Banks, Liquidity Management and Monetary Policy

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Introduction

- Last 5 years, Central Banks facing unprecedented challenges
  - Equity losses
  - Collapse in interbank lending
  - Increased loan spreads, weak lending
- Monetary policy has been changing in response...
- Center of debate: *banks' reaction to monetary stimuli*
  - Why are banks holding on to so many liquid reserves and lending so little?

Our View

- Want: model of **banks' liquidity management** in **monetary policy transmission**
- Why: monetary policy implemented through the banking system
  - Understand banks' reactions to stimuli
  - Understand effects under special conditions
- No coincidence that debates occur *post*
  - Interbank-market freeze
  - Bank equity losses ▸ Bank Equity

Model Overview

1. Liquidity Management Trade-Off
   - (+) Profit on Loans
     - Spread between loans and deposits
   - (-) Illiquidity Risk
     - After deposits transferred, bank may be short of reserves

2. Monetary Policy
   - Illiquidity Risk: precautionary holdings of central bank reserves
   - Policy Instruments: operate through this tradeoff

3. Tractability

Application

- Why are banks stockpiling reserves instead of lending?
- Four Hypothesis
  1. Equity Losses
  2. Interbank Uncertainty
  3. Capital Requirements
  4. Weak Loan Demand
- *Approach*
  - Illustrate effects of shocks and contrast with data patterns (today)
  - Estimate shocks (in progress)
  - Evaluate relative importance of shocks and policy (in progress)

Literature Review

- Call for studying banks in transmission of MP in Macro:
  - Woodford (2010, JEP), Mishkin (2012, JEP), Greenwood &Stiglitz (2003),
- Closest Papers
  - Brunnermeier & Sannikov (2012), Williamson (2012), Corbae-D'Erasmo (2012a,b).
- Other papers studying implementation of monetary policy
  - Afonso & Lagos (2012a,b),
  - Gertler & Karadi(2009), Gertler & Kiyotaki (2011,2012), Curdia & Woodford(2009), Stein(2012)
- Empirical Work
  - Kashyap & Stein(1998), Krishnamurthy & Vissing-Jorgenson (JPE 2012a,2012b),
- Influential Work
  - Banking: Diamond & Dybvig (1983), Allen & Gale (1998), Holmstrom & Tirole (1997,1998)
  - Reserve Management: Frost (JPE,1971), Bolton et al. (2012), Saunders et al. (2011)
  - Payments: Freeman(AER,1996), Cavalcanti et al. (1998)
  - Monetary Economics: CIA, Money-Search, Kiyotaki and Moore (2012)
  - OMO: Wallace (1983), Sargent and Wallace (1983)

Model

Model - Environment

- **Time:** t=1,2,3,....
  - **Two stages:** s=l,b
  - Lending stage (l) and balancing stage (b)
- Continuum of Heterogeneous Banks $z \in [0, 1]$
- **Utility function:** Concave utility U over dividends div_t

Bank's State Variable - Bank Balance Sheet

- Liabilities:
  - D_t demand deposits (*numeraire*)
- Assets:
  - C_t reserves (only traded among banks or with FED)
  - B_t loans
- Equity
  - $N_t = B_t + C_t - D_t$

Liquidity Management

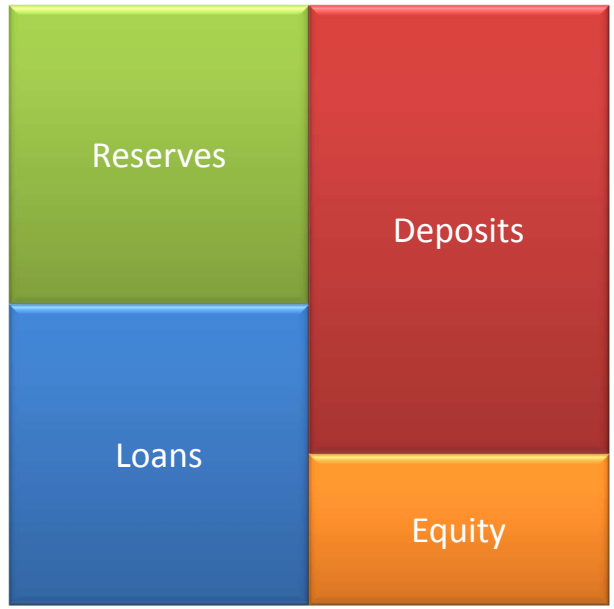


Figure : Bank Balance Sheet

Liquidity Management

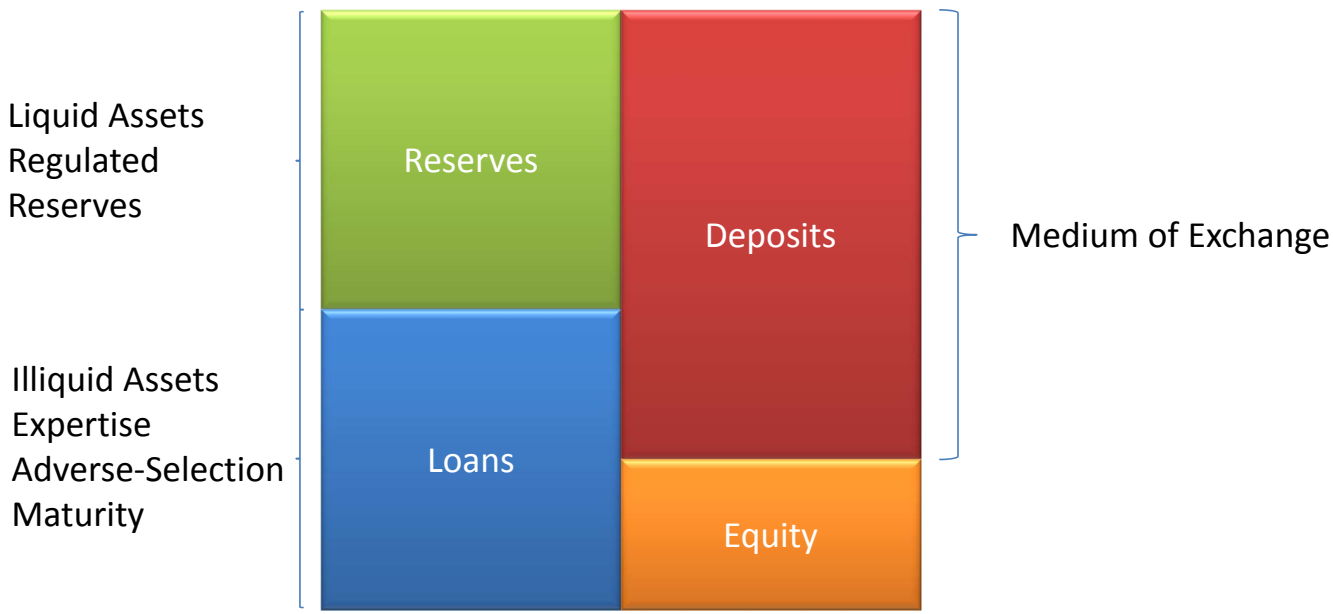


Figure : Bank Balance Sheet

Loans B_t

- Loans: perpetual securities (long maturity)
  - Decaying-coupon Consol

Loans B_t

- Loan contract specifies:
  1. price q_t^l
  2. loan size face value I_t
  3. $q_t^l I_t$ checks given to firms or households
  4. I_t payments owed

- Repayment:
  - $I_t (1 - \delta) \delta^n$ in period $n \geq 0$ after loan
  - Introduces maturity (beyond 1 period, not essential)

Loans B_t

- Recursively, bank loans l.o.m.:

$$B_{t+1} = \delta B_t + I_t$$

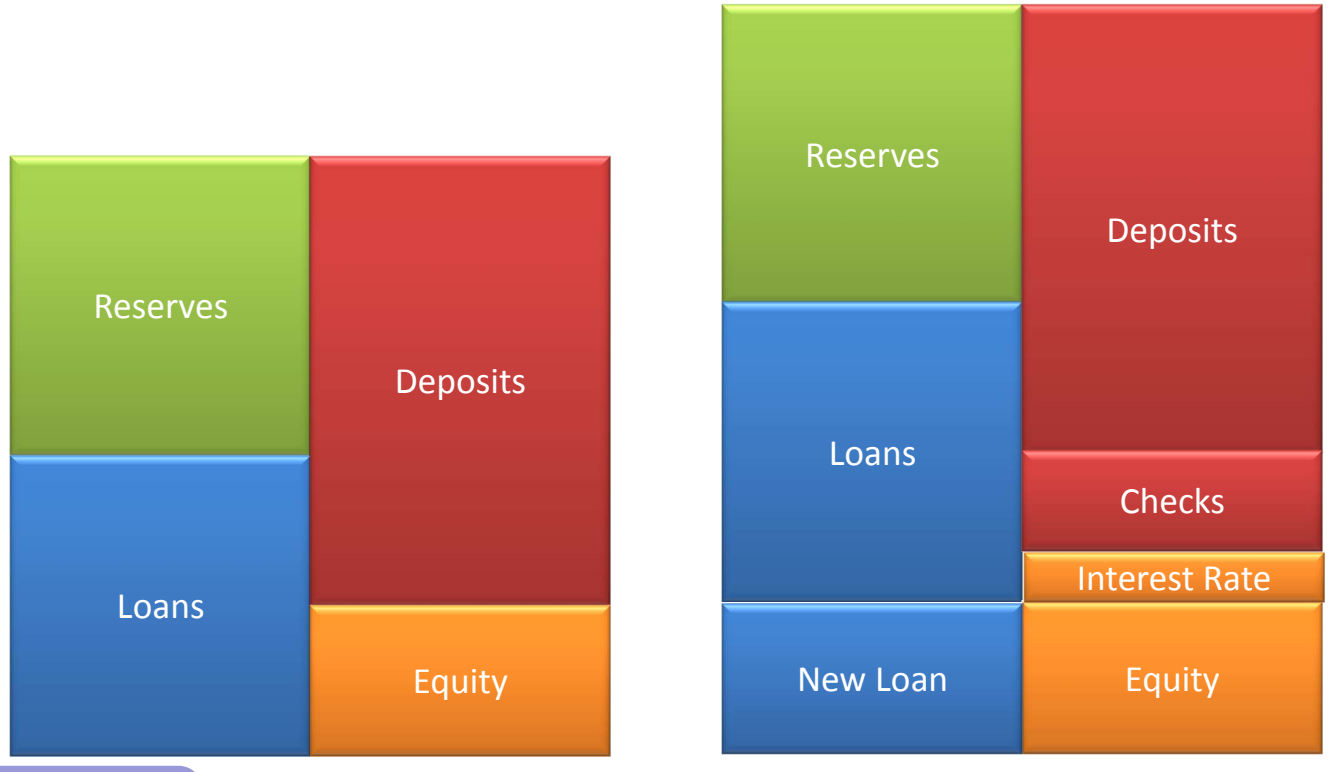
- Loan is illiquid:
  - Lending stage: Loans **can** be sold
  - Balancing stage: Loans **cannot** be sold

Loans B_t

- Where's q coming from?
- Downward (weakly) sloping curve
  - $I_t^d = \Theta_t \left(q_t^l\right)^{\in}$

▸ To Derivation

Liquidity Management



▸ Rest of the Economy

Figure : Bank Balance Sheet

Deposits D_t - Lending Stage:

- Deposits change because:
  - Lending qI_t
  - Paying Dividends DIV_t
  - Purchasing Reserves φ_t
- Decreases Deposits through
  - Inflow of loan coupons
- Leverage Constraint:
  - $D_t \leq \kappa N_t$ (only during lending stage)

Deposits D_t - Balancing Stage

- $\omega \in (-\infty, 1]$ random fraction of D_t leaves bank
  - Randomness in payments system

- Withdrawal, pay other bank with reserves
  - $\omega \sim F_t(\omega)$
  - $\mathbb{E}(\omega) = 0$ - deposits don't leave banking system

- Reserve requirements $\rho_t \in [0, 1]$
- Reserve Deficit: $x = \rho_t D_t - C_t$
- Penalty for insufficient reserves: $\chi_t(x_t)$:

$$\chi_t(x) = \begin{cases} \underline{\chi}_t x \ if & x \leq 0 \\ \overline{\chi}_t x \ if & x > 0 \end{cases}$$

Detour - Derivation of χ_t

- FED chooses corridor system rates: $r_t^l > r_t^b$
- Mass (normalized) of reserve deficits and surpluses:

$$M^- \text{ and } M^+$$

- Probability of match:

$$\gamma^- = \min\left(1, \frac{M^+}{M^-}\right) \text{ and } \gamma^+ = \min\left(1, \frac{M^-}{M^+}\right).$$

- Bargaining Problem of dollar in surplus and deficit:

$$\max_{r^{FedFunds}} \left(r_t^l - r^{FedFunds}\right)^{\xi} \left(r^{FedFunds} - r_t^b\right)^{1-\xi}$$

- Spline penalty function:

$$\underline{\chi}_t = \gamma^+(1 + r^{FedFunds}) + \left(1 - \gamma^+\right)\left(1 + r_t^b\right)$$

for dollar in surplus and for dollar in deficit

$$\overline{\chi}_t = \gamma^-(1 + r^{FedFunds}) + \left(1 - \gamma^-\right)\left(1 + r_t^l\right).$$

Reserves C_t

- Fixed Aggregate Supply determined by FED: $M0_t$
- Transferred across banks
  - Loan withdrawal
  - Interbank purchases φ_t
- Precautionary saving
  - Avoid penalty χ

Liquidity Management

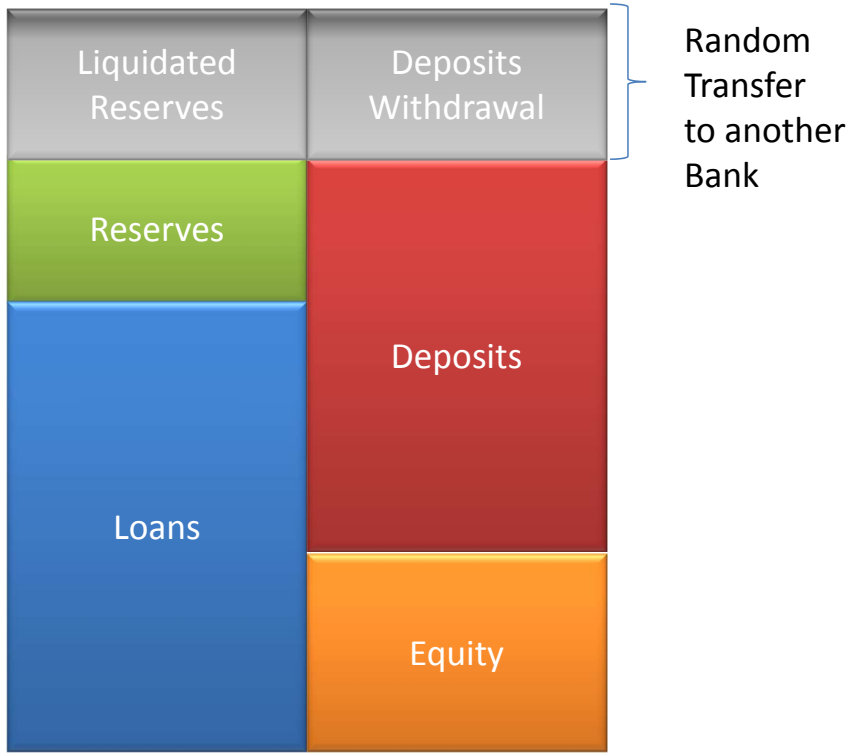
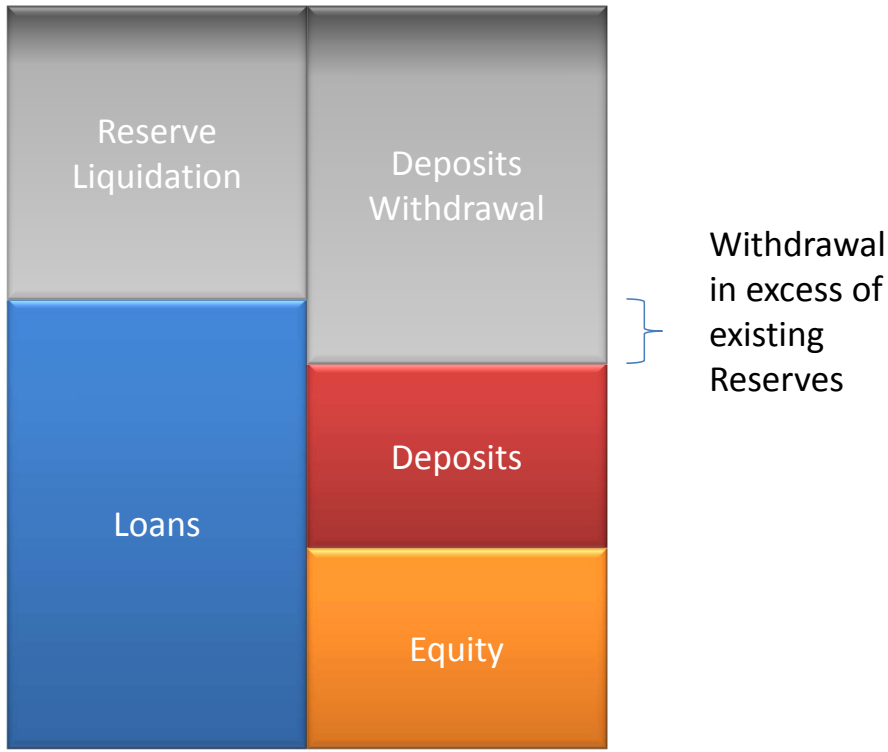


Figure : Bank Balance Sheet - Liquid Assets

Liquidity Management



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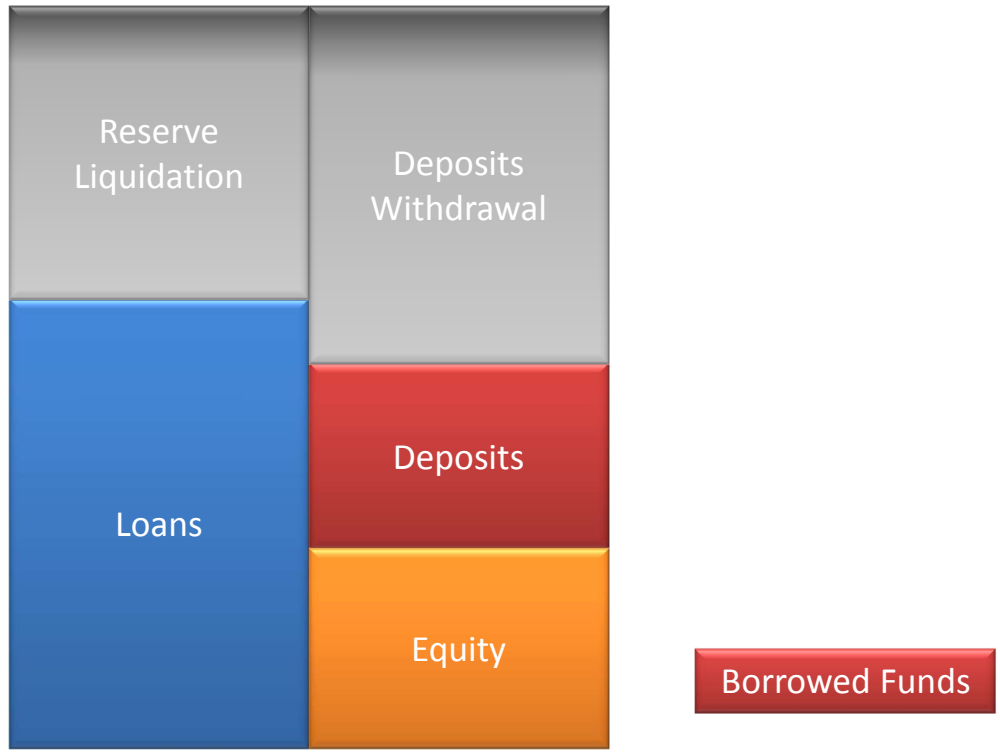

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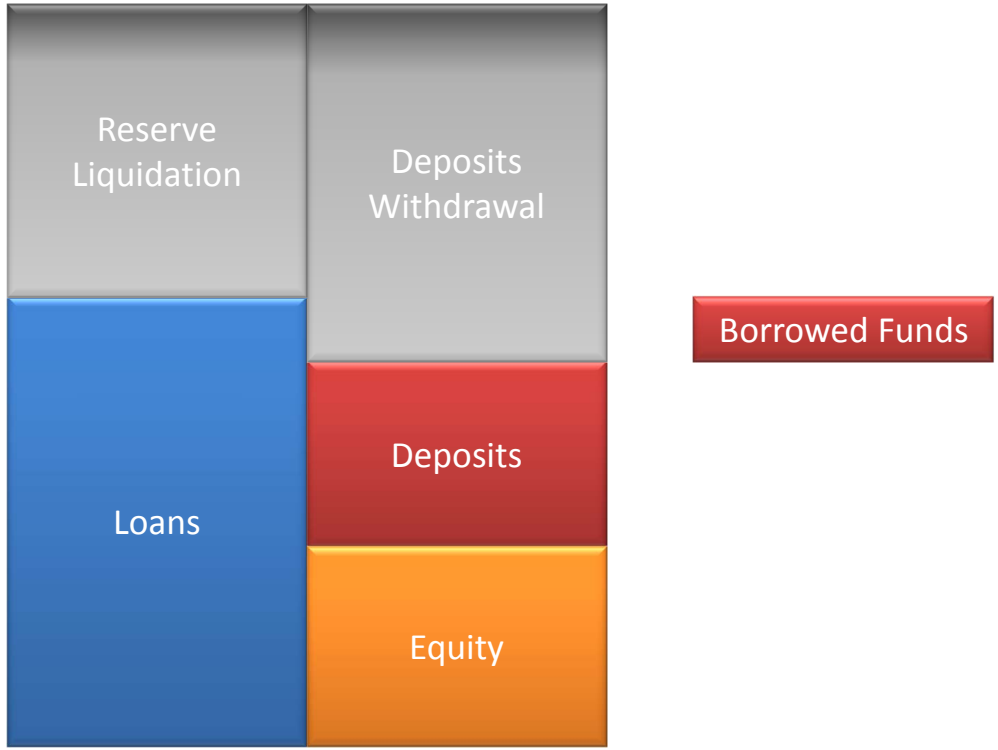

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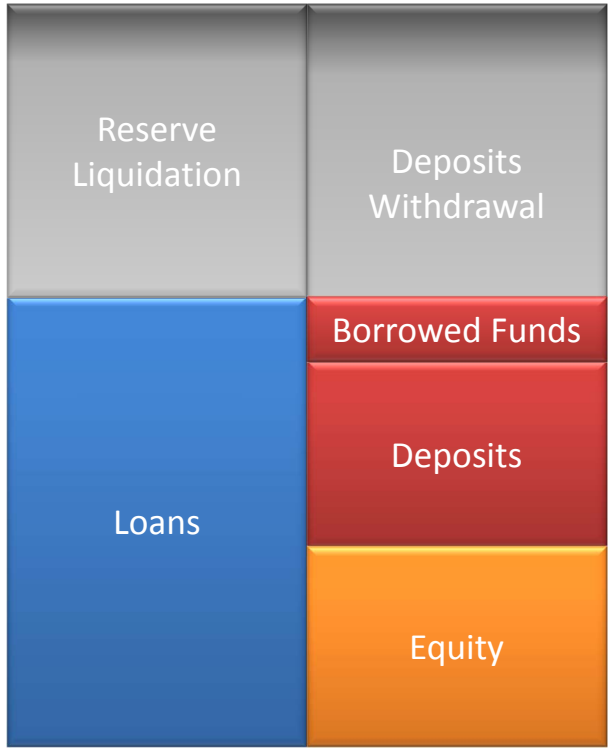

