Leverage Restrictions in a Business Cycle Model

Lawrence J. Christiano
Daisuke Ikeda

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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?
- How should monetary policy react to bank leverage, if at all?
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.

• Explore some of the dynamic implications of the models.
Outline

• Model
  – first, without leverage restriction
    • observable effort benchmark
    • unobservable case
  – then, with leverage restriction

• Steady state properties of leverage restrictions

• Implications for dynamic effects of shocks
Standard Model

Firms

Labor market

household

Market for Physical Capital

L

K
Standard Model

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

Arrows indicate the flow of factors of production:

- $L$ to Firms
- $C$ to Firms
- $I$ to Firms
- $K$ to Firms

Standard Model with Banking

- Firms
- Labor market
- Household
- Entrepreneurs

Relations:
- $L$ from Labor market to Firms
- $K$ from Entrepreneurs to Firms
Entrepreneur pays everything to the bank and has nothing.
Standard Model with Banking

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

Mutual funds
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 $\rightarrow e^{bt}$ units, effective capital
- good: 1 unit, raw capital $\rightarrow e^{gt}$ units, effective capital

- return to capital enjoyed by entrepreneurs:

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

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

- In effect, entrepreneurs operate linear investment technologies,

$$R^g_{t+1} > R^b_{t+1}$$
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:
  \[
  E_t \lambda_{t+1} \left\{ p(e_t) \left[ R^g_{t+1} (N_t + d_t) - R^d_{g,t+1} d_t \right] + (1 - p(e_t)) \left[ R^b_{t+1} (N_t + d_t) - R^d_{b,t+1} d_t \right] \right\} - \frac{1}{2} e_t^2
  \]

- Bankers cannot pay out cash they do not have:
  \[ R^b_{t+1} (N_t + d_t) \geq R^d_{b,t+1} d_t \]
Bankers and their Creditors

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

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

- 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
  \((d_t, e_t, R_{g,t+1}^d, R_{b,t+1}^d)\)'s that satisfy

  MF zero profits : \( p(e_t) R_{g,t+1}^d + (1 - p(e_t)) R_{b,t+1}^d = R_t, \)
  cash constraint : \( R_{t+1}^b (N_t + d_t) \geq R_{b,t+1}^d d_t \)

• Each banker chooses the most preferred contract from the
  above set of contracts to maximize

  \[
  E_t \lambda_{t+1} \{ p(e_t) \left[ R_{t+1}^g (N_t + d_t) - R_{g,t+1}^d d_t \right] \\
  + (1 - p(e_t)) \left[ R_{t+1}^b (N_t + d_t) - R_{b,t+1}^d d_t \right] \} - \frac{1}{2} e_t^2
  \]
Observed Effort Benchmark

• Substitute the MF zero profit condition out from the bankers’ objective:

\[ E_t \lambda_{t+1} \{ p (e_t) R^g_{t+1} (N_t + d_t) \]  
\[ + (1 - p (e_t)) R^b_{t+1} (N_t + d_t) - R_t d_t \} - \frac{1}{2} e_t^2 \]

• Two properties of optimal contract:
  – first order condition:

\[ e_t = E_t \lambda_{t+1} p'_t (e_t) \left( R^g_{t+1} - R^b_{t+1} \right) (N_t + d_t) \]

  – \( R^g_{t+1}, R^b_{t+1} \) can be selected arbitrarily to satisfy the constraints, and play no role in determining banker effort.
Unobserved Effort

- When $e_t$ cannot be observed by the mutual fund, the banker is under no compulsion to actually set $e_t$ to the value agreed in the loan contract.

- After the terms of a loan contract have been agreed upon and it is time for the banker to choose a value for $e_t$, the banker takes the other terms in the contract, $d_t, R_{g,t+1}^d, R_{b,t+1}^d$, as given.
  
  - The value of $e_t$ that optimizes a banker’s objective after the contract has been agreed upon is:

\[
\text{incentive: } e_t = E_t \lambda_{t+1} p_t'(e_t) \left[ \left( R_{g,t+1}^g - R_{b,t+1}^b \right) (N_t + d_t) \right. \\
- \left. \left( R_{g,t+1}^d - R_{b,t+1}^d \right) d_t \right].
\]

- When $e_t$ cannot be observed, then mutual funds know that whatever value for $e_t$ is written into a loan contract, $e_t$ will always be set according to ‘incentive’.
Unobserved Effort

- Loan contracts which incorporate a value for $e_t$ that does not satisfy ‘incentive’ are not feasible.
  - They are no more feasible than a loan contract that does not satisfy the cash constraint.

