Leverage Restrictions in a Business Cycle Model

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Background

• Increasing interest in the following sorts of questions:
  – What restrictions should be placed on bank leverage?
  – How should those restrictions be varied over the business cycle?
What We Do

• Modify a standard medium-sized DSGE model to include a banking sector.

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loans and other securities</td>
<td>Deposits</td>
</tr>
<tr>
<td>Banker net worth</td>
<td></td>
</tr>
</tbody>
</table>

• Job of bankers is to identify and finance good investment projects.
  – doing this requires exerting costly effort.

• Agency problem between bank and its creditors:
  – banker effort is not observable.

• Consequence: leverage restrictions on banks generate a very substantial welfare gain in steady state.

• Desirable to encourage low leverage in good times, so that banks in better position to absorb bad shocks to net worth.
Outline

• Model
  – first, without leverage restriction
    • observable effort benchmark
    • unobservable case
  – then, with leverage restriction
• Steady state properties of leverage restrictions
• Dynamics
Standard Model

- Firms
- Labor market
- Household
- Market for Physical Capital

Flows:
- Labor market to Firms: $L$
- Household to Firms: $C$
- Firms to Market for Physical Capital: $K$
- Firms to Labor market: $I$
Standard Model with Banking

Entrepreneur pays everything to the bank and has nothing.
Standard Model with Banking

- Firms
- Entrepreneurs
- Capital Producers
- banks
- Mutual funds
- household
- Labor market
Entrepreneurs

- After goods production in period $t$: Purchase raw capital from capital producers, for price $P_{k',t}$.
  - entrepreneurs have no resources of their own and must obtain financing from banks.
- Entrepreneurs convert raw capital into effective capital.
  - Some are good at it and some are bad.
- In period $t+1$:
  - entrepreneurs rent capital to goods-producers in competitive markets, at rental rate, $r_{t+1}$.
  - after production, sell undepreciated capital back to capital producers at price, $P_{k',t+1}$.
  - entrepreneurs pay all earnings to bank at end of $t + 1$, keeping nothing.
  - no agency problems between entrepreneurs and banks.
Earnings of Entrepreneurs

• there are good entrepreneurs and bad entrepreneurs.

• bad: 1 unit, raw capital $\rightarrow e^b$ units, effective capital

• good: 1 unit, raw capital $\rightarrow e^g > e^b$ units, effective capital

• return to capital enjoyed by entrepreneurs:

$$R^g_{t+1} = e^g R^k_{t+1}, \quad R^b_{t+1} = e^b R^k_{t+1}$$

$$R^k_{t+1} = \frac{r^k_{t+1} P_{t+1} + (1 - \delta) P_{k,t+1}}{P_{k',t}}$$
Bankers

- each has net worth, $N_t$.
- a banker can only invest in one entrepreneur (asset side of banker balance sheet is risky).
- by exerting effort, $e_t$, a banker finds a good entrepreneur with probability $p$:
  \[ p(e_t) = \bar{a} + \bar{b}e_t \]

- in $t$, bankers seek to optimize:
  \[
  E_t \lambda_{t+1} \left\{ p(e_t) \left[ R^g_{t+1} (N_t + d_t) - R^g_{d,t+1} d_t \right] \right.
  
  + (1 - p(e_t)) \left[ R^b_{t+1} (N_t + d_t) - R^b_{d,t+1} d_t \right] \}
  - \frac{1}{2} e^2_t
  \]

- Bankers have a cash constraint:
  \[ R^b_{t+1} (N_t + d_t) \geq R^b_{d,t+1} d_t \]
Bankers and their Creditors

- Bankers and Mutual Funds interact in competitive markets for loan contracts:
  \[ (d_t, e_t, R_{d,t+1}^g, R_{d,t+1}^b) \]

- Free entry and competition among mutual funds implies:
  \[ p(e_t) R_{d,t+1}^g + (1 - p(e_t)) R_{d,t+1}^b = R_t \]

