Leverage Restrictions in a Business Cycle Model

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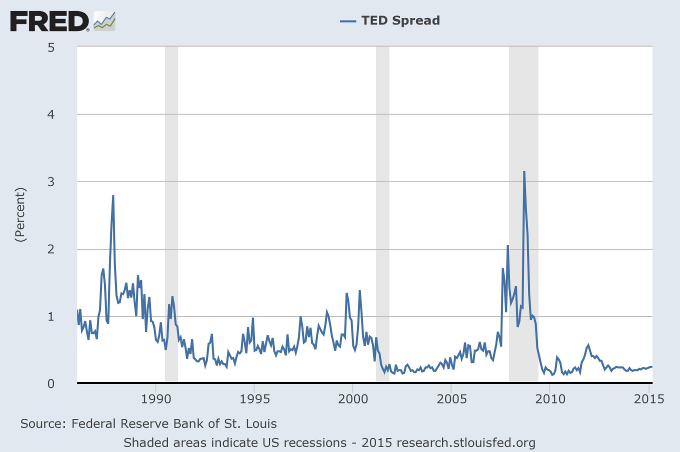
Background

- Wish to address the following sorts of questions:
  - What restrictions should be placed on bank borrowing?
  - How should those restrictions be varied over the business cycle?

- Want an environment with the following properties:
  - model includes problem that restrictions on bank borrowing are supposed to solve.
    - if you want an interesting model to help think about how many umbrellas to build, there had better be rain in the model.
  - riskiness of banks varies over time.


FRED
TED Spread
5
4
3
2
1
0
(Percent)
1990
1995
2000
2005
2010
2015
Source: Federal Reserve Bank of St. Louis
Shaded areas indicate US recessions - 2015 research.stlouisfed.org

What We Do

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

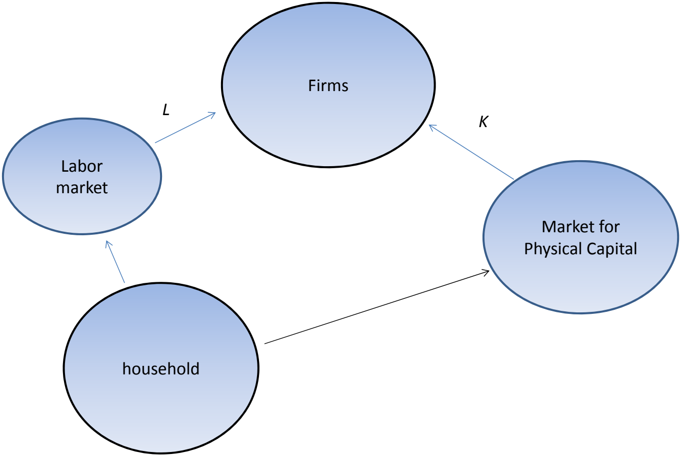
Assets	Liabilities
Loans and other securities	Deposits
	Banker net worth

- 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: borrowing restrictions on banks may generate substantial welfare gains.

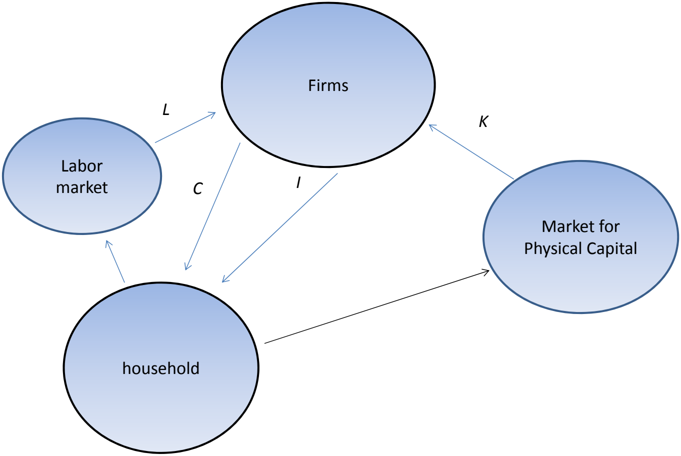
Outline

- Model
  - first, without borrowing restriction
    - observable effort benchmark
    - unobservable case
  - potential welfare gains of borrowing restriction
- Dynamics