- So, when $e_t$ is unobserved, then ‘incentive’ must be added to the set of constraints that restrict the loan contract:
  - Bankers can choose a contract, $\left( d_t, e_t, R_{g,t+1}^d, R_{b,t+1}^d \right)$, from a set defined by:

    MF zero profits: $p(e_t) R_{g,t+1}^d + (1 - p(e_t)) R_{b,t+1}^d = R_t$

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

    incentive: $e_t = E_t \lambda_{t+1} p_t'(e_t) \left[ (R_{t+1}^g - R_{t+1}^b) (N_t + d_t) - (R_{g,t+1}^d - R_{b,t+1}^d) d_t \right]$

- One factor that can make $e_t$ inefficiently low:
  - $R_{g,t+1}^d > R_{b,t+1}^d$. 
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

\[
N_{t+1} = \gamma_{t+1}\left\{ p(e_t) \left[ R^g_{t+1} (N_t + d_t) - R^d_{g,t+1} d_t \right] + (1 - p(e_t)) \left[ R^b_{t+1} (N_t + d_t) - R^d_{b,t+1} d_t \right] \right\} + T_{t+1}
\]
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N_{t+1} = \gamma_{t+1}\left\{ p\left( e_t \right) \left[ R_{t+1}^g \left( N_t + d_t \right) - R_{g,t+1}^d d_t \right] \right. \\
\left. + \left( 1 - p\left( e_t \right) \right) \left[ R_{t+1}^b \left( N_t + d_t \right) - R_{b,t+1}^d d_t \right]\right\} \\
+ T_{t+1}
\]
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.
Suppose something makes banker net worth, $N_t$, drop. For given $d_t$, bank cash constraint gets tighter:

$$R^b_{t+1} (N_t + d_t) \geq R^d_{b,t+1} d_t.$$

So, $R^d_{b,t+1}$ 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 $R^d_{g,t+1}$ high

So, interest rate spread, $R^d_{g,t+1} - R_t$, high, banker effort low.

Banks get riskier (cross sectional mean return down, standard deviation up).
Leverage Restrictions

• Banks face the following restriction:

\[ L_t \geq \frac{N_t + d_t}{N_t}. \]

• What is the consequence of this restriction?
  
  – With less \( d_t \), banks with bad assets more able to cover losses
    
    • interest rate spread, \( R^d_b - R \), 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:

\[
\left[ p(e_t) \left( R^g_{t+1} - R^d_{g,t+1} \right) + (1 - p(e_t)) \left( R^b_{t+1} - R^d_{b,t+1} \right) \right] \frac{d_t}{N_t}
\]

  • makes \( N_t \) grow, offseting incentive effects of decline in \( d_t \).
Review of Monopsony in Banking

- Monopsony: market in which one buyer (e.g., monopsony bank) faces many sellers (e.g., depositors).
- Consider a monopsony bank that earns $R^k d$ on its assets and faces a supply curve for deposits that is increasing in deposits, $S(d), S'(d) > 0$.
- Problem:
  \[
  \max_d \left[ R^k d - S(d) d \right], \quad S'(d) > 0
  \]

  marginal revenue product of deposits \hspace{2cm} marginal cost of deposits

  \[
  R^k = S'(d) d + S(d)
  \]

- Perfect competition, $S(d)$ exogenous to individual bank ($d \sim$ aggregate deposits, not a function of $d$), so profit maximization leads to:
  \[
  R_k = S(d)
  \]
Review of Monopsony in Banking

• Results:

\[ d = d^m \quad R^k = \frac{S'(d^m) d^m + S(d^m)}{S(d^m)} \]

monopsony marginal cost of \( d \) to monopsonist

\[ d = d^c \quad R^k = \frac{S(d^c)}{} \]

competition marginal cost of \( d \), perfect competition

• So,
  - monopsonist restricts demand: \( d^m < d^c \)
  - monopsonist makes positive profits, competition yields zero profits

• (Possibly unintended) effect of leverage restriction:
  - by legislating a reduction in deposits, implicitly enables competitive banks to collude and collectively restrict demand for deposits.
  - bank profits increase.
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>
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)
### Parameter Values