- Two scenarios:
  - banker effort, \( e_t \), is observed by mutual fund
  - banker effort, \( e_t \), is unobserved.
Observed Effort Benchmark

- Set of contracts available to bankers is the \( (d_t, e_t, R^g_{d,t+1}, R^b_{d,t+1}) \)'s that satisfy

\[
\begin{align*}
\text{MF zero profits:} & \quad p(e_t) R^g_{d,t+1} + (1 - p(e_t)) R^b_{d,t+1} = R_t, \\
\text{cash constraint:} & \quad R^b_{t+1} (N_t + d_t) \geq R^b_{d,t+1} d_t
\end{align*}
\]

- Each banker chooses the most preferred contract from the menu.
- Key feature of observed effort equilibrium:

\[
e_t = E_t \lambda_{t+1} p'(e_t) \left( R^g_{t+1} - R^b_{t+1} \right) (N_t + d_t)
\]
In this case, banker always sets $e_t$ to its privately optimal level, whatever $e_t$ is specified in the loan contract:

\[
\text{incentive: } e_t = E_t \lambda_{t+1} p' (e_t) \left[ \left( R^g_{t+1} - R^b_{t+1} \right) (N_t + d_t) \right. \\
\left. - \left( R^g_{d,t+1} - R^b_{d,t+1} \right) d_t \right].
\]

Set of contracts available to bankers is the $(d_t, e_t, R^g_{d,t+1}, R^b_{d,t+1})$'s that satisfy ‘incentive’ in addition to:

- MF zero profits: $p (e_t) R^g_{d,t+1} + (1 - p (e_t)) R^b_{d,t+1} = R_t$,
- cash constraint: $R^b_{t+1} (N_t + d_t) \geq R^b_{d,t+1} d_t$

One factor that can make $e_t$ inefficiently low:

\[
- R^g_{d,t+1} > R^b_{d,t+1}.
\]
Law of Motion of Net Worth

- Bankers live in a large representative household, with workers (as in Gertler-Karadi, Gertler-Kiyotaki).
  - Bankers pool their net worth at the end of each period (we avoid worrying about banker heterogeneity)

- Law of motion of banker net worth

\[
N_{t+1} = \gamma_{t+1} \left\{ p\left(e_t\right) \left[ R^g_{t+1} (N_t + d_t) - R^g_{d,t+1} d_t \right] + (1 - p\left(e_t\right)) \left[ R^b_{t+1} (N_t + d_t) - R^b_{d,t+1} d_t \right] \right\} + T_{t+1}
\]

profits when bank assets good

profits when bank assets are bad

lump sum transfer, households to their bankers
Model Assumption that Banks Don’t Systematically Rely on Equity Issues to Finance Assets

- Evidence from two sources provide support for this assumption as a description of the data.
  - Adrian and Shin’s examination of the assets and liabilities of two large French financial firms.
  - US flow of funds data on assets and liabilities of financial corporations.

- Adrian and Shin, ‘Procyclical Leverage and Value-at-Risk’
  - Changes in financial firm equity not systematically related to their assets.
  - Changes in financial firm debt moves one-for-one with changes in assets.
Material taken from the work of Adrian Shin.
Displays a scatter plot change in equity and debt on the horizontal axis against change in assets on the horizontal axis. Note that the slope of changes in debt against changes in assets is essentially unity, while the slope of changes in equity against changes in assets has a slope of zero.
The results are consistent with the notion that this financial company headquartered in Paris finances changes in assets with changes in debt and not changes in equity.

Figure 3. BNP Paribas: annual change in assets, equity and debt (1999-2010) (Source: Bankscope)


Figure 4. Société Générale: annual change in assets, equity and debt (1999-2010) (Source: Bankscope)
• The model assumes that when bankers want funds, issuing equity is not an option.