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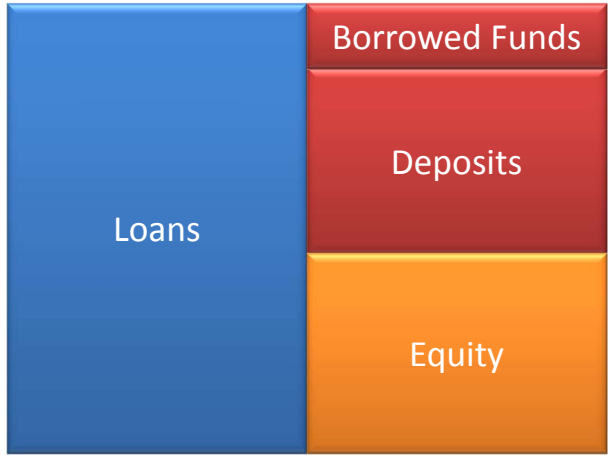

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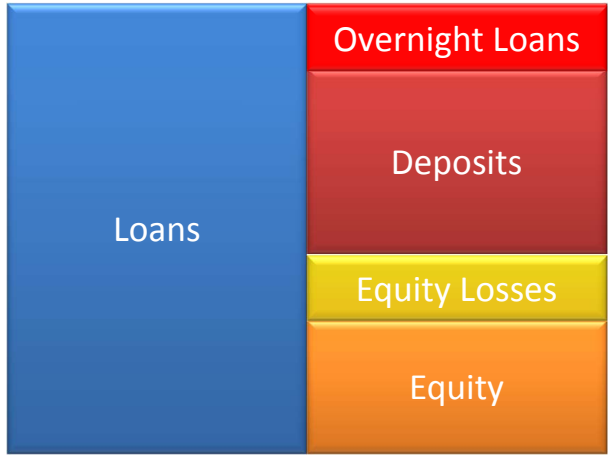

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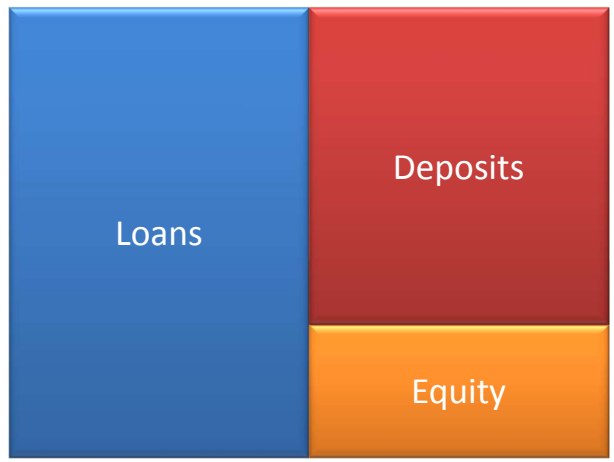

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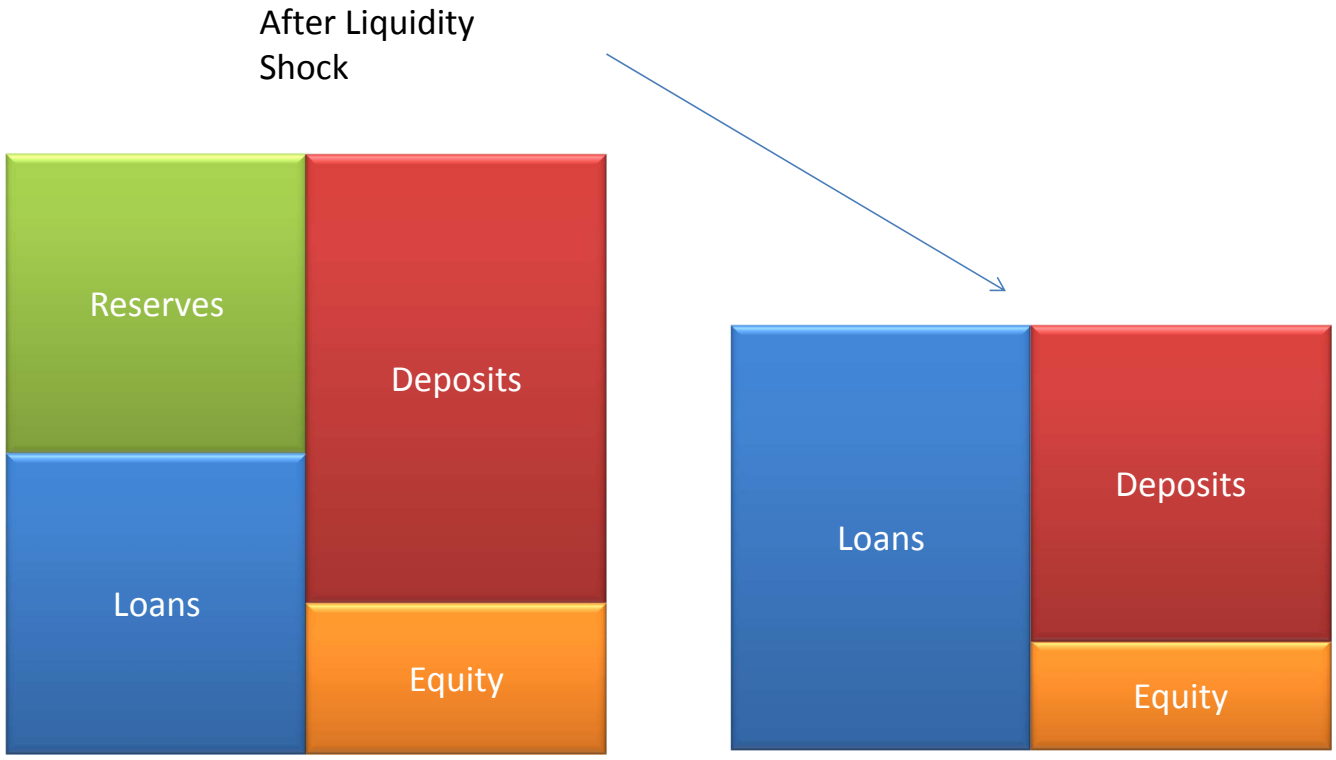


Figure : Bank Balance Sheet - Liquid Assets

The Aggregate State

- Governments Policy Path $\left\{\rho_t, M0_t, D_t^{FED}, B_t^{FED}, \kappa_t, \underline{\chi}_t, \overline{\chi}_t\right\}_{t\geq 0}$
- Θ_t is the slope of demand curve.
- F_t process for withdrawal risk
- Potentially: Distribution of Bank state variables
  - Only one endogenous state variable E_t
- Aggregate State: X_t
  - Model recursive in X_t

Value Function - Lending Stage

$$
\begin{aligned}
V^l(C,B,D;X) &= \max_{I,\varphi,DIV} u(DIV) + \beta E_{\omega'}[V^b(\tilde{C},\tilde{B},\tilde{D},\omega';X)] \\
\tilde{D} &= D + qI + DIV + \varphi(1+r) - B(1-\delta) \\
\tilde{C} &= C + \varphi \\
\tilde{B} &= \delta B + I \\
\tilde{D} &\leq \kappa(\tilde{B}q + \tilde{C}(1+r) - \tilde{D}), \tilde{D} \geq 0.
\end{aligned}
$$

Value Function - Balancing Stage

$$
\begin{aligned}
V^b\left(C, D, B, \omega; X\right) &= \beta \mathbb{E}[V^l\left(C', B', D'; X'\right)] \\
&\quad \text{subject to} \\
C' &= C - \omega D \\
D' &= D - \omega D + \chi\left(\rho D\left(1 - \omega\right) - C'\right) \\
B' &= B
\end{aligned}
$$

One Value Function

$$
\begin{aligned}
V^l(C,B,D;X) &= \max_{\{I,DIV,\tilde{C},\tilde{D}\}\in\mathbb{R}^4} U\left(DIV\right)... \\
&\quad +\beta\mathbb{E}\left[V^l(\tilde{C}-\omega'\tilde{D},\tilde{B},\tilde{D}(1-\omega')+\chi(\rho\tilde{D}-(\tilde{C}-\omega'\tilde{D}));X')|X\right] \\
\tilde{D} &= D+qI+DIV+\varphi(1+r)-B(1-\delta) \\
\tilde{B} &= \delta B+I \\
\tilde{C} &= \varphi+C \\
\tilde{D} &\leq \kappa(\tilde{B}q+\tilde{C}(1+r)-\tilde{D}),\tilde{D}\geq 0.
\end{aligned}
$$

Characterization

Characterization

1. Single endogenous state

2. Portfolio Separation Theorem
   - Dividend-Savings independent of Portfolio Weights

3. Analysis of the Power of Monetary Policy

Solution

- Law of motion for deposits

$$\tilde{D} = D + q \underbrace{I}_{\tilde{B}-\delta B} + DIV + (1+r) \underbrace{\varphi}_{\tilde{C}-C} - B(1-\delta).$$

- and substitute for I and φ...

$$\tilde{D} = D + q(\tilde{B} - \delta B) + DIV + (\tilde{C} - C)(1+r) - B(1-\delta)$$

- and rearrange terms to obtain...

$$DIV + (1+r)\tilde{C} + q\tilde{B} - \tilde{D} = \underbrace{C(1+r) + (q\delta + (1-\delta))\, B - D}_{E}.$$

- We can collapse all state-variables into one: E!

Solution

Proposition (Single-State)

We have

$$V^l(C, B, D; X) = V^l(E; X)$$

$$E \equiv C(1+r) + q\delta B + B(1-\delta) - D.$$

Proposition (Homogeneity and Separation)

With CRRA,

$$V^l(E; X) = v^l(X)\, E^{1-\gamma}$$

where:

$$v^l(X) = \max_{div \in \mathbb{R}_+} div^{1-\gamma} + \beta \mathbb{E}\left[v^l(X') \,|X\right] \left(\Omega(X)\,(1-div)\right)^{1-\gamma}$$

where $\Omega(X)$ *is Return to Bank Portfolio.*

Bank Portfolio Problem

- Four Returns:
  - Return on Loans:
$$R_t^B \equiv \frac{\delta q_{t+1} + (1-\delta)}{q_t},$$
  - Return on Reserves:
$$R_t^C \equiv \left(\frac{1 + r_{t+1}}{1 + r_t} \right)$$
  - Return on Deposits:
$$R_t^D(\omega') \equiv 1 + r_{t+1}\omega'$$
  - Liquidity Cost:
$$R^{\chi}\left(w_d, w_c, \omega'\right) \equiv \chi \left(\left(\rho + \omega'\right) w_d - \frac{w_c}{(1+r)} \right)$$

Bank Portfolio Problem

- Effects of MP captured by $\Omega(X)$
- $\Omega(X)$ certainty equivalent portfolio:

$$\max_{\{w_b,w_d,w_c\}\in\mathbb{R}^3_+} \left(\mathbb{E}_{\omega'}\left[\left(R^B w_b + R^C w_c - R^D w_d - R^\chi(w_d, w_c)\right)^{1-\gamma}\right]\right)^{\frac{1}{1-\gamma}}$$

subject to,

$$\begin{aligned} 1 &= w_b + w_c - w_d \\ w_d &\leq \kappa\left(w_b + w_c - w_d\right) \end{aligned}$$

- Original Policies: $[\tilde{D}, \tilde{B}, \tilde{C}] = [w_d, w_b, w_c] \cdot E \cdot (1 - div)$

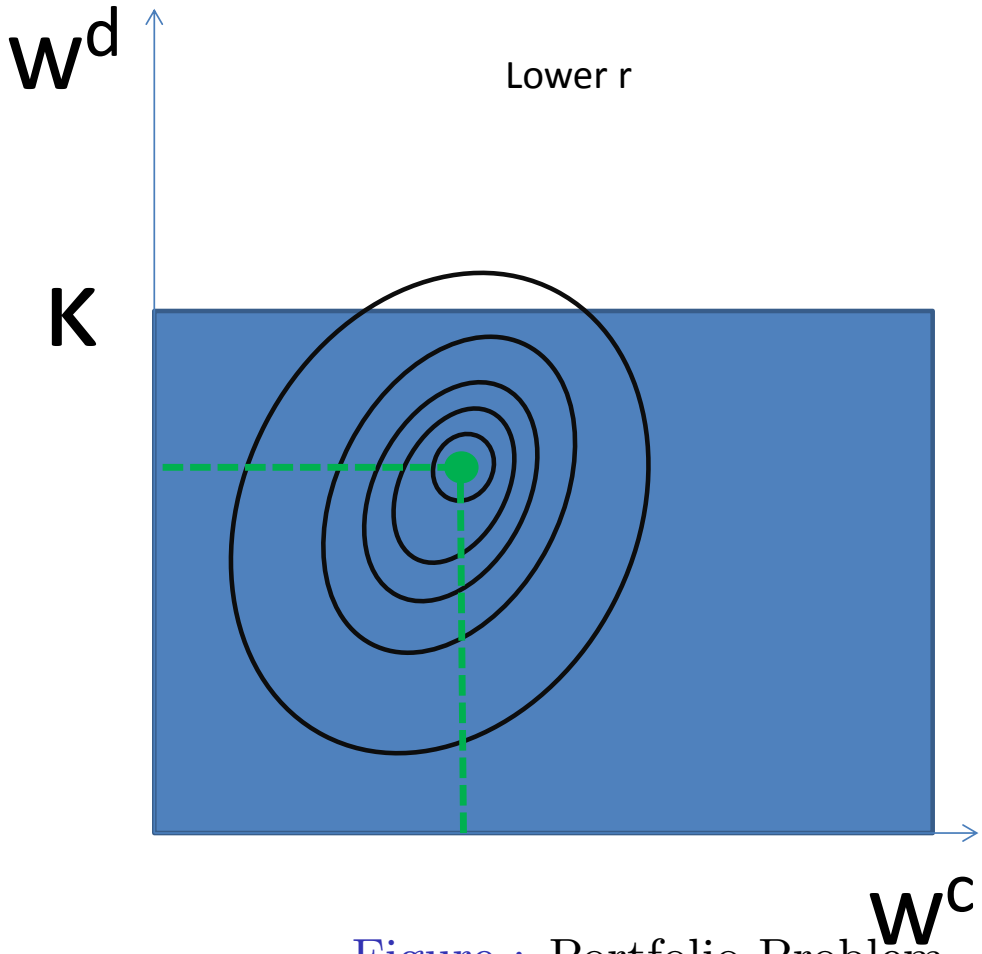
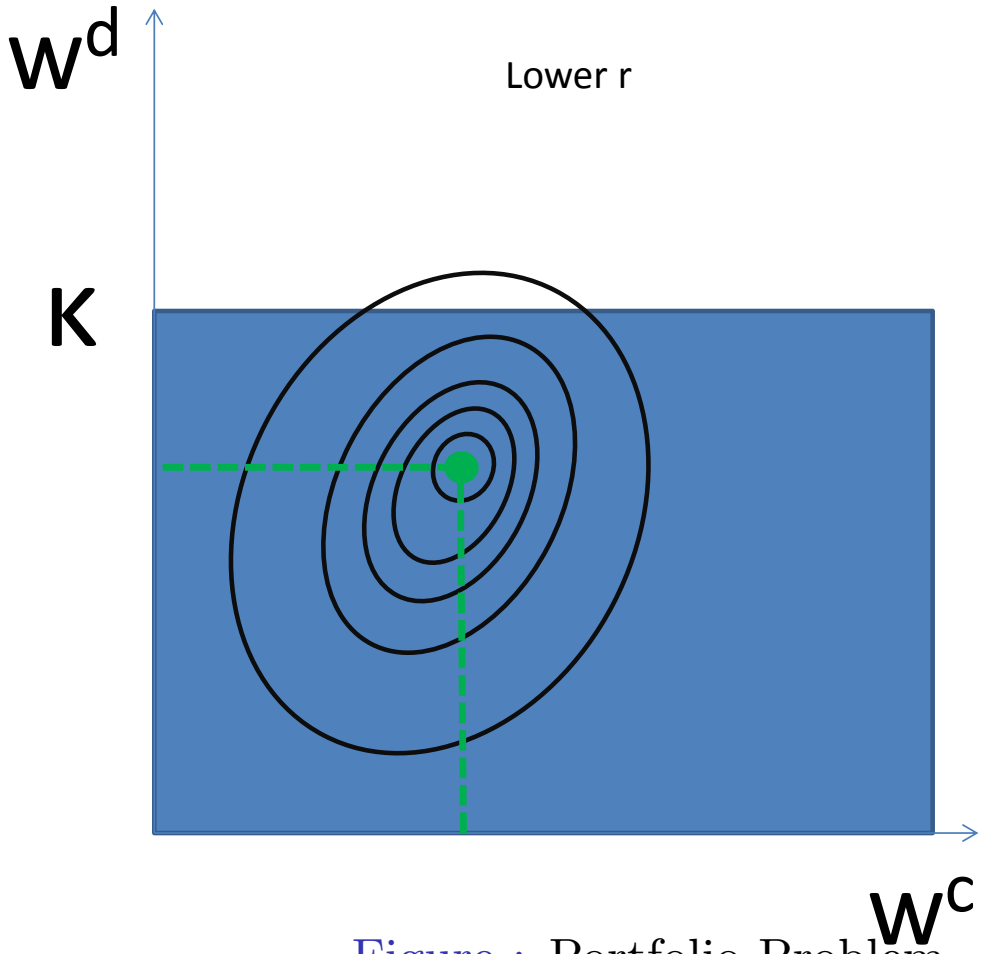


Figure : Portfolio Problem

Liquidity Management and Monetary Policy

- Monetary Policy Instruments
  - Discount window: χ_t
  - Reserve requirements ρ_t
  - Long-Term Loans: $M0_t$
  - Open-market operations: (b_t, c_t)



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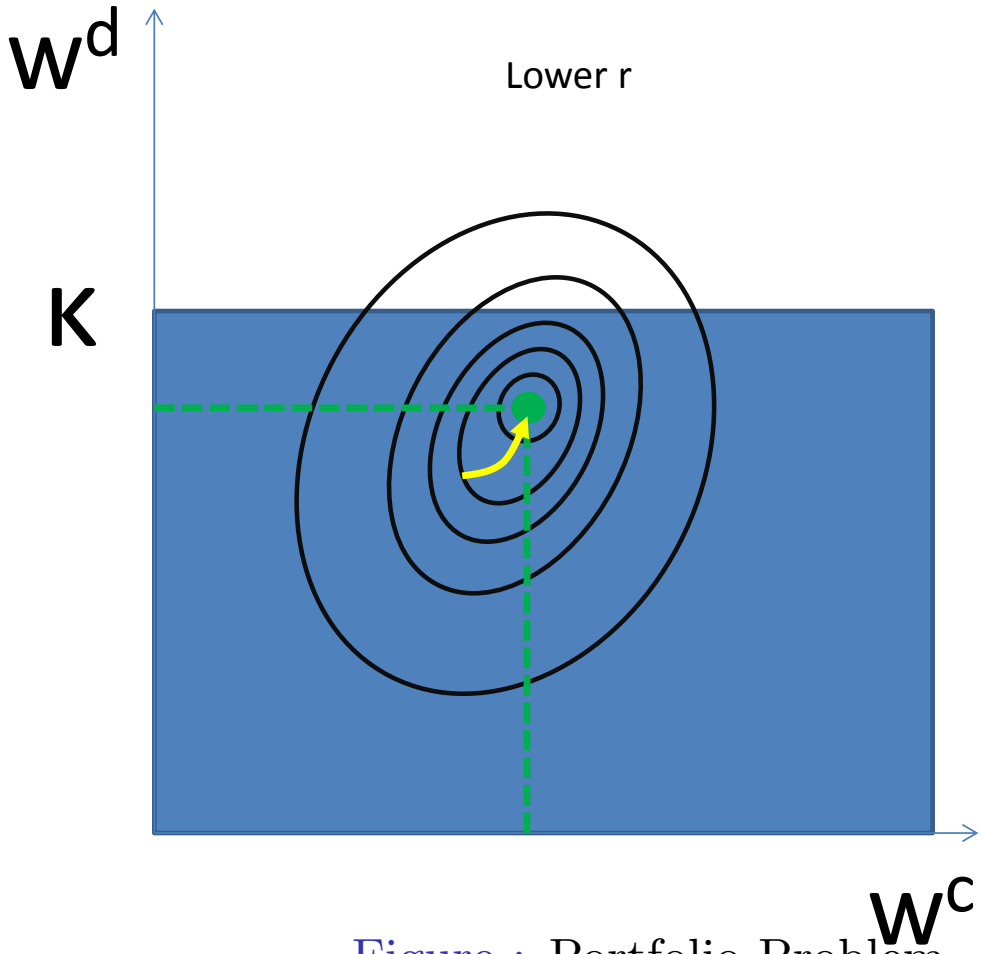

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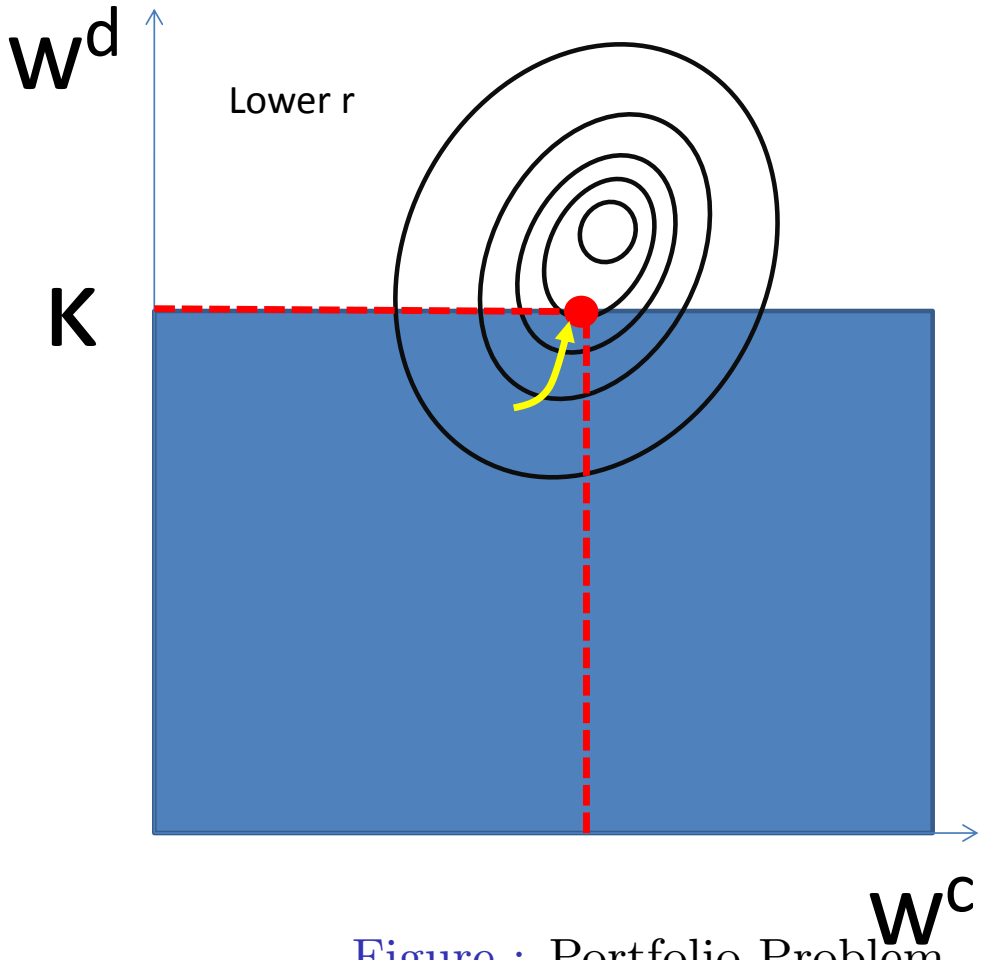


