Banks Adjust Slowly
Evidence and Lessons for Modeling

Juliane Begenau (Stanford & NBER)
Saki Bigio (UCLA & NBER)
Jeremy Majerovitz (MIT)

SITE - Stanford 2018

Motivation

Question: How to improve bank models used in macro-finance?

This paper:

- Goal is to map bank- models closer to bank behavior
- Study bank behavior using cross-sectional data
  - ⋆ Model with meaningful differences in accounting and market values
  - ⋆ Book and market value constraints only occasionally binding
  - ⋆ Balance sheets adjust slowly to shocks
- Sketch out a partial equilibrium version of such a model
- Test balance sheet adj. costs

Standard formulations of bank's problem

Banks max revenue subject to

1. Regulatory constraints

   Fraction of risk-weighted measure of book assets $\leq$ Book equity

2. Market value constraints

   Fraction of market value assets $\leq$ Market equity

Standard capital structure models more rarely applied

- e.g. target leverage from dynamic trade-off theory model

Outline

1. **Five empirical facts**
2. Partial equilibrium bank optimization model with
   - adjustment costs
   - role for accounting
   - occasionally binding leverage constraints
2. Estimate post-crisis balance sheet adjustment costs

Bank Data

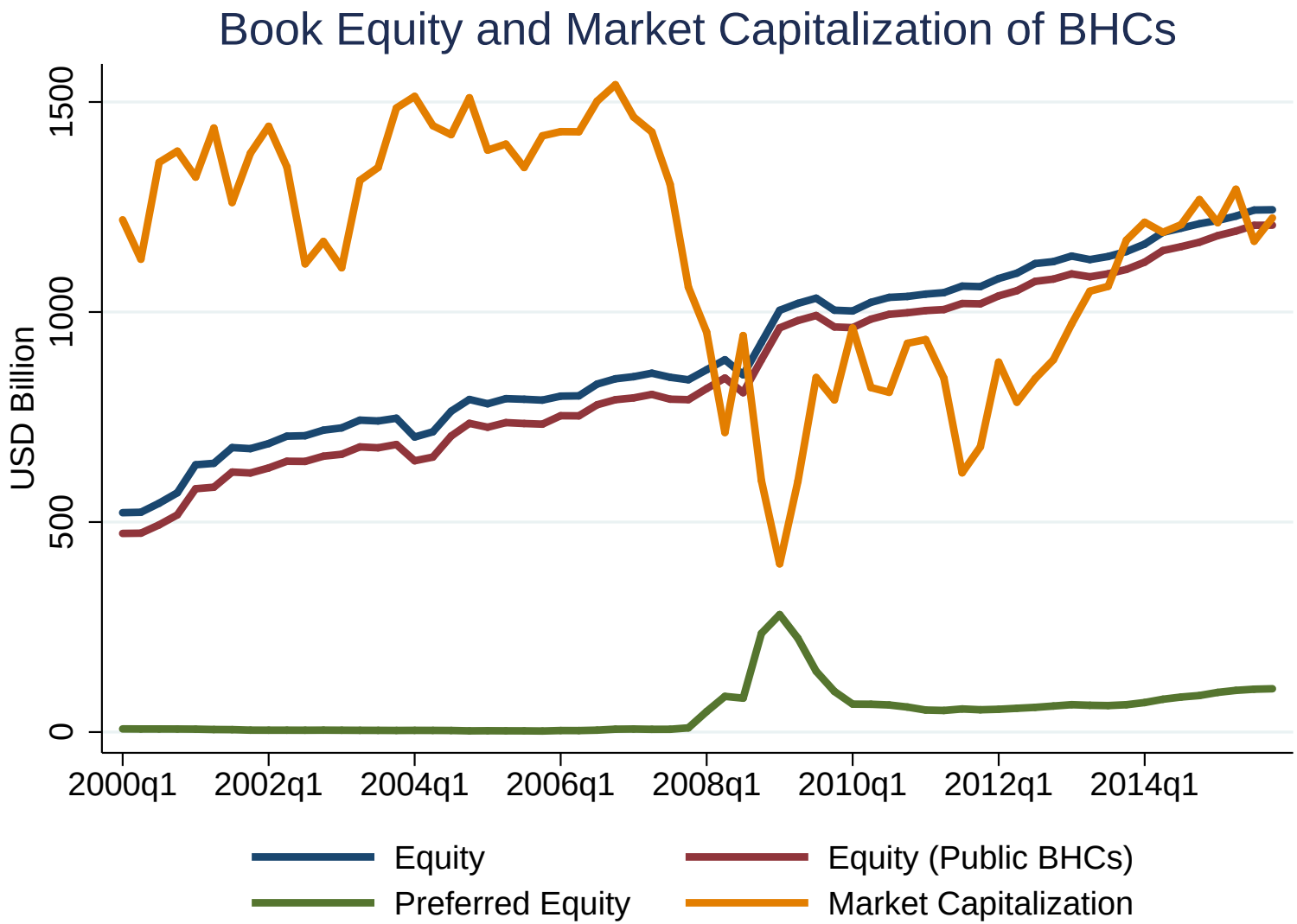
- FR Y-9C quarterly filings for bank holding companies (BHC)
  - BHC consolidates banks' position across different subdivisions
  - Exclude new entrants (e.g. GS, MS, ...)
  - Merge with CRSP data

Fact 1.

