Balance Sheet Adjustment and Policy Choice

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Motivation and Literature Review

Motivation

:

- Massive leverage and system risk before financial crisis.
- A need for modeling financial institution behaviors and financial frictions

Literature Review

- Financial Accelerator Bernanke (1999)
  - Adverse shock to economy is magnified
  - Supply of credit is linked with market value of net asset of firms.

Literature Review

- Bank Balance Sheet Shin (2010) :
  - Short term interest rate determines profit margin and equity capacity
  - Equity E meets total value at risk

    $$E = v \times A$$

    v is unit VaR (Value at Risk per dollar of assets)

    $$\partial A = (1/v) \times \partial E$$

    Change in leverage

    $$\partial L = \partial A - \partial E = [(1/v)-1] \times \partial E \quad (\text{where } v<1)$$

    Notice ∂E is unrealized book gain
  - Low interest rate leads to increase in size of bank's liability and assets, depress the risk premium.

Literature Review

- If one considers financial institutions’ balance sheet is a levered portfolio of assets. One can think of banks’ balance sheet adjustment as a portfolio optimization problem.

Basic Model

Balance Sheet Identity

- Balance Sheet Identity

Asset	Liability and Equity
Liquidity asset	Short term Funding
Reserve Short Term Asset	Deposit
Loan	Equity

Balance Sheet Identity

$$A_i + L_i + \mathrm{T}_i \mathrm{D}_i = B_i + D_i + E_i$$

Short term asset	A_i
Deposit (Normalized to Unity)	D_i
Central Bank Reserve Requirement	T_i
Reserve	$\mathrm{T}_i \mathrm{D}_i$
Short term funding	B_i
Equity	E_i

Market Rates

- Return on loan I is equilibrium rate in credit market. (lending rate)
- Rate on short term asset (or short term funding) is central bank policy rate p plus credit risk premium nk where k is risk appetite and n is constant.
- Cost of equity r_i is most expensive among funding sources.

Balance Sheet as Levered Portfolio

- Portfolio Return of Bank Balance Sheet

$$R_i = \frac{(A_i + \mathrm{T}_i \mathrm{D}_i)}{\mathbf{W}_i}(\mathrm{p} + \mathrm{nk}) + \frac{L_i}{\mathbf{W}_i}\mathrm{I} - \frac{E_i}{\mathbf{W}_i} r_i - \frac{D_i}{\mathbf{W}_i}\mathrm{I}_D - \frac{B_i}{\mathbf{W}_i}(\mathrm{p} + \mathrm{nk})$$

$$R_i = \frac{1}{\mathbf{W}_i}(\mathrm{I}L_i + (\mathrm{p} + \mathrm{nk})(A_i + \mathrm{T}_i \mathrm{D}_i)) - \frac{1}{\mathbf{W}_i}(r_i E_i + (\mathrm{p} + \mathrm{nk})B_i) - \frac{D_i}{\mathbf{W}_i}\mathrm{I}_D$$

$$\mathbf{W}_i = L_i + A_i + \mathrm{T}_i \mathrm{D}_i = B_i + D_i + E_i$$

- Portfolio Risk of Bank Balance Sheet

$$k_{\mathrm{i}}\Omega_i = k_{\mathrm{i}}(B_i - A_i)$$

Utility Function of Bank

A Function of utility can be written in linear fashion

$$\pi_i = \Delta i_2 (B_i)^2 - r_i (E_i)^2 + \Delta i_1 (L_i)^2 - \Delta i_1 (A_i)^2 - k_{\mathrm{i}} \Omega_i \qquad (1)$$

Subject to

$$A_i = \delta_i \mathrm{E}_i - L_i - \mathrm{T}_i \mathrm{D}_i$$

$$B_i = \delta_i \mathrm{E}_i - E_i - \mathrm{D}_i$$

$$\Omega_i = B_i - A_i = L_i + \mathrm{t}_i \mathrm{D}_i - (\mathrm{D}_i + \mathrm{E}_i)$$

$$\Delta i_1 = \mathrm{I} - (\mathrm{p} + \mathrm{nk})$$

$$\Delta i_2 = \mathrm{h} - (\mathrm{p} + \mathrm{nk})$$

Since t_i are central bank reserve requirement, which is exogenous and D_i is deposit, which is modeled as unity, Ω_i is linear with $L_i - \mathrm{E}_i$