Figure : Portfolio Problem

Calibration

Table : Parameter Values

	Value	Reference
Capital requirement	$\kappa = 17$	6% Tier-2 Capital
Discount factor	$\beta = 0.99$	Return on Equity=8%
Risk aversion	$\gamma = 1$	Benchmark
Loan Maturity	$\delta = 0.5$	Residual duration + buy-backs
Interest rate (annualized)	$r = 4\%$	LIBOR
Liquidity Requirement	$\rho = 0.10$	Res. Req.
Loan Demand Elasticity	$\epsilon = 8.0$	-
Penalty	$\chi^L = 0.0\%$	FedRate
Penalty	$\chi^H = 3.2\%$	Liquidity Ratio
Withdrawal-shock volatility F_t	Non-Param	Data

Calibration of Dispersion

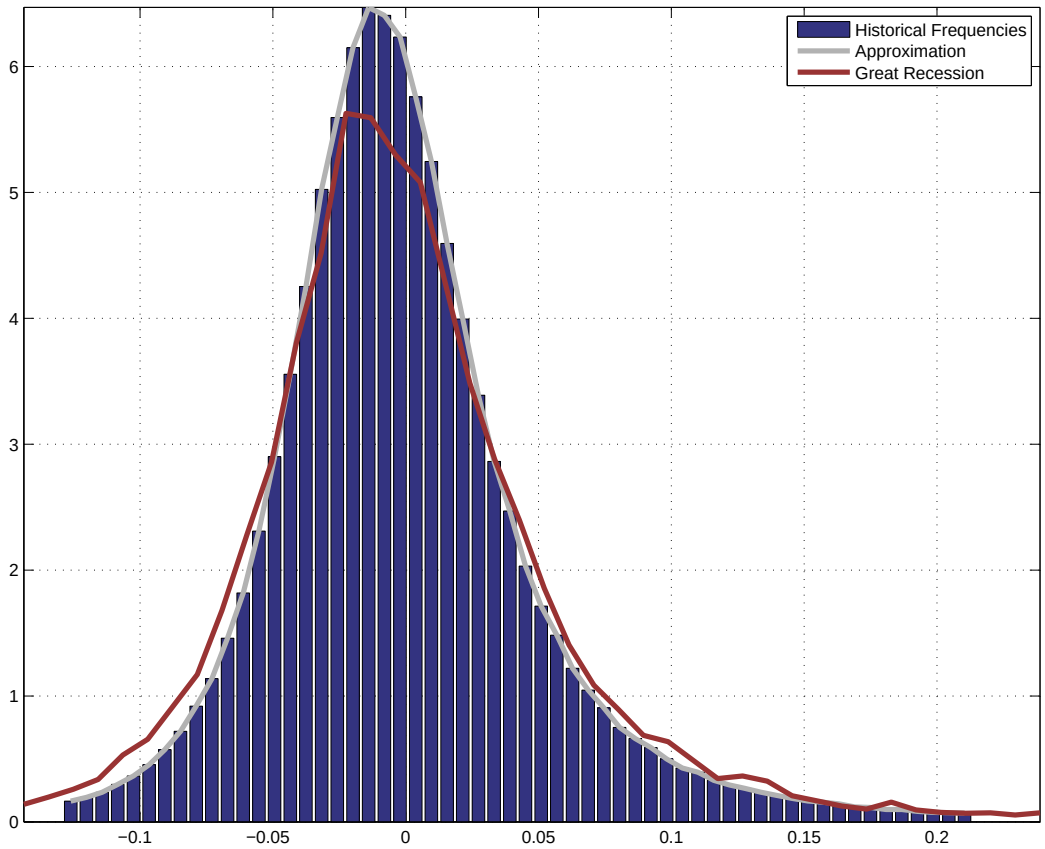


Figure : Cross-Sectional Distribution of Deviation from Cross-Sectional Average Growth Rates

Calibration of Dispersion

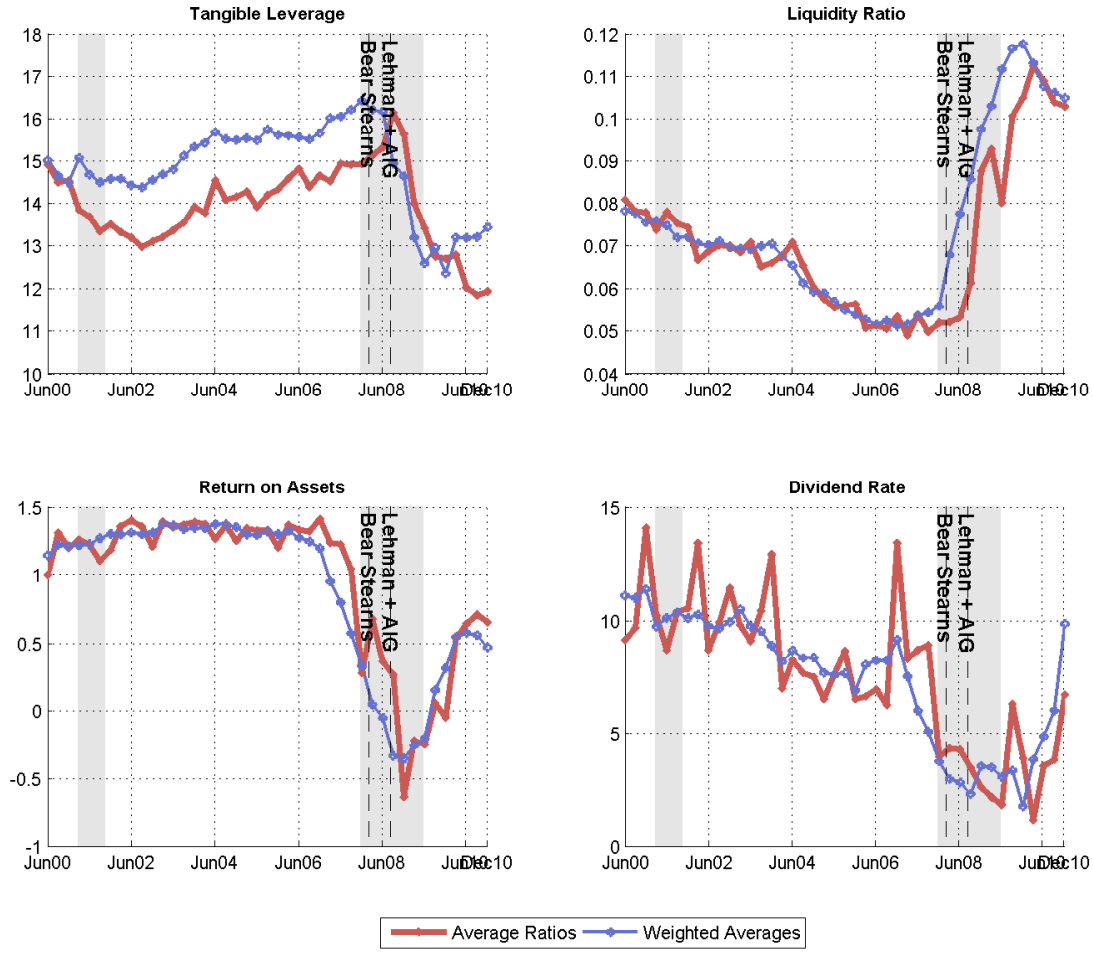


Figure : Key Historical Ratios

Quantitative Application

- Why are banks stockpiling cash rather than lending?

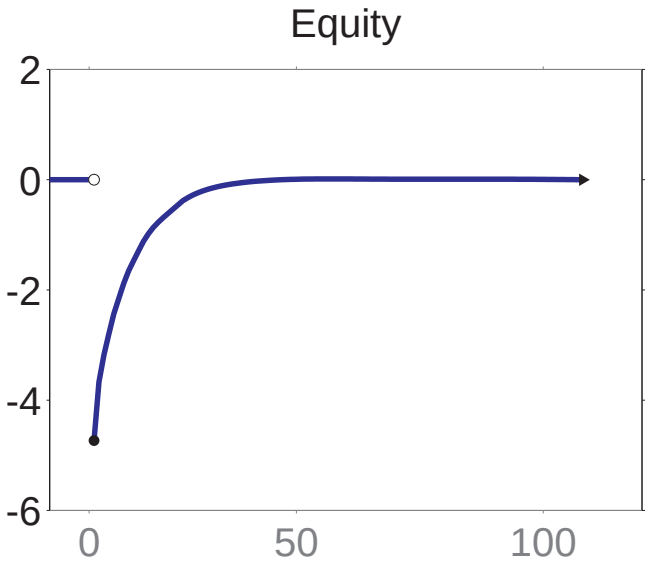
- Four Hypothesis
  1. Equity Losses
  2. Capital Requirements
  3. Uncertainty in Interbank markets
  4. Weak Loan Demand

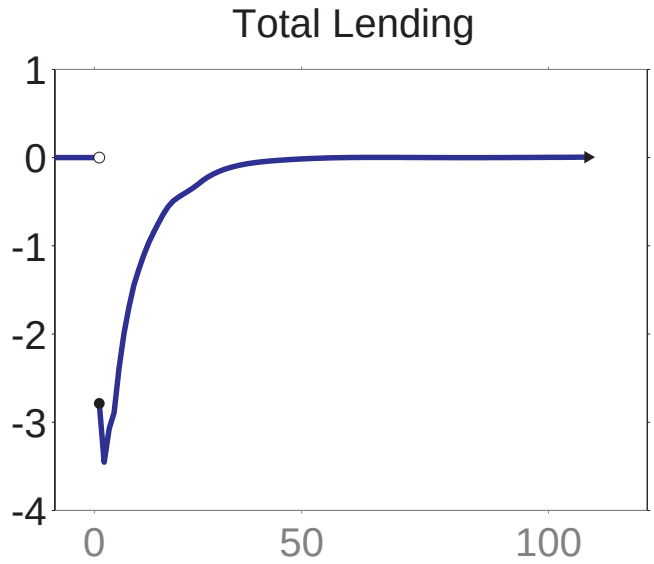
Workings of the Model

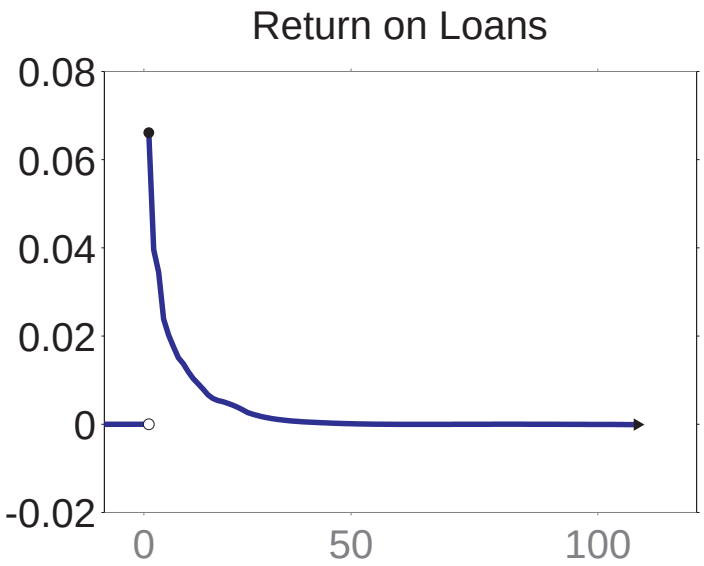
- Deterministic Transitional Dynamics
- Steady-state:
  - Fix $\left\{\rho_t, M0_t, \kappa_t, \underline{\chi}_t, \overline{\chi}_t\right\}_{t\geq 0}$
  - Find (q,r) such that equity doesn't grow
  - Solve for E: financial sector size
- Transitional Dynamics: one shock at a time
  - Find (q_t, r_t), consistent with equity growth and convergence

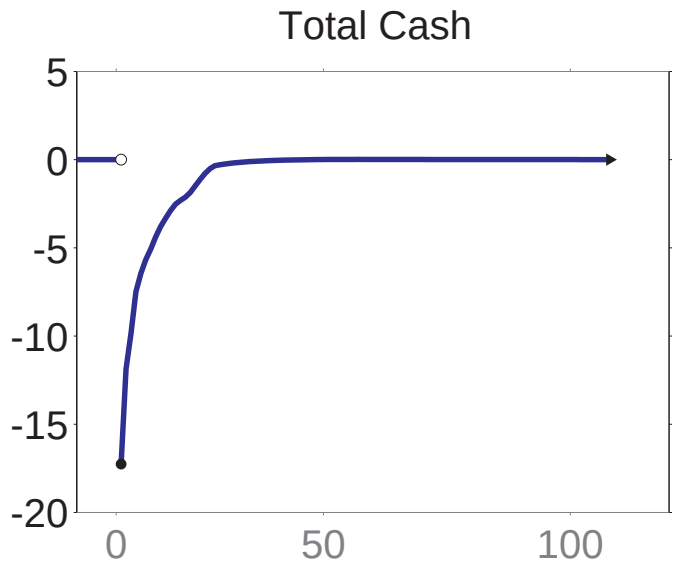
Equity Loss- $\downarrow E_0$ by 4 percent

Eq.loss

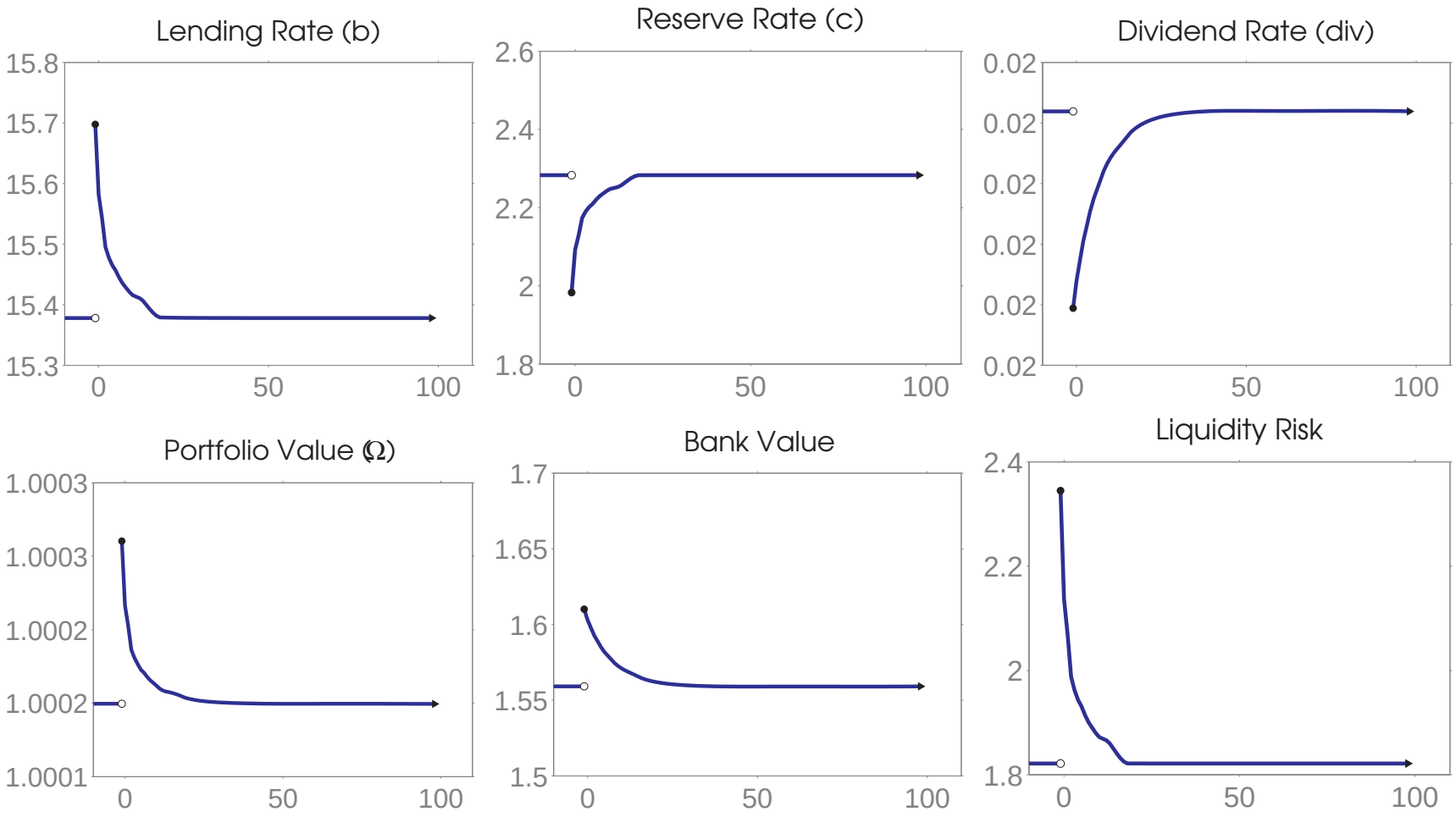

Equity
2
0
-2
-4
-6
0
50
100


Total Lending
1
0
-1
-2
-3
-4
0
50
100


Return on Loans
0.08
0.06
0.04
0.02
0
-0.02
0
50
100

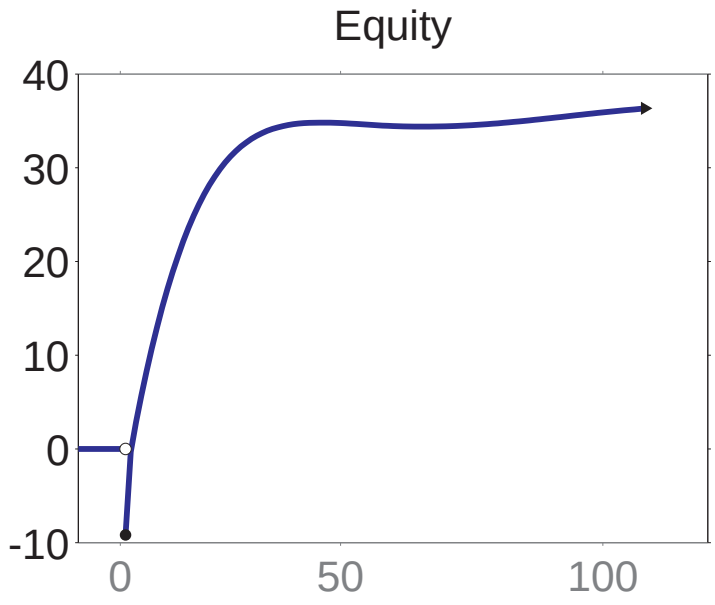

Total Cash
5
0
-5
-10
-15
-20
0
50
100

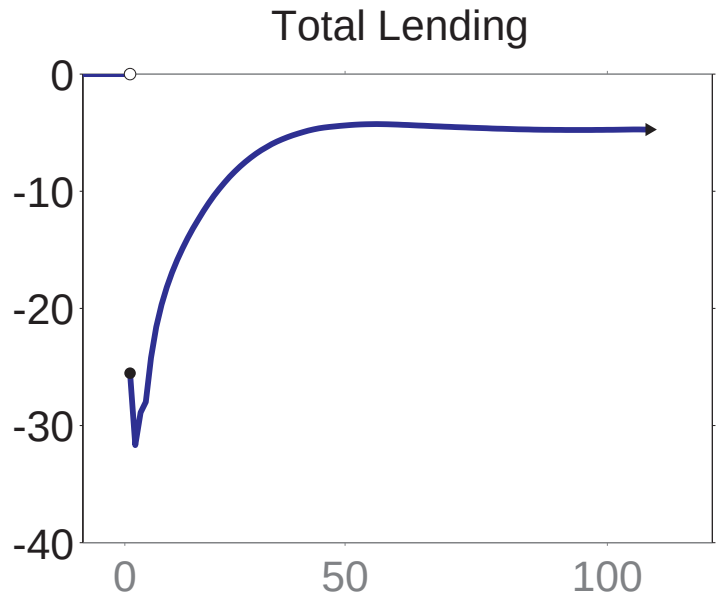
Eq.loss

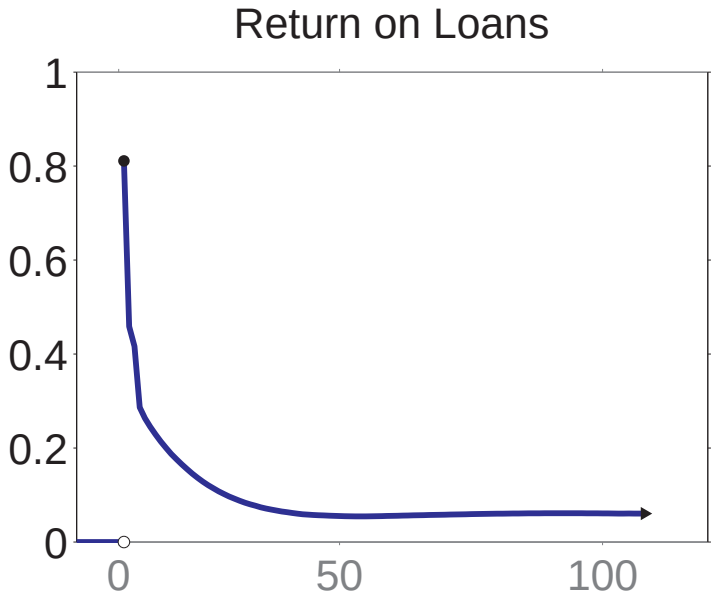

Lending Rate (b)
15.8
15.7
15.6
15.5
15.4
15.3
0
50
100
Reserve Rate (c)
2.6
2.4
2.2
2
1.8
0
50
100
Dividend Rate (div)
0.02
0.02
0.02
0.02
0.02
0
50
100
Portfolio Value (Ω)
1.0003
1.0003
1.0002
1.0002
1.0001
0
50
100
Bank Value
1.7
1.65
1.6
1.55
1.5
0
50
100
Liquidity Risk
2.4
2.2
2
1.8
0
50
100