This shows how major debt instruments were used at private depository institutions in the wake of the crisis.
• The model assumes that when bankers want funds, issuing equity is not an option.
‘Crisis’

- Suppose something makes banker net worth, $N_t$, drop.
- For given $d_t$, bank cash constraint gets tighter:

$$R_{t+1}^b (N_t + d_t) \geq R_{d,t+1}^b d_t.$$ 

- So, $R_{d,t+1}^b$ has to be low
  - when $N_t$ is low, banks with bad assets cannot cover their own losses and creditors must share in losses.
  - then, creditors require $R_{d,t+1}^g$ high

- So, interest rate spread, $R_{d,t+1}^g - R_t$, high, banker effort low.
- Banks get riskier (cross sectional mean return down, standard deviation up).
Endogenous Risk

- Rate of return on equity, good banks and bad banks:

\[
p(e_t) \text{ good banks } : \frac{R^g_{t+1} (N_t + d_t) - R^g_{d,t+1} d_t}{N_t},
\]

\[
1 - p(e_t) \text{ bad banks } : \frac{R^b_{t+1} (N_t + d_t) - R^b_{d,t+1} d_t}{N_t} = 0
\]

- Mean, \(E^b_{t+1}\), and cross sectional standard deviation, \(s^b_{t+1}\), of return on equity across banks:

\[
E^b_{t+1} = p(e_t) \frac{R^g_{t+1} (N_t + d_t) - R^g_{d,t+1} d_t}{N_t}
\]

\[
[p(e_t) (1 - p(e_t))]^{1/2} \frac{R^g_{t+1} (N_t + d_t) - R^g_{d,t+1} d_t}{N_t}
\]

- In a crisis, risk rises and mean return falls.
Macro Model

- Sticky wages and prices
- Investment adjustment costs
- Habit persistence in consumption
- Monetary policy rule
## Calibration targets

### Table 2: Steady state calibration targets for baseline model

<table>
<thead>
<tr>
<th>Variable meaning</th>
<th>variable name</th>
<th>magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-sectional standard deviation of quarterly non-financial firm equity returns</td>
<td>$s^b$</td>
<td>0.20</td>
</tr>
<tr>
<td>Financial firm interest rate spreads (APR)</td>
<td>$400(R^d_g - R)$</td>
<td>0.60</td>
</tr>
<tr>
<td>Financial firm leverage</td>
<td>$L$</td>
<td>20.00</td>
</tr>
<tr>
<td>Allocative efficiency of the banking system</td>
<td>$p(e)e^g + (1 - p(e))e^b$</td>
<td>1</td>
</tr>
</tbody>
</table>
Data behind calibration targets

Figure 1: Cross-section standard deviation financial firm quarterly return on equity, HP-filtered US real GDP

Cross-section volatility (left scale)
Data behind calibration targets

Figure 1: Cross-section standard deviation financial firm quarterly return on equity, HP-filtered US real GDP

Cross-section volatility (left scale)

HP-filtered GDP (right scale)