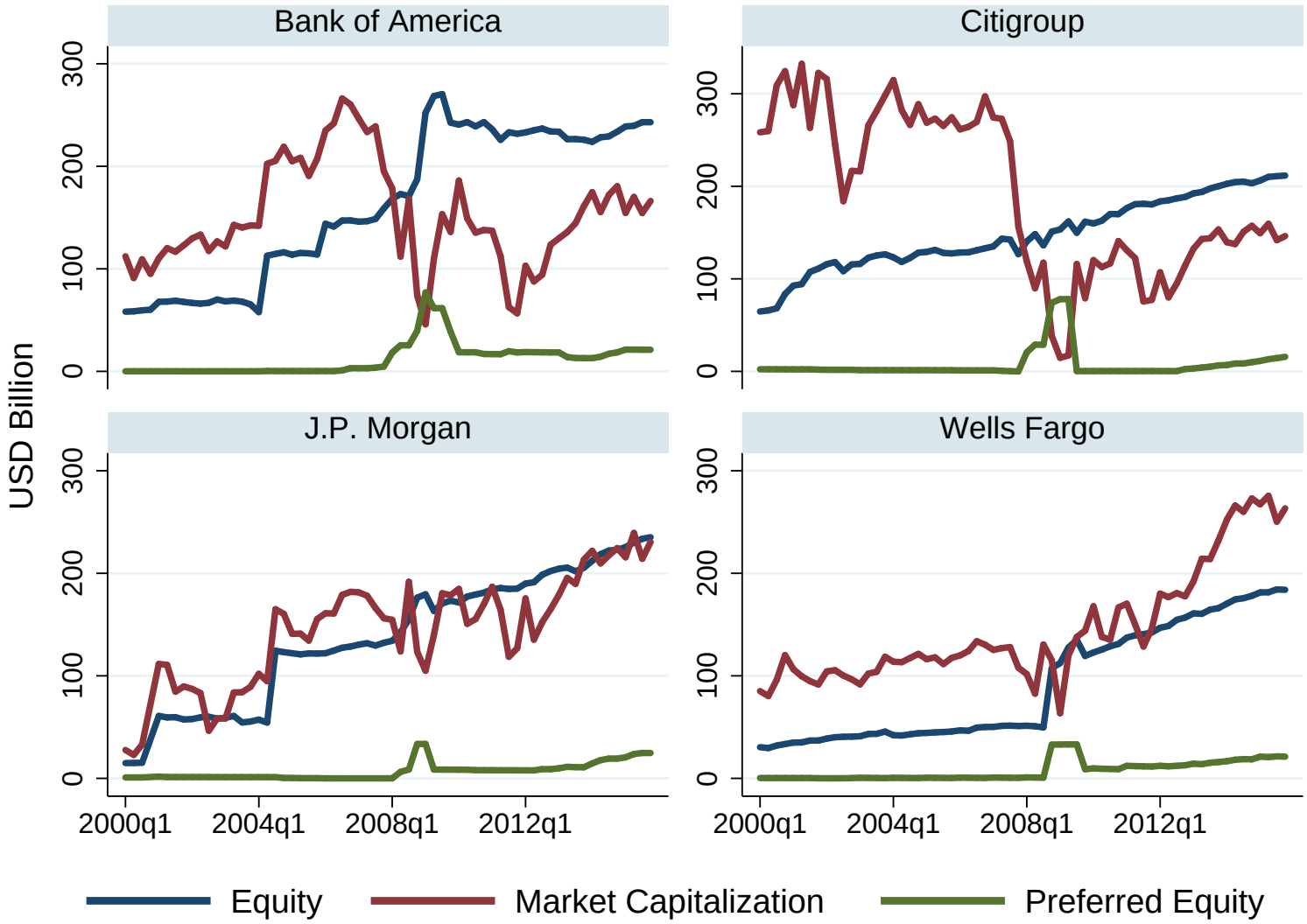
Fact

Book values and market values diverged during the crisis. Between 2007 Q3 and 2008 Q4, BHCs lost **$705 billion** *in* **market** *capitalization, a* **decline of 54%**. **Book** *equity was up* **$94 billion (+11.83%)** *and* **common equity** *was* **down 17.35%**.

Discrepancy between Book & Market – Aggregate



Discrepancy between Book & Market – Big Four



Quick recovery in books - Slow in market values

	Real Change Since 2007 Q3		
	2008	2009	2010
Market Cap.	-54.08% (-$705B)	-39.35% (-$513B)	-29.03% (-$378B)
Book Equity	11.83% ($94B)	21.70% ($172B)	25.97% ($206B)
Common Equity (Tier 1)	-17.35% (-$145B)	8.29% ($69B)	16.64% ($139B)

Accounting matters

- Accountants view the purpose of accounting as to inform the market
- At odds with discrepancy b/w book and market equity during crisis

- Accounting of securities (i.e., how to value securities) - two methodologies:
  - Amortized historical cost (the security is worth what it did cost the bank to buy it with appropriate amortization)
  - Fair value accounting - plenty of discretion how to value (e.g., Level 3 uses unobservable inputs into valuation model)

- Assets held at historical costs (e.g., loans) give banks the choice to not acknowledge impairments at all if deemed temporary

- Laux and Leuz (2010) document substantial discrepancy between banks' internal estimates of loan losses compared to external estimates

Fact 2.

Fact

Market values capture information that book values do not.

Information content of book equity

- How much information content is in book equity?
- Run cross-sectional regression

$$\log\left(\text{Market Cap.}_i\right) = \alpha + \beta \log\left(\text{Book Equity}_i\right) + f(X_i) + \epsilon_i$$

  with X_i variable of interest

- Idea: if book equity accurately reflects net worth of banks $f(X_i)$ should not add predictive power