Cost of Equity

Consider the value of equity a bank can be written as:

$$MVL + \mathrm{T}_i \mathrm{D}_i - \mathrm{D}_i - (B_i - A_i)$$

Where MVL is the market value of the loan portfolio. If we define $L_i{}'$ as amount of loan that has to be sold immediately in order to cover liquidity shortfall $B_i - A_i$ and define m is the market premium or discount to the book value of the loan, MVL can be written as

$$m + L_i - L_i{}'$$

Suppose

$$\frac{B_i - A_i}{\boldsymbol{\beta}_i} = L_i{}'$$

Where $\boldsymbol{\beta}_i$ is called fire sell discount, equity value can be written as

$$m + L_i - \frac{B_i - A_i}{\boldsymbol{\beta}_i} + \mathrm{T}_i \mathrm{D}_i - \mathrm{D}_i - (B_i - A_i)$$

Cost of Equity

Cost of equity funding is in inverse relation with the value of equity, one can write cost of equity funding r_i as

$$r_i = m + \left(\frac{1}{\boldsymbol{\beta}_i} - 1\right)(-\mathrm{E}_i + L_i - (1 - \mathrm{T}_i)\mathrm{D}_i)$$

If we define $1 - \frac{1}{\boldsymbol{\beta}_i} = \lambda_i$, cost of funding can be written as λ_i

$$r_i = m + \lambda_i(-\mathrm{E}_i + L_i - (1 - \mathrm{T}_i)\mathrm{D}_i) \qquad (2)$$

Since Ω_i is linear with $L_i - \mathrm{E}_i$, cost of equity r_i is positive related with Ω_i

Banks' Optimization Problem

- Equity (1) defines the financial institutions portfolio decision and equation (2) defines the cost of equity.

- Financial Institution choose level for equity E_i , capital ratio $\frac{1}{\delta_i}$ and supply of loan L_i

- First Order condition of (1) with respect to E_i , δ_i and L_i

$$\frac{\partial \pi_i}{\partial \delta_i} = 0 \qquad (3)$$

$$\frac{\partial \pi_i}{\partial L_i} = 0 \qquad (4)$$

$$\frac{\partial \pi_i}{\partial E_i} = 0 \qquad (5)$$

Credit Market

An entrepreneur has a range of projects Y_i whose return is normally distributed

$$Y_i \sim (u, \sigma)$$

Suppose an entrepreneur chooses to only borrow and finance project whose return excess cost of borrowing, so P $(Y_i > I)$ gets finance where I is the entrepreneur's cost of borrowing. So the demand for loan can be return:

$$P\,(Y_i > I) - \Theta$$

where Θ is entrepreneur's equity. P $(Y_i > I)$ – Θ is positively related with σ and u and negatively related with I and loan demand function is written as:

$$L = \frac{v}{I}\,\xi \qquad (6)$$

where $v = \sigma u$ and ξ is constant. u is expected return.

The Basic Model

- if we consider financial system instead of an individual financial intermediary, we can drop the subscript, (3) and (4) (5) defines bank's balance sheet adjustment, (6) is loan demand curve, (2) is cost of equity

- Our focus is to solve balance sheet variable E_i , δ_i and L_i ; market variable I and r

$$(\mathrm{h}-(\mathrm{p}+\mathrm{nk}))(\boldsymbol{\delta} E-E-D)=(I-(\mathrm{p}+\mathrm{nk}))(\boldsymbol{\delta} E-L-TD)$$

$$(I-(\mathrm{p}+\mathrm{nk}))(E-TD)=\frac{\mathrm{k}}{2}$$

$$(I-(\mathrm{p}+\mathrm{nk}))(\boldsymbol{\delta} E-L-TD)\,\boldsymbol{\delta}-(\mathrm{h}-(\mathrm{p}+\mathrm{nk}))(\boldsymbol{\delta} E-E-D)(\boldsymbol{\delta}-1)+rE=-\frac{\mathrm{k}}{2}$$

$$r=m+\boldsymbol{\lambda}(E+(1-T)D-L)$$

$$L=\frac{\mathrm{v}}{I}\xi$$

Linearization

Loglinearize the system and use lower case letter to denote steady state value and letter with "hat" to denote log variance:

$$\boldsymbol{\varpi}_1 = \boldsymbol{\varpi}_2$$

$$(\ \tilde{\imath} i - n\tilde{k}k - \tilde{p}p)(\ e - t\ ) + i_1(e - t) + i_1(\tilde{e}e - \tilde{t}t) = \frac{1}{2}k(\tilde{k} + 1)$$

$$(\tilde{r}r + \tilde{e}e + re) + \left(\tilde{\delta}\delta i_1 \mathrm{a} - \tilde{\delta}\delta i_2 \mathrm{b}\right) + \{\delta\boldsymbol{\varpi}_1 - (\delta - 1)\boldsymbol{\varpi}_2\} = -\frac{1}{2}k(\tilde{k} + 1)$$

$$r\tilde{r} = (m - r) + \tilde{\lambda}\lambda(e - l - t) + \lambda(\tilde{e}e - \tilde{l}l - \tilde{t}t) + \widetilde{m}m$$

$$\tilde{l}l = \xi\, v\,(1 + \tilde{v}v - \tilde{\imath}i) - \ l$$

Where

$$\boldsymbol{\varpi}_1 = i_2\ (\ \tilde{\delta}\delta e + \delta\tilde{e}e - \tilde{e}e) + (\ i_2 - n\tilde{k}k - \tilde{p}p)\,b$$

$$\boldsymbol{\varpi}_2 = i_1\ (\ \tilde{\delta}\delta e + \delta\tilde{e}e - \tilde{l}l - \tilde{t}t) + (\ i_1 - (\ \tilde{\imath}i - n\tilde{k}k - \tilde{p}p))\,a$$

$$i_1 = i - p - nk$$

$$i_2 = h - p - nk$$

Defining Steady State

- Capital Ratio 4% (Basel II)

  Loan over short term asset 7

  Short term asset to short term liability 0.9

- This helps us pin down below steady state rate

  Capital 0.05

  Loan 0.99

  Short term asset 0.14

  Short term liability 0.15

Defining Steady State

- Reserve requirement 6%
  Policy rate 4%
  Lending rate 6%
  Cost of equity 8%
  Risk Appetite 0.08
  Spread between lending rate and short term asset return 2%
  Spread between Deposit rate and short term funding rate 2%

- This helps us pin down steady state value for deposit rate, coefficient n

- A) short term funding cost lower than cost of equity, otherwise, banks will fund themselves through equity purely without need to take on any risk. B) liquidity risk is higher than short term funding cost otherwise bank will borrow and lend infinitively. C) liquidity risk is no lower than equity cost.

Solution

$$\begin{pmatrix} \tilde{\delta} \\ \tilde{e} \\ \tilde{\imath} \\ \tilde{l} \\ \tilde{r} \\ \tilde{b}-\tilde{a} \end{pmatrix} = \begin{pmatrix} - & - & - & - & - & - \\ + & + & + & + & + & - \\ + & + & + & + & + & - \\ - & - & - & - & - & + \\ - & + & + & - & - & + \\ - & + & + & - & - & + \end{pmatrix} \begin{pmatrix} \tilde{k} \\ \tilde{m} \\ \tilde{\lambda} \\ \tilde{p} \\ \tilde{t} \\ \tilde{v} \end{pmatrix}$$

Model's Prediction

- It shows decrease in risk appetite (higher $\tilde{k}$) will lead to increase in capital ratio, higher equity, higher lending rate, lower lending, lower cost of equity and lower risk exposure.

