The relationship between capital, liquidity and risk in commercial banks

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Motivation

- Background: banking system stability
- Framework: effects of regulatory design on banks' risk appetites

$$(1)\ \textit{Capital requirements} \Rightarrow \begin{cases} (2a)\ \textit{Riskiness of bank portfolio} \\ (2b)\ \textit{Adequate liquidity} \end{cases}$$

- General perception: (1) is enough to regulate (2)

Motivation

- What have changed: liquidity crisis

Trends in banking before the crisis:

- **Change in the model of lending**
  - from "originate & transform" to "originate & distribute"
- **Change in funding structure**
  - shorter maturity liabilities
  - greater relience on whole-sale funding
  - securitization

Problem:

- securitized illiquid loans do not appear on the balance sheet of a bank $\Rightarrow$ inadequate liquidity provisions
- banks can reduce capital requirements and avoid regulation by transferring illiquid assets off-shore to an SPV

Research Idea

1. Assess how the US commercial banks adjust risk, capital & liquidity buffers under capital regulation.
2. Test theoretical implications of Repullo (2005):
   - capital $\uparrow \Rightarrow$ risk $\downarrow \Rightarrow$ liquidity $\downarrow$
3. Test the impact of securitization on capital-risk-liquidity decisions.

Related Literature: Theoretical Studies

Bank's Liquidity

- Baltensperger (1980), Santomero (1984): liquidity buffer should reflect the cost of forgone return and raising funds at a short notice.

Bank's Capital and Risk

- Kahane (1977), Koehn and Santomero (1980), Kim and Santomero (1988): increased regulatory capital standards may lead to an increase in bank risk-taking.
- Merton (1977), Sharpe (1978), Furlong and Keeley (1989): capital adequacy regulation may reduce incentives for banks to increase portfolio risk levels.

Bank's Capital, Risk and Liquidity

- Repullo (2005): optimal liquidity, capital and risk in different regimes.

Related Literature: Empirical studies

Bank Capital and Risk:

- Shrieves & Dahl (1992), Aggarwal and Jacquers (2001), Heid, Porath and Stolz (2004), Jokipii and Milne (2011): a positive relationshipe b/w capital and risk.
- Jacquers and Nigro (1997): a negative influence of capital changes on risk changes in case of the total risk-based capital constraints.

Bank Capital and Liquidity:

- Distinguin, Roulet and Tarazi (2013): banks decrease their capital ratios when there is a decline in liquidity.

Liquidity:

- Aspachs, Nier & Tiesset (2005): liquidity moral hazard and counter-cyclicality of liquidity buffers.

Contribution to the Literature

- Jointly examine capital, risk and liquidity decisions of the U.S. commercial banks.
- Examine the impact of securitization on capital-risk-liquidity decisions.
- Examine how banks had reshuffled capital, liquidity and risk, and in effect relaxed constraints of the banking regulations.
- Assess the accuracy of improving the regulatory framework by adding liquidity requirements to capital standards.
- Compare banks behavior prior to the financial crisis to their behavior during the crisis.

Methodology

Partial adjustment framework based on Shrieves and Dahl (1992).

- Observed changes consist of discretionary component and random shock.
- Discretionary component is modeled using a partial adjustment framework
- To recognize possible simultaneity of capital, risk and liquidity adjustments:

$$\triangle CAP_{it} = \alpha(CAP^*_{it} - CAP_{it-1}) + \varphi_1 \triangle RISK_{it} + \varphi_2 \triangle LIQ_{it} + \zeta_{it}, \quad (1)$$

$$\triangle RISK_{it} = \beta(RISK^*_{it} - RISK_{it-1}) + \phi_1 \triangle CAP_{it} + \phi_2 \triangle LIQ_{it} + \xi_{it}, \quad (2)$$

$$\triangle LIQ_{it} = \gamma(LIQ^*_{it} - LIQ_{it-1}) + \psi_1 \triangle CAP_{it} + \psi_2 \triangle RISK_{it} + \vartheta_{it}. \quad (3)$$