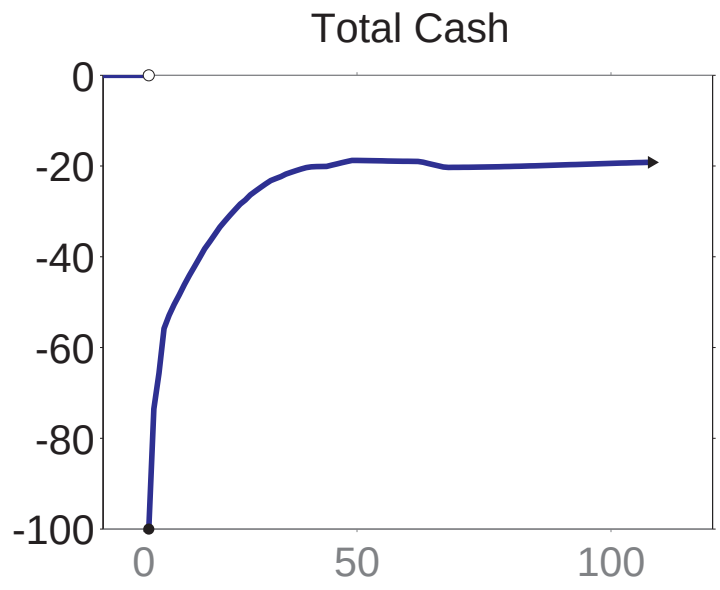
Permanent Rise in Capital Requirements - (AR-1 process, extra 2.5 % capital)

Perman. Rise in Cap. Requirements

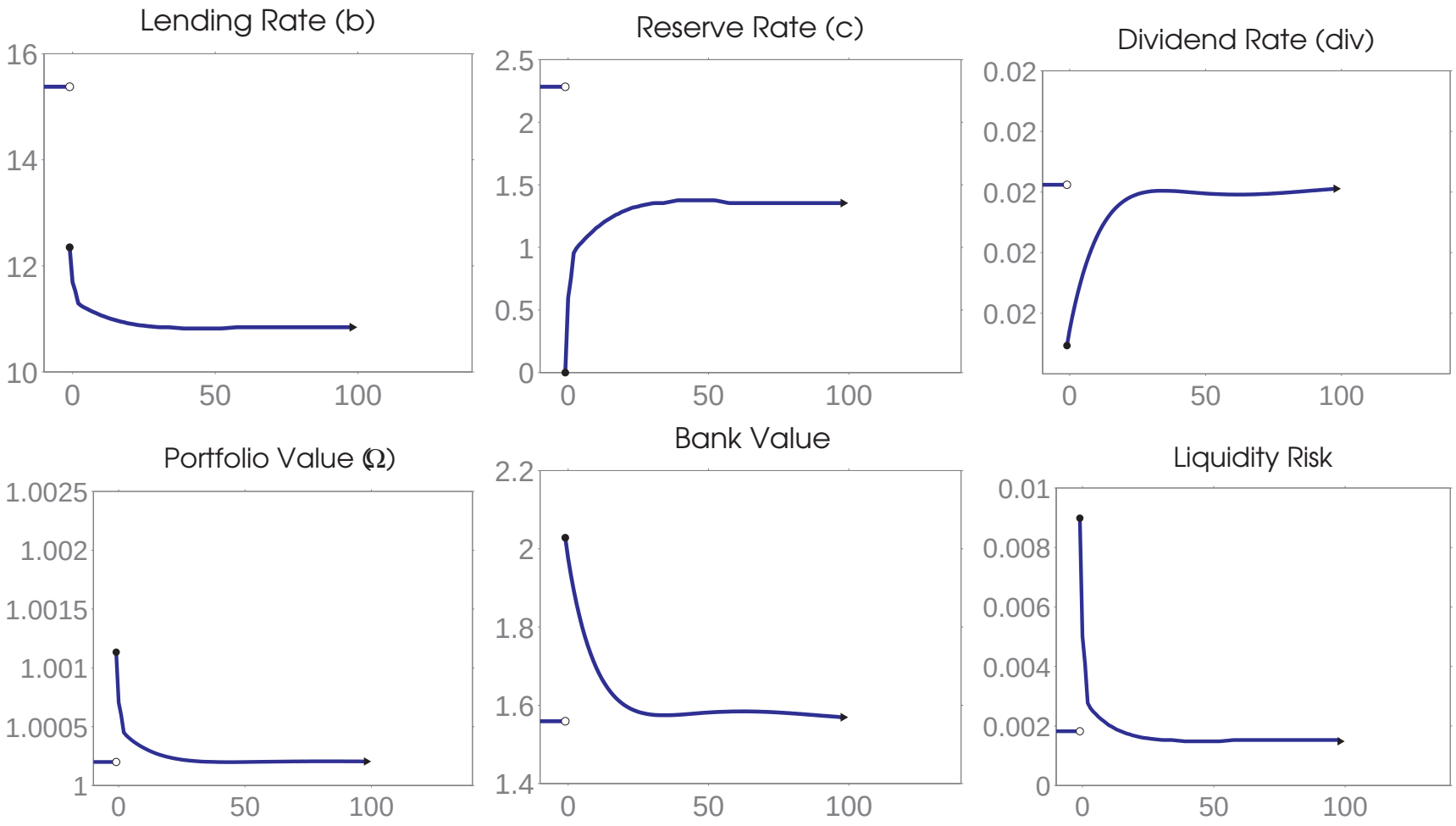






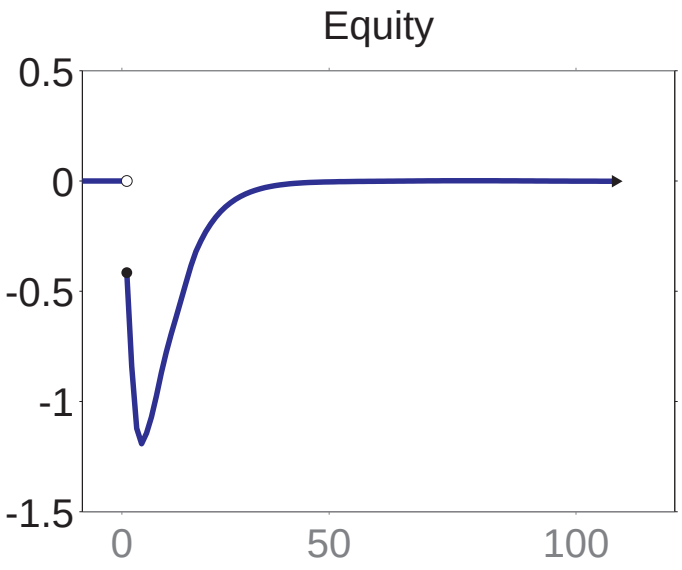


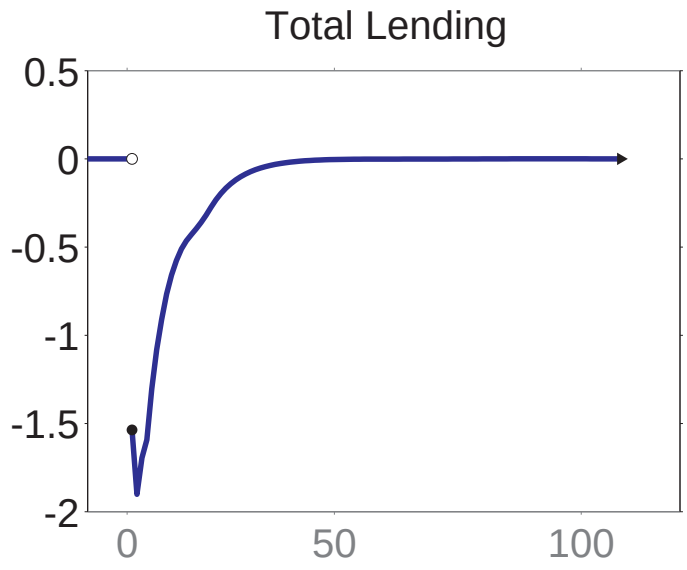
Permanent Rise in Cap. Requirements

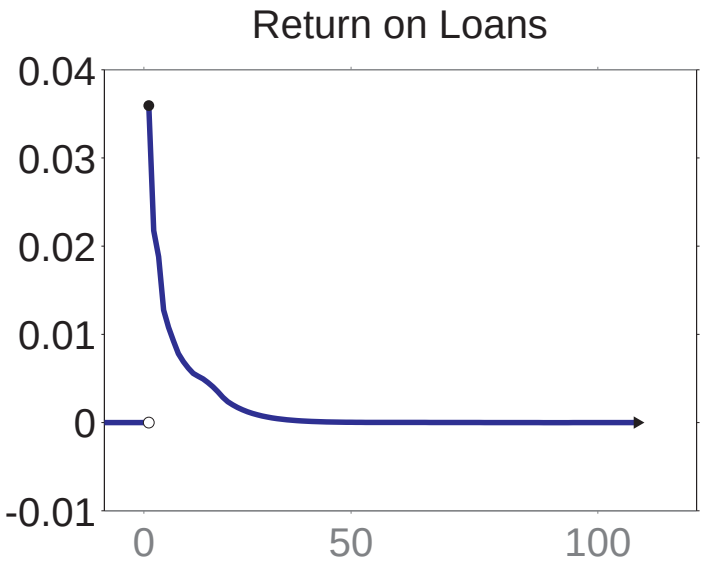


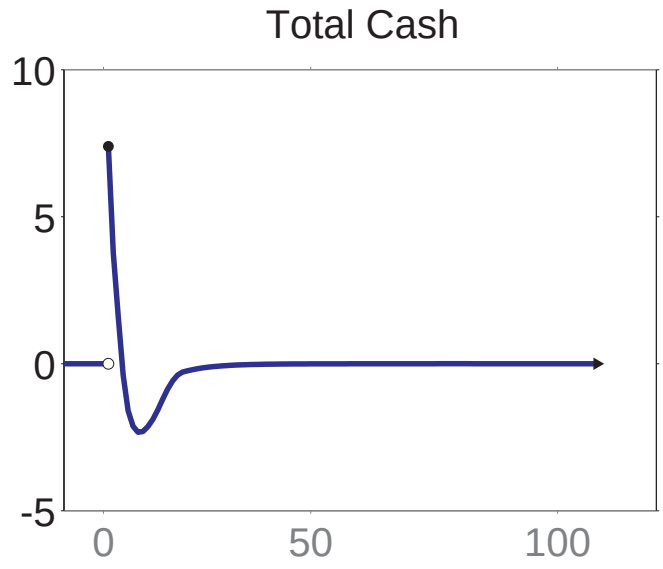
Shock to probability of bank-run (AR-1 process, initial increase is 10 percent)

Bank-run Risk

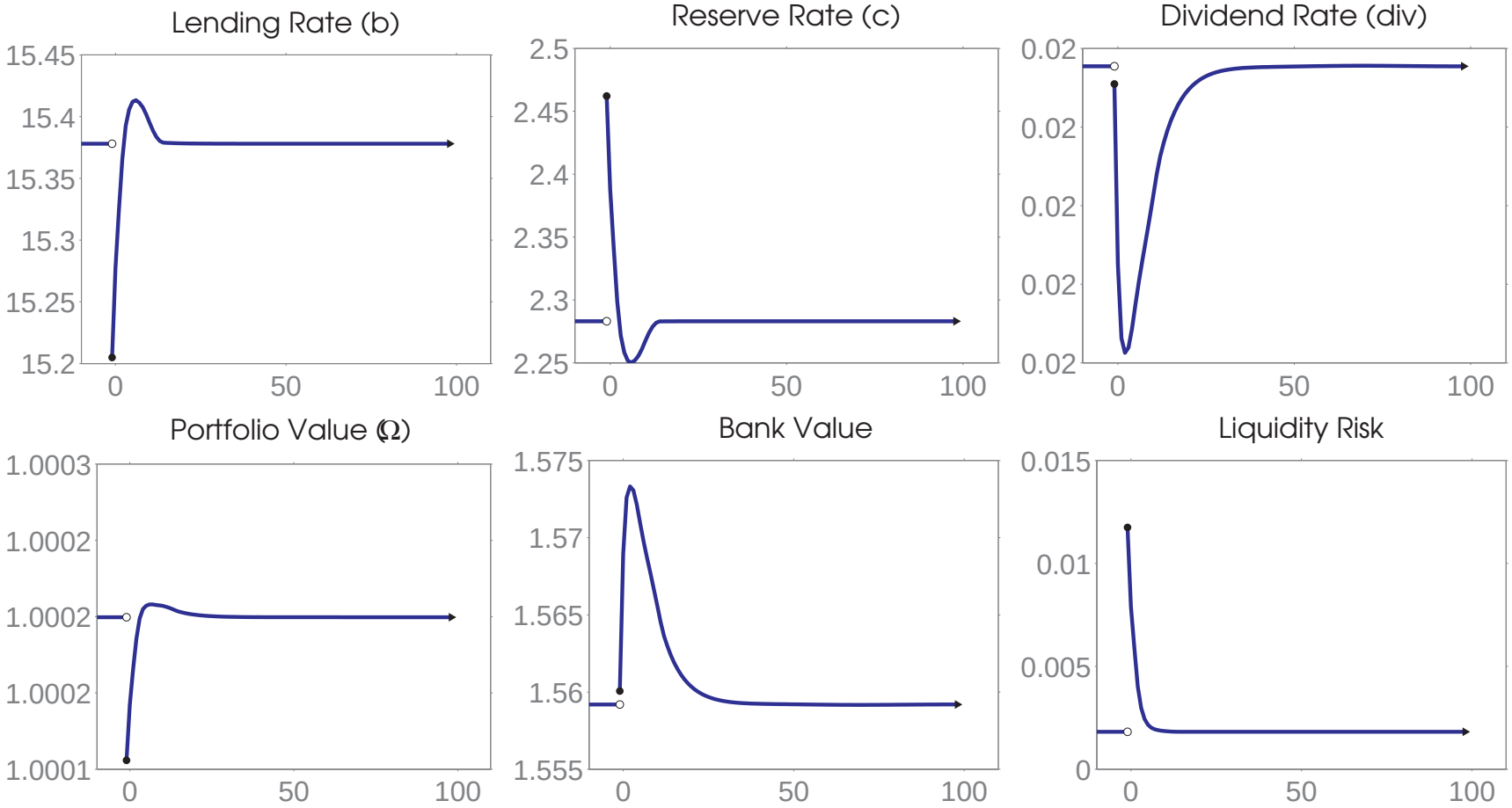






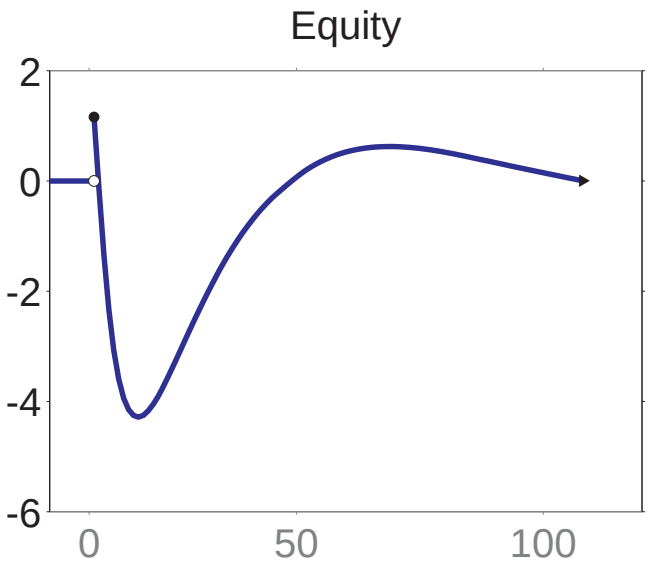


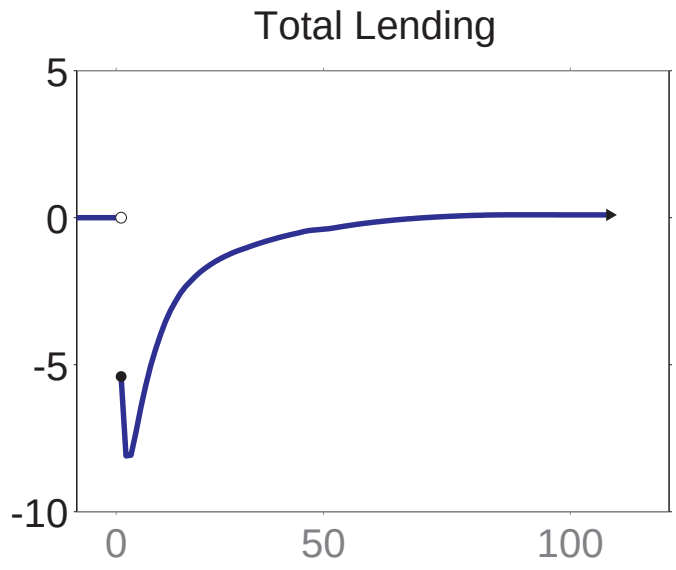
Bank-run Risk

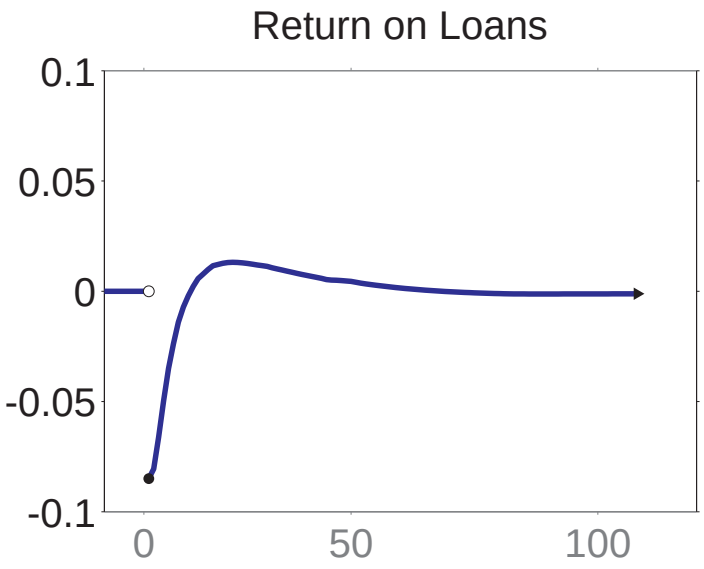


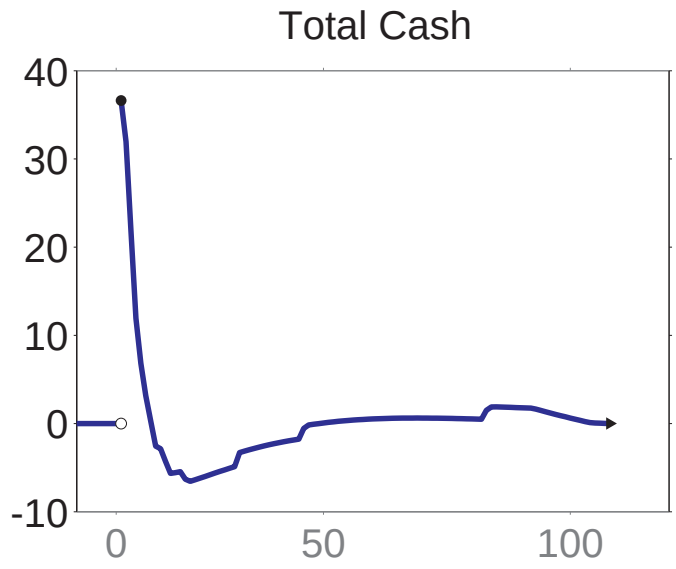
Loan Demand Shock - $\downarrow \Theta_t$ (AR (1) process, 20 percent initial decrease)