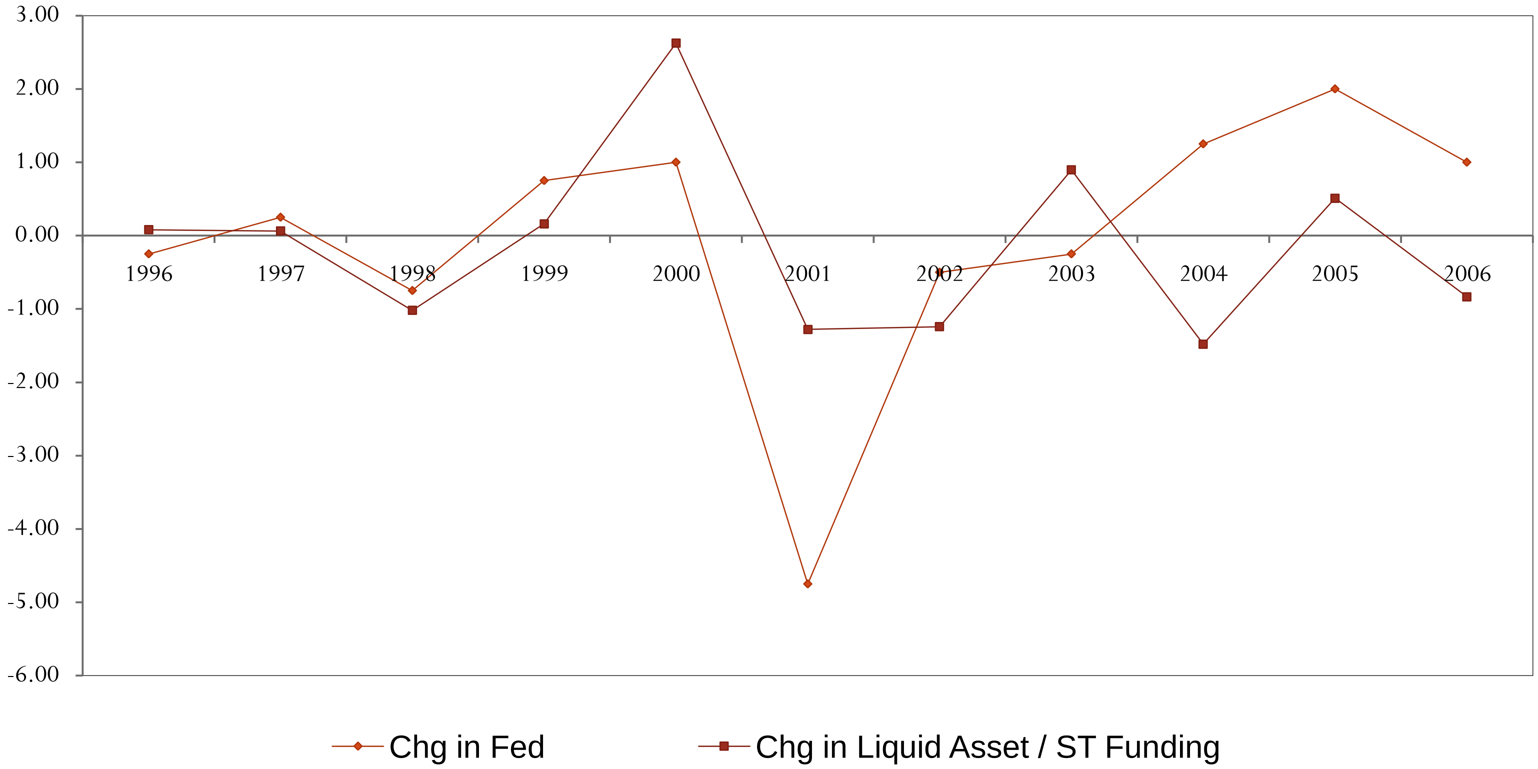
- Worsening capital market condition (higher $\widetilde{m}$)or higher fire sell premium (higher $\tilde{\lambda}$)will lead to higher capital ratio and higher cost of equity.

- Increase in policy rate (higher $\tilde{p}$) or reserve requirement (higher $\tilde{t}$)will lead to a higher capital ratio, equity, lending rate, a lower lending, cost of equity and risk exposure.

