) \) subject to \( \gamma_s \leq k_s \leq 1 \)
Equilibrium

• Sequence of state-contingent pairs \((k_s^*, r_s^*)\) \(s = h, l\) that satisfy

  – **Banks’ optimization**
    \[
    k_s^* = \arg \max_{k_s \in [\gamma_s, 1]} v_s(k_s, r_s^*)
    \]

  – **Banks’ zero net value condition**
    \[
    v_s(k_s^*, r_s^*) = 0
    \]

• Banks’ objective function is neither concave nor convex
  – There may be corner or interior solutions
  – We derive comparative statics for interior solutions
  – Focus on numerical solutions
Parameterization (i)

• Transition probabilities (for annual frequency)

\[ q_h = \Pr(s_t = h \mid s_{t-1} = h) = 0.55 \]
\[ 1 - q_l = \Pr(s_t = l \mid s_{t-1} = l) = 0.80 \]

→ Expected duration of high default state: 2.2 years
→ Expected duration of low default state: 5 years

• Distributions of the default rate, \( F_h(x_t) \) and \( F_l(x_t) \), as in Basel II
Parameterization (ii)

- Basel II capital requirements are $\gamma_s = \lambda F_s^{-1}(0.999)$

- State-contingent probabilities of default (PDs)
  - Focus presentation on medium volatility of PDs scenario
    - $p_h = 3.7\% \rightarrow$ Basel II $\gamma_h = 11.2\%$
    - $p_l = 1.1\% \rightarrow$ Basel II $\gamma_l = 6.6\%$

  - Paper also considers high and low volatility scenarios
  - PDs chosen so that average capital requirement is 8\%
Parameterization (iii)

- Other parameters
  - Success return of investment projects $a = 5\%$
  - Loss given default (LGD) $\lambda = 45\%$
  - Deposit rate normalized to zero
  - Cost of bank capital (Tier 1 + Tier 2) $\delta = 5\%$
  - Cost of setting up relationship $c = 4\%$
Loan rates and capital buffers

Equilibrium first period loan rates and capital buffers

• Basel I

\[ r^*_h = 3.3\% \quad k^*_h = 12.1\% \quad k^*_h - \gamma_h = 4.1\% \]
\[ r^*_l = 1.5\% \quad k^*_l = 11.6\% \quad k^*_l - \gamma_l = 3.6\% \]

• Basel II

\[ r^*_h = 3.4\% \quad k^*_h = 13.5\% \quad k^*_h - \gamma_h = 2.3\% \]
\[ r^*_l = 1.6\% \quad k^*_l = 12.3\% \quad k^*_l - \gamma_l = 5.7\% \]

→ Basel II: lower capital buffer in high default state
→ Basel II: higher capital buffer in low default state
Expected credit rationing (i)

Expected **credit rationing** conditional on transition from $s = h$

<table>
<thead>
<tr>
<th></th>
<th>Basel I</th>
<th>Basel II</th>
</tr>
</thead>
<tbody>
<tr>
<td>$s = h \rightarrow s' = h$</td>
<td>2.7%</td>
<td>5.3%</td>
</tr>
<tr>
<td>$s = h \rightarrow s' = l$</td>
<td>2.7%</td>
<td>0.6%</td>
</tr>
</tbody>
</table>

→ Basel II: more rationing when staying in high default state
→ Basel II: less rationing when moving to low default state

(Expected CR conditional on $s = h$ goes from 2.7 to 3.2%)
Expected credit rationing (ii)

Expected **credit rationing** conditional on transition from \( s = l \)

<table>
<thead>
<tr>
<th></th>
<th>Basel I</th>
<th>Basel II</th>
</tr>
</thead>
<tbody>
<tr>
<td>( s = l \rightarrow s' = l )</td>
<td>1.3%</td>
<td>0.3%</td>
</tr>
<tr>
<td>( s = l \rightarrow s' = h )</td>
<td>1.3%</td>
<td>15.6%</td>
</tr>
</tbody>
</table>

→ Basel II: less rationing when staying in low default state

→ Basel II: **huge rationing when moving to high default state**

(Expected CR conditional on \( s = l \) goes from 1.3 to 3.3%;
unconditionally, it goes from 1.8% to 3.3%)
A sample path

