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?
  - 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.

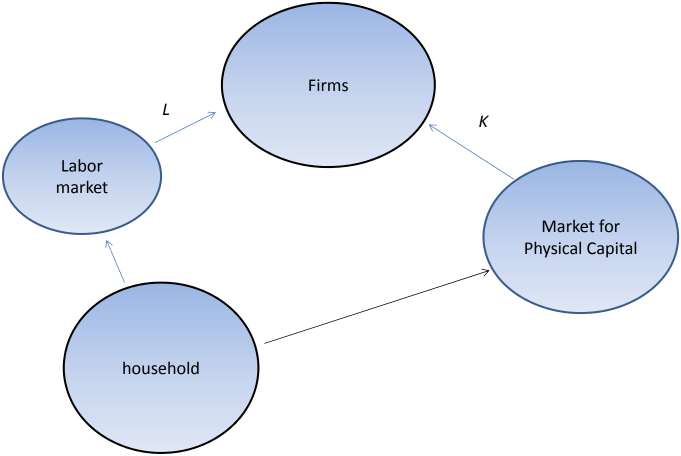
Assets	Liabilities
Loans and other securities	Deposits
	Banker net worth

- 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



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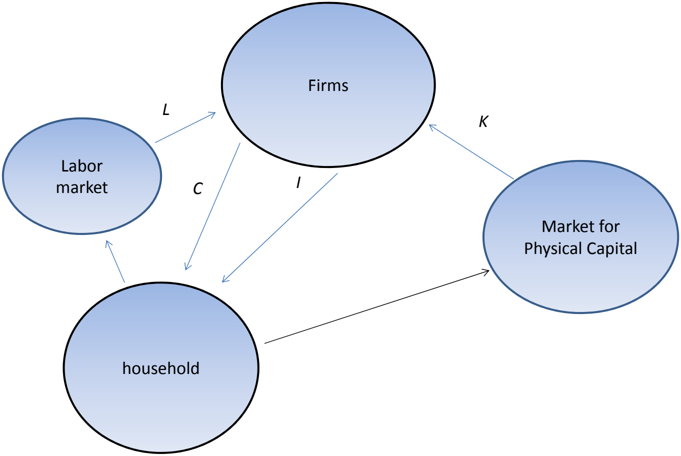
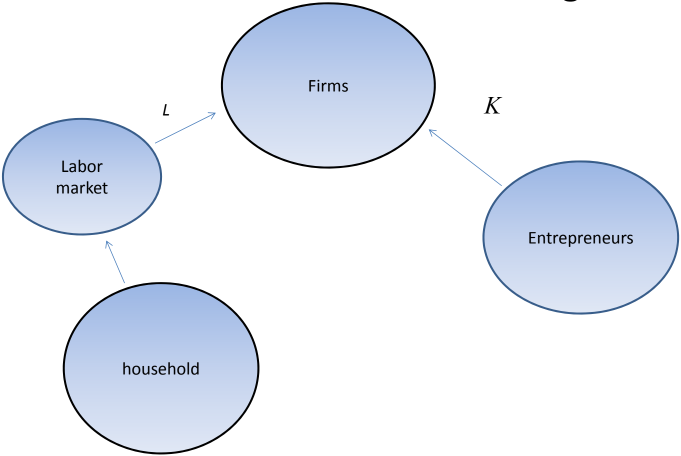