Some Empirical Evidence

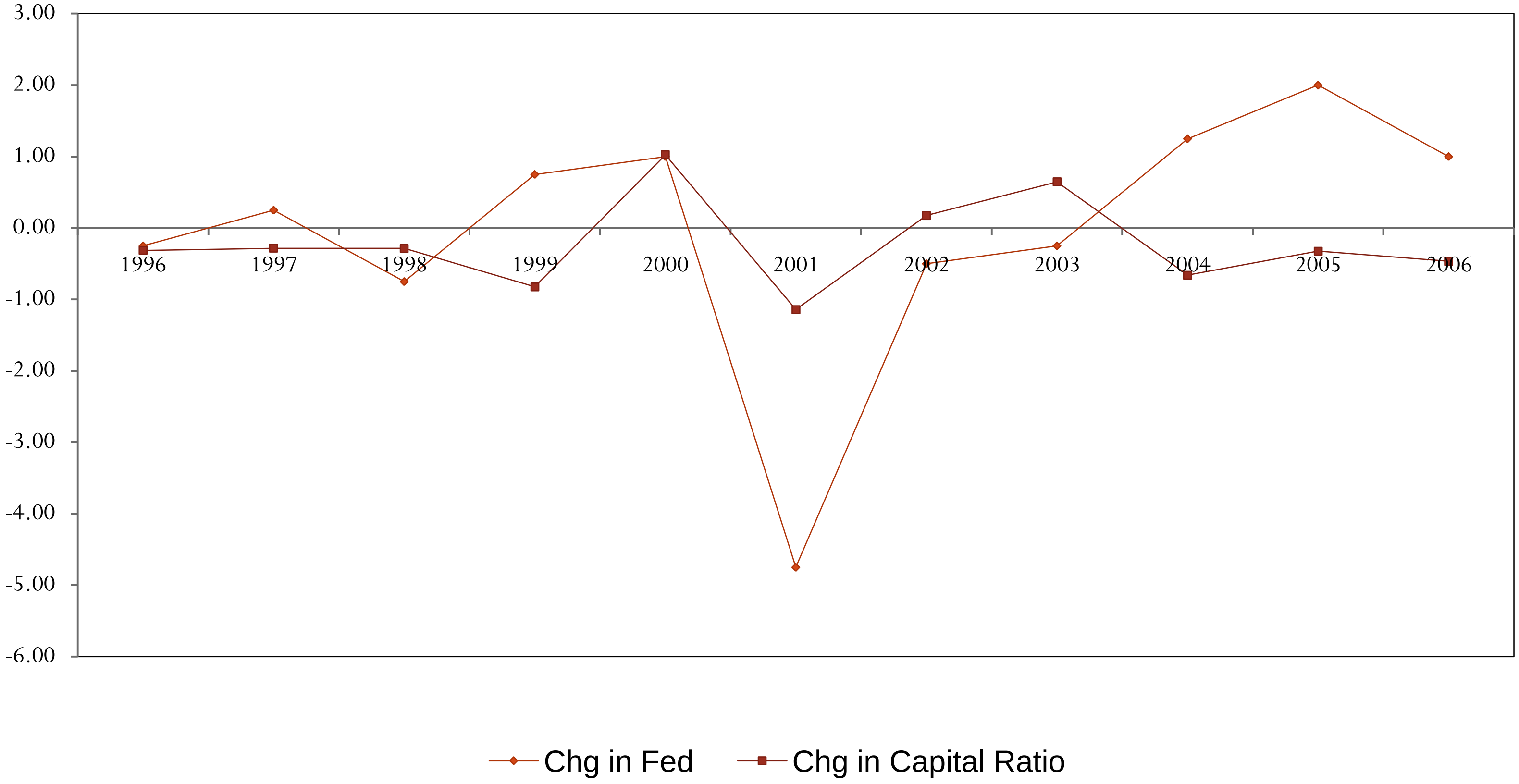
Fed Funds Target

Table 1 Change in Fed Fund Target in year t-1 and Change in Liquid Asset / ST Funding in year t



