

Notes for a Model With Banks and Net Worth Constraints

(Revised)

- Joint work with Roberto Motto and Massimo Rostagno
- Combines Previous Model with Banking Model of Chari, Christiano, Eichenbaum (JMCB, 1990's) and Net Worth Model of Bernanke, Gertler and Gilchrist (Handbook of Macroeconomics).

- Motive for Introducing Banking Sector
 - What Monetary Aggregates are Suitable for Targeting by Monetary Authority?
 - What is the Role of Monetary Policy in Accommodating Money Demand Shocks?
 - The Fed's Failure to Properly Monitor and Control M1 is Reputed to be the Reasons for Its Greatest Failure: Exacerbating, Rather than Mitigating, the US Great Depression. Is this View Quantitatively Plausible?
- Motive for Introducing Net Worth Considerations.
 - Periodically, Net Worth 'Disappears' When there is a Stock Market Crash. Is there Anything a Central Bank Can, or Should, Do about this?
 - How do Net Worth Considerations Affect the Propagation of Technology, Monetary and Other Shocks?

Agents in the Model

- Households: now much simpler than before. They don't own physical capital, or do investment.
- Entrepreneurs: own capital and rent it out (this is where Net Worth considerations are located).
- Firms: Final Goods, Intermediate Goods, as Before.
- Producers of Capital: buy old capital from entrepreneurs, buy investment goods, put the two together and sell new capital to entrepreneurs.

Households

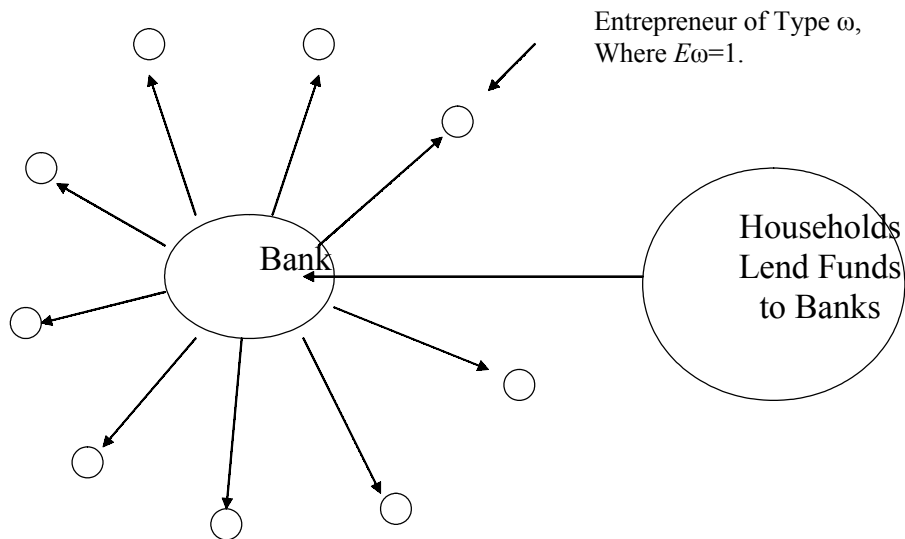
- Observe Technology Shock
- Make Consumption Decision
- Set Wages as in Calvo (Erceg, Henderson and Levin).
- Monetary Action Realized.
- Before Goods Market, Household Allocates ‘High Powered Money’ between Currency and Demand Deposits.
- Household Goes to Goods Market.
- Household Purchases a Time Deposit, Which Pays off In Next Day.

Firms

- Same Dixit-Stiglitz Structure, as Before.

Entrepreneurs and Net Worth

- Capital Owned by Entrepreneurs.
- Entrepreneurs Have Only a Limited Amount of Net Worth, N_{t+1} , of their Own, So They Need Outside Funding, To Buy Capital, $\bar{K}_{t+1}$.
- Entrepreneurs Borrow From Banks, Who Receive Funds from Households.
- The Individual Entrepreneur is ‘Risky’ Because $\bar{K}_{t+1}$ Converted into $\bar{K}_{t+1}\omega$, $E\omega = 1$.
- Entrepreneur Receives a CSV Contract:
 - Pays a Specified Rate of Interest To Banks.
 - Entrepreneurs with ω too Low are ‘Bankrupt’ and They Hand Everything Over to Bank.
 - Entrepreneurs Who Declare Bankruptcy Must Be Monitored for Verification.