Demand Shock

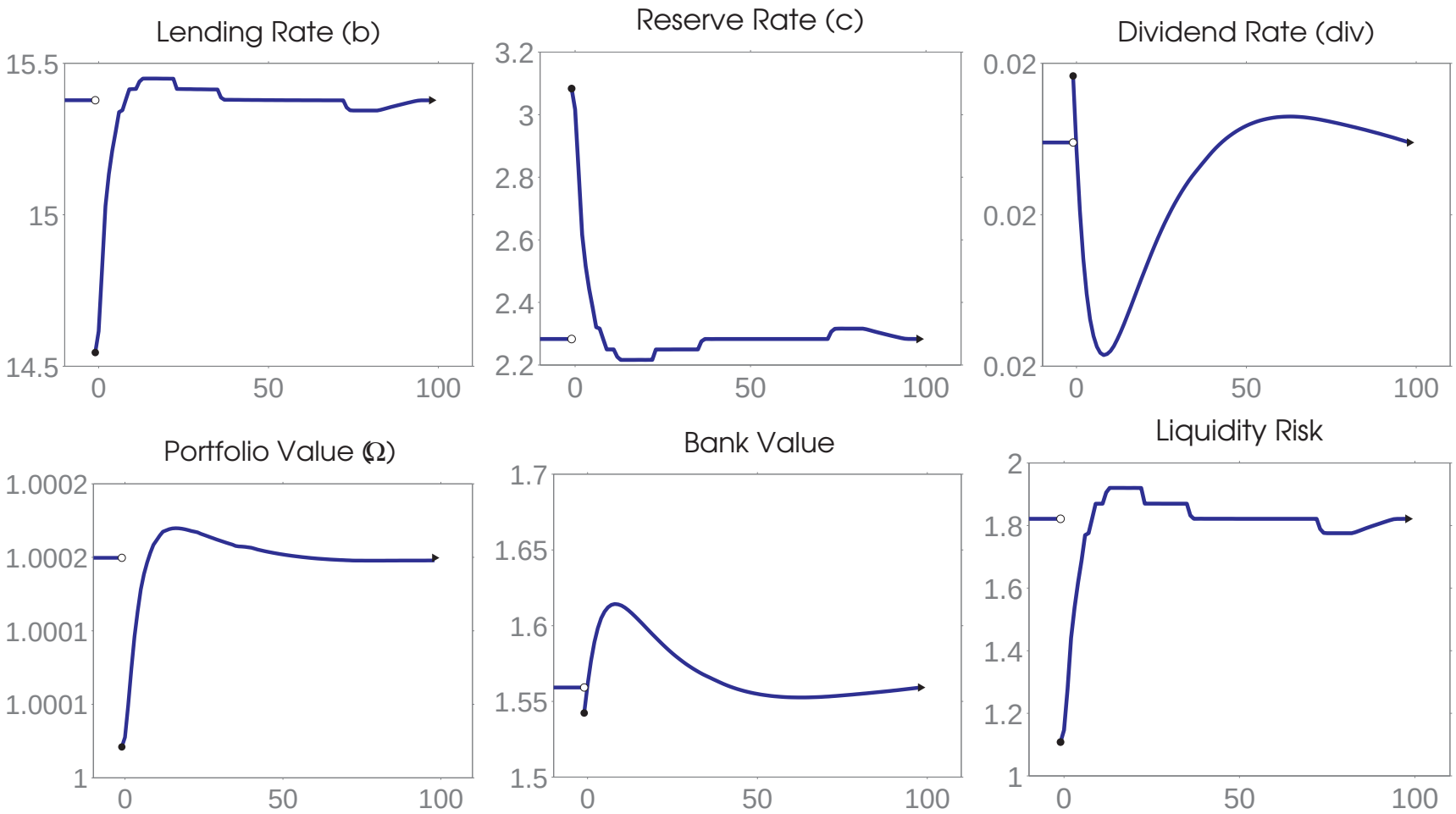






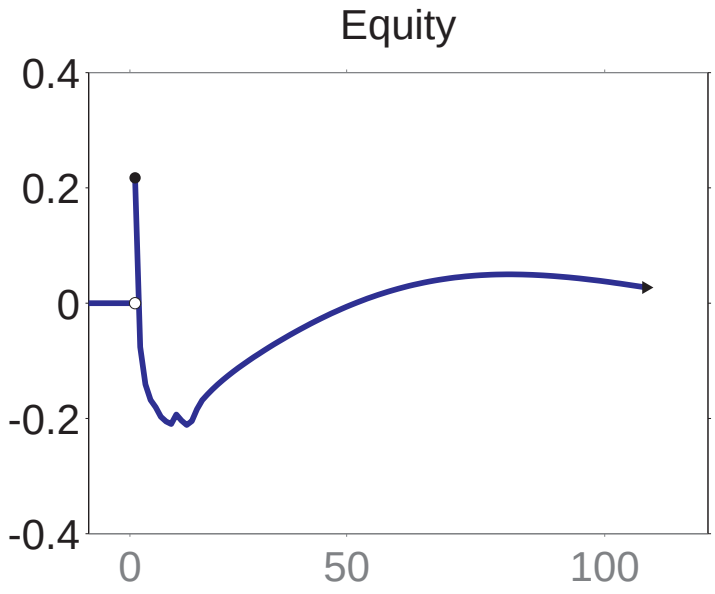


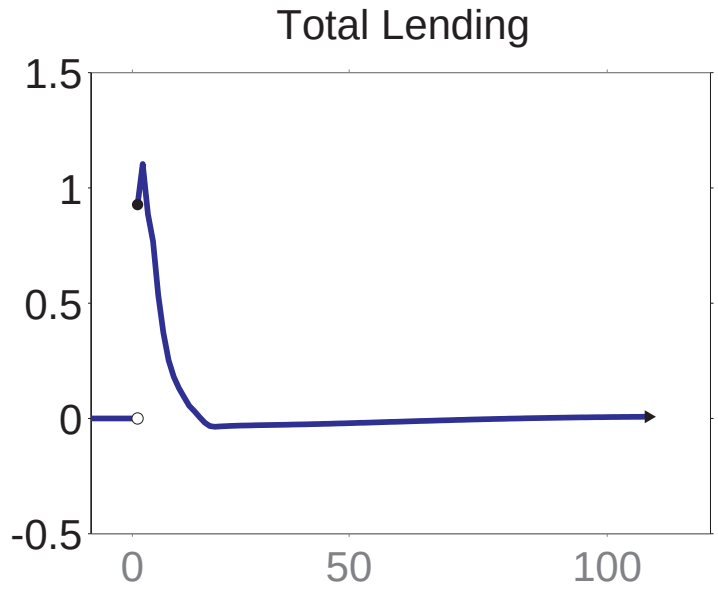
Demand Shock

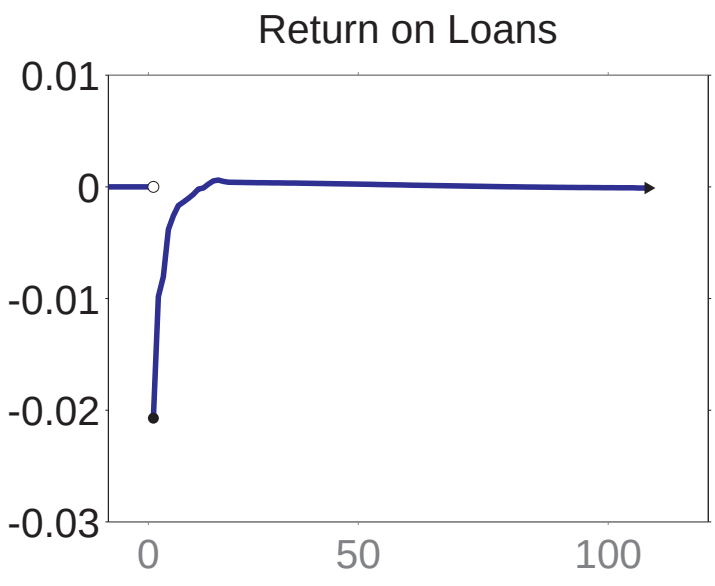


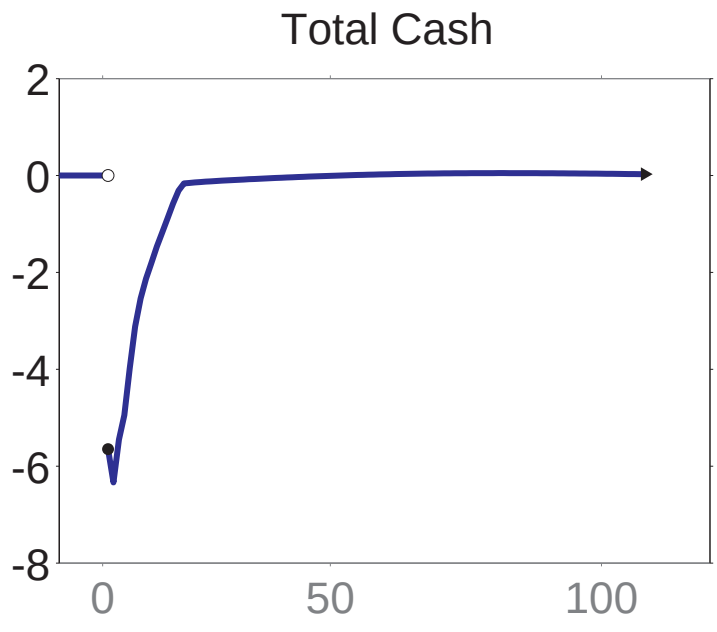
Transitory Reduction in χ (20 % initial reduction, AR-1 process)

Transitory Reduction in χ

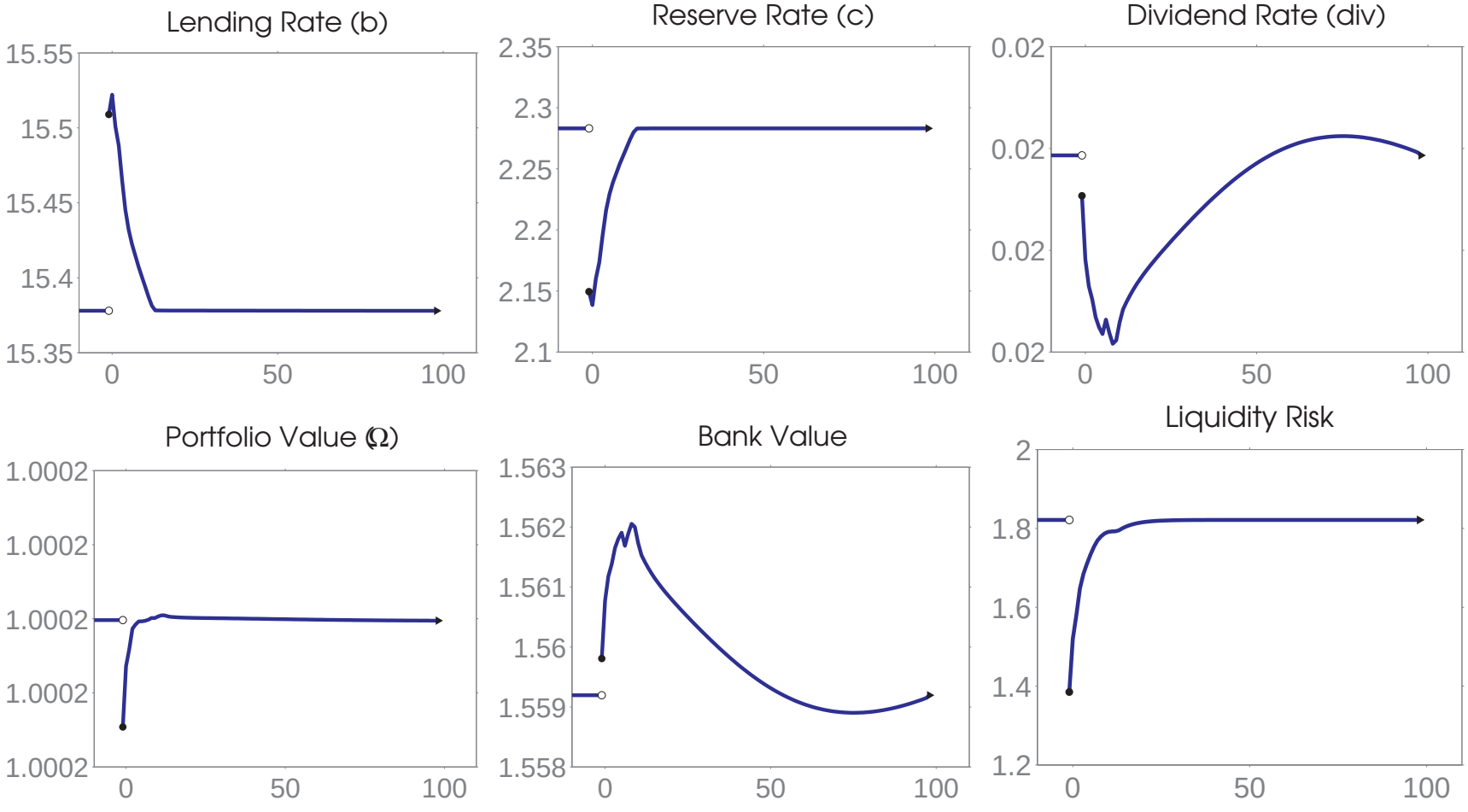






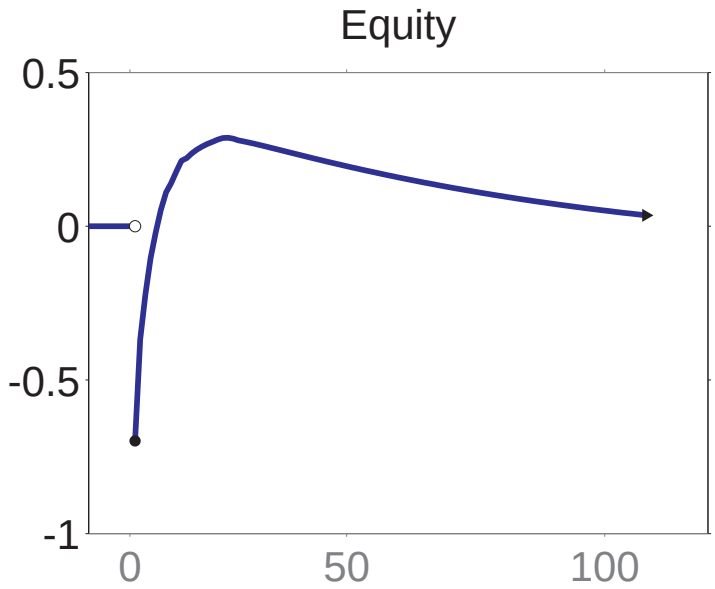


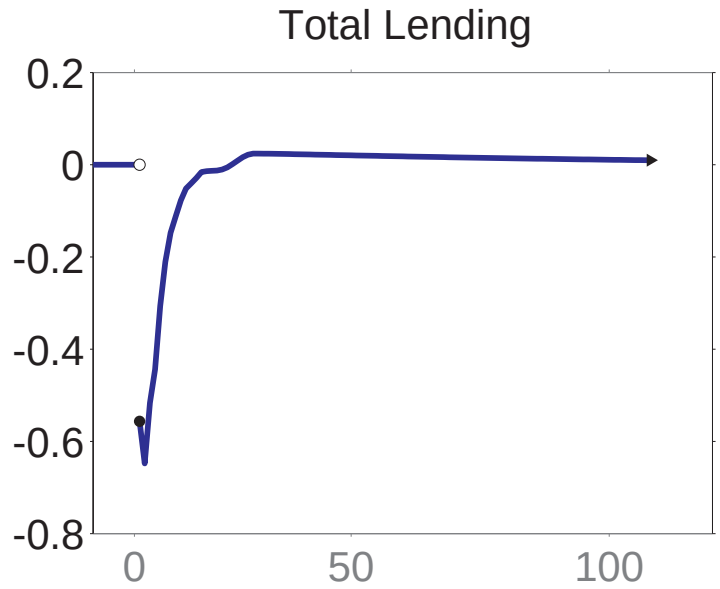
Transitory Reduction in χ

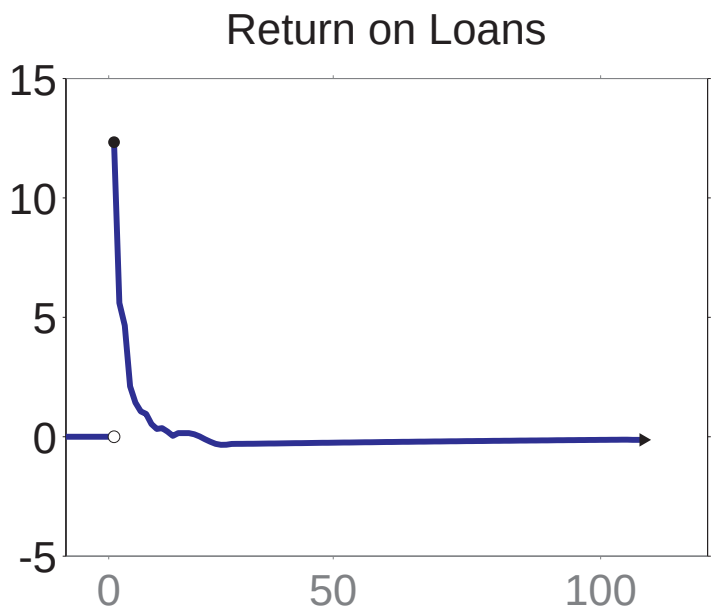


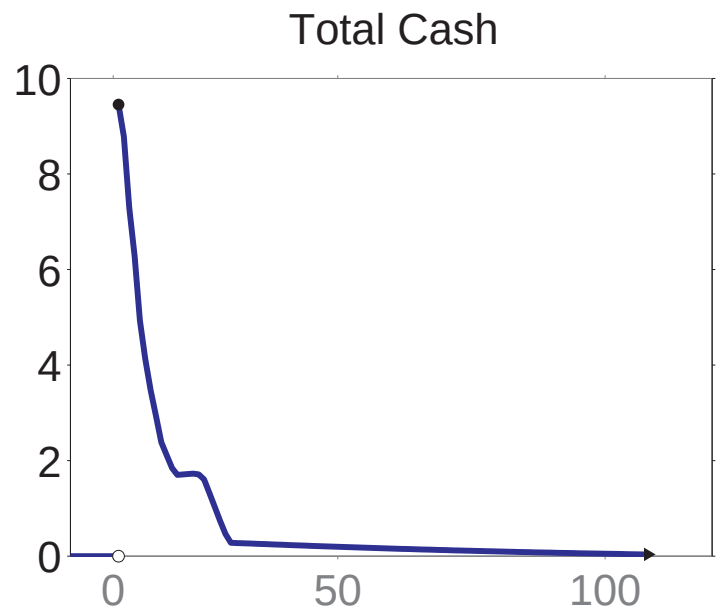
Transitory Reduction in r (50 % initial reduction, AR-1 process)

Transitory Reduction in r

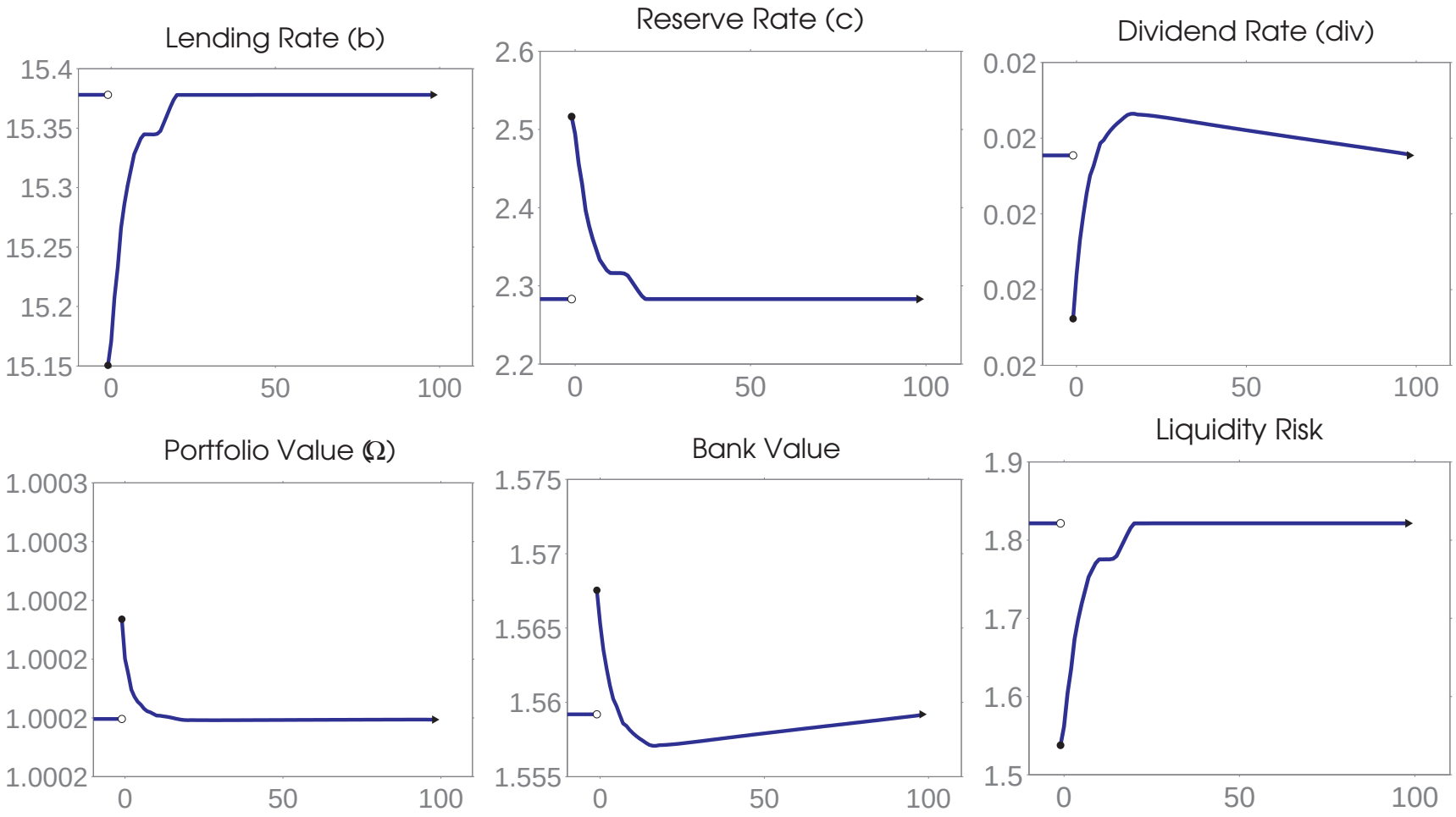








Transitory Reduction in r



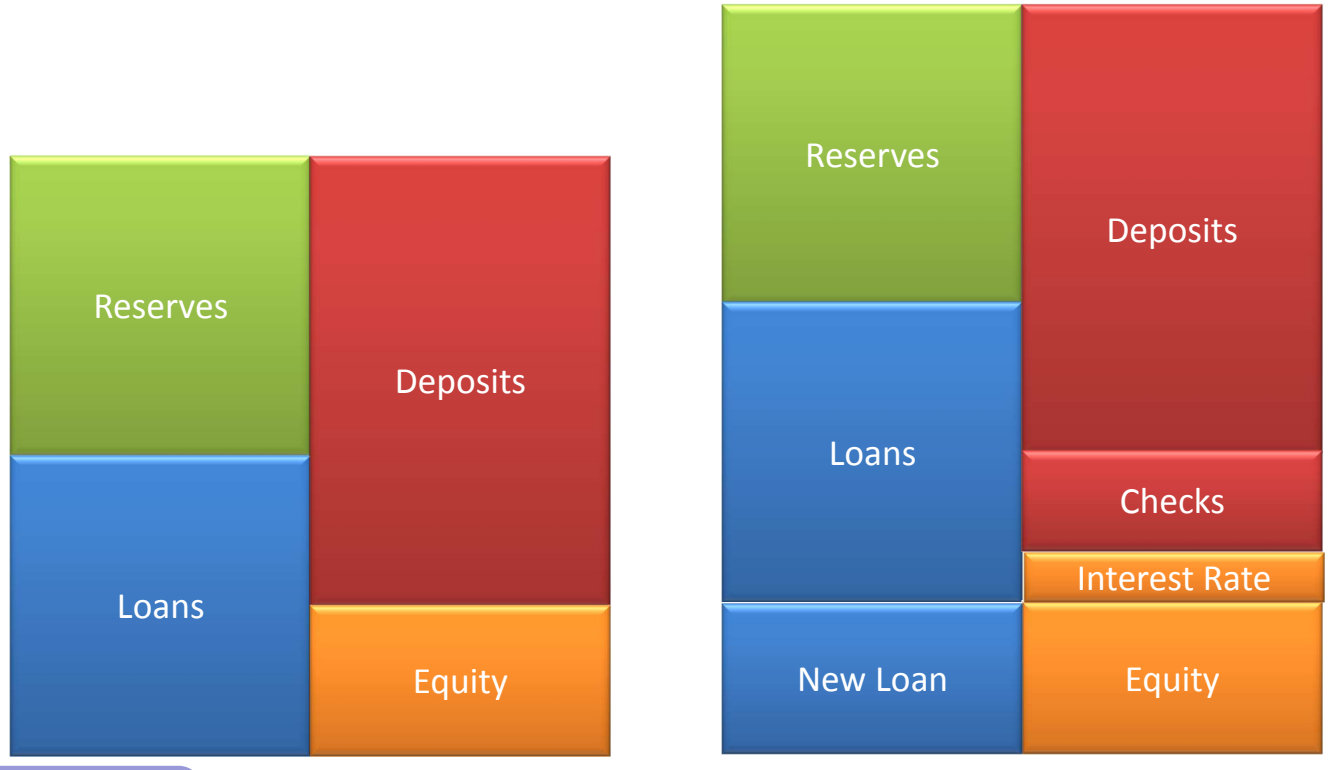
Summary

- Equity Losses and Capital Requirements
  - Similar Effects
  - Expect High Marginal Returns - contraction of Loan Supply
  - Drop in Reserves
  - Dividends Accumulation
- Withdrawal Uncertainty
  - Explain initial spike in cash not persistence
- Seems that Best fit is via Loan Demand
  - Consistent with decline in lending, profits
  - High dividend rate
  - At ZLB can explain big part of FED's Balance Sheet

- Caveat: Feed-back effect (credit quality vs. actual demand)

End

Liquidity Management



▸ Rest of the Economy

Figure : Bank Balance Sheet

Loan Demand

- Risk-Neutral Workers
- Risk-Neutral Entrepreneurs
  - Cannot prepay debt
  - Borrow to purchase hours from workers
  - Hold debt and deposits to repay debt
- Spirit of Kiyotaki and Moore (2002), Lagos and Wright (2003)