Fed Funds Target

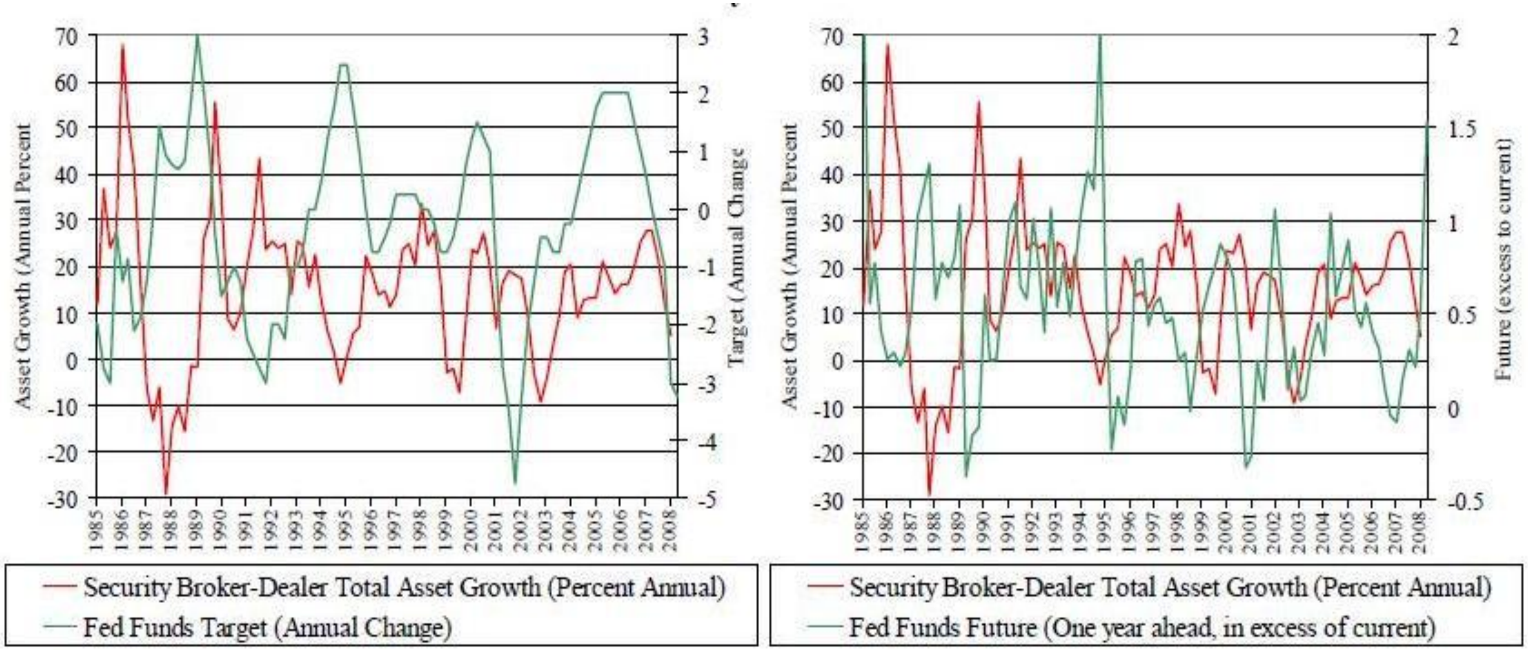
Table 2 Change in Fed Fund Target in year t-1 and Change in Capital Ratio in year t



Fed Funds Target

The predicted response of balance sheet to short term rate is very evident in Broker-Dealer sector

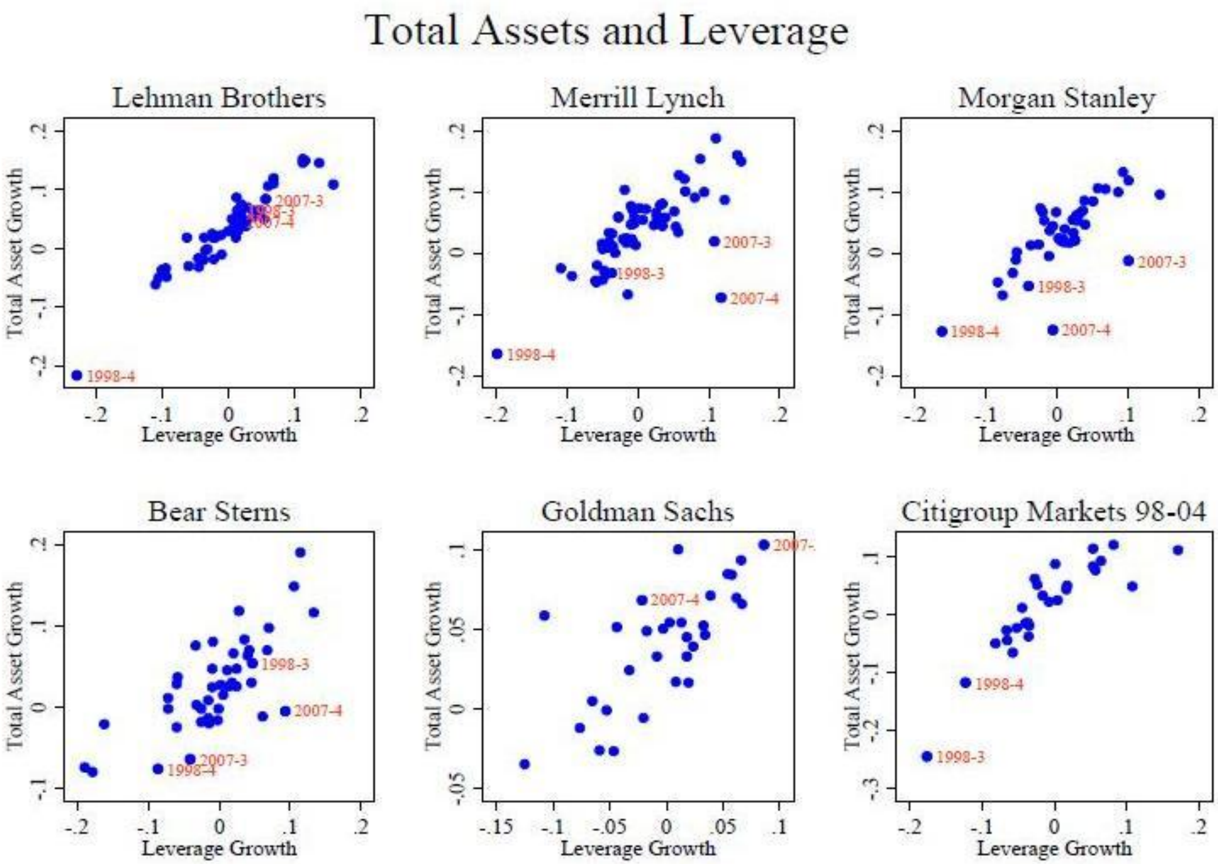
Table 3 Broker-Dealer Asset Growth and Fed Funds Target