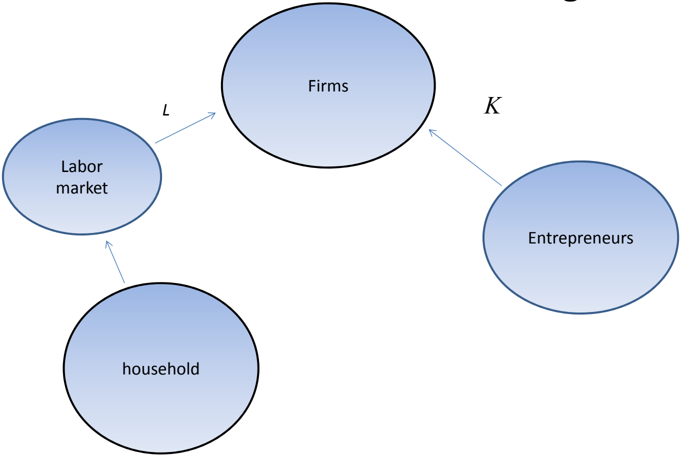
Standard Model



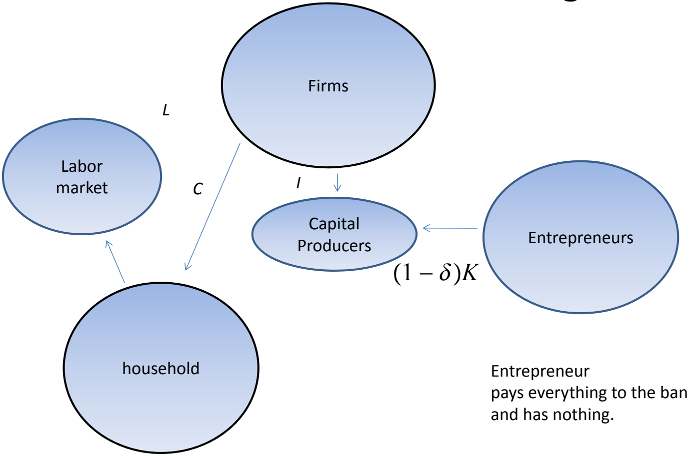
Standard Model



Standard Model with Banking

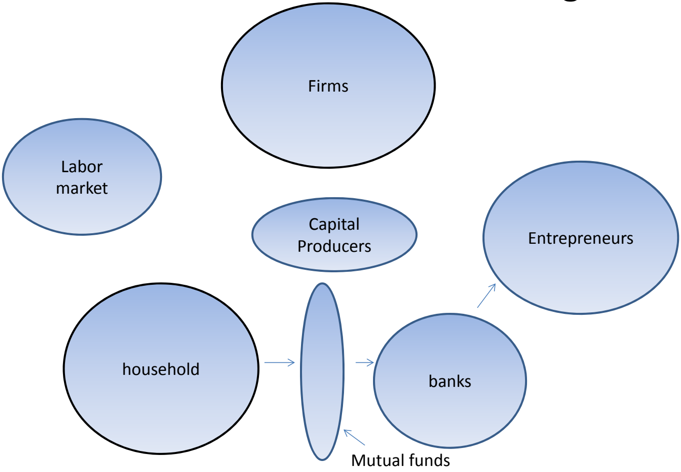


Standard Model with Banking



Entrepreneur
pays everything to the bank
and has nothing.

Standard Model with Banking



Entrepreneurs

- bad entrepreneur: 1 unit, raw capital $\longrightarrow e^{b_t}$ units, effective capital
- good entrepreneur: 1 unit, raw capital $\longrightarrow e^{g_t} > e^{b_t}$ units, effective capital
- return to capital enjoyed by entrepreneurs:

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

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

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:

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

- Bankers have a cash constraint:

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

Bankers and their Creditors

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

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

- Free entry and competition among mutual funds implies:

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

- 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 $\left(d_t, e_t, R^g_{d,t+1}, R^b_{d,t+1}\right)$'s that satisfy

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

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

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

Unobserved Effort

- In this case, banker always sets e_t to its privately optimal level, whatever e_t is specified in the loan contract:

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

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

$$\text{MF zero profits:} \quad p(e_t) R^g_{d,t+1} + (1 - p(e_t)) R^b_{d,t+1} = R_t,$$

$$\text{cash constraint:} \quad R^b_{t+1} (N_t + d_t) \geq R^b_{d,t+1} d_t$$

- One factor that can make e_t inefficiently low:
  - $R^g_{d,t+1} > R^b_{d,t+1}$.

Source of Inefficiency in Unobserved Effort Model

- The presence of a market interest rate in the incentive constraint creates a 'pecuniary externality'.
- Basic idea:
  - Private cost to bank of higher funds, d :
    - interest paid on deposits, R.
  - Social cost of higher d:
    - R plus damage to bank incentives when R rises with bigger d.
    - Consequence: equilibrium d may be too high, in which case limit on d is desirable.
- Most straightforward to see in a simple two-period setting.
  - Grateful to Saki Bigio and Emmanuel Fahri for bringing following argument to our attention.