Standard Model with Banking



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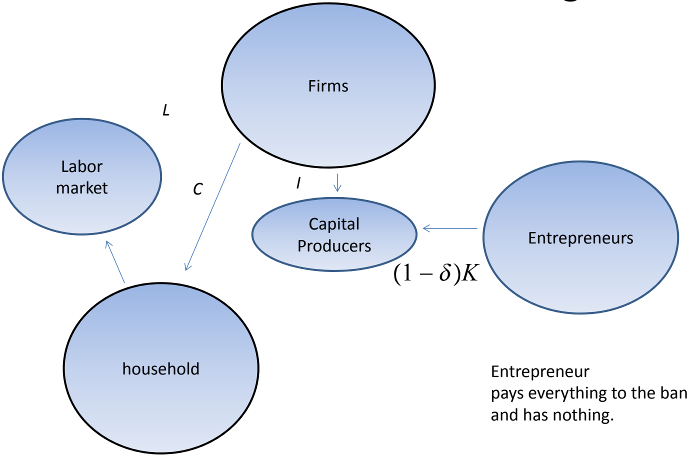
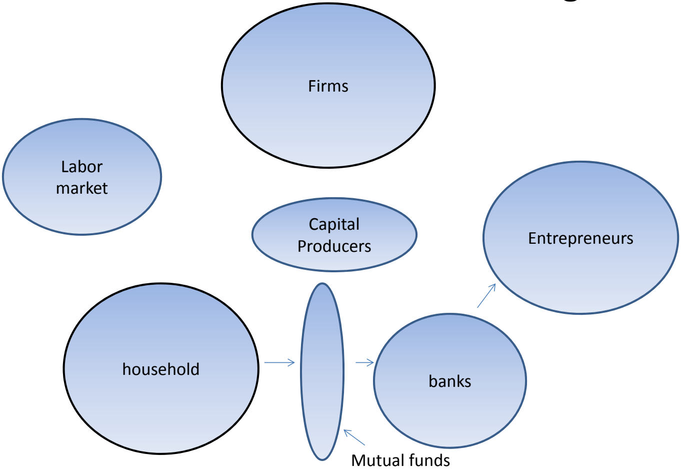


Entrepreneur
pays everything to the bank
and has nothing.

Standard Model with Banking



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 $\longrightarrow e^{b_t}$ units, effective capital
- good: 1 unit, raw capital $\longrightarrow e^{g_t}$ units, effective capital

- return to capital enjoyed by entrepreneurs:

$$R_{t+1}^{g} = e^{g_t} R_{t+1}^{k},\ R_{t+1}^{b} = e^{b_t} R_{t+1}^{k}$$

$$R_{t+1}^{k} \equiv \frac{r_{t+1}^{k} P_{t+1} + (1-\delta) P_{k,t+1}}{P_{k't}}$$

- In effect, entrepreneurs operate linear investment technologies,

$$R_{t+1}^{g} > R_{t+1}^{b}$$

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 :

$$p\left(e_t\right) = \bar{a} + \bar{b}e_t$$

- in t, bankers seek to optimize:

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

- Bankers cannot pay out cash they do not have:

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

Bankers and their Creditors

- Bankers and Mutual Funds interact in competitive markets for loan contracts:

$$\left(d_t, e_t, R^d_{g,t+1}, R^d_{b,t+1}\right)$$

- Free entry and competition among mutual funds implies:

$$p\left(e_t\right) R^d_{g,t+1} + \left(1 - p\left(e_t\right)\right) R^d_{b,t+1} = R_t$$

- 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 $\left(d_t, e_t, R^d_{g,t+1}, R^d_{b,t+1}\right)$'s that satisfy

$$\begin{aligned} \text{MF zero profits} &: \quad p(e_t)\, R^d_{g,t+1} + (1 - p(e_t))\, R^d_{b,t+1} = R_t, \\ \text{cash constraint} &: \quad R^b_{t+1}(N_t + d_t) \geq R^d_{b,t+1} d_t \end{aligned}$$

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

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

Observed Effort Benchmark

- Substitute the MF zero profit condition out from the bankers' objective:

$$
\begin{aligned}
& E_t \lambda_{t+1} \{ p(e_t) R^g_{t+1} (N_t + d_t) \\
& + (1 - p(e_t)) R^b_{t+1} (N_t + d_t) - R_t d_t \} - \frac{1}{2} e_t^2
\end{aligned}
$$

- 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, $d_t, R^d_{g,t+1}, R^d_{b,t+1}$, as given.
  - The value of e_t that optimizes a banker's objective *after* the contract has been agreed upon is:

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

- 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, $\left(d_t, e_t, R^d_{g,t+1}, R^d_{b,t+1}\right)$, from a set defined by:

$$\begin{array}{ll} \text{MF zero profits:} & p\left(e_t\right) R^d_{g,t+1} + \left(1 - p\left(e_t\right)\right) R^d_{b,t+1} = R_t \\ \text{cash constraint:} & R^b_{t+1}\left(N_t + d_t\right) \geq R^d_{b,t+1} d_t \\ \text{incentive:} & e_t = E_t \lambda_{t+1} p'_t\left(e_t\right) \left[\left(R^g_{t+1} - R^b_{t+1}\right)\left(N_t + d_t\right)\right. \\ & \left. - \left(R^d_{g,t+1} - R^d_{b,t+1}\right) d_t\right] \end{array}$$