Sources: Tobias Adrian, Hyun Song Shin, Financial Intermediaries, Financial Stability, and Monetary Policy, 2010

Balance Sheet Management

Table 4 Broker-Dealer Sector



Sources: Tobias Adrian, Hyun Song Shin, Procyclical Leverage and Value-at-Risk , 2010

Policy Implications

Role of Capital Regulation

- If monetary policy does influence financial stability, the question is then how to coordinate monetary policy and financial stability policy such as Basel agreement.

- To introduce the impact of regulation on capital in our model is to treat capital ratio as exogenous. What would happen to the solution of the model If capital ratio is set by regulators ?

Role of Capital Regulation

- Capital requirement is irrelevant when Statutory Ratio < Market determined Ratio
- Based on our analysis, following conditions will lead to a low capital ratio if left freely to financial institutions. We call those conditions as risk-conducive environment.
  - High risk appetite
  - favorable capital market condition
  - Low Fire sell discount
  - Low economic growth prospect
  - Low economic uncertainty
  - Low policy rate
  - Low reserve requirement

Role of Capital Regulation

- Policy Conflict may arise in risk conducive environment
- Treat Capital ratio as given by regulation and find the solution to the model. (Dropping the equation (3) out of equation system and reduce 5 unknown variables to 4)

Role of Capital Requirement

$$\begin{pmatrix} \tilde{e} \\ \tilde{\imath} \\ \tilde{l} \\ \tilde{r} \\ \tilde{b}-\tilde{a} \end{pmatrix} = \begin{pmatrix} + & + & + & + & + & - & + \\ + & + & + & + & + & - & + \\ - & - & - & - & - & + & - \\ - & + & + & - & - & + & - \\ - & + & + & - & - & + & - \end{pmatrix} \begin{pmatrix} \tilde{k} \\ \tilde{m} \\ \tilde{\lambda} \\ \tilde{p} \\ \tilde{t} \\ \tilde{v} \\ 1/\tilde{\delta} \end{pmatrix}$$

Capital Requirement v Monetary Policy

- Solutions remain the same.
- Capital rule will have the same impact on dependent variables as monetary tightening does.
- one will be likely to see a weakened impact of monetary ease and magnified impact of monetary tightening compared to the time when the high capital regulatory regime such as today's was not in place.
- such an interplay could be more evident in the risk conducive environment for the reasons already discussed

Conclusion

- Portfolio optimization theory can be applied to analyze balance sheet adjustment.
- Monetary policy and policy aiming to regulate the balance sheet variables can be analyzed in this framework