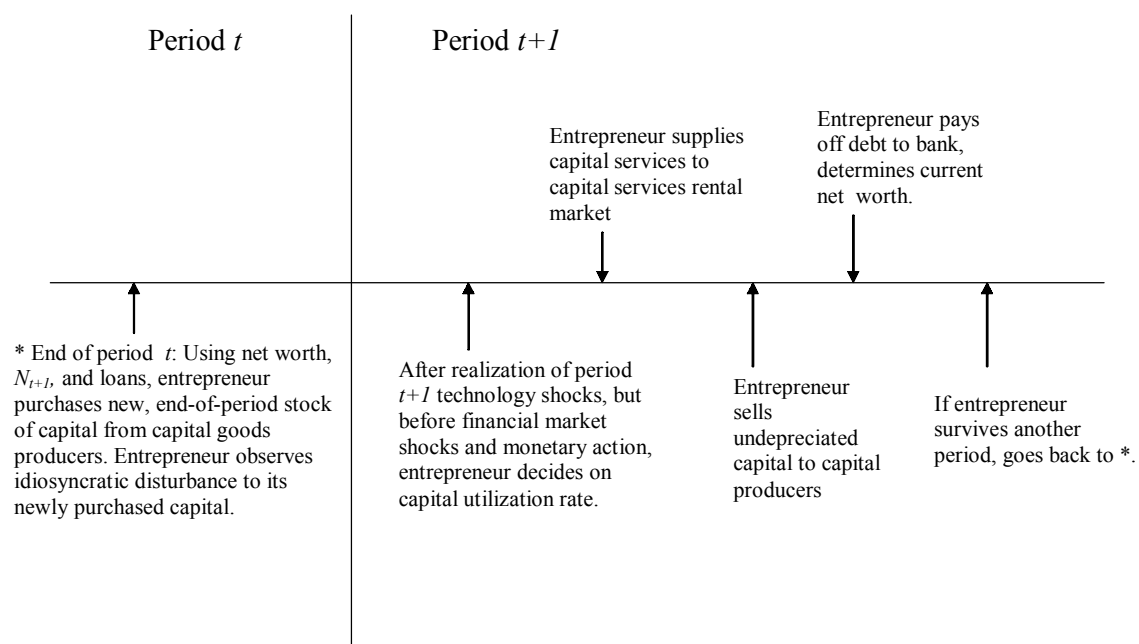
- Households Opens Time Deposit in Bank
After Period t Goods Market, Receives
Sure R_{t+1}^e in $t + 1$
- Bank Lends Funds on to Entrepreneur.
- Entrepreneur Buys Physical Capital,
 $\bar{K}_{t+1}$, in t Earns Return, $R_{t+1}^k \omega$ in $t + 1$.
- Entrepreneur Pays Back Bank in $t + 1$,
Which Pays Household then.

Rate of Return to Capital for an Entrepreneur

$$1 + R_{t+1}^k = \frac{[u_{t+1}r_{t+1}^k - a(u_{t+1})] P_{t+1} + (1 - \delta)Q_{\bar{K}',t+1}}{Q_{\bar{K}',t}}$$

$Q_{\bar{K}',t}$ currency price of capital in t

FIGURE 2: A Day in the Life of an Entrepreneur



CSV Contract

- Competition By Banks in Supply of CSV Contract Implies Two Things:
 - Banks Must Make Zero Profits in Each State of Nature.
 - Contract Must Optimize ‘Utility’ of Entrepreneur.
- ‘Pins Down’ Two Things: Loan Amount to Entrepreneurs and Interest Rate They Pay.

CSV Contract, Cont'd...

- Monitoring Costs, μ , Imply Entrepreneurs on Average Pay More For Loans Than Banks Pay Households

$$\underbrace{1 + R_t^e}_{\text{Gross Return to Household}} + \underbrace{\frac{\mu \int_0^{\bar{\omega}_t} \omega dF(\omega) (1 + R_t^k) Q_{\bar{K}',t-1} \bar{K}_t}{Q_{\bar{K}',t-1} \bar{K}_t - N_t}}_{\text{'External Finance Premium'}}$$

- Loan Amount Depends on Net Worth of Entrepreneur:

$$Q_{\bar{K}',t} \bar{K}_{t+1} = \psi\left(\frac{E[(1 + R_{t+1}^k) | \Omega_t^\mu]}{(1 + R_{t+1}^e)}\right) N_{t+1}$$