Desirability of Borrowing Restrictions in Two Period Version of Model

- Bankers and workers live in large, identical households.
  - as in Gertler-Karadi, Gertler-Kiyotaki.
- Representative household's problem:

$$\max_{\{c_0, c_1, d\}} u(c_0) + c_1,$$

$$s.t. \quad c_0 + d = y, \; c_1 = Rd + \pi.$$

where π denotes the profits brought home by bankers:

$$\pi = p(e)\left[R^g(N+d) - R_d^g d\right] + (1 - p(e))\left[R^b(N+d) - R_d^b d\right].$$

Optimality condition for deposits:

$$R = u'(y-d)$$

Desirability of Borrowing Restrictions in Two Period Version of Model

- Banker problem (with potentially binding borrowing restriction):

$$
\begin{aligned}
&\max_{\{R_d^g, R_d^b, d, e\}} p\left(e\right)\left[R^g\left(N+d\right)-R_d^g d\right] \\
&+\left(1-p\left(e\right)\right)\left[R^b\left(N+d\right)-R_d^b d\right]-\frac{1}{2}e^2 \\
&+\nu\left[R^b(N+d)-R_d^b d\right] \\
&+\eta\left\{p'(e)\left[(R^g-R^b)(N+d)-\left(R_d^g-R_d^b\right)d\right]-e\right\} \\
&+\mu(\bar{d}-d)
\end{aligned}
$$

subject to zero profit condition on loan contract.

Desirability of Borrowing Restrictions in Two Period Version of Model

- Use zero profit condition and binding cash constraint to simplify banker problem (drop R_d^g, R_d^b) :

$$\max_{\{d,e\}} p(e) R^g (N+d) + (1-p(e)) R^b (N+d) - Rd - \frac{1}{2}e^2$$
$$+\eta \left\{ p'(e) \left[(R^g - R^b)(N+d) - \frac{Rd - R^b(N+d)}{p(e)} \right] - e \right\}$$
$$+\mu(\bar{d} - d)$$

- Optimality condition for d:

$$p(e)R^g + (1-p(e))R^b = R + \frac{\mu}{1+\eta p'(e)/p(e)}.$$

borrowing restriction raises cost of funds above R.

Ramsey Problem in Two Period Version of Model

- After substituting out zero profit condition, cash constraint and deposit supply

$$\max_{e,d}\{ \overbrace{u(y-d)}^{\text{utility of period 0 consumption}} + c_1 - \frac{1}{2}e^2$$

$$+\eta\left(p'(e)\left[(R^g-R^b)(N+d)-\frac{u'(y-d)d-R^b(N+d)}{p(e)}\right]-e\right)$$

s.t.

$$c_1 = u'(y-d)d + p(e)R^g(N+d) + (1-p(e))R^b(N+d) - u'(y-d)d$$

Ramsey Problem in Two Period Version of Model

- Optimality condition for d:

$$
\begin{aligned}
& p(e)R^g + (1-p(e))R^b \\
= \;& R + \overbrace{\frac{\eta p'(e)/p(e)(-u''(y-d))d}{1+\eta p'(e)/p(e)}}^{\text{extra marginal cost associated with extra } d}.
\end{aligned}
$$

- To get the private d decision to coincide with Ramsey-optimal decision, must choose $\bar{d}$ so that multiplier, μ, on private problem satisfies:

$$\mu = \eta p'(e)/p(e)(-u''(y-d))d > 0$$

Back to Dynamic Model

- Model dynamics requires law of motion for banker net worth.
- Introduces an additional borrowing consideration.

Law of Motion of Net Worth

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

$$
\begin{aligned}
N_{t+1} \quad = \quad & \gamma_{t+1}\{p\left(e_t\right)\overbrace{\left[R_{t+1}^{g}\left(N_t+d_t\right)-R_{d,t+1}^{g}d_t\right]}^{\text{profits of banks with good assets}} \\
& +\left(1-p\left(e_t\right)\right)\overbrace{\left[R_{t+1}^{b}\left(N_t+d_t\right)-R_{d,t+1}^{b}d_t\right]}^{\text{profits of banks with bad assets}}\} \\
& + \overbrace{T_{t+1}}^{\text{lump sum transfer, households to their bankers}}
\end{aligned}
$$

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.