Weak Predictive Power of Book Equity

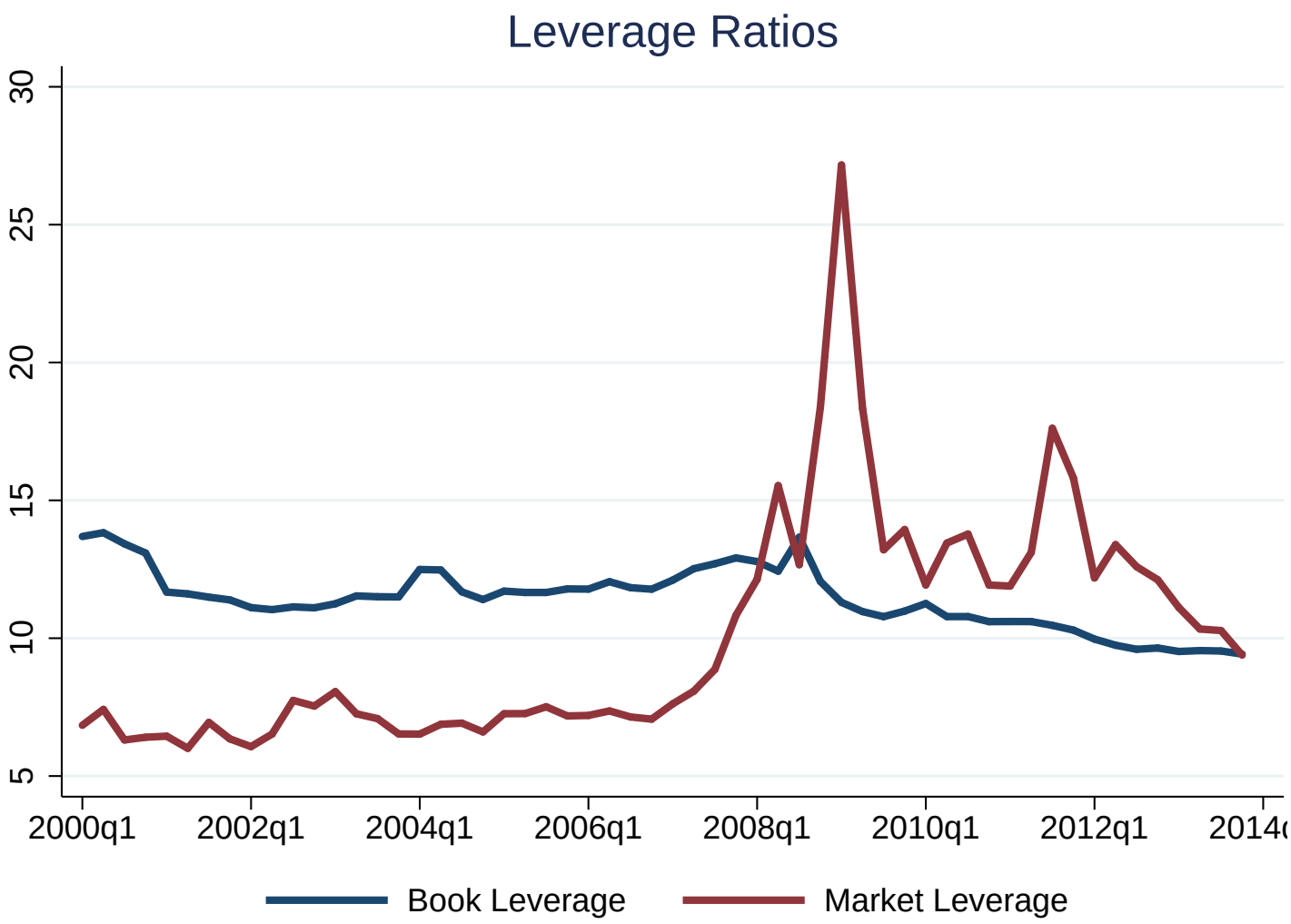
Partial R^2 for Different Predictors of Market Capitalization	*2009 Q1*					
Log Book Equity	0.837	0.255	0.872	0.909	0.910	0.191
Log Liabilities (Quadratic)		0.027				0.022
Log Delinquent Loans Ratio (Quartic)			0.307			0.050
Log RoE over Past Year (Quartic)				0.473	0.267	0.204
Log RoE over Next Year (Quartic)					0.057	0.014
Log RoE Year After Next (Quartic)						0.057
Root Mean Squared Error	0.694	0.687	0.580	0.508	0.497	0.466
Observations	280	280	280	280	280	280

Fact 3.