quarterly data
<table>
<thead>
<tr>
<th>Panel A: financial parameters</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>return parameter, bad entrepreneur</td>
<td>$b$</td>
<td>-0.09</td>
</tr>
<tr>
<td>return parameter, good entrepreneur</td>
<td>$g$</td>
<td>0.00</td>
</tr>
<tr>
<td>constant, effort function</td>
<td>$\tilde{a}$</td>
<td>0.83</td>
</tr>
<tr>
<td>slope, effort function</td>
<td>$\tilde{b}$</td>
<td>0.30</td>
</tr>
<tr>
<td>lump-sum transfer from households to bankers</td>
<td>$\tilde{T}$</td>
<td>0.38</td>
</tr>
<tr>
<td>fraction of banker net worth that stays with bankers</td>
<td>$\gamma$</td>
<td>0.85</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B: Parameters that do not affect steady state</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>steady state inflation (APR)</td>
<td>$400(\pi - 1)$</td>
<td>2.40</td>
</tr>
<tr>
<td>Taylor rule weight on inflation</td>
<td>$\alpha_z$</td>
<td>1.50</td>
</tr>
<tr>
<td>Taylor rule weight on output growth</td>
<td>$\alpha_{\lambda y}$</td>
<td>0.50</td>
</tr>
<tr>
<td>smoothing parameter in Taylor rule</td>
<td>$\rho_p$</td>
<td>0.80</td>
</tr>
<tr>
<td>curvature on investment adjustment costs</td>
<td>$S''$</td>
<td>5.00</td>
</tr>
<tr>
<td>Calvo sticky price parameter</td>
<td>$\xi_p$</td>
<td>0.75</td>
</tr>
<tr>
<td>Calvo sticky wage parameter</td>
<td>$\xi_w$</td>
<td>0.75</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel C: Nonfinancial parameters</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>steady state gdp growth (APR)</td>
<td>$\mu_{z^*}$</td>
<td>1.65</td>
</tr>
<tr>
<td>steady state rate of decline in investment good price (APR)</td>
<td>$\tilde{\gamma}$</td>
<td>1.69</td>
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<tr>
<td>capital depreciation rate</td>
<td>$\delta$</td>
<td>0.03</td>
</tr>
<tr>
<td>production fixed cost</td>
<td>$\Phi$</td>
<td>0.89</td>
</tr>
<tr>
<td>capital share</td>
<td>$\alpha$</td>
<td>0.40</td>
</tr>
<tr>
<td>steady state markup, intermediate good producers</td>
<td>$\lambda_f$</td>
<td>1.20</td>
</tr>
<tr>
<td>habit parameter</td>
<td>$b_u$</td>
<td>0.74</td>
</tr>
<tr>
<td>household discount rate</td>
<td>$100(\beta^{-4} - 1)$</td>
<td>0.52</td>
</tr>
<tr>
<td>steady state markup, workers</td>
<td>$\lambda_w$</td>
<td>1.05</td>
</tr>
<tr>
<td>Frisch labor supply elasticity</td>
<td>$1/\sigma_L$</td>
<td>1.00</td>
</tr>
<tr>
<td>weight on labor disutility</td>
<td>$\psi_L$</td>
<td>1.00</td>
</tr>
<tr>
<td>steady state scaled government spending</td>
<td>$\tilde{g}$</td>
<td>0.89</td>
</tr>
</tbody>
</table>
Leverage Restrictions

• Banks taxed for issuing deposits $d_t$
  – 1.2% AR (versus 3% AR on the risk free nominal rate).
  – revenues redistributed back to banks in lump-sum form.

• What is the consequence of this restriction?
  – With less $d_t$, banks with bad assets more able to cover losses
    • interest rate spread falls, so banker effort rises.
  – Second effect of leverage restriction,
    • leverage restriction in effect implements collusion among bankers
    • allows them to behave as monopsonists
    • make profits on demand deposits....lots of profits:

\[
\left[ p(e_t) \left( R_{t+1}^g - R_{d,t+1}^g \right) + (1 - p(e_t)) \left( R_{t+1}^b - R_{d,t+1}^b \right) \right] \frac{d_t}{N_t}
\]

• makes $N_t$ grow, offseting incentive effects of decline in $d_t$.  
Impact of Loss of Bank Net Worth

Bank net worth (N)

Deposit rate, bad (failed) banks (APR)

Interest rate spread (APR)

Std dev, in cross section, financial firm equity returns

GDP

Consumption

Investment

Inflation (APR)

Bank leverage

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Std dev, in cross section, financial firm equity returns

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Inflation (APR)

Bank leverage

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Conclusion

• Described a model in which there is a problem that is mitigated by the introduction of leverage restrictions.

• Currently exploring what are the optimal dynamic properties of leverage.
  – the cyclical behavior of the tax on leverage depends on which shock drives the cycle.
  – if driven by permanent technology shocks, then act to discourage debt in a boom.