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

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

$$
\begin{aligned}
N_{t+1} &= \gamma_{t+1}\{p\left(e_t\right)\overbrace{\left[R^g_{t+1}\left(N_t+d_t\right)-R^d_{g,t+1}d_t\right]}^{\text{profits when bank assets good}} \\
&\quad +\left(1-p\left(e_t\right)\right)\overbrace{\left[R^b_{t+1}\left(N_t+d_t\right)-R^d_{b,t+1}d_t\right]}^{\text{profits when bank assets are bad}}\} \\
&\quad + \overbrace{T_{t+1}}^{\text{lump sum transfer, households to their bankers}}
\end{aligned}
$$

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&\quad + \overbrace{T_{t+1}}^{\text{lump sum transfer, households to their bankers}}
\end{aligned}
$$

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.

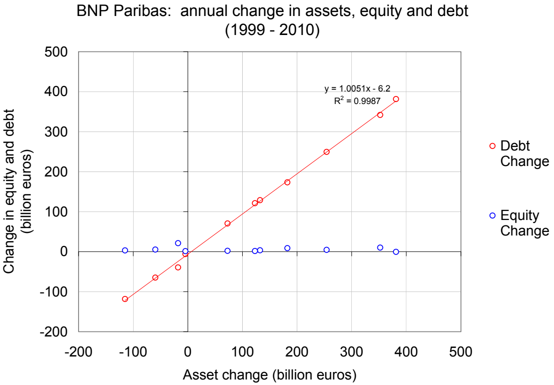


Figure 3. BNP Paribas: annual change in assets, equity and debt (1999-2010) (Source: Bankscope)

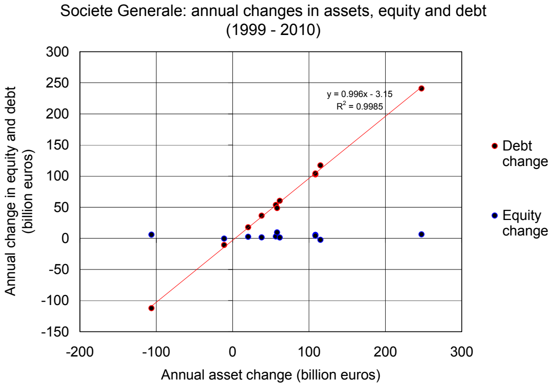
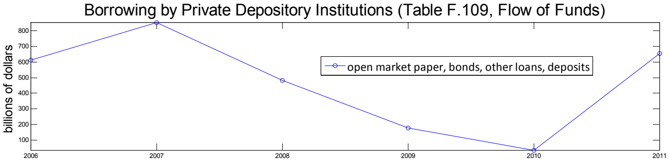


Figure 4. Société Générale: annual change in assets, equity and debt (1999-2010) (Source: Bankscope)

- 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.

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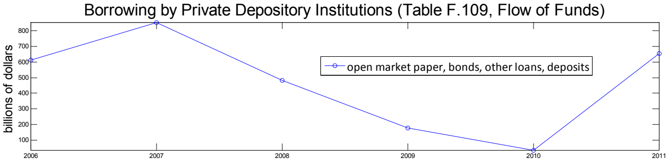
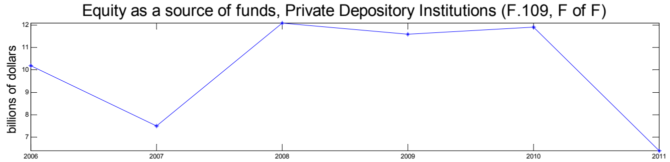




'Crisis'

- 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, $R_b^d - R$, 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:

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

    - 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:

$$\max_d \left[R^k d - S(d)\, d \right],\ S'(d) > 0$$

$$\overbrace{R^k}^{\text{marginal revenue product of deposits}} = \overbrace{S'(d)\, d + S(d)}^{\text{marginal cost of deposits}}$$