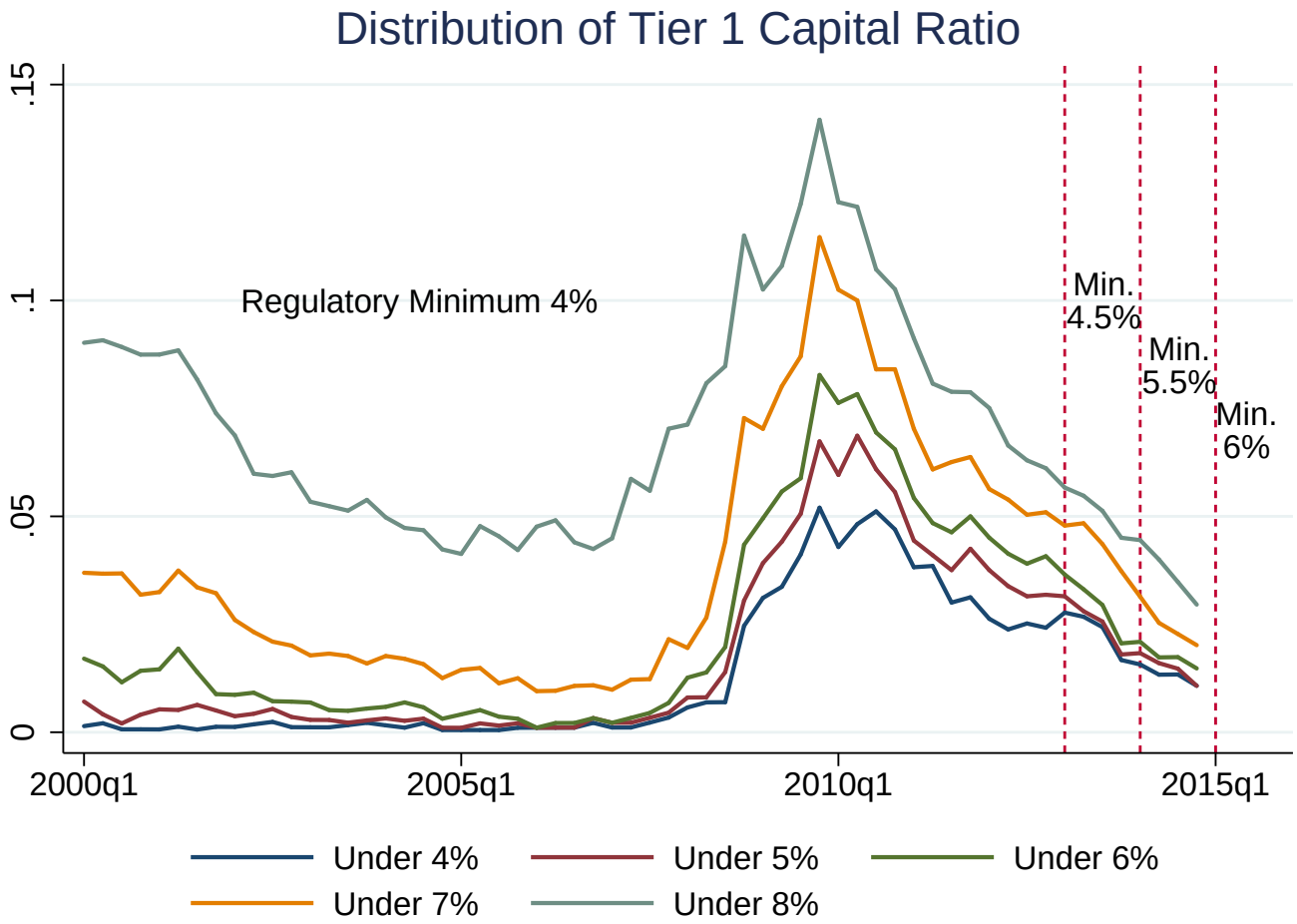
Fact

Neither regulatory nor market constraints bind strictly for most banks.

Market Leverage binding?



Book Equity / Regulatory Constraints?



Fact 4.

Fact

Banks seem to operate with a target leverage ratio
(also in Adrian, Boyarcharenko, Shin (2017))

Slow adjustment, indicative of adjustment costs

Identify target leverage adjustments

- w/ leverage adj. costs (e.g. equity issuance costs and balance sheet stickiness) leverage choice is dynamic
- Target leverage plus adj. costs: slow return to optimal level
- Panel regression: 1990 Q3 - 2016Q4

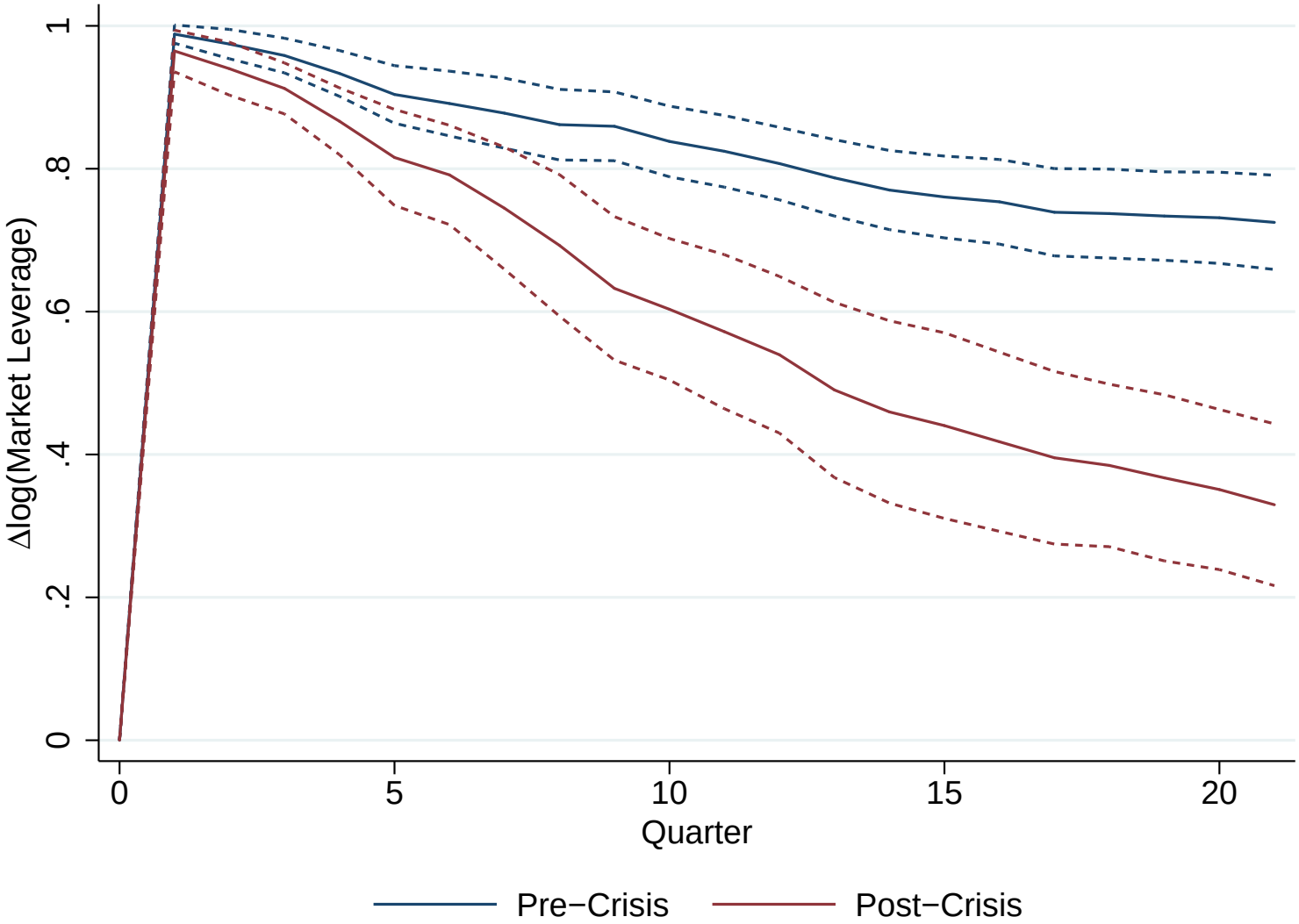
$$\Delta \log(y_{i,t}) = \alpha_t + \sum_{h=0}^{20} \beta_h \cdot \log(1 + r_{i,t-h}) + \gamma_h \cdot Post_t \ \log(1 + r_{i,t-h}) + \epsilon_{i,t}$$

- Identification assumption:
  In efficient-markets excess returns unpredictable *ex ante* after risk-premium adjustment.
  $\Rightarrow$cross-sectional variation in returns $\approx$ idiosyncratic unanticipated shocks

How do banks adjust to net worth shocks?