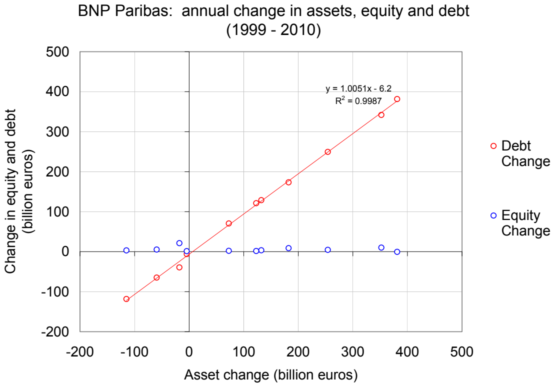


Figure 3. BNP Paribas: annual change in assets, equity and debt (1999-2010) (Source: Bankscope)

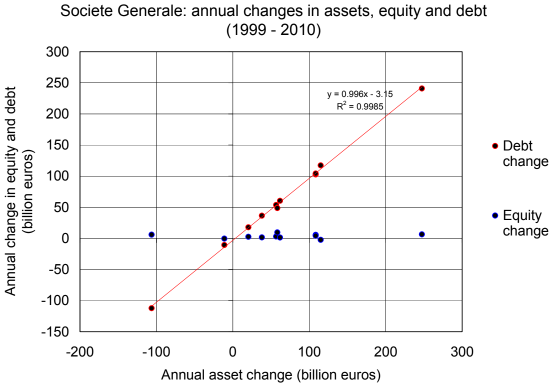
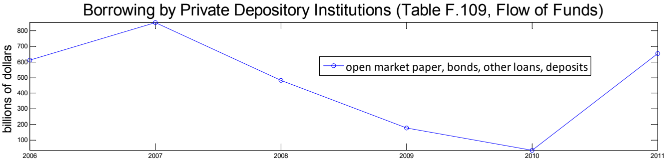


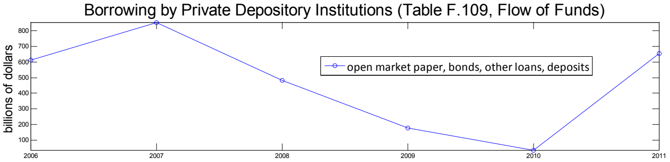
Figure 4. Société Générale: annual change in assets, equity and debt (1999-2010) (Source: Bankscope)

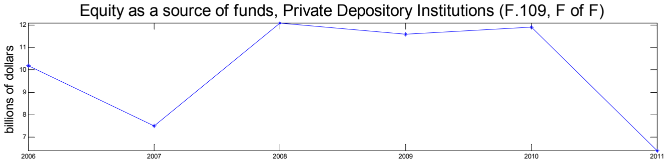
- The model assumes that when bankers want funds, issuing equity is not an option.



This shows how major debt instruments were used at private depository institutions in the wake of the crisis.

- 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:

$$R^b_{t+1}\left(N_t + d_t\right) \geq R^b_{d,t+1} d_t.$$

- So, $R^b_{d,t+1}$ 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 $R^g_{d,t+1}$ high
- So, interest rate spread, $R^g_{d,t+1} - R_t$, 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:

$$\begin{aligned} p(e_t) \text{ good banks} &: \frac{R^g_{t+1}(N_t+d_t)-R^g_{d,t+1}d_t}{N_t}, \\ 1-p(e_t) \text{ bad banks} &: \frac{R^b_{t+1}(N_t+d_t)-R^b_{d,t+1}d_t}{N_t}=0 \end{aligned}$$

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

$$\begin{aligned} s^b_{t+1} &= \left[p(e_t)(1-p(e_t))\right]^{1/2}\frac{R^g_{t+1}(N_t+d_t)-R^g_{d,t+1}d_t}{N_t} \\ E^b_{t+1} &= p(e_t)\frac{R^g_{t+1}(N_t+d_t)-R^g_{d,t+1}d_t}{N_t} \end{aligned}$$