- Perfect competition, $S(\mathbf{d})$ exogenous to individual bank ($\mathbf{d}$ ~ aggregate deposits, not a function of d), so profit maximization leads to:

$$R_k = S(\mathbf{d}).$$

Review of Monopsony in Banking

- Results:

$$\begin{array}{llll} \text{monopsony} & d = d^m & R^k = & \overbrace{S'(d^m)\, d^m + S(d^m)}^{\text{marginal cost of } d \text{ to monopsonist}} \\ \text{competition} & d = d^c & R^k = & \overbrace{S(d^c)}^{\text{marginal cost of } d\text{, perfect competition}} \end{array}$$

- So,
  - monopsonist restricts demand: $d^m < d^c$
  - monopsonist makes positive profits, competion 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.

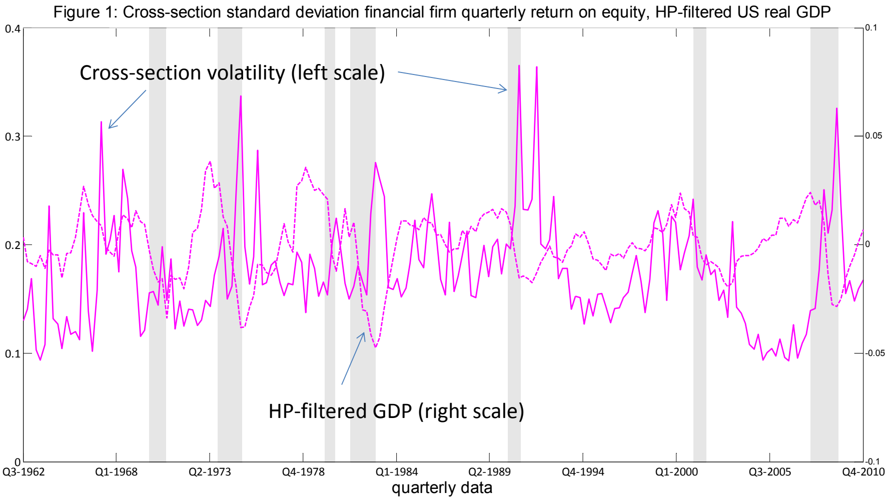
Macro Model

- 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		
Variable meaning	variable name	magnitude
Cross-sectional standard deviation of quarterly non-financial firm equity returns	s^b	0.20
Fnancial firm interest rate spreads (APR)	$400(R_g^d - R)$	0.60
Financial firm leverage	L	20.00
Allocative efficiency of the banking system	$p(e)e^g + (1 - p(e))e^b$	1

Data behind calibration targets



Parameter Values

Table 1: Baseline Model Parameter Values		
Meaning	Name	Value
Panel A: financial parameters		
return parameter, bad entrepreneur	b	-0.09
return parameter, good entrepreneur	g	0.00
constant, effort function	$\bar{a}$	0.83
slope, effort function	$\bar{b}$	0.30
lump-sum transfer from households to bankers	$\tilde{T}$	0.38
fraction of banker net worth that stays with bankers	γ	0.85
Panel B: Parameters that do not affect steady state		
steady state inflation (APR)	$400(\pi - 1)$	2.40
Taylor rule weight on inflation	α_π	1.50
Taylor rule weight on output growth	$\alpha_{\Delta y}$	0.50
smoothing parameter in Taylor rule	ρ_p	0.80
curvature on investment adjustment costs	S''	5.00
Calvo sticky price parameter	ξ_p	0.75
Calvo sticky wage parameter	ξ_w	0.75
Panel C: Nonfinancial parameters		
steady state gdp growth (APR)	μ_{z^*}	1.65
steady state rate of decline in investment good price (APR)	Υ	1.69
capital depreciation rate	δ	0.03
production fixed cost	Φ	0.89
capital share	α	0.40
steady state markup, intermediate good producers	λ_f	1.20
habit parameter	b_u	0.74
household discount rate	$100(\beta^{-4} - 1)$	0.52
steady state markup, workers	λ_w	1.05
Frisch labor supply elasticity	$1/\sigma_L$	1.00
weight on labor disutility	ψ_L	1.00
steady state scaled government spending	$\tilde{g}$	0.89