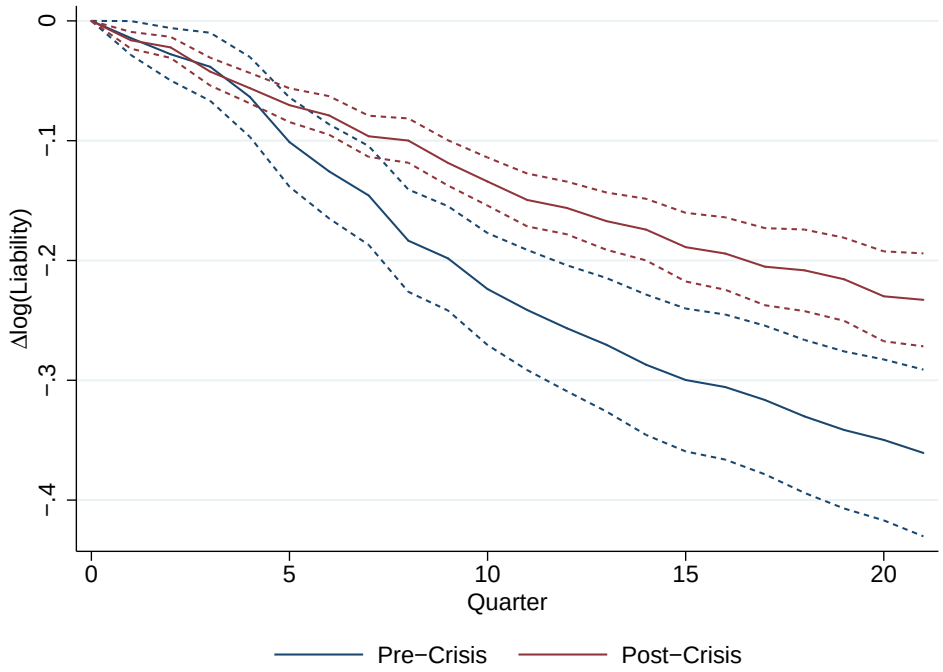
With leverage target IRF return to initial level

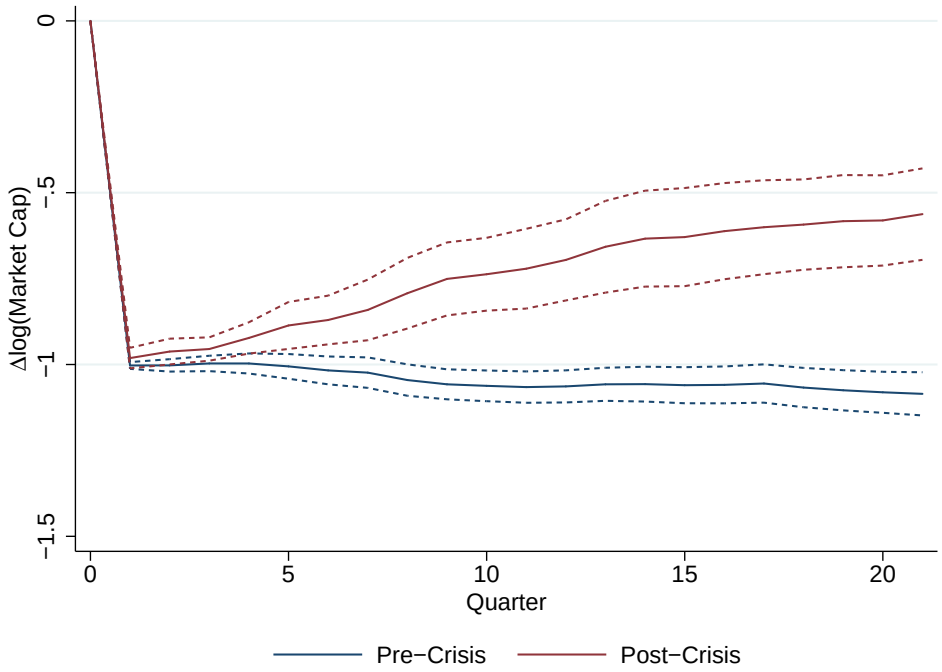
Figure: Estimated Impulse Responses to Negative Equity Return Shock



How are adjustments back to target carried out?