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

Macro Model

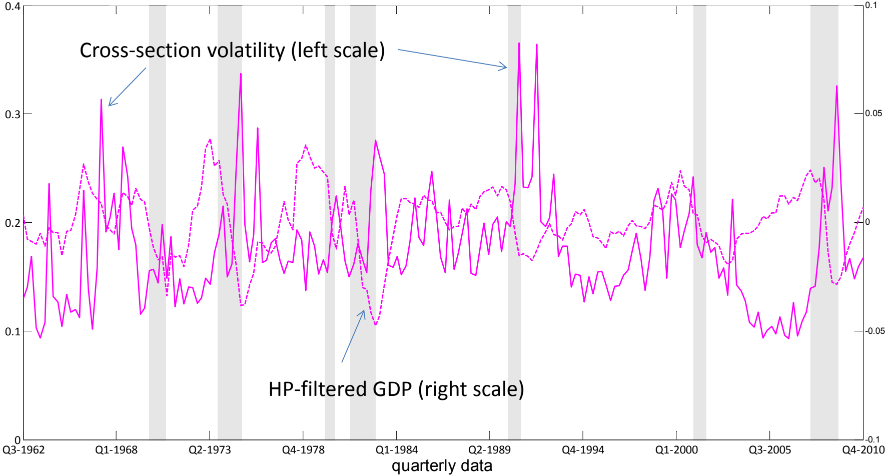
- Sticky wages and prices
- Investment adjustment costs
- Habit persistence in consumption
- Monetary policy rule

Calibration targets

Table 2: Steady state calibration targets for baseline model		
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

Data behind calibration targets

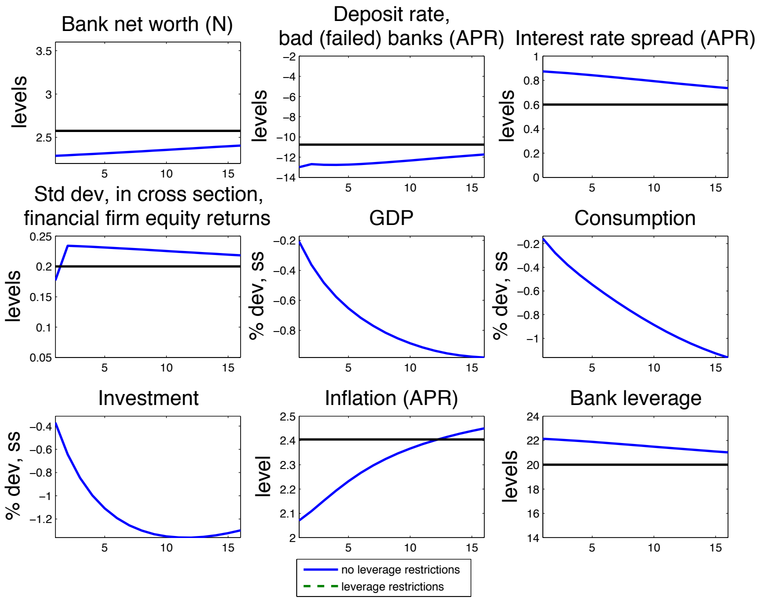
Figure 1: Cross-section standard deviation financial firm quarterly return on equity, HP-filtered US real GDP



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

Impact of Loss of Bank Net Worth



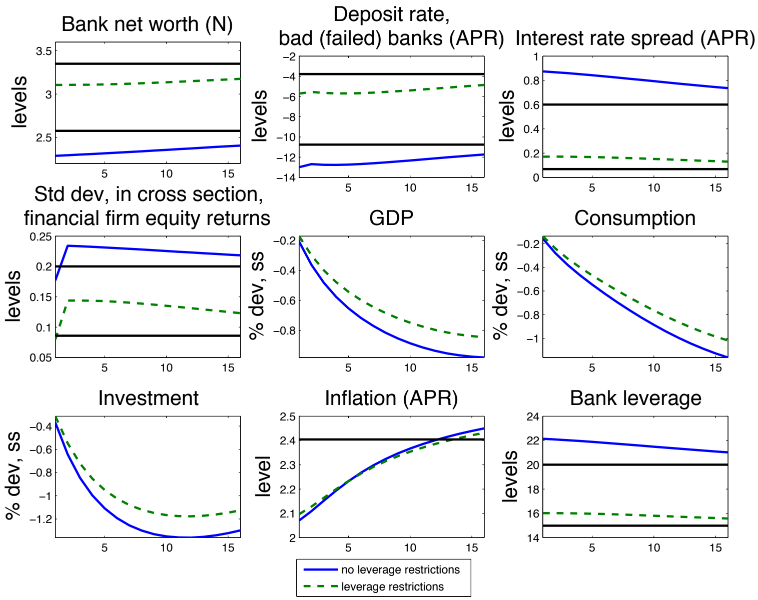
Borrowing Restrictions

- 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 borrowing restriction,
    - borrowing restriction in effect implements collusion among bankers
    - allows them to behave as monopsonists
    - make profits on demand deposits....lots of profits:

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

    - makes N_t grow, offseting incentive effects of decline in d_t.

Impact of Loss of Bank Net Worth



Conclusion

- Described a model in which there is a problem that is mitigated by the introduction of borrowing 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.