Methodology

- Proxies of internal targets: size, profitability, loan losses, core deposits ratio, net interest margin, loan growth, securitization.

$$\triangle CAP_{it} = \alpha_0 + \alpha_1 SIZE_{it} + \alpha_2 LLOSS_{it} + \alpha_3 ROA_{it} + \alpha_4 Core\ Deposits_{it} + \alpha_5 SEC_{it} - \\ - \alpha_6 CAP_{it-1} + \alpha_7 \triangle RISK_{it} + \alpha_8 \triangle LIQ_{it} + \mu_i + \delta_t + \varepsilon_{it}, \tag{4}$$

$$\triangle RISK_{it} = \beta_0 + \beta_1 SIZE_{it} + \beta_2 LLOSS_{it} + \beta_3 Core\ Deposits_{it} + \beta_4 SEC_{it} - \\ - \beta_5 RISK_{it-1} + \beta_6 \triangle CAP_{it} + \beta_7 \triangle LIQ_{it} + \mu_i + \delta_t + \epsilon_{it}, \tag{5}$$

$$\triangle LIQ_{it} = \gamma_0 + \gamma_1 SIZE_{it} + \gamma_2 Core\ Deposits_{it} + \gamma_3 NIM_{it} + \gamma_4 LOAN_{it} + \gamma_5 SEC_{it} - \\ - \gamma_6 LIQ_{it-1} + \gamma_7 \triangle RISK_{it} + \gamma_8 \triangle CAP_{it} + \mu_i + \delta_t + \nu_{it}, \tag{6}$$

- The coefficients α_7, α_8, β_6, β_7, γ_7 and γ_8 are of our main interest.
- Dynamic panel structure of the models.
- Bank fixed effects, μ_i.

Methodology

Two-step Arellano-Bond difference GMM estimator (Arellano and Bond, 1991):

- Estimates the equation in first differences thereby removing all unobserved time invariant bank-level effects.
- Uses available lags of dependant variable in levels as instruments for the first-differenced equation.
- Allows to account for the endogeneity of capital, risk and liquidity adjustments in the estimation procedure: use lags of $\triangle CAP_{it}$, $\triangle RISK_{it}$ and $\triangle LIQ_{it}$ as GMM-type instruments.

The validity of instruments:

- Testing for the presence of autocorrelation in first-differenced residuals: if autocorrelation of order n is detected, only deeper lags (e.g., $n+1$) of variable can be used as instruments (Roodman, 2009).
- Checking the validity of instruments as a group and correctness of model specification is done by the Hansen J-test of overidentifying restrictions.

Methodology

Four measures of bank capital (*CAP*):

1. total equity capital to total assets,
2. risk-based capital ratio (equity capital to risk-weighted assets),
3. Tier 1 risk-based capital ratio (core capital divided by risk-weighted assets),
4. total risk-based capital ratio (total risk-based capital divided by risk-weighted assets).

Two measures of risk (*RISK*):

1. ratio of risk-weighted assets to total assets (*RWATA*)
2. ratio of nonperforming loans to total loans (*NPL*).

LIQ - the ratio of liquid assets to total assets:

- liquid assets = cash, reverse repurchase agreements, marketable securities and Federal funds sold.

Methodology

- *SIZE* - logarithm of total assets,
- *ROA* - ratio of net income to total assets,
- *LLOSS* - ratio of new loan provisions in the current period to total assets,
- *Core Deposits* - ratio of small denomination time deposits and all transaction deposits to total assets,
- *NIM* - ratio of net interest income to average total assets,
- *LOAN* - loan growth rate,
- *SEC*- ratio of assets sold and securitized with recourse and other credit enhancements to total assets.

Data Description

Data sources: U.S. based

1. FDIC Call Reports – financial statement data for U.S. banks.
2. 2001-2010, quarterly.

Sample:

- Pre-crisis period: 2001 q1 - 2007 q2 (26 quarters), around 8000 banks.
- Crisis period: 2007 q3 - 2009 q4 (11 quarters), around 6500 banks.
- Aggregated at Bank Holding Company (BHC) level.
- Excludes mergers in each quarter (asset growth $> 10\%$).
- Excludes if total assets are at 1st and 99th percentiles.
- All variables are winsorized at the 1st and 99th percentiles.