$Q_{\bar{K}',t}$ currency price of capital in t

$F(\bar{\omega})$ probability that $\omega \leq \bar{\omega}$

Law of Motion of Aggregate Net Worth

- Technical Issue: Must Prevent Entrepreneurs From Accumulating too Much Net Worth

$1 - \gamma_t$ die exogenously in each period

$1 - \gamma_t$ are born each period, with a tiny endowment, W^e

- Law of Motion of Net Worth:

$$\begin{aligned}
 N_{t+1} = & \gamma_t \{ \underbrace{(1 + R_t^k) Q_{\bar{K}', t-1} \bar{K}_t}_{\text{Gross Earnings of Entrepreneurs}} \\
 & - \underbrace{\left[1 + R_t^e + \frac{\mu \int_0^{\bar{\omega}_t} \omega dF(\omega) (1 + R_t^k) Q_{\bar{K}', t-1} \bar{K}_t}{Q_{\bar{K}', t-1} \bar{K}_t - \bar{N}_t} \right]}_{\text{Interest Per Unit of Currency Borrowed, Paid to Bank By Average Entrepreneur}} \\
 & \times \underbrace{(Q_{\bar{K}', t-1} \bar{K}_t - \bar{N}_t)}_{\text{Total Units of Currency Borrowed By Entrepreneurs}} \} \\
 & + \underbrace{W_t^e}_{\text{transfer to } \gamma \text{ old entrepreneurs who survive, plus to } 1-\gamma \text{ newly born entrepreneurs}}
 \end{aligned}$$

Expected Properties of Model

- Drop in Net Worth, N_{t+1} , Forces a Contraction in Purchases of Investment Goods.
- Period t Shocks Can Cause this If:
 - Drop in γ_t – (Stock Market Crash?)
 - Drop in R_t^k ($Q_{\bar{K}',t}$, and/or $P_t r_t^k$ fall)
 - Jump in $\bar{\omega}_t$ (Increase in Bankruptcies)

Capital Producers

- Buy Old Capital, $\bar{K}_t$ From Entrepreneurs at the End of Period t Goods Market
- Buy Investment Goods in Period t Goods Market
- Manufacture New Capital, $\bar{K}_{t+1}$, Using Investment Technology
- Sell New Capital to Entrepreneurs, Who Finance Purchase with their Net Worth, and Bank Loans.
- Capital Producers Have No Financing Requirement.

Banks

Bank Balance Sheets

Assets	Liabilities
Reserves	
A_t (Household Deposit)	D_t (interest, R_a)
X_t (Monetary Transfer to Household)	
Short-term Working Capital Loans	
S_t^w (interest, R_t)	
‘Long-term’, Entrepreneurial Loans	
B_t	T_{t-1} (interest, R_e)

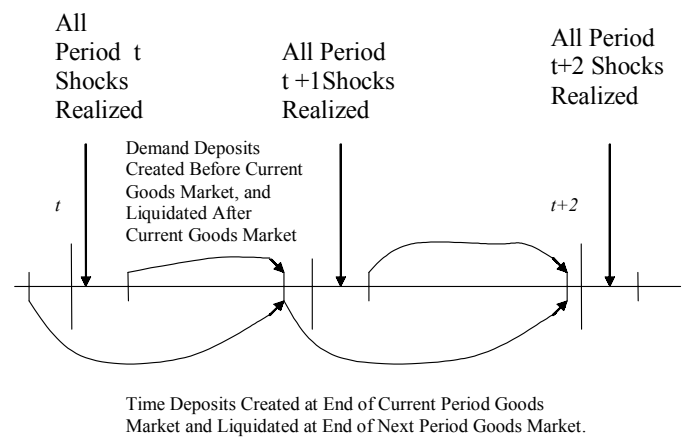


Figure 3: Maturity Structure of Time and Demand Deposits

Bank Use of Resources

- For Monitoring Bankrupt Entrepreneurs
- For Managing Demand Deposits

$$\frac{D_t}{P_t} = a^b x_t^b \left((K_t^b)^\alpha (z_t l_t^b)^{1-\alpha} \right)^{\xi_t} \left(\frac{E_t^r}{P_t} \right)^{1-\xi_t}$$

E_t^r excess reserves

- Excess Reserves Help Banks Manage Deposits.