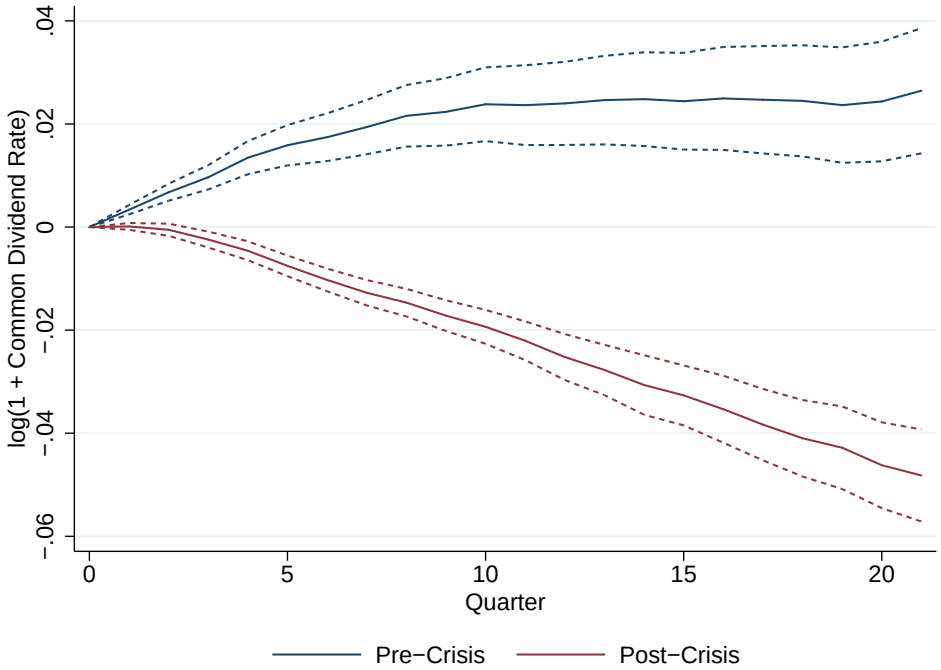
Balance Sheet adjustment pre-crisis

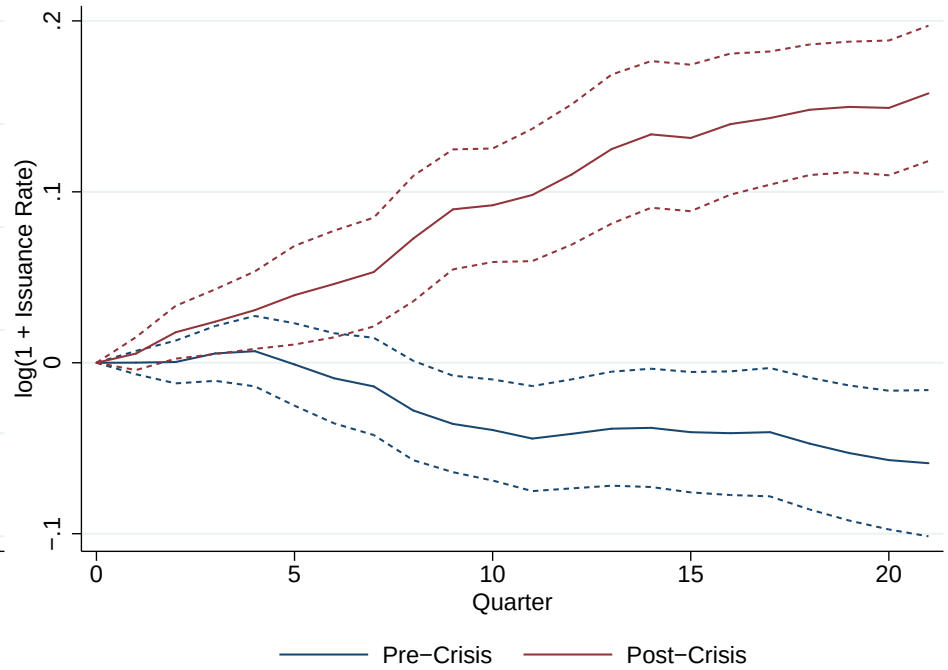




Equity adjustments post-crisis

Via issuances and retained earnings post-crisis





Fact 5.

Fact

Prior to the crisis, banks adjusted leverage primarily by reducing debt keeping equity unchanged. Post-crisis, banks adjust faster. Instead of deleveraging they raised equity through retained earnings and issuance.

Why?

- Asymmetric information?
- Post-crisis anticipated and actual regulatory changes
- Deleveraging became harder
  - avoid regulation
  - lack of securitization
- Note: equal weighted regression means smaller banks (not stress-tested banks) are the focus

Outline

1. Empirical Facts
2. **Partial equilibrium bank optimization model with**
   - adjustment costs
   - role for accounting
   - occasionally binding leverage constraints
2. Estimate post-crisis balance sheet adjustment costs

Stylized dynamic partial equilibrium model

- Bankers: Epstein-Zin with risk-neutrality and dividend smoothing motives
- Loans
  - Long term, mature at rate δ
  - Idiosyncratic fraction ϵ defaults $\sim F(\epsilon)$
  - Flow of new loans I_t funded with deposits at price $p(I_t, b_t, L_t) = 1 + \gamma \frac{I_t}{b_t - L_t}$
    Implies quad. adj. costs & decreasing loan value (e.g., asym. info)

    γ : decline in levered loan value per new loan
  - Distinction b/w book $\bar{b}$ and market value b of loans
    Law of motion (for market and book)

$$b' = (1 + r^b)(1 - \delta) b + I$$
$$\bar{b}' = (1 + r^b)(1 - \delta) \bar{b} + I$$

    Key: b is directly affected by ϵ, while $\bar{b}$ isn't

Stylized dynamic partial equilibrium model

- Deposits
  - Perfectly elastic supply of deposits at rate r^L
  - Law of motion for deposits L

$$L' = (1 + r^L)L - \delta b + p(\cdot) I + d$$

recall $p(I_t, b_t, L_t) = 1 + \gamma \frac{I_t}{b_t - L_t}$

- Bank states variables $\{b, L, \bar{b}\}$ with wealth: $W = b - L$
- Leverage

$$\lambda \equiv b/W$$

- No equity issuances
- Liquidation
  - market based liquidation if

$$b/W > \bar{\lambda}$$

  - regulatory liquiditation if

$$L' > \rho \bar{b}'$$

Bank's Problem

Standard consumption-portfolio choice problem augmented with reg. & mkt constraints, price impact

$$V\left(b, L, \bar{b}\right) = \max_{\{d, I\}} U\left(d\right) + \beta U\left[\mathbb{E}\left[U^{-1}\left[V\left(\varepsilon b', L', \bar{b}'\right)\right]\right]\right]$$

subject to:

$$\begin{aligned}
\text{(loans) } b' &= \left(1 + r^b\right)\left(1 - \delta\right) b + I \\
\text{(book loans) } \bar{b}' &= \left(1 + r^b\right)\left(1 - \delta\right) \bar{b} + I \\
\text{(deposits) } L' &= \left(1 + r^L\right) L - \delta b + p\left(I, b, L\right) I + d \\
\text{(regulation) } L' &\leq \rho \bar{b}' \\
\text{(market) } b/\left(b - L\right) &\leq \bar{\lambda}
\end{aligned}$$

and

$$V\left(\varepsilon b', L', \bar{b}'\right) = 0 \text{ if } \left\{\varepsilon b', L', \bar{b}'\right\} \in \Gamma^{liquidation}$$

Summary of model properties

Proposition: *For a given combination of leverage $\lambda = \frac{b}{W}$ and market to book value of loans $q = \frac{b}{\bar{b}}$, the value function is homothetic in wealth $W = b - L$, with solutions $I = \iota W$ (loan issuances with ι as the loan issuance rate) and $d = cW$ (dividends)*

- Leverage trade-off
  - increases equity return
  - increases liquidation risk
- Discrepancy b/w book and mkt value of loans - shock affects b and V but not $\bar{b}$ and $\bar{\lambda}$
- Price impact equation leads banks to slowly adjust portfolio

Parametrization

Parameter	**Description**	**Target**	Model	Data
$\beta = 0.99$	Discount factor	Mean dividend rate	1.66%	0.63%
$\psi = 0$	Risk aversion	Mean leverage	7.80	8.68