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					
Variable meaning	Variable name	Unobserved Effort		Observed Effort	
		Leverage Restriction		Leverage Restriction	
		non-binding	binding	non-binding	binding
Spread	$400(R_g^d - R)$	0.600		NA	
scaled consumption	c	1.84		2.01	
labor	h	1.18		1.15	
scaled capital stock	k	51.52		59.75	
bank assets	$N + d$	51.52		59.55	
bank net worth	N	2.58		2.58	
bank deposits	d	48.94		56.98	
bank leverage	$(N + d)/N$	20.00		23.12	
bank return on equity (APR)	$400\left(\frac{\left[p(e_t)R_{t+1}^g+(1-p(e_t))R_{t+1}^b\right](N_t+d_t)-R_t d_t}{N_t}-1\right)$	4.59		4.59	
fraction of firms with good balance sheets	$p(e)$	0.962		1.000	
Benefit of leverage (in c units)	100χ	NA		NA	
Benefit of making effort observable (in c units)	100χ	NA		6.11	

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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scaled consumption	c	1.84	1.88	2.01	
labor	h	1.18	1.16	1.15	
scaled capital stock	k	51.52	51.40	59.75	
bank assets	$N+d$	51.52	51.31	59.55	
bank net worth	N	2.58	3.02	2.58	
bank deposits	d	48.94	48.29	56.98	
bank leverage	$(N+d)/N$	20.00	17.00	23.12	
bank return on equity (APR)	$400\left(\frac{\left[p(e_t)R^g_{t+1}+(1-p(e_t))R^b_{t+1}\right](N_t+d_t)-R_t d_t}{N_t}-1\right)$	4.59	14.96	4.59	
fraction of firms with good balance sheets	$p(e)$	0.962	0.982	1.000	
Benefit of leverage (in c units)	100χ	NA	1.19	NA	
Benefit of making effort observable (in c units)	100χ	NA	NA	6.11	

Cut in leverage in the unobserved effort economy moves things towards observed effort.

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Variable meaning	Variable name	Unobserved Effort		Observed Effort	
		Leverage Restriction		Leverage Restriction	
		non-binding	binding	non-binding	binding
Spread	$400(R_g^d - R)$			NA	NA
scaled consumption	c			2.01	1.95
labor	h			1.15	1.14
scaled capital stock	k			59.75	53.86
bank assets	$N + d$			59.55	53.68
bank net worth	N			2.58	3.16
bank deposits	d			56.98	50.52
bank leverage	$(N + d)/N$			23.12	17.00
bank return on equity (APR)	$400\left(\frac{\left[p(e_t)R_{t+1}^g+(1-p(e_t))R_{t+1}^b\right](N_t+d_t)-R_t d_t}{N_t} - 1\right)$			4.59	17.63
fraction of firms with good balance sheets	$p(e)$			1.000	1.000
Benefit of leverage (in c units)	100χ			NA	-2.70
Benefit of making effort observable (in c units)	100χ			6.11	2.03

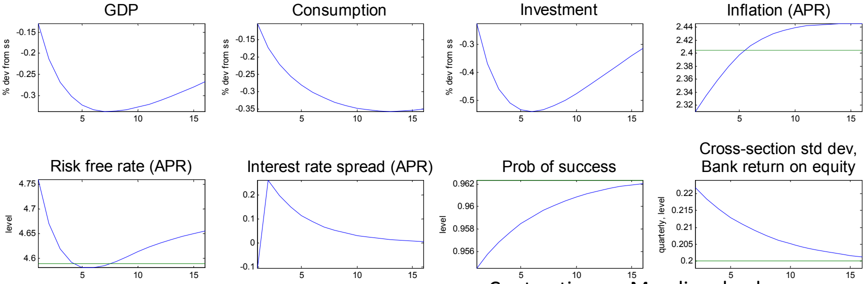
Hidden effort assumption is *essential*. Otherwise, leverage restriction *reduces* utility.

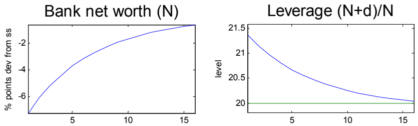
Dynamics

- 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.