Properties of the Model Worth Studying

- ‘Flight to Quality’ Phenomenon:
 - Banks Want to Hold More Excess Reserves
 - Households Want to Hold More Currency
- How Will Various Standard Monetary Policy Rules Work In the Presence of Such Shocks?

Households

- Preferences:

$$E_t^j \sum_{l=0}^{\infty} \beta^{l-t} \{ u(C_{t+l} - bC_{t+l-1}) - \zeta_{t+l} z(h_{j,t+l}) - v_{t+l} \frac{\left[\left(\frac{P_{t+l} C_{t+l}}{M_{t+l}} \right)^{\theta_{t+l}} \left(\frac{P_{t+l} C_{t+l}}{D_{t+l}^h} \right)^{1-\theta_{t+l}} \right]^{1-\sigma_q}}{1 - \sigma_q} \}$$

- They ‘Like’ Currency, M_t , and deposits, D_t^h
- They Hold Time Deposits Only Because they Pay Interest. They Generate No Transactions Services.

Monetary Aggregates

- Monetary Base, M_t^b : Households Holds All this in the ‘Morning’
- Currency, M_t : Part of Monetary Base Household Holds on to During the Period
- Demand Deposits, D_t : Short term liabilities of Banks to Households and to Firms
- Time Deposits, T : Longer-term Liabilities of Banks to Finance Loans to Entrepreneurs
- Reserves: Part of Monetary Base Turned over to Banks By Households.
- Required Reserves: Fraction (0.015) of Demand Deposits that Must be Backed by Base Money.
- $M1$: Currency in Hands of Households Plus Firm and Household D Deposits.
- $M3$: $M1$ plus Time Deposit Liabilities of Banks.

Monetary and Fiscal Authorities

- Exogenous Government Spending Requirement.
- There Are Taxes Everywhere.
- Money Growth Has Endogenous Component, And Feeds Back on Shocks.
- Trivial to Put in Taylor or other Such Rule.

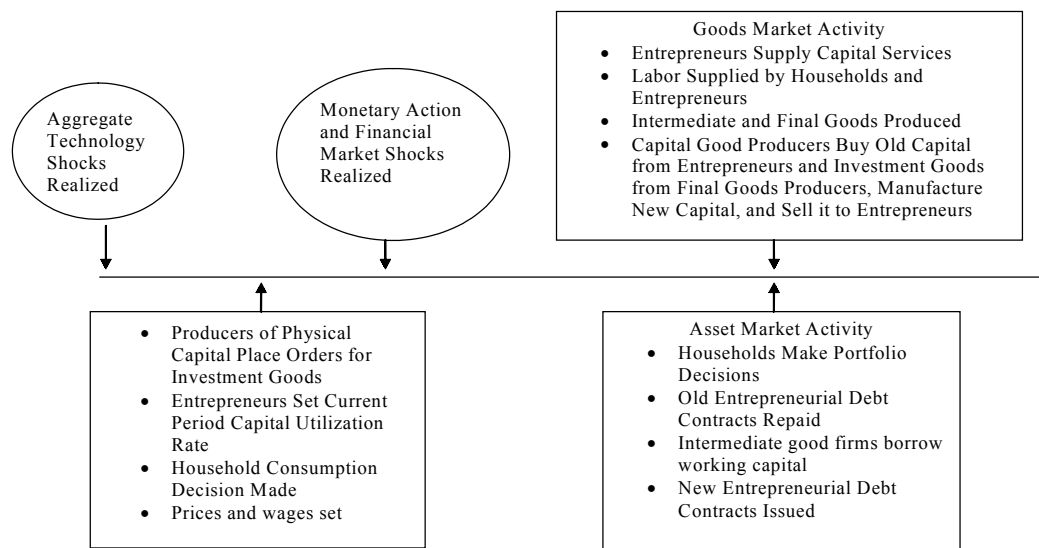


Figure 1: Timing in Model

Following Slides

- Parameter Values and Properties of Steady State
- Two Sets of Figures Showing Response to Exogenous Monetary Policy Shock.
(Money Growth is Normally 0.015, or 6 percent per year in annual percentage point terms (APR). The Shock Raises Money Growth in the Impact Period to 0.0167 or 6.68 percent per year. Interest rates are APR, other variables are percent deviations from steady state, in *decimal* terms. That is, 0.001 means ‘one-tenths of one percent’. The second set of Figures Depict Ratios. Numbers in (1,1), (1,2), (2,1) figures should add to unity.)
- Two Sets of Figures Showing Response to Persistent ($\rho = .9$), Exogenous Drop in γ_t from 0.97 (3% bankruptcy rate) to 0.96.