Return

Liquidity Management

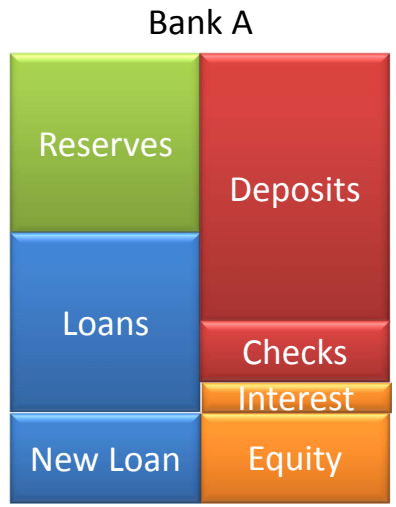


Figure : Bank Balance Sheet

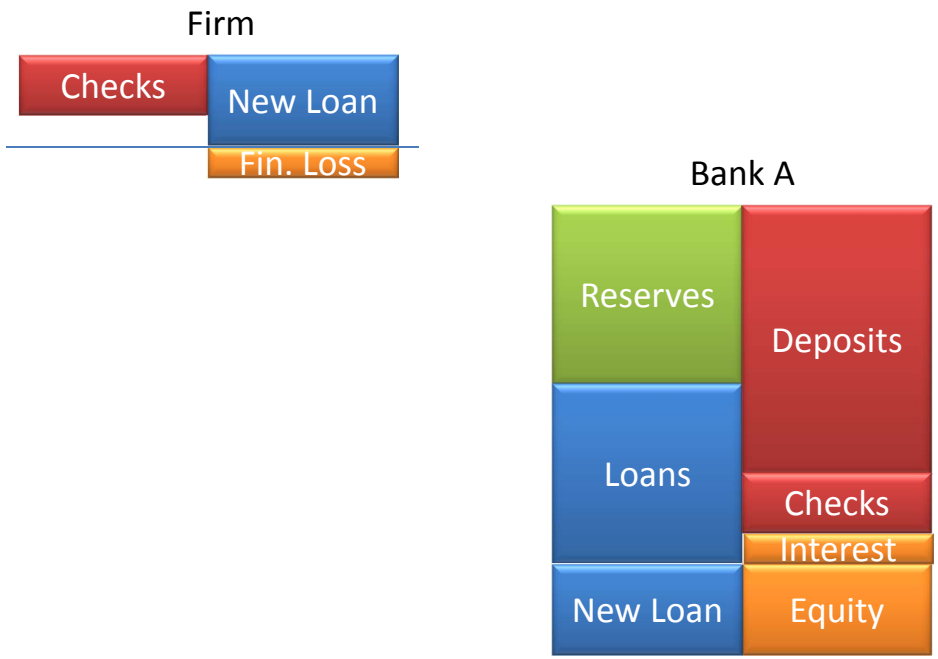


Figure : Bank Balance Sheet

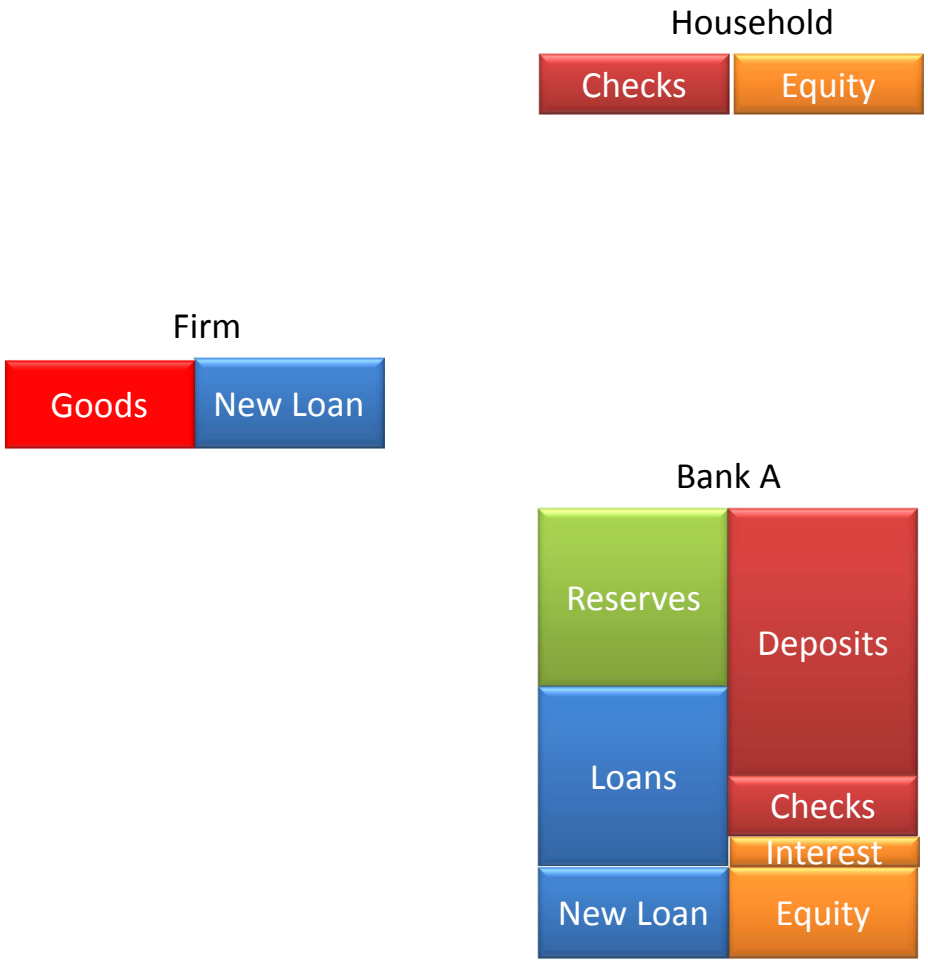


Figure : Bank Balance Sheet

Liquidity Management

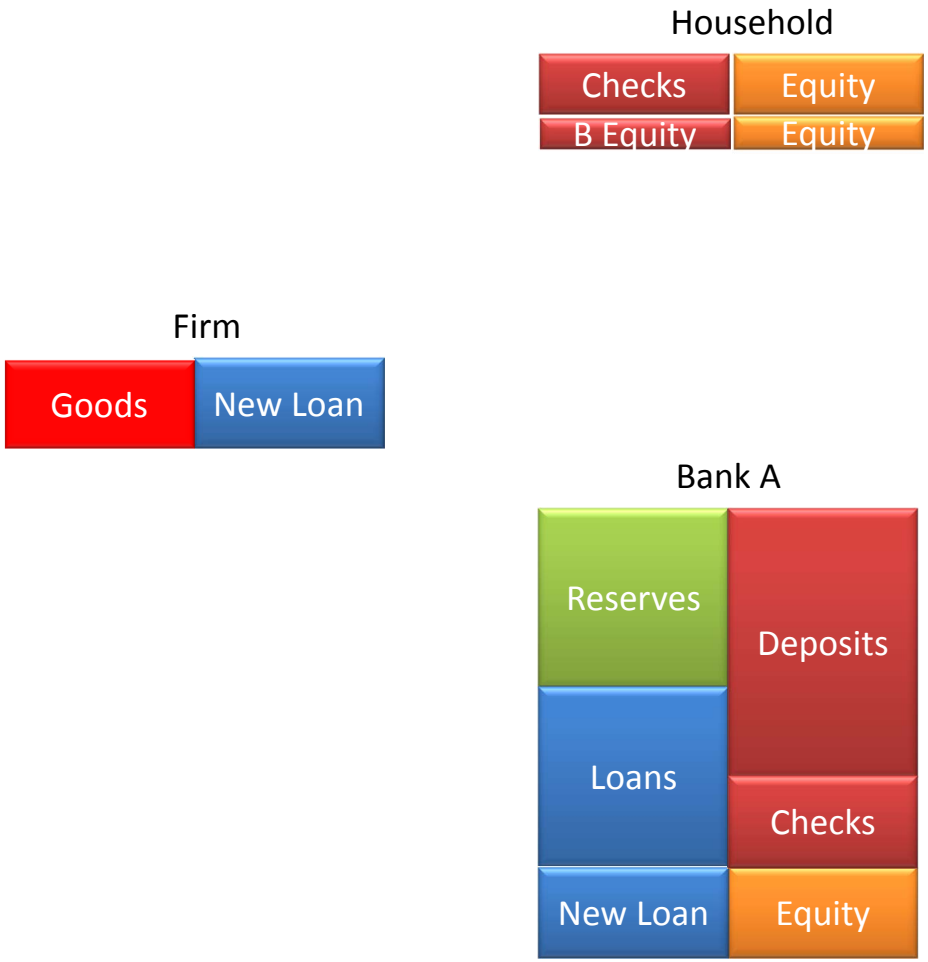


Figure : Bank Balance Sheet

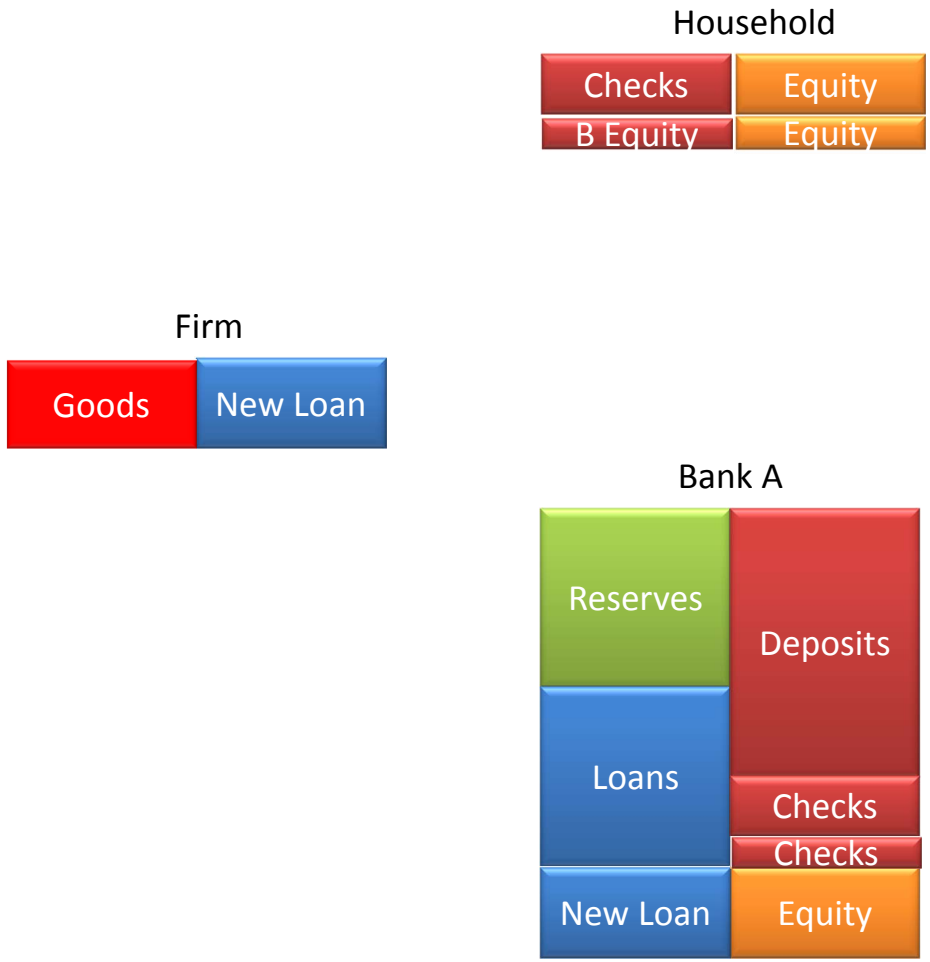


Figure : Bank Balance Sheet

Liquidity Management

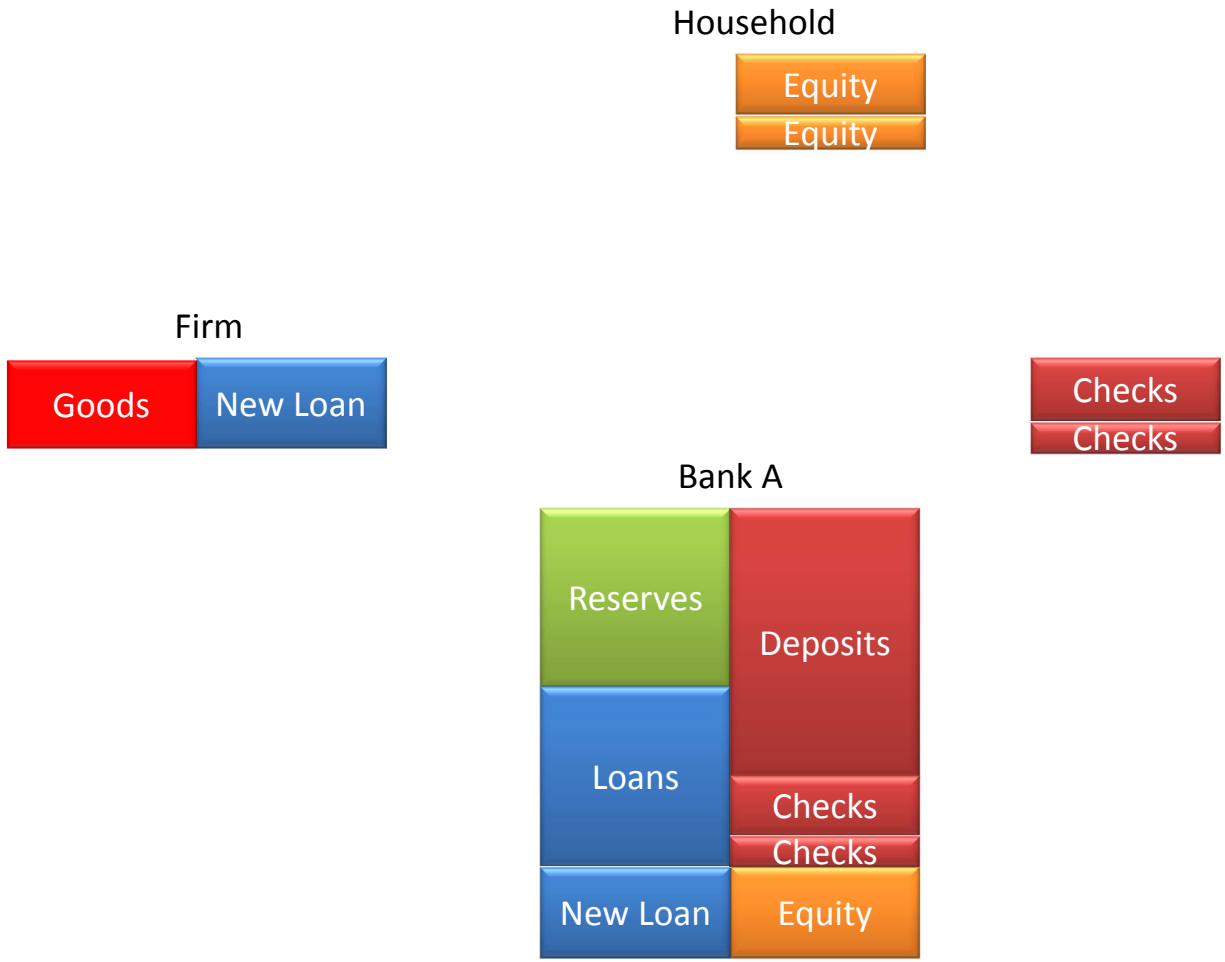


Figure : Bank Balance Sheet

Liquidity Management

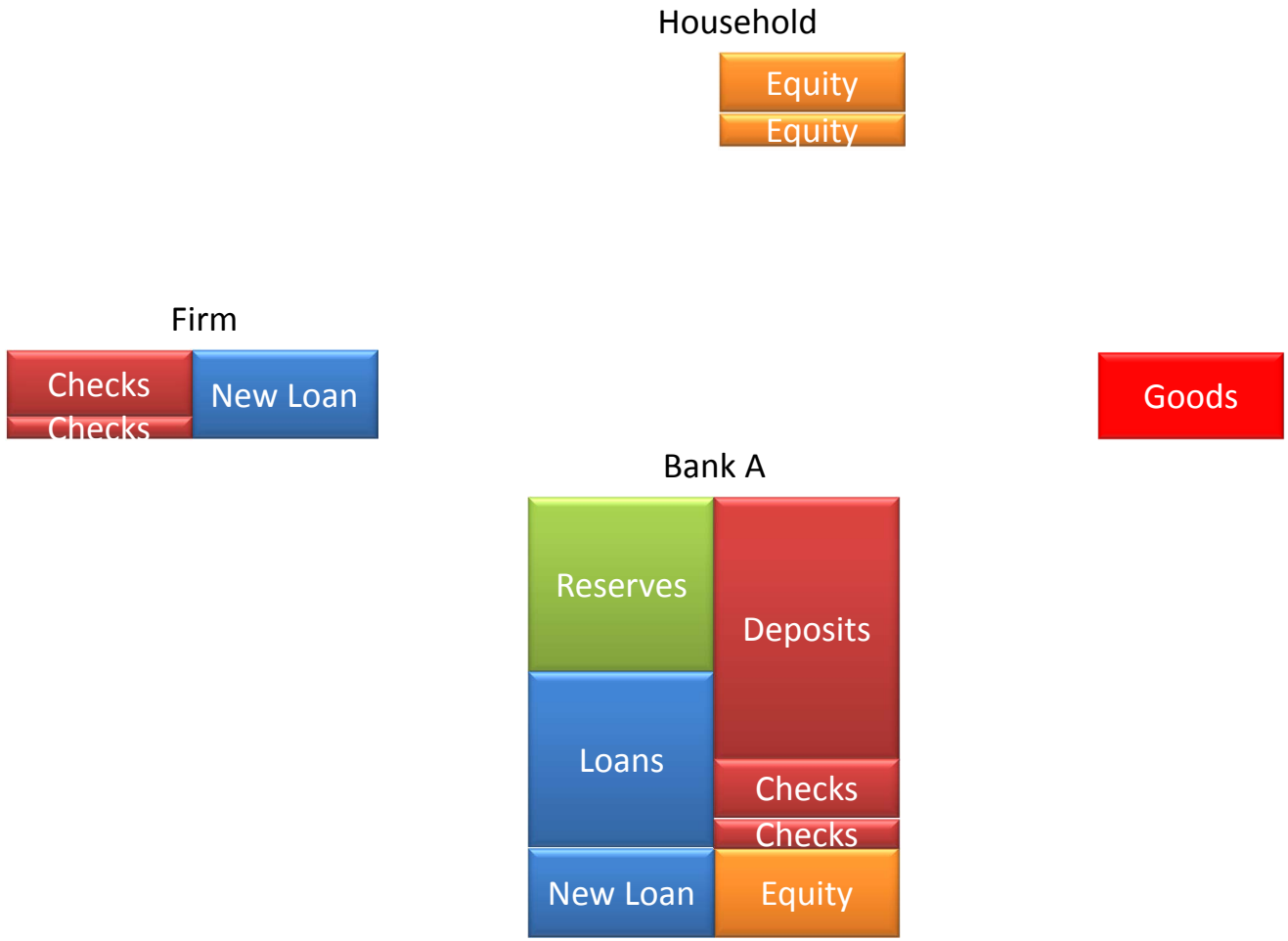
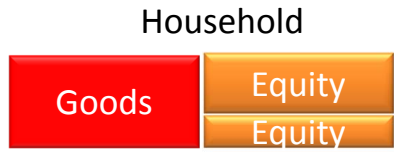


Figure : Bank Balance Sheet

Liquidity Management



Firm

Rest of the Economy

Figure : Bank Balance Sheet

Liquidity Management

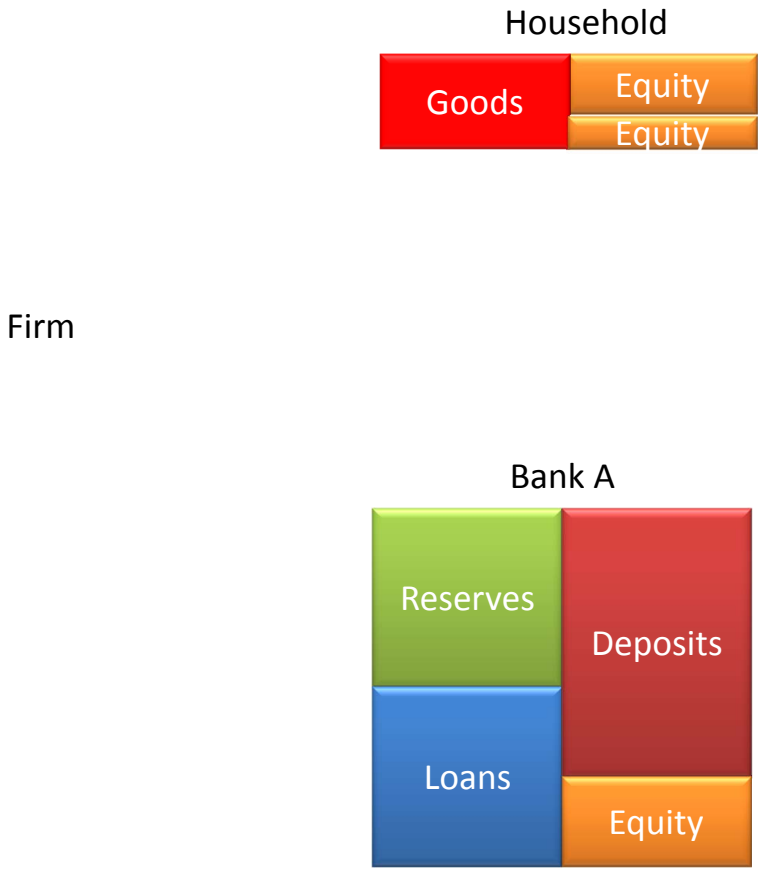


Figure : Bank Balance Sheet

Liquidity Management

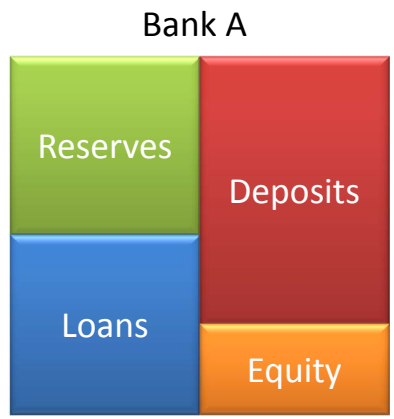
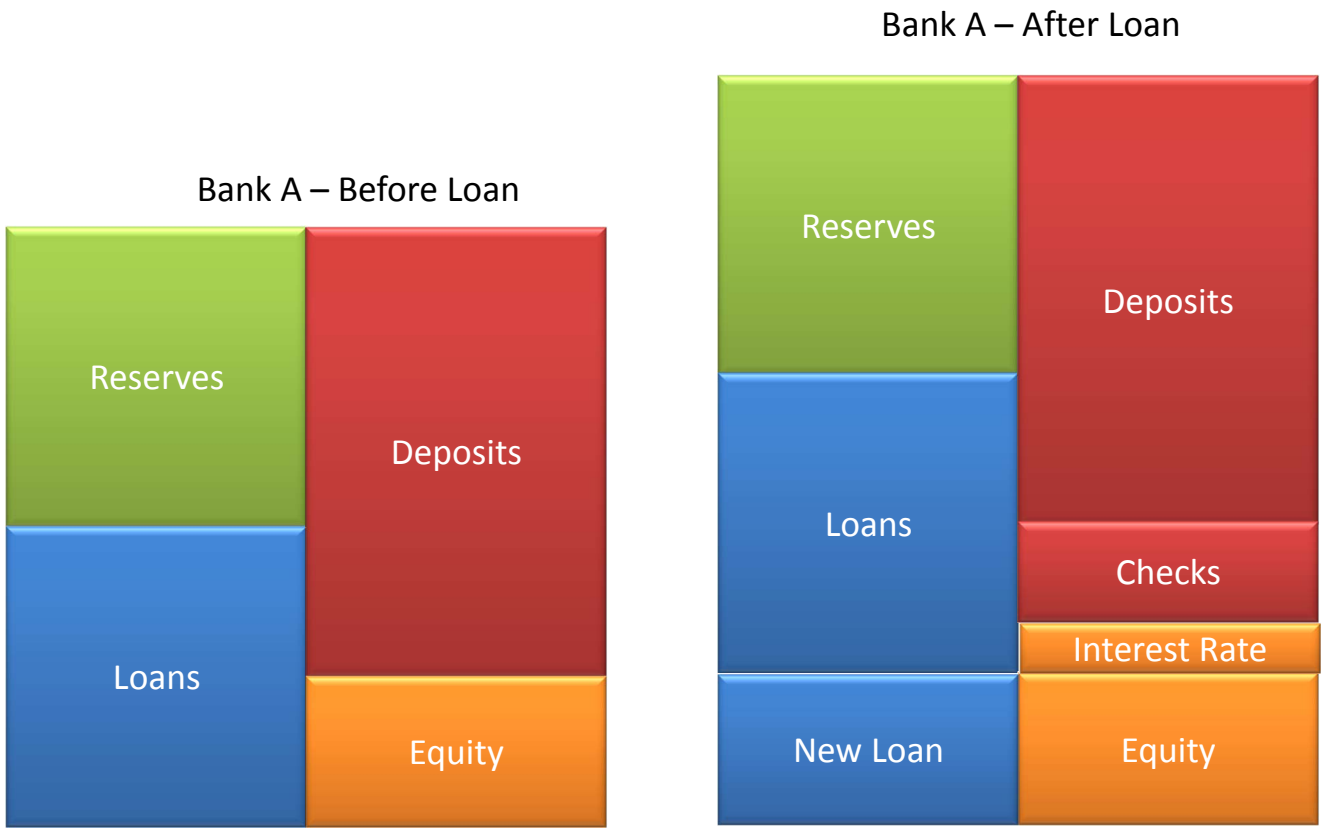