Parameter	**Description**	**Target**
$\sigma = 0.5$	Inverse IES	Dividend Elasticity
$r^b = 0.015$	Loan yield	BHC data: interest income / loans
$r^l = 0.010$	Bank debt yield	BHC data: interest expense / debt
$\delta = 0.06$	Loan maturity	BHC data: average loan maturity
$\bar{\lambda} = 50$	Market leverage cap	BHC data: maximum market leverage
$\rho = 0.95$	Capital req (asset to debt)	FR-Y-9C loan rw & lev constraint
$\sigma_\epsilon = 0.03$	Vol of default shocks	Loan default rates
$\gamma^{pre} = 0.10$	Adjustment cost pre-crisis	**Estimated** using IRF
$\gamma^{crisis} = 0.16$	Adjustment cost post-crisis	

Outline

1. Empirical Facts
2. Partial equilibrium bank optimization model with
   - adjustment costs
   - role for accounting
   - occasionally binding leverage constraints
2. **Estimate post-crisis balance sheet adjustment costs**

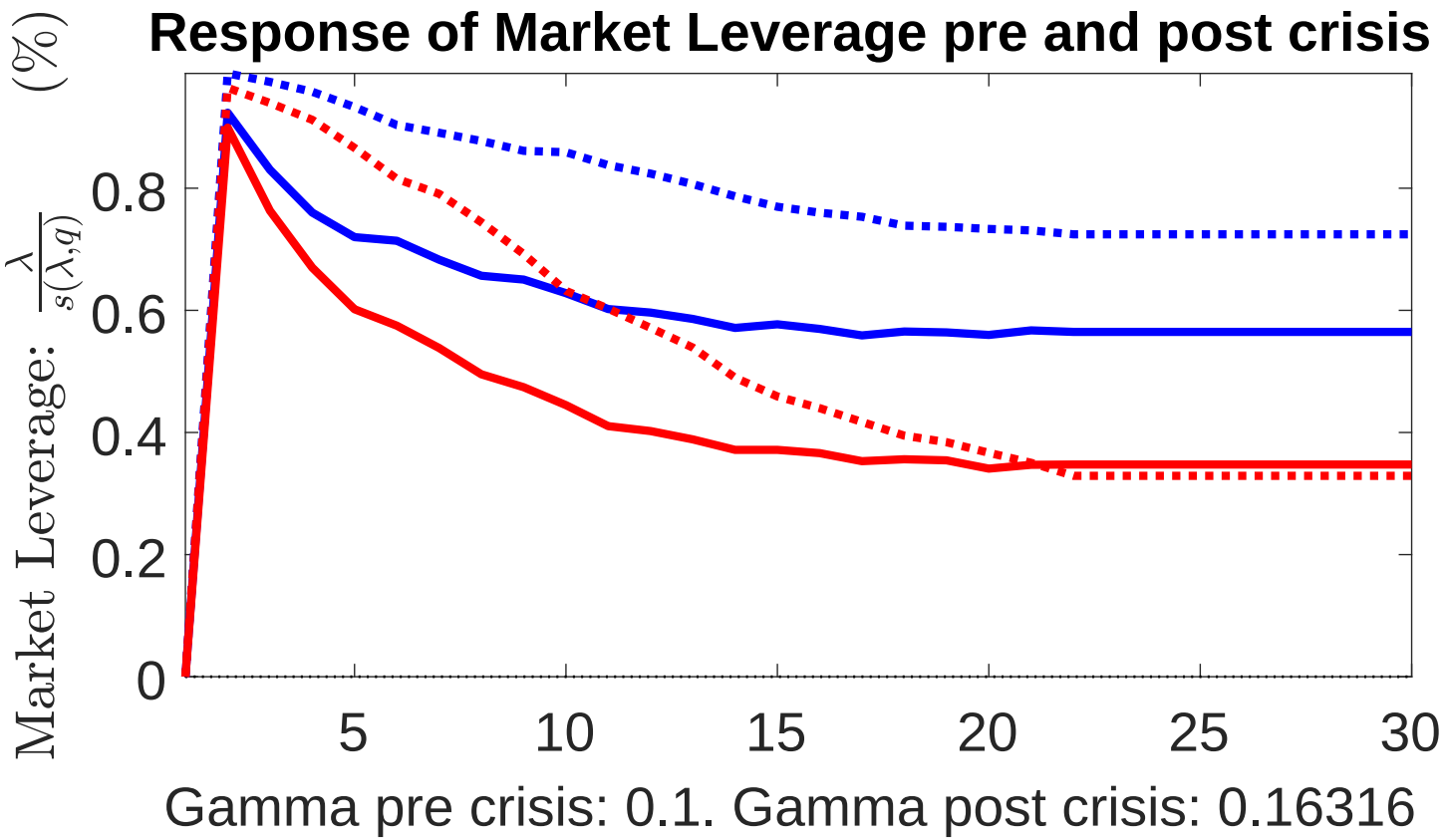
Model implied impulse response function

- Simulate the model and compute model implied impulse response functions as:

$$\Delta R(\varepsilon) = R(\varepsilon) - \bar{R} = \left(s\left(\lambda', q'\right)\Omega(\varepsilon) - \mathbb{E}\left[s\left(\lambda', q'\right)\Omega(\varepsilon)\right]\right)/s(\lambda, q)$$