A simulated sample path (65 years)

- Output measured by realized value of all investment projects
- Two sources of uncertainty
  - State of the economy (two-state Markov process)
  - Failure rate of investment projects $\rightarrow$ loan defaults
Basel I

Economic Activity
(realized value of investment projects)
Basel I and Basel II

Economic Activity
(realized value of investment projects)
Banks’ solvency

Conditional 1st period **probabilities of bank failure**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Basel I</th>
<th>Basel II</th>
</tr>
</thead>
<tbody>
<tr>
<td>$s = l$</td>
<td>0.02%</td>
<td>0.01%</td>
</tr>
<tr>
<td>$s = h$</td>
<td>0.14%</td>
<td>0.06%</td>
</tr>
</tbody>
</table>

→ Basel II makes banks safer (esp. in high default states)

→ Under Basel II the probability of failure is **well below 0.1%**

  – Banks hold capital buffers
  – Banks get interest income from non-defaulting loans
Effect of \( a \)

Increase in **success return** \( a \) from 5% to 6%

<table>
<thead>
<tr>
<th></th>
<th>Basel I</th>
<th></th>
<th>Basel II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( a = 5% )</td>
<td>( a = 6% )</td>
<td>( a = 5% )</td>
</tr>
<tr>
<td>( r_h^* )</td>
<td>3.3%</td>
<td>2.4%</td>
<td>3.4%</td>
</tr>
<tr>
<td>( r_l^* )</td>
<td>1.5%</td>
<td>0.6%</td>
<td>1.6%</td>
</tr>
<tr>
<td>( k_h^* )</td>
<td>12.1%</td>
<td>13.3%</td>
<td>13.5%</td>
</tr>
<tr>
<td>( k_l^* )</td>
<td>11.6%</td>
<td>12.7%</td>
<td>12.3%</td>
</tr>
<tr>
<td>( CR(l \rightarrow h) )</td>
<td>1.3%</td>
<td>1.1%</td>
<td>15.6%</td>
</tr>
</tbody>
</table>

*Note: The value in red is highlighted for emphasis.*
### Effect of $c$

Increase in **cost of setting up relationship** $c$ from 4% to 5%

<table>
<thead>
<tr>
<th></th>
<th>Basel I</th>
<th>Basel II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$c = 4%$</td>
<td>$c = 5%$</td>
</tr>
<tr>
<td>$r_h^*$</td>
<td>3.3%</td>
<td>4.4%</td>
</tr>
<tr>
<td>$r_l^*$</td>
<td>1.5%</td>
<td>2.5%</td>
</tr>
<tr>
<td>$k_h^*$</td>
<td>12.1%</td>
<td>12.1%</td>
</tr>
<tr>
<td>$k_l^*$</td>
<td>11.6%</td>
<td>11.7%</td>
</tr>
<tr>
<td>$CR(l \rightarrow h)$</td>
<td>1.3%</td>
<td>1.4%</td>
</tr>
</tbody>
</table>
## Effect of $\delta$

Increase in **cost of equity capital** $\delta$ from 5% to 6%

<table>
<thead>
<tr>
<th></th>
<th>Basel I</th>
<th></th>
<th>Basel II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\delta = 5%$</td>
<td>$\delta = 6%$</td>
<td>$\delta = 5%$</td>
</tr>
<tr>
<td>$r_h^*$</td>
<td>3.3%</td>
<td>3.5%</td>
<td>3.4%</td>
</tr>
<tr>
<td>$r_l^*$</td>
<td>1.5%</td>
<td>1.7%</td>
<td>1.6%</td>
</tr>
<tr>
<td>$k_h^*$</td>
<td>12.1%</td>
<td>11.5%</td>
<td>13.5%</td>
</tr>
<tr>
<td>$k_l^*$</td>
<td>11.6%</td>
<td>11.3%</td>
<td>12.3%</td>
</tr>
<tr>
<td>$CR(l \rightarrow h)$</td>
<td>1.3%</td>
<td>1.6%</td>
<td>15.6%</td>
</tr>
</tbody>
</table>
**Effect of longer expansions**