Properties of the Model

$\frac{k}{y}$	8.14
$\frac{l}{y}$	0.19
$\frac{c}{y}$	0.62
$\frac{g}{y}$	0.18
r^k	0.045
Bankruptcy Rate (per quarter)	3%
$\frac{N}{K-N}$ ('Equity to Debt')	1.29
$\frac{W^e}{py}$	0.06
Fraction of Goods Output Devoted to Monitoring	0.006
Fraction of Aggregate Labor and Capital in Banking	2%
Inflation	4.6%

Consolidated Banking Sector Balance Sheet					
Assets (Fraction of GNP)	4.40		Liabilities (Fraction of GNP)	4.40	
Reserves	0.018		Demand Deposit	0.205	
Required		0.005	Firms		0.187
Excess		0.013	Households		0.018
Working Capital Loans	0.187				
Capital Expenditures		0.042	Time Deposits	0.795	
Labor Expenditures		0.015			
'Long Term', Entrepreneurial Loans	0.795				
Note: Unless Otherwise Indicated, Numbers are Ratios to Total Bank Assets.					

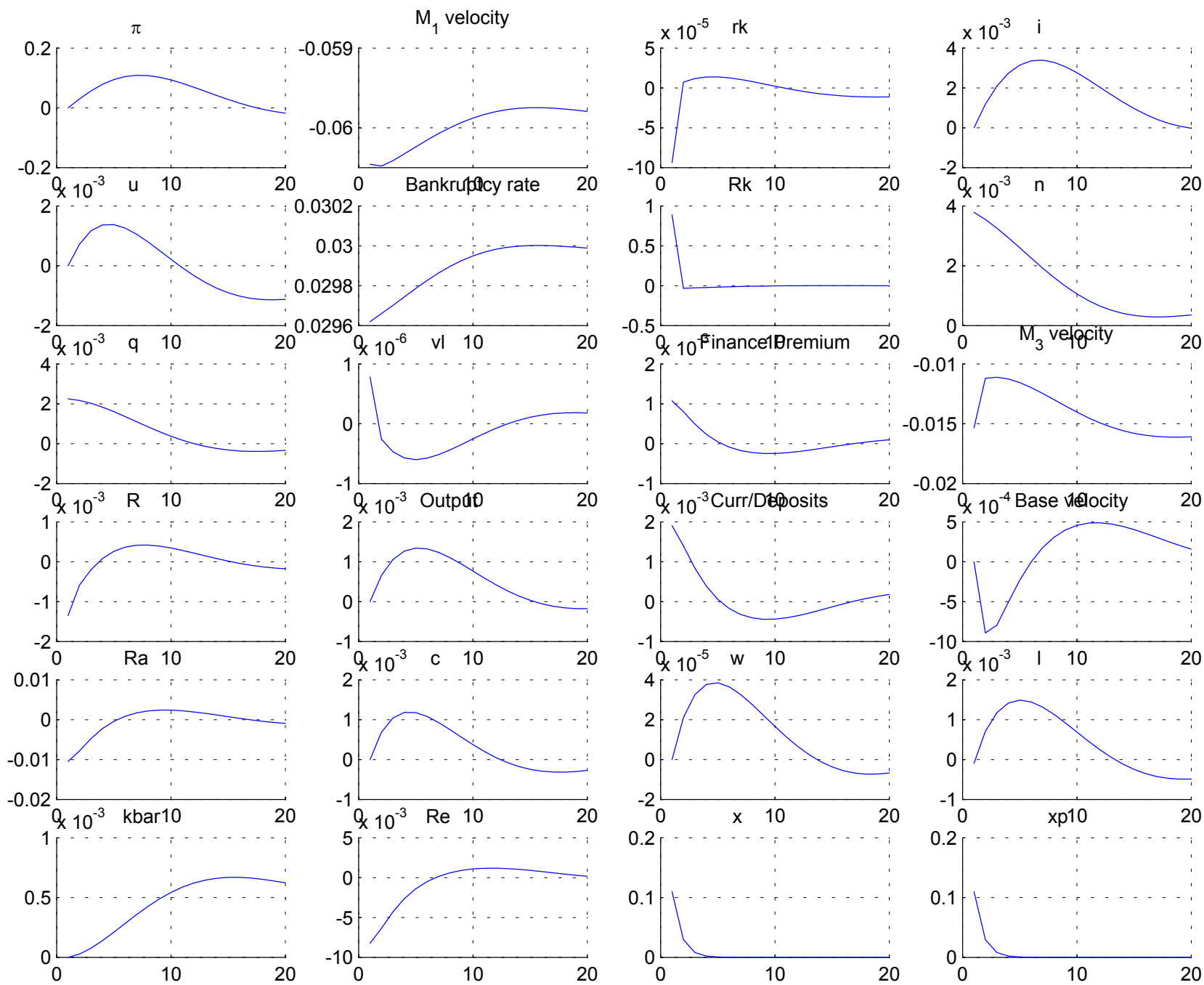
Money and Interest Rates				
Velocity	Model	US Data	Interest Rates (APR)	
Monetary Base	11.	13	Demand Deposits	0.63
M1	3.36	6.0	Time Deposits	9.32
M3	0.85	1.2	Rate of Return on Capital	12.28
Currency to Demand Deposit Ratio	0.32	0.60	Loans to Entrepreneurs	11.81
Currency to Monetary Base Ratio	0.80	0.80	Interest Rate on Working Capital Loans	10.42