**Table 1: Baseline Model Parameter Values**

<table>
<thead>
<tr>
<th>Meaning</th>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: financial parameters</strong></td>
<td></td>
<td></td>
</tr>
<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>$\bar{a}$</td>
<td>0.83</td>
</tr>
<tr>
<td>slope, effort function</td>
<td>$\bar{b}$</td>
<td>0.30</td>
</tr>
<tr>
<td>lump-sum transfer from households to bankers</td>
<td>$\hat{T}$</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>
<tr>
<td><strong>Panel B: Parameters that do not affect steady state</strong></td>
<td></td>
<td></td>
</tr>
<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>
<tr>
<td><strong>Panel C: Nonfinancial parameters</strong></td>
<td></td>
<td></td>
</tr>
<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>$\bar{\gamma}$</td>
<td>1.69</td>
</tr>
<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>$b_h$</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>
Steady State Calculations

- Next study steady state impact of leverage
  - Quantify role of hidden effort in the analysis (essential!)
### Table 3: Steady State Properties of the Model

<table>
<thead>
<tr>
<th>Variable meaning</th>
<th>Variable name</th>
<th>Unobserved Effort</th>
<th>Observed Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Leverage Restriction</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>non-binding</td>
<td>binding</td>
</tr>
<tr>
<td>Spread</td>
<td>$400(R_d^a - R)$</td>
<td>0.600</td>
<td>NA</td>
</tr>
<tr>
<td>scaled consumption</td>
<td>$c$</td>
<td>1.84</td>
<td>2.01</td>
</tr>
<tr>
<td>labor</td>
<td>$h$</td>
<td>1.18</td>
<td>1.15</td>
</tr>
<tr>
<td>scaled capital stock</td>
<td>$k$</td>
<td>51.52</td>
<td>59.75</td>
</tr>
<tr>
<td>bank assets</td>
<td>$N + d$</td>
<td>51.52</td>
<td>59.55</td>
</tr>
<tr>
<td>bank net worth</td>
<td>$N$</td>
<td>2.58</td>
<td>2.58</td>
</tr>
<tr>
<td>bank deposits</td>
<td>$d$</td>
<td>48.94</td>
<td>56.98</td>
</tr>
<tr>
<td>bank leverage</td>
<td>$(N + d)/N$</td>
<td>20.00</td>
<td>23.12</td>
</tr>
<tr>
<td>bank return on equity (APR)</td>
<td>$400\left(\frac{[p(e_i)R_{t+1}^d + (1-p(e_i))R_{t+1}^h]}{N_i}(N_t+d_t)-R_{d_t} - 1\right)$</td>
<td>4.59</td>
<td>4.59</td>
</tr>
<tr>
<td>fraction of firms with good balance sheets</td>
<td>$p(e)$</td>
<td>0.962</td>
<td>1.000</td>
</tr>
<tr>
<td>Benefit of leverage (in c units)</td>
<td>$100\chi$</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>Benefit of making effort observable (in c units)</td>
<td>$100\chi$</td>
<td>NA</td>
<td>6.11</td>
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Note: (i) NA, not applicable, indicates that the number is not defined. (ii) All calculations based on a single set of parameter values, reported in Table 1.