Descriptive Statistics

	Unit	N	Mean	St. Dev.	Min	Max
Pre-crisis period						
△EQ CAP	%	156561	0.04***	0.8	-27.9	39.3
△RB CAP	%	156447	-0.04***	1.8	-76.7	81.5
△Tier1 RB CAP	%	156447	-0.01***	1.7	-75.5	78.7
△Total CAP	%	156447	-0.01***	1.7	-76.1	79.6
△RWATA	%	156561	0.39***	3.4	-88.3	92.5
△NPL	%	155954	0.00***	0.7	-6.9	6.9
△LIQ	%	156561	-0.42***	3.8	-87.6	85.9
Crisis period						
△EQ CAP	%	59650	-0.03	0.8	-22.1	29.0
△RB CAP	%	59606	-0.07	1.8	-54.8	72.7
△Tier1 RB CAP	%	59606	-0.11	1.6	-55.6	73.9
△Total CAP	%	59606	-0.10	1.7	-55.5	74.3
△RWATA	%	59650	0.05	3.3	-62.3	58.0
△NPL	%	59368	0.21	1.2	-14.1	14.1
△LIQ	%	59650	-0.18	3.4	-79.6	59.2

- Tests for significant differences in means between the pre-crisis and the crisis periods are based on the Welch's t-test statistics.
- ***, ** and * are significance levels at 1%, 5%, and 10%, respectively.

Results

1. Capital equation:
   - (1a) Risk is measured by *RWATA*
   - (1b) Risk is measured by *NPL*
2. Risk equation:
   - (2a) Risk is measured by *RWATA*
   - (2b) Risk is measured by *NPL*
3. Liquidity equation:
   - (3a) Risk is measured by *RWATA*
   - (3b) Risk is measured by *NPL*

Results: **(1a) Capital Equation**

	Pre-crisis period (2001 Q1 - 2007 Q2)			Crisis period (2007 Q3 - 2009 Q4)		
	(1) △EQ CAP	(3) △Tier1 RB CAP	(4) △Total CAP	(5) △EQ CAP	(7) △Tier1 RB CAP	(8) △Total CAP
Panel A: Risk is measured by RWATA						
Core Deposits	-0.094**	0.005	-0.001	0.024 ♭	0.089	0.084
	(-2.22)	(0.08)	(-0.02)	(0.55)	(1.22)	(1.13)
SIZE	-0.031***	-0.043**	-0.043**	-0.089***♭♭	-0.107**	-0.104**
	(-3.09)	(-2.28)	(-2.24)	(-4.19)	(-2.50)	(-2.40)
LLOSS	0.294	-0.976	-1.060	1.193**	2.514**	2.601**
	(0.28)	(-0.46)	(-0.51)	(2.10)	(1.98)	(2.05)
ROA	2.820***	5.638***	5.697***	1.611***	1.411 ♭♭♭	1.387 ♭♭♭
	(3.77)	(5.37)	(5.36)	(3.19)	(1.26)	(1.24)
SEC	0.481*	-0.279	-0.133	0.180	0.021	0.020
	(1.80)	(-0.44)	(-0.22)	(0.78)	(0.04)	(0.05)
CAP_{t-1}	-0.744***	-0.915***	-0.875***	-0.726***	-0.544***♭♭♭	-0.537***♭♭
	(-10.53)	(-6.98)	(-6.82)	(-21.60)	(-10.73)	(-10.80)
△RWATA	0.015	-0.190***	-0.198***	-0.032	-0.267***	-0.274***
	(0.52)	(-2.93)	(-3.15)	(-0.92)	(-3.79)	(-3.83)
△LIQ	-0.014	-0.102**	-0.099**	-0.051**	-0.146***	-0.153***
	(-0.61)	(-2.27)	(-2.24)	(-2.15)	(-2.89)	(-2.98)
N	148227	148181	148181	52849	52864	52864
Hansen J-test	0.116	0.083	0.078	0.622	0.235	0.217
AR(1) test	0.000	0.003	0.001	0.002	0.000	0.000
AR(2) test	0.736	0.472	0.543	0.479	0.570	0.572

♭♭♭, ♭♭ and ♭ are significance levels at 1%, 5%, and 10%, respectively for the differences in regression coefficients between two periods.