Figure : Bank Balance Sheet

Liquidity Management



Rest of the Economy

Figure : Bank Balance Sheet

Fact 1 - Disruption in Fed-Funds Market

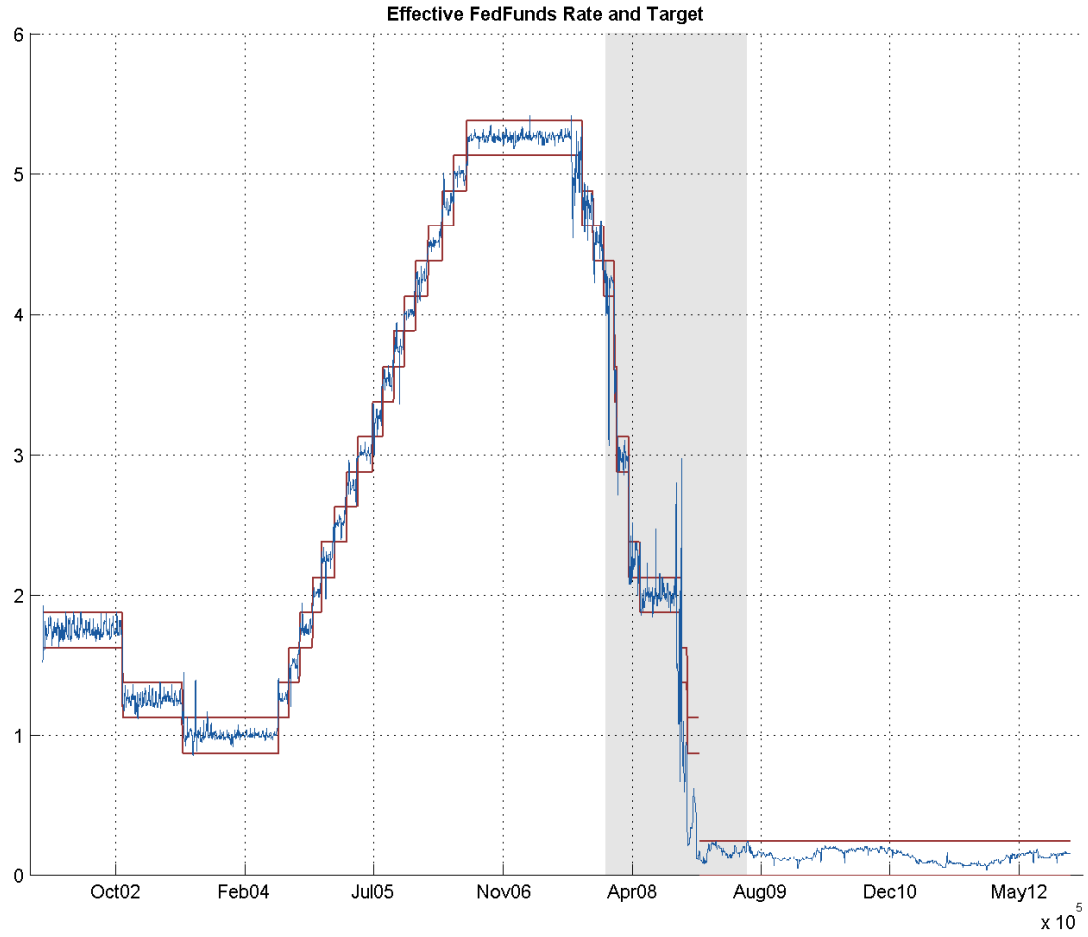


Figure : Fed Funds Rate 2002-2012

Fact 1 - Disruption in Fed-Funds Market and ZLB

Back

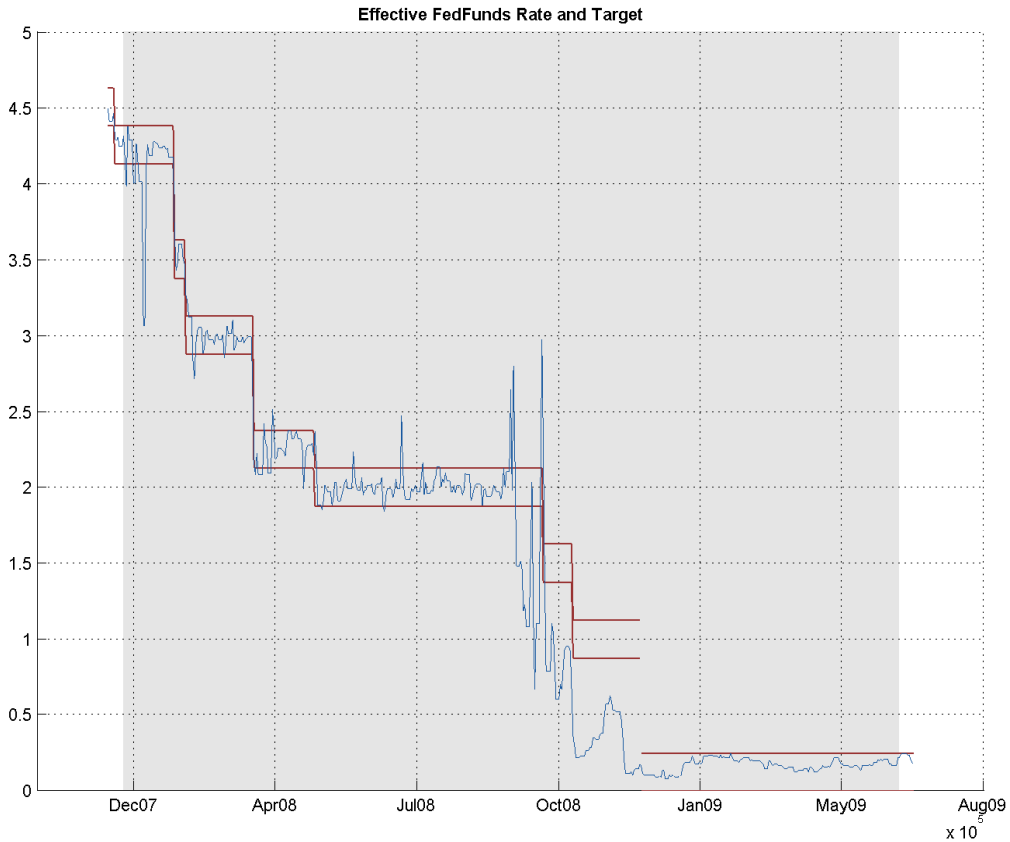


Figure : Fed Funds Rate 2008-2012

Fact 2 - Unconventional Policy

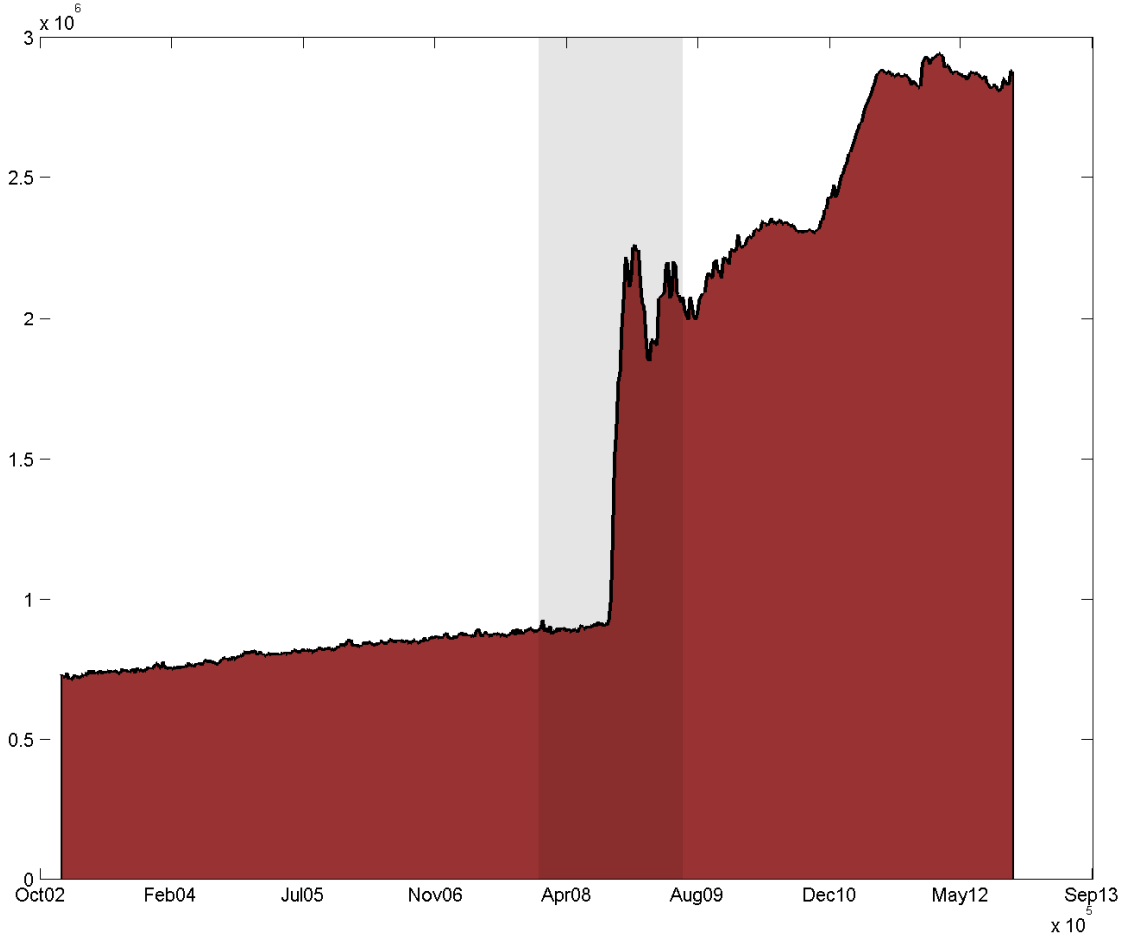


Figure : Fed Balance Sheet 2002-2012: Total Assets

Fact 2 - Unconventional Policy: Open Market Ops

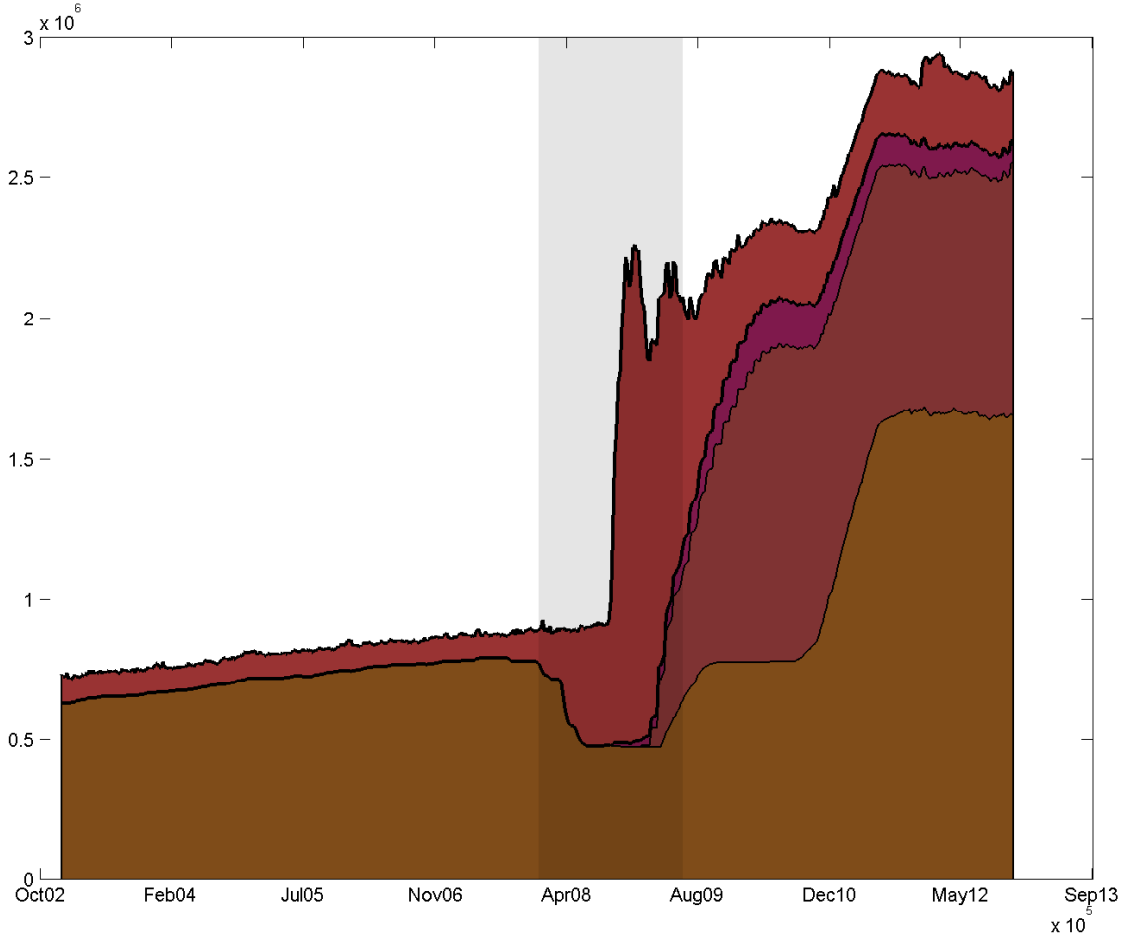


Figure : Fed Balance Sheet: Treasuries, Gov Secs, MBS

Fact 2 - Unconventional Policy: OMO + Lending

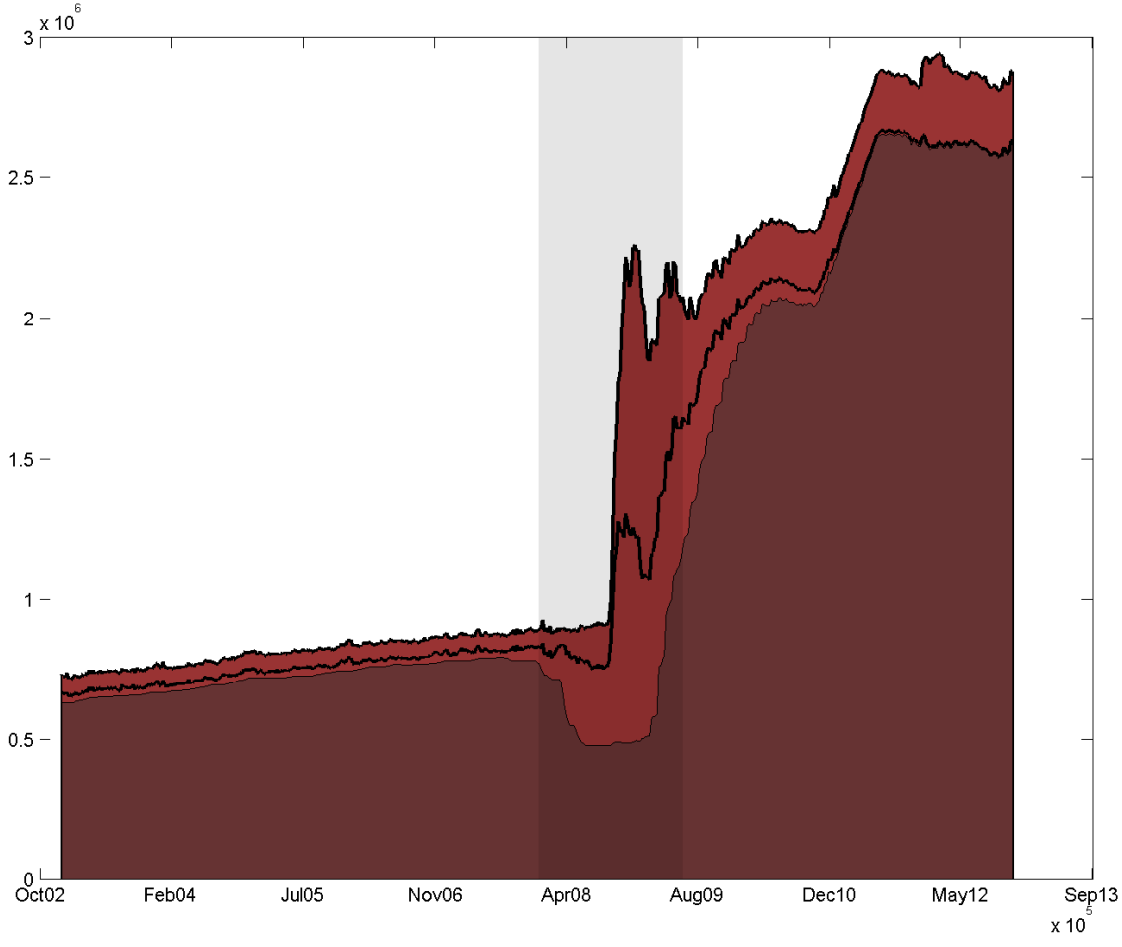


Figure : Fed Balance Sheet: OMO

Fact 2 - Unconventional Policy: OMO + Lending

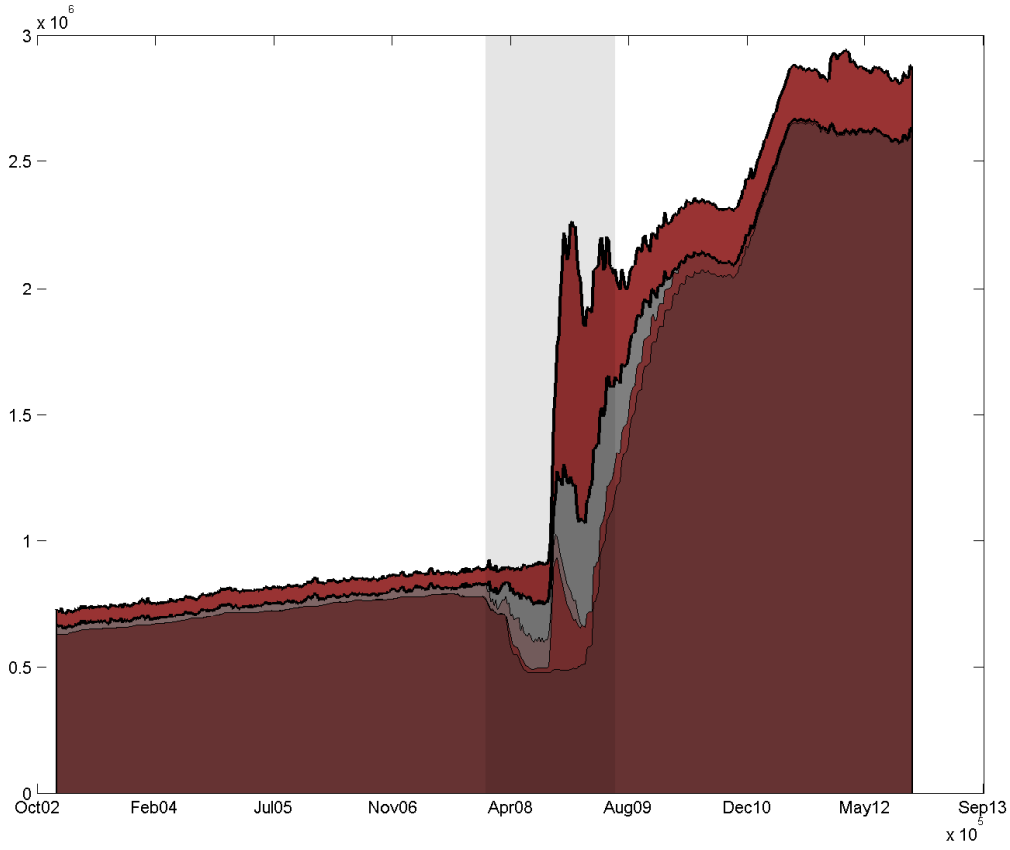


Figure : Fed Balance Sheet: OMO

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Fact 3 - Required Reserves

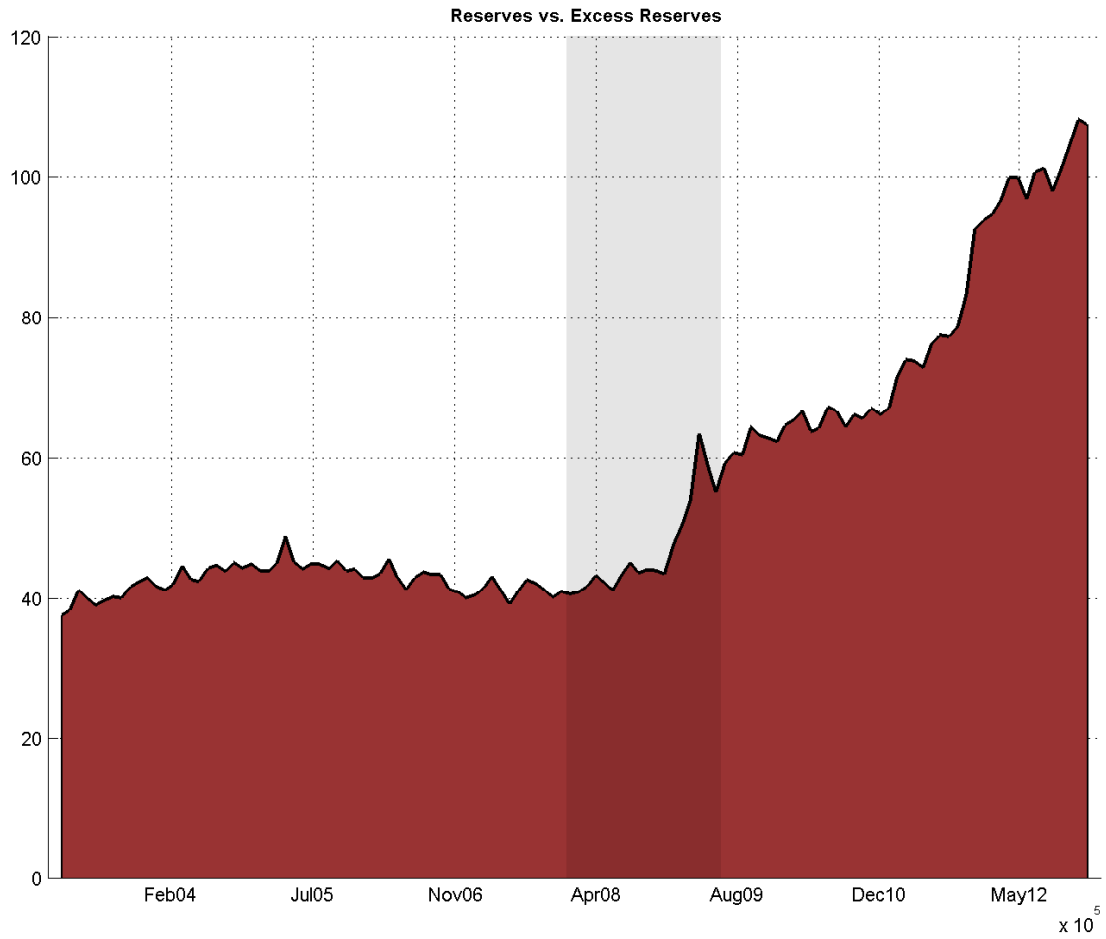

Figure : Required Reserves at Commercial Banks

Fact 3 - Required vs. Excess Reserves