Increase in **expected duration of expansions** from 5y to 7.1y

<table>
<thead>
<tr>
<th></th>
<th>Basel I</th>
<th>Basel II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$q_l = 0.20$</td>
<td>$q_l = 0.14$</td>
</tr>
<tr>
<td>$r^*_h$</td>
<td>3.3%</td>
<td>3.3%</td>
</tr>
<tr>
<td>$r^*_l$</td>
<td>1.5%</td>
<td>1.5%</td>
</tr>
<tr>
<td>$k^*_h$</td>
<td>12.1%</td>
<td>12.1%</td>
</tr>
<tr>
<td>$k^*_l$</td>
<td>11.6%</td>
<td>11.7%</td>
</tr>
<tr>
<td>$CR(l \rightarrow h)$</td>
<td>1.3%</td>
<td>1.3%</td>
</tr>
</tbody>
</table>
Effect of higher cyclicality of PDs

Move to **high volatility scenario** (with \( p_h = 4.2\% \) and \( p_l = 1\% \))

<table>
<thead>
<tr>
<th></th>
<th>Basel I</th>
<th>Basel II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>( r_h^* )</td>
<td>3.3%</td>
<td>3.7%</td>
</tr>
<tr>
<td>( r_l^* )</td>
<td>1.5%</td>
<td>1.5%</td>
</tr>
<tr>
<td>( k_h^* )</td>
<td>12.1%</td>
<td>12.1%</td>
</tr>
<tr>
<td>( k_l^* )</td>
<td>11.6%</td>
<td>11.6%</td>
</tr>
<tr>
<td>( CR(l \rightarrow h) )</td>
<td>1.3%</td>
<td>1.3%</td>
</tr>
</tbody>
</table>
Robustness checks

• In sum, qualitative results are robust to changes in parameters
• Rationing when entering recession is greater in economies with
  – Lower investment returns
  – Higher cost of bank capital
  – Lower probability of going into recession
  – Higher cyclical variation of PDs
Policy simulations (i)

• New requirements have a VaR foundation

• Procyclical effects derive from a point-in-time approach

• Must “confidence levels” be guaranteed period-by-period or on a LT basis?

• LT confidence levels are compatible with smoother capital requirements (and lower CR)

• Reducing the ST confidence level at start of recessions and increasing the ST confidence level in the middle of expansions might dramatically reduce expected CR
Policy simulations (ii)

• Adjusting some “scaling factor” over the business cycle
  – Either **shifting down capital charge curve in recessions**
    → Reduce $\gamma_h$ by 10% (from 11.2% to 10%)
  – Or **shifting up capital charge curve in expansions**
    → Increase $\gamma_l$ by 10% (from 6.6% to 7.25%)
Policy simulations (iii)

- Adjustment of the "scaling factor"

\[
\begin{align*}
\gamma_h &= 11.2\% & \gamma_h &= 10\% & \gamma_h &= 11.2\% \\
\gamma_l &= 6.6\% & \gamma_l &= 6.6\% & \gamma_l &= 7.25\% \\
r_h^* &= 3.4\% & r_h^* &= 3.4\% & r_h^* &= 3.5\% \\
r_l^* &= 1.6\% & r_l^* &= 1.5\% & r_l^* &= 1.6\% \\
k_h^* &= 13.5\% & k_h^* &= 12.7\% & k_h^* &= 13.5\% \\
k_l^* &= 12.3\% & k_l^* &= 12.5\% & k_l^* &= 12.9\% \\
CR(l \rightarrow h) &= 15.6\% & CR(l \rightarrow h) &= 4.7\% & CR(l \rightarrow h) &= 10.6\% 
\end{align*}
\]
Concluding remarks (i)

• Paper evaluates potential procyclicality of capital requirements

• Focuses on supply side of bank lending market
  – Demand side and feedback effects ignored
  – How much procyclicality comes from the supply side?
  – How this will be affected by Basel II?

• Contribution is partly methodological and partly substantive
Concluding remarks (ii)

• Methodological contribution
  → Fully-fledged dynamic model of the credit market with
    – Relationship lending
    – Frictions in banks’ access to equity financing
  → Endogenous capital buffers and loan rates

• Numerical results
  – Procyclical capital buffers of realistic size
  – Basel II may have significant effects on cyclicality
    (Credit crunch as economy goes into a recession)