Results: **(1b) Capital Equation**

	Pre-crisis period (2001 Q1 - 2007 Q2)			Crisis period (2007 Q3 - 2009 Q4)		
	(1) △EQ CAP	(3) △Tier1 RB CAP	(4) △Total CAP	(5) △EQ CAP	(7) △Tier1 RB CAP	(8) △Total CAP
Panel B: Risk is measured by NPL						
Core Deposits	-0.010**	0.106**	0.112***	-0.055	0.052	0.051
	(-2.36)	(2.53)	(2.63)	(-0.77)	(0.53)	(0.51)
SIZE	-0.027**	0.007	0.006	0.06** ♮♮♮	-0.082* ♮	-0.083* ♮
	(-2.30)	(0.47)	(0.39)	(2.28)	(-1.66)	(-1.67)
LLOSS	0.060	1.133	1.230	-0.529	3.318*	3.529**
	(0.05)	(0.72)	(0.79)	(-0.70)	(1.94)	(2.09)
ROA	2.650***	4.390***	4.469***	-0.107 ♮♮	4.445**	4.589**
	(3.24)	(4.40)	(4.45)	(-0.13)	(2.23)	(2.32)
SEC	0.884**	0.066	0.104	-0.618 ♮♮	-0.329	-0.328
	(2.30)	(0.14)	(0.23)	(-0.98)	(-0.38)	(-0.34)
CAP_{t-1}	-0.719***	-0.855***	-0.853***	-0.568***	-0.505***♮♮	-0.510***♮♮
	(-8.41)	(-8.11)	(-8.08)	(-11.34)	(-5.30)	(-5.34)
△NPL	0.0513	0.389*	0.378*	-0.323*	-0.521* ♮♮	-0.524* ♮♮
	(0.32)	(1.95)	(1.90)	(-1.78)	(-1.78)	(-1.79)
△LIQ	-0.016	0.084***	0.085***	0.019	0.113**	0.115**
	(-1.13)	(3.63)	(3.66)	(0.43)	(2.03)	(2.10)
N	148210	148164	148164	52839	52855	52855
Hansen J-test	0.194	0.238	0.223	0.099	0.804	0.750
AR(1) test	0.000	0.002	0.001	0.000	0.000	0.000
AR(2) test	0.535	0.168	0.183	0.193	0.613	0.671

♮♮♮, ♮♮ and ♮ are significance levels at 1%, 5%, and 10%, respectively for the differences in regression coefficients between two periods.

Results: (2a) Risk Equation - △RWATA

	Pre-crisis period (2001 Q1 - 2007 Q2)			Crisis period (2007 Q3 - 2009 Q4)		
	(1)	(3)	(4)	(5)	(7)	(8)
		△RWATA			△RWATA	
Core	0.086	-0.058	-0.064	0.080	0.022	0.014
Deposits	(0.99)	(-0.54)	(-0.59)	(0.97)	(0.13)	(0.08)
SIZE	0.003	0.028	0.025	0.076**	0.070	0.062
	(0.08)	(0.56)	(0.51)	(1.97)	(0.79)	(0.71)
LLOSS	0.010	-3.871	-3.934	-0.457	-1.104	-1.154
	(0.00)	(-1.10)	(-1.10)	(-0.78)	(-1.15)	(-1.22)
SEC	0.711	0.773	0.771	-0.402	-1.529	-1.411
	(0.76)	(0.71)	(0.70)	(-0.53)	(-1.02)	(-0.96)
$RWATA_{t-1}$	-0.106*	0.069	0.067	-0.149***	-0.180** ♮♮	-0.185** ♮♮
	(-1.86)	(1.10)	(1.06)	(-2.67)	(-2.03)	(-2.09)
△CAP	0.044	-0.190**	-0.190**	0.310***	0.304♮♮	0.309* ♮♮
	(0.37)	(-2.00)	(-1.99)	(2.68)	(1.63)	(1.67)
△LIQ	-0.808***	-0.718***	-0.715***	-0.635***♮♮	-0.703***	-0.700***
	(-14.40)	(-14.13)	(-14.05)	(-14.87)	(-9.70)	(-9.62)
N	148227	148181	148181	52849	52864	52864
Hansen J-test	0.114	0.374	0.371	0.649	0.785	0.757
AR(1) test	0.000	0.000	0.000	0.000	0.000	0.000
AR(2) test	0.000	0.000	0.000	0.097	0.093	0.087
AR(3) test	0.159	0.212	0.212	0.316	0.346	0.312