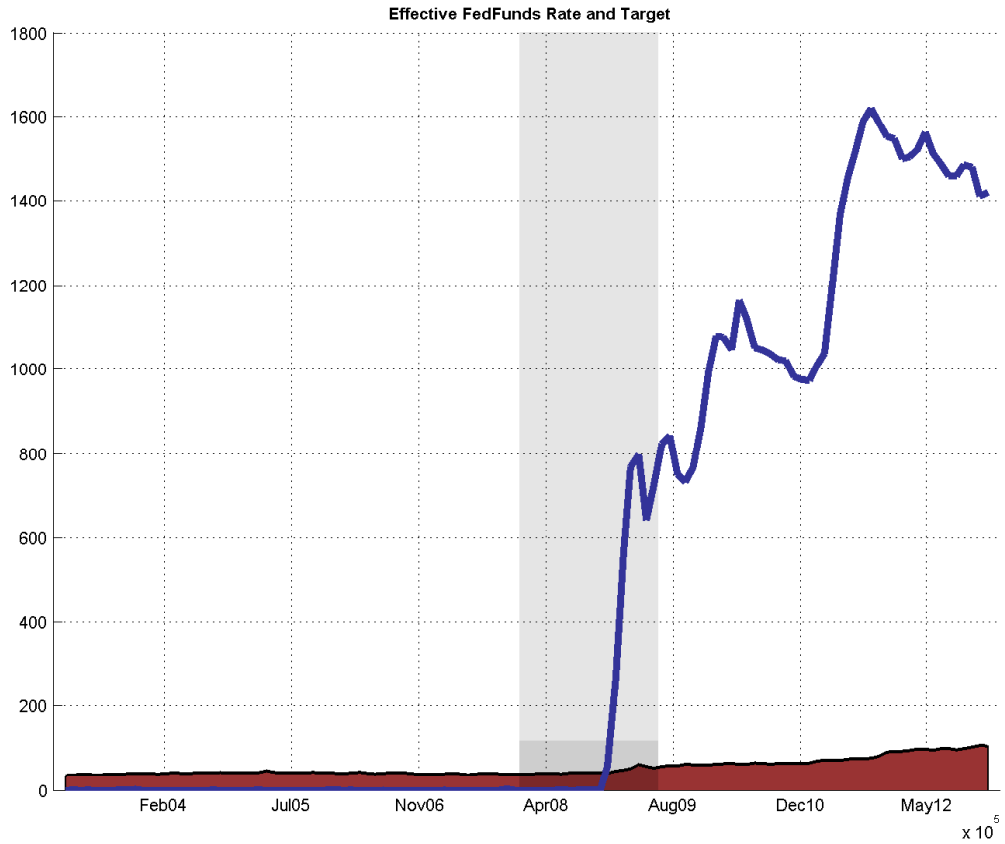

Figure : Required vs. Excess Reserves at Commercial Banks

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Fact 4 - Bank Lending

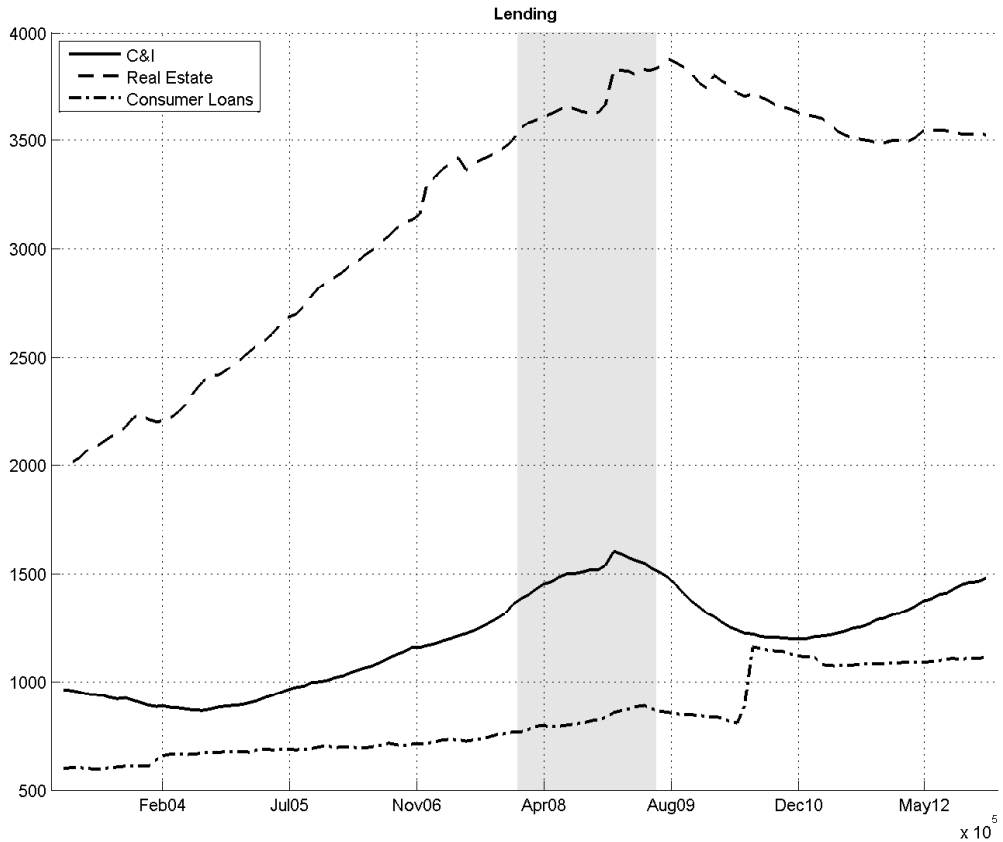

Figure : Lending of Commercial Banks

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Fact 4.b - My McGrattan Prescott Slide

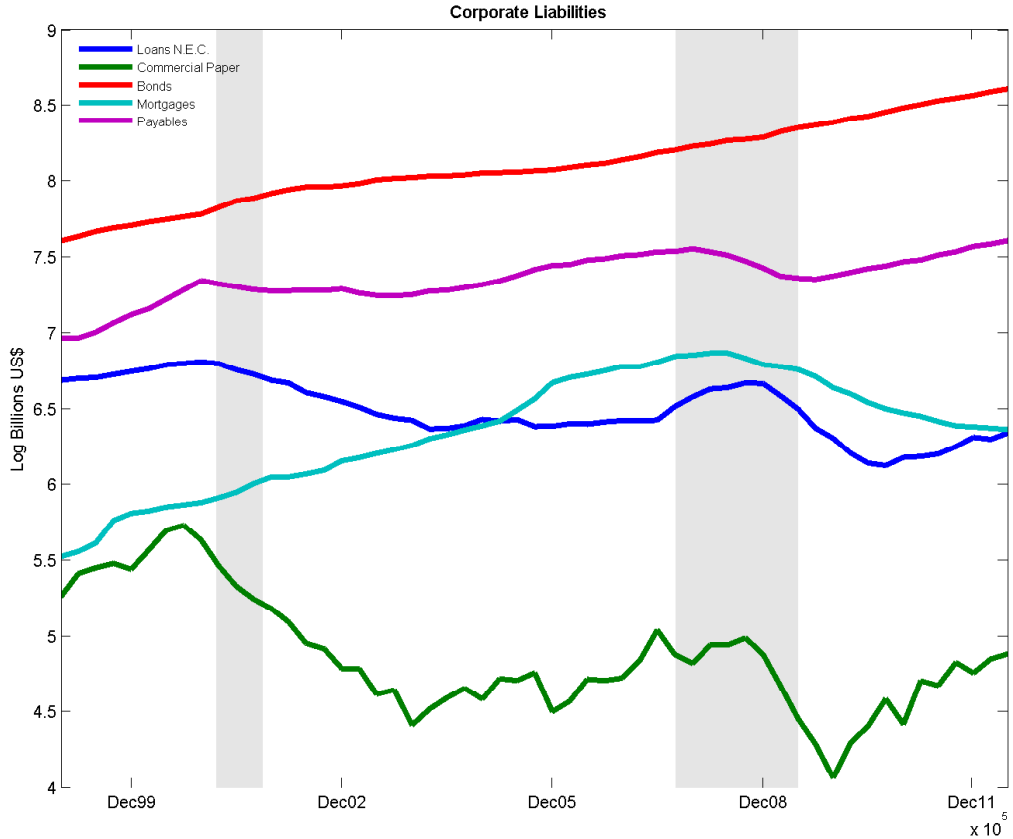

Figure : Liabilities of Corportations

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Fact 4.b - Ellen Slide

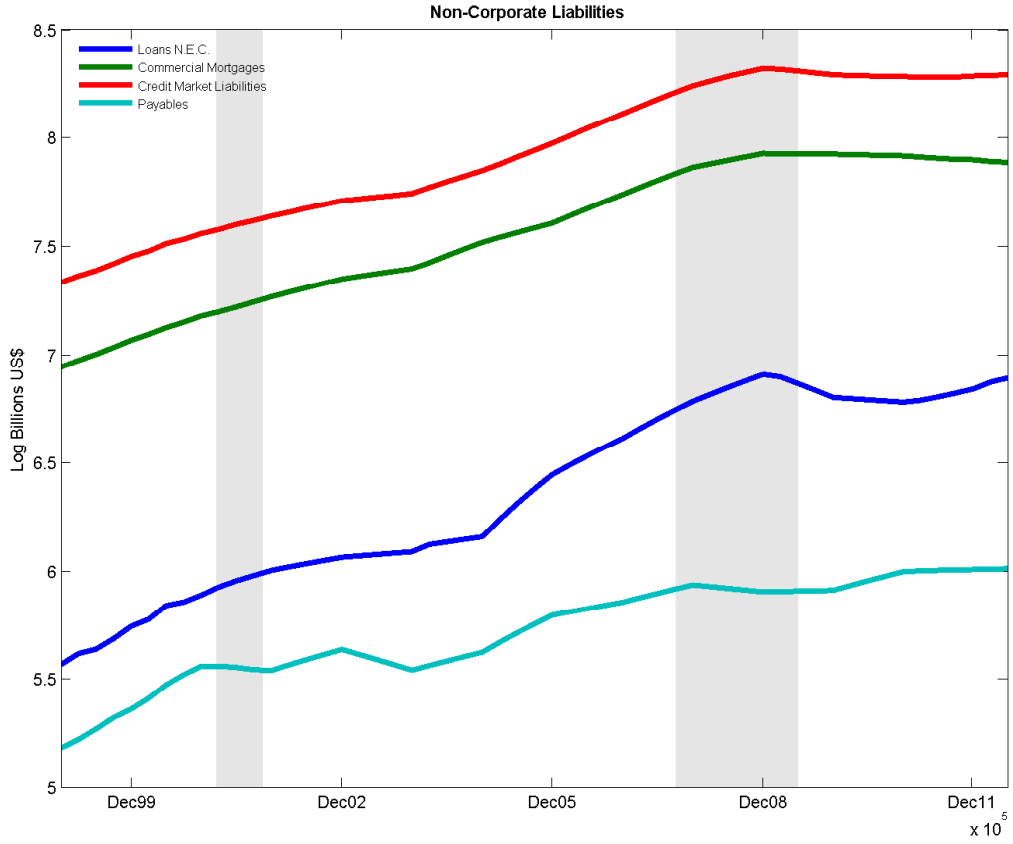

Figure : Liabilities of Non-Corporate Sector

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Fact 5 - Banks Not Issuing Liabilities

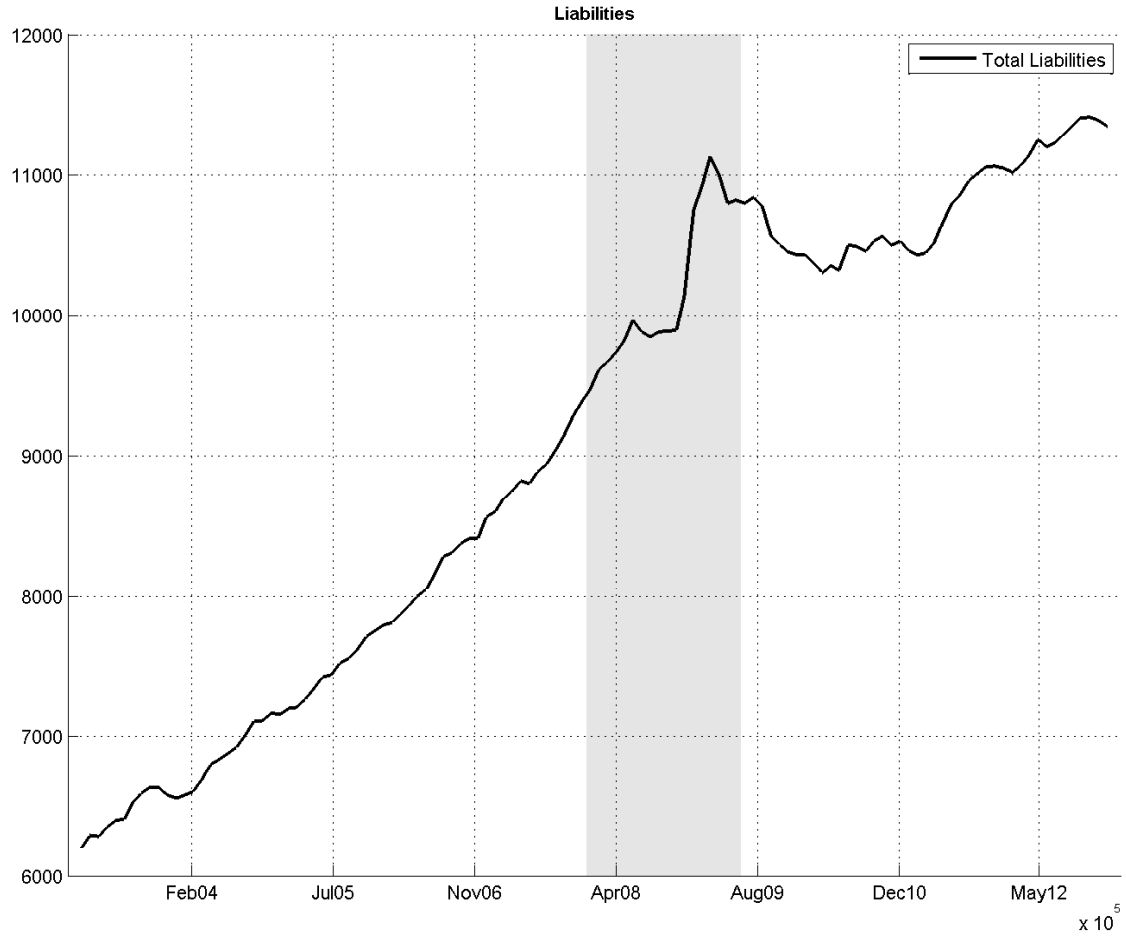

Figure : Total Liabilities of Commercial Banks

Fact 4 & 5 - Drop in Money Multiplier

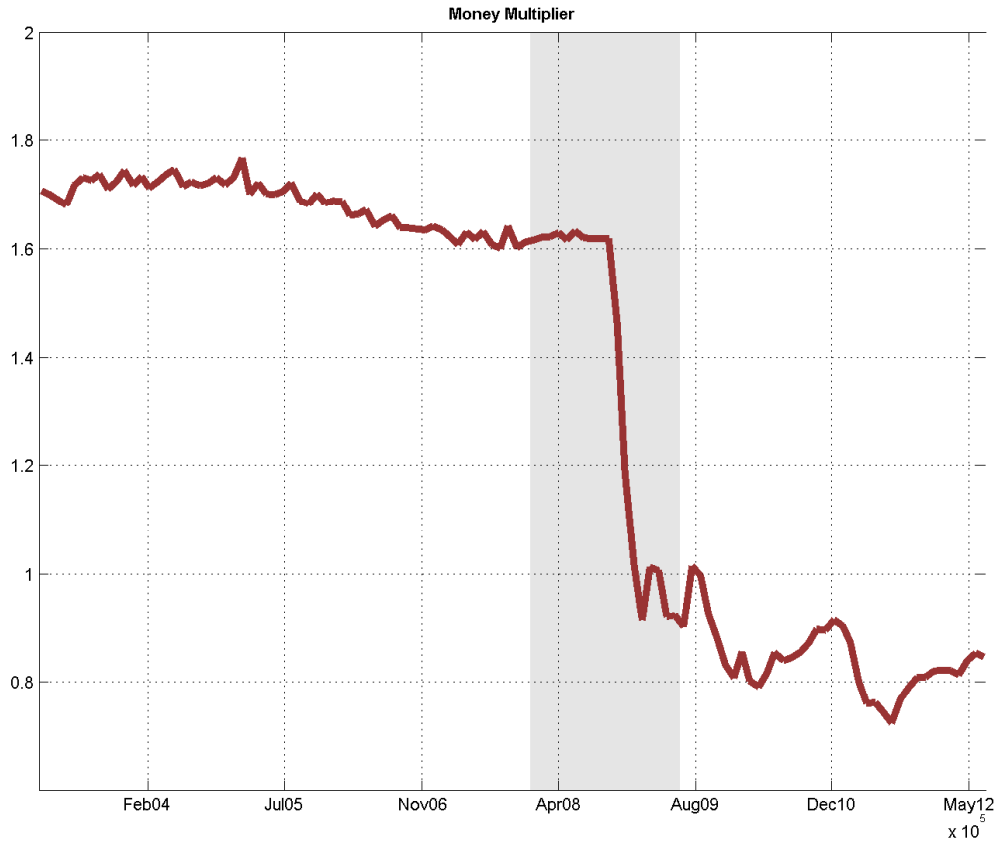

Figure : Total Liabilities of Commercial Banks

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Fact 6 - Bank Equity Losses

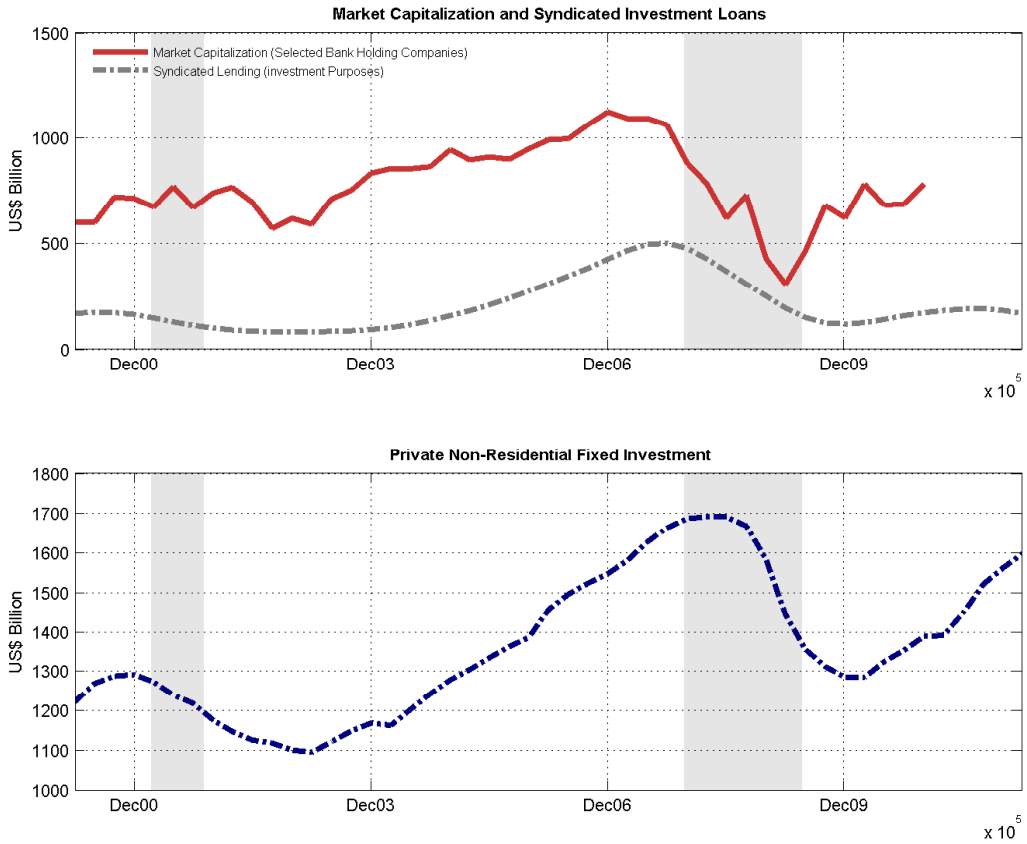

Figure : Bank Equity

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