Making effort observable makes things a lot better, equivalent to a 6% permanent jump in consumption!
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Interestingly, leverage goes up.
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<td></td>
<td>non-binding</td>
<td>binding</td>
</tr>
<tr>
<td>Spread</td>
<td>$400(R_g^d - R)$</td>
<td>0.600</td>
<td>0.211</td>
</tr>
<tr>
<td>scaled consumption</td>
<td>$c$</td>
<td>1.84</td>
<td>1.88</td>
</tr>
<tr>
<td>labor</td>
<td>$h$</td>
<td>1.18</td>
<td>1.16</td>
</tr>
<tr>
<td>scaled capital stock</td>
<td>$k$</td>
<td>51.52</td>
<td>51.40</td>
</tr>
<tr>
<td>bank assets</td>
<td>$N + d$</td>
<td>51.52</td>
<td>51.31</td>
</tr>
<tr>
<td>bank net worth</td>
<td>$N$</td>
<td>2.58</td>
<td>3.02</td>
</tr>
<tr>
<td>bank deposits</td>
<td>$d$</td>
<td>48.94</td>
<td>48.29</td>
</tr>
<tr>
<td>bank leverage</td>
<td>$(N + d)/N$</td>
<td>20.00</td>
<td>17.00</td>
</tr>
<tr>
<td>bank return on equity (APR)</td>
<td>$400 \left( \frac{p(e_t)R_g^d + (1-p(e_t))R_d^d}{N_t} \right) - 1$</td>
<td>4.59</td>
<td>14.96</td>
</tr>
<tr>
<td>fraction of firms with good balance sheets</td>
<td>$p(e)$</td>
<td>0.962</td>
<td>0.982</td>
</tr>
<tr>
<td>Benefit of leverage (in $c$ units)</td>
<td>$100 \chi$</td>
<td>NA</td>
<td>1.19</td>
</tr>
<tr>
<td>Benefit of making effort observable (in $c$ units)</td>
<td>$100 \chi$</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Note: (i) NA, not applicable, indicates that the number is not defined. (ii) All calculations based on a single set of parameter values, reported in Table 1.

Cut in leverage in the unobserved effort economy moves things towards observed effort.
Table 3: Steady State Properties of the Model

<table>
<thead>
<tr>
<th>Variable meaning</th>
<th>Variable name</th>
<th>Unobserved Effort</th>
<th>Observed Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Leverage Restriction</td>
<td>Leverage Restriction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>non-binding</td>
<td>binding</td>
</tr>
<tr>
<td>leverage restriction</td>
<td>Leverage Restriction</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>spread</td>
<td>$400(R_{g}^{d} - R)$</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>scaled consumption</td>
<td>$c$</td>
<td>2.01</td>
<td>1.95</td>
</tr>
<tr>
<td>labor</td>
<td>$h$</td>
<td>1.15</td>
<td>1.14</td>
</tr>
<tr>
<td>scaled capital stock</td>
<td>$k$</td>
<td>59.75</td>
<td>53.86</td>
</tr>
<tr>
<td>bank assets</td>
<td>$N + d$</td>
<td>59.55</td>
<td>53.68</td>
</tr>
<tr>
<td>bank net worth</td>
<td>$N$</td>
<td>2.58</td>
<td>3.16</td>
</tr>
<tr>
<td>bank deposits</td>
<td>$d$</td>
<td>56.98</td>
<td>50.52</td>
</tr>
<tr>
<td>bank leverage</td>
<td>$(N + d)/N$</td>
<td>23.12</td>
<td>17.00</td>
</tr>
<tr>
<td>bank return on equity (APR)</td>
<td>$400\left(\frac{p(e)R_{n+1}^{d} + (1-p(e))R_{n+1}^{b}}{N} \right) - 1$</td>
<td>4.59</td>
<td>17.63</td>
</tr>
<tr>
<td>fraction of firms with good balance sheets</td>
<td>$p(e)$</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Benefit of leverage (in c units)</td>
<td>$100\chi$</td>
<td>NA</td>
<td>-2.70</td>
</tr>
<tr>
<td>Benefit of making effort observable (in c units)</td>
<td>$100\chi$</td>
<td>6.11</td>
<td>2.03</td>
</tr>
</tbody>
</table>

Hidden effort assumption is essential. Otherwise, leverage restriction reduces utility.
Here, we consider the dynamic effects of two shocks

- shock to monetary policy
- lump sum shock to net worth
\[ R_t = 0.80R_{t-1} + (1 - 0.80)[1.5\pi_{t+1} + 0.5g_{y,t}] + \varepsilon_t^p \]

\[ \varepsilon_0^p = +25 \text{ annual basis points} \]

Contractionary M policy shock:
- fall in:
  - \( c, i, y \),
  - bank net worth, \( N \),
  - inflation
- Rise in:
  - leverage
  - cross-sectional dispersion of bank performance
Conclusion

- Described a model in which there is a problem that is mitigated by the introduction of leverage restrictions.
- Described some loose tests of the model by looking at its dynamic implications.
- Studied steady state implications of leverage.
- Currently exploring what are the optimal dynamic properties of leverage.
- Conjecture:
  - leverage restrictions useful in a boom, so banks to build up a lot of net worth then.
  - so, when a recession occurs, banks have enough net worth to shield depositors from losses on bank balance sheets.