Notes on Response to Monetary Policy Shock

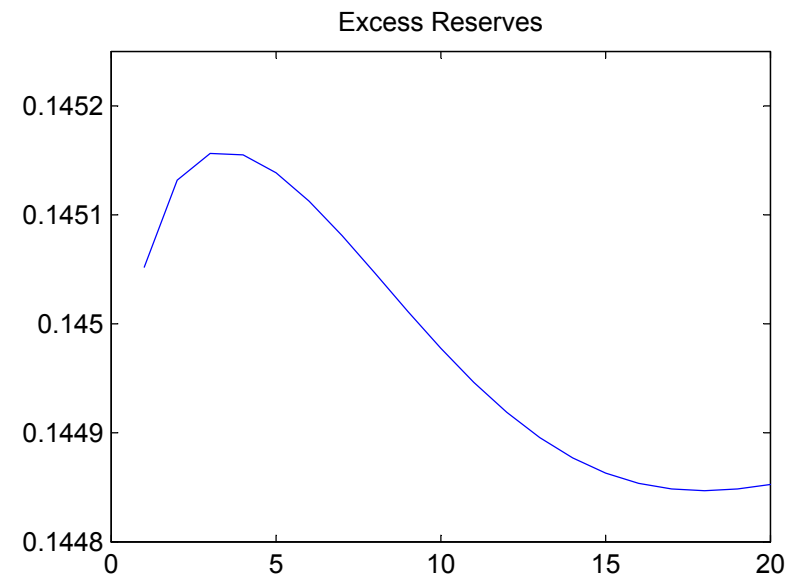
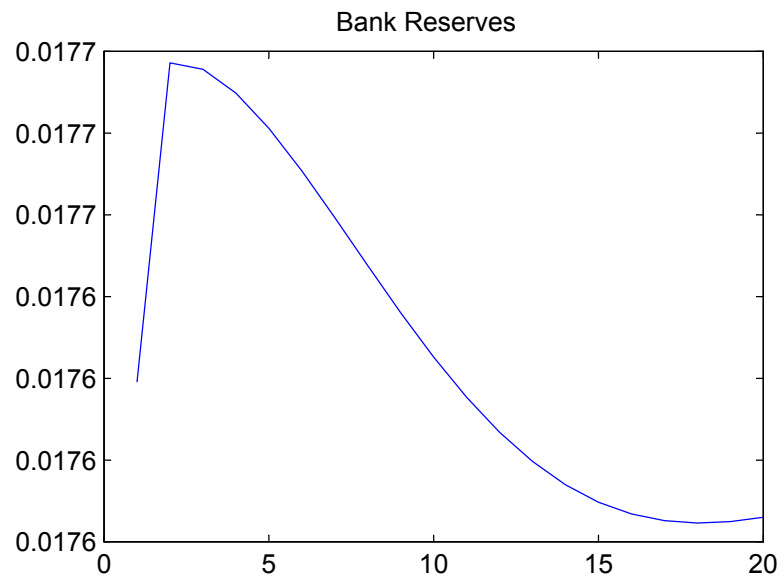
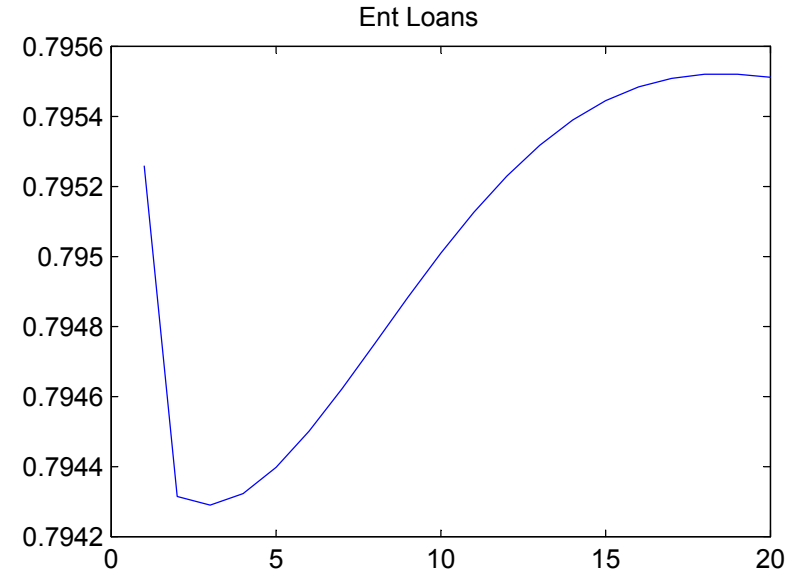
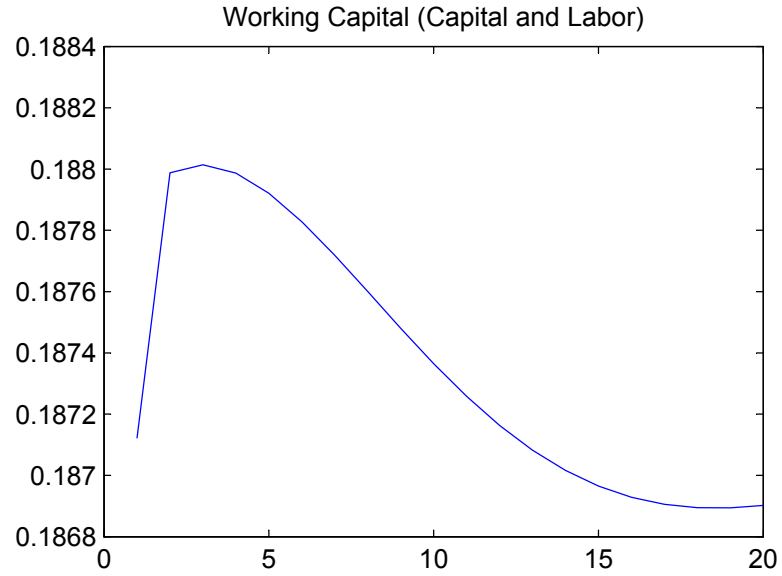
- Qualitatively Similar to Previous Model.
 - Interest Rates Down, Output Up.
 - Substantial Inflation Inertia, Output Persistence.
 - Hump-shaped Employment, Capacity Utilization, Labor, Output, Consumption, Investment.
- Quantitatively, Somewhat Different
 - Interest Rate Effects Tiny (Need to Fix Money Demand Elasticities?)
 - Output Effects Somewhat Smaller (Around 0.15 percent up here versus over 0.2 percent before).
 - Counterfactually Small Interest Rate Effects May be The Reason For Smallish Quantity Effects.

Monetary Policy Shock, Cont'd

- Other Variables:
 - Velocity of Base, M1, M3 Down With Lower Interest Rates
 - Bankruptcy Rate Down
 - Price of Capital (q) High, But Falling (Prospective Capital Losses)
 - Rate of Return on Capital Down After One Period (Apparently, Due to Capital Losses)
 - Latter Explains Fall in Loans to Entrepreneurs.
 - Net Worth Up, Probably Due to High Level of Price of Capital.
 - Loans for Working Capital Expand.
 - Some of the Extra Money Ends Up in Higher Excess Reserves.