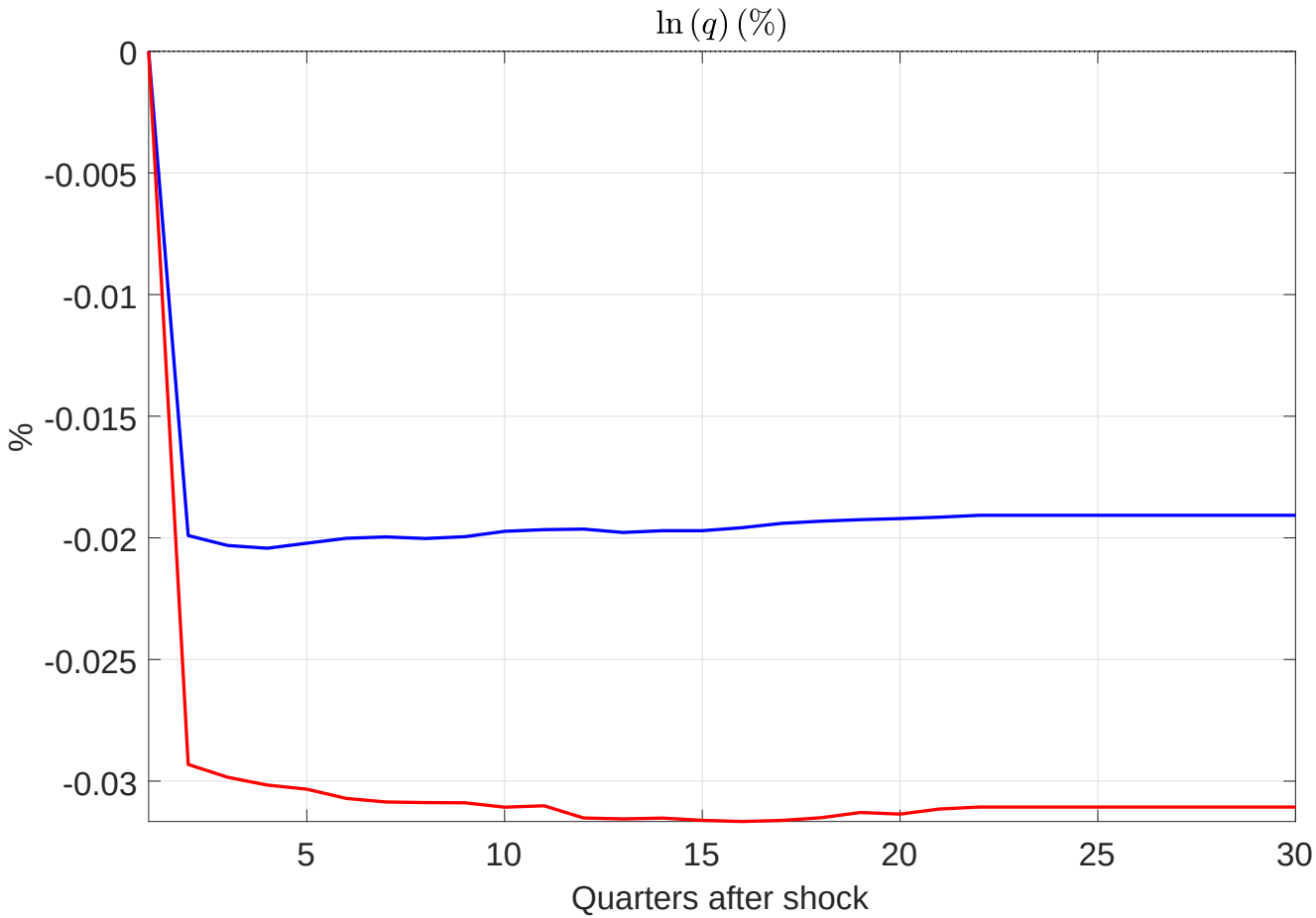
Market Leverage

Model: solid line – Data dashed line – pre-crisis blue – crisis red



Loan Market-book ratio

Negative shock lowers market to book ratio / pre-crisis blue – post-crisis red

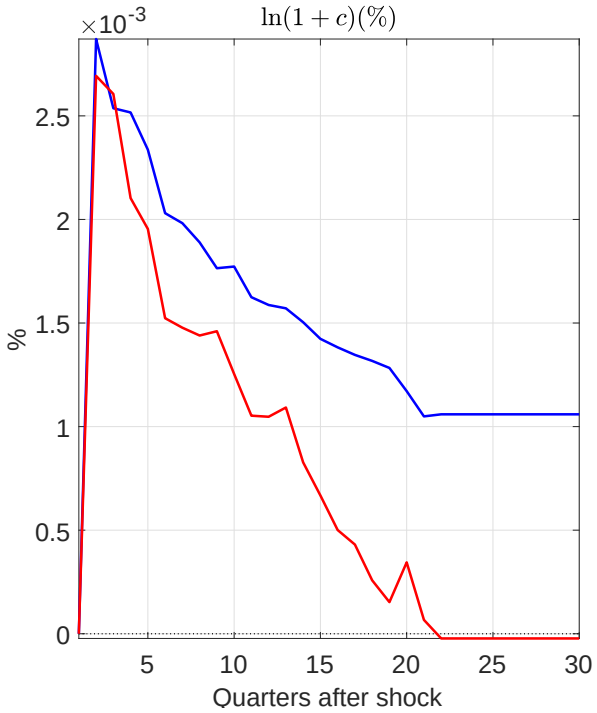


Wrap

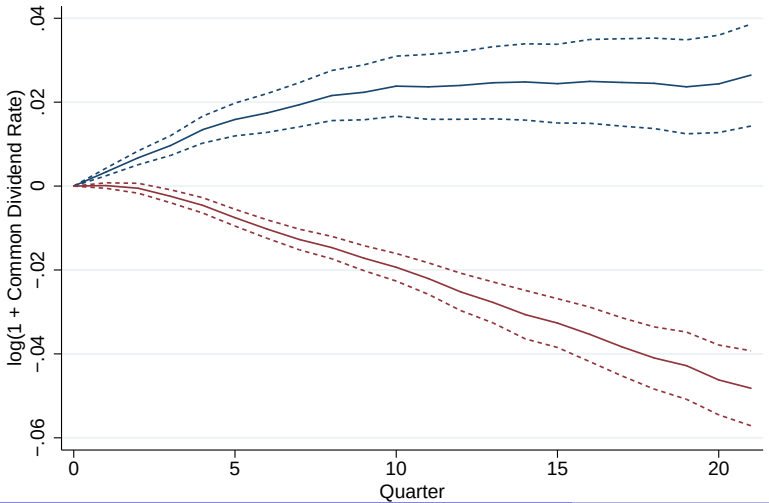
- Bank data suggests complex interaction b/w book and market value constraints
- Reliance on accounting data (typical data source in banking) insufficient
- Propose simple building block to use in macro model
  - distinction b/w market and book values
  - balance sheet adjustment costs

Dividends

Model: solid line – Data dashed line – Pre-crisis blue – Crisis red



Model



Lagged provisions and charge-offs