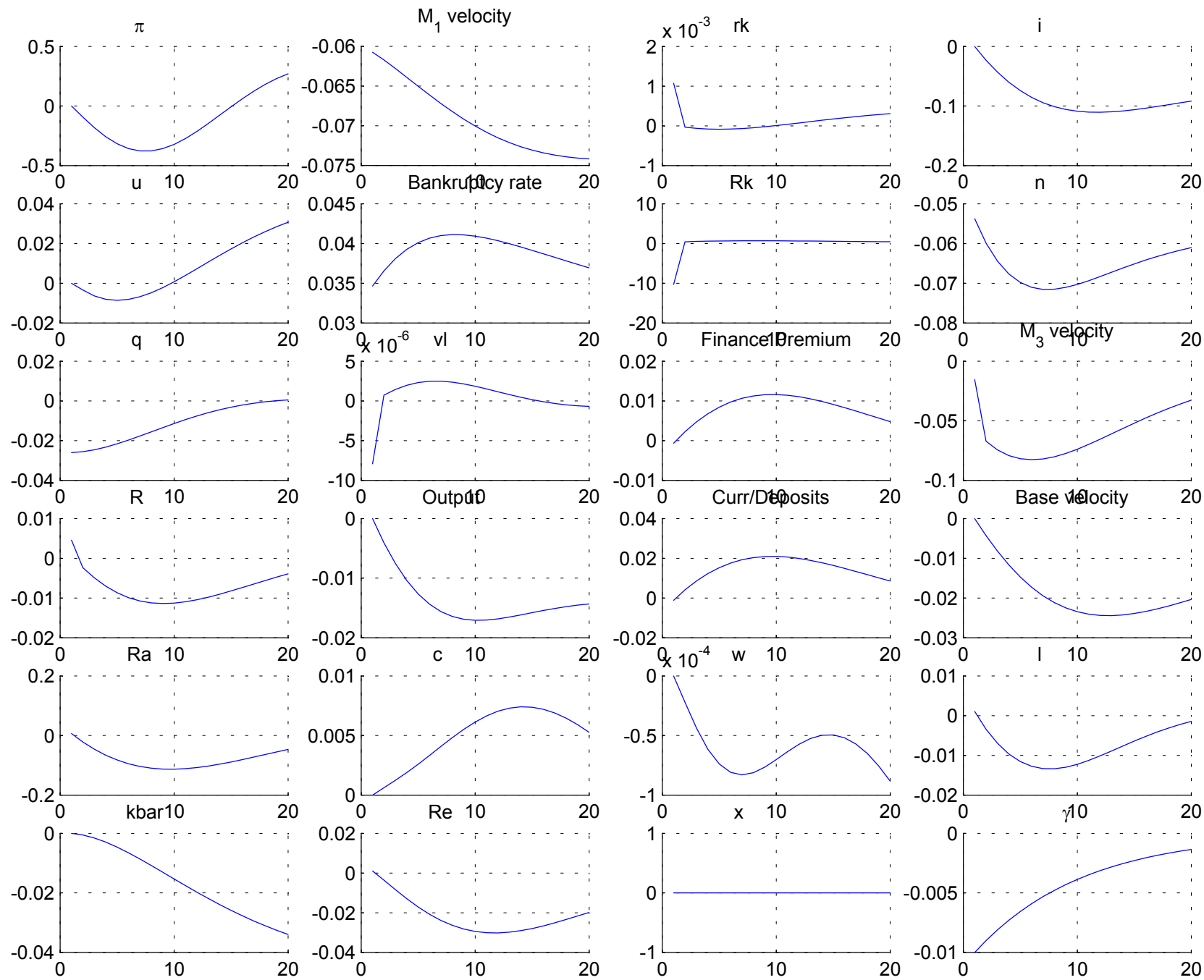


These Are Bank Assets Expressed as a Ratio to Total Bank Assets



Notes Response to Bad Net Worth Shock (γ)

- Investment Falls, Employment, Output, Inflation, Interest Rates, Capital Stock, Fall.
- Bankruptcies Rise.
- Unattractive Feature of Model: Consumption *Rises*, Apparently the Households Jump in and Take the Goods that the Entrepreneurs Can't Afford Anymore.



These Are Bank Assets Expressed as a Ratio to Total Bank Assets