***, ** and * are significance levels at 1%, 5%, and 10%, respectively.
♮♮♮, ♮♮ and ♮ are significance levels at 1%, 5%, and 10%, respectively for the differences in regression coefficients between two periods.

Results: (2b) Risk Equation - △NPL

	Pre-crisis period (2001 Q1 - 2007 Q2)			Crisis period (2007 Q3 - 2009 Q4)		
	(1) △NPL	(3) △NPL	(4) △NPL	(5) △NPL	(7) △NPL	(8) △NPL
Core Deposits	0.059*	0.053	0.055	-0.003	0.003	0.003
	(1.76)	(1.57)	(1.64)	(-0.04)	(0.06)	(0.07)
SIZE	0.043***	0.041***	0.042***	0.030**	0.028***	0.028***
	(3.00)	(2.90)	(2.90)	(1.98)	(2.59)	(2.58)
LLOSS	-1.583***	-1.543**	-1.596**	-0.404**♮	-0.3769** ♮	-0.387**♮
	(-2.62)	(-2.26)	(-2.36)	(-2.02)	(-2.00)	(-2.04)
SEC	0.229	0.446	0.421	1.178*	0.266	0.248
	(0.35)	(0.72)	(0.67)	(1.79)	(0.83)	(0.78)
NPL_{t-1}	-0.684***	-0.708***	-0.708***	-0.859***	-0.899***	-0.891***
	(-6.10)	(-6.70)	(-6.62)	(-2.82)	(-5.26)	(-5.28)
△CAP	0.064	0.090**	0.0814**	0.266**	0.106*	0.102*
	(1.13)	(2.29)	(2.13)	(2.00)	(1.85)	(1.82)
△LIQ	-0.043**	-0.060***	-0.060***	0.012	-0.017 ♮	-0.016 ♮
	(-2.43)	(-3.27)	(-3.23)	(0.35)	(-1.10)	(-1.09)
N	148205	148159	148159	52837	52853	52853
Hansen J-test	0.160	0.603	0.579	0.170	0.0964	0.110
AR(1) test	0.000	0.000	0.000	0.446	0.306	0.285
AR(2) test	0.927	0.914	0.914	0.571	0.877	0.862

***, ** and * are significance levels at 1%, 5%, and 10%, respectively.
♮♮♮, ♮♮ and ♮ are significance levels at 1%, 5%, and 10%, respectively for the differences in regression coefficients between two periods.

Results: **(3a) Liquidity Equation**

	Pre-crisis period (2001 Q1 - 2007 Q2)			Crisis period (2007 Q3 - 2009 Q4)		
	(1)	(3)	(4)	(5)	(7)	(8)
Panel A: Risk is measured by RWATA						
Core Deposits	0.146**	0.109*	0.0987*	0.734*	0.537***♮♮	0.542***♮♮
	(2.04)	(1.90)	(1.72)	(1.89)	(3.03)	(3.04)
SIZE	-0.065***	-0.051***	-0.054***	-0.234	-0.237***♮♮	-0.244***♮♮
	(-2.73)	(-2.87)	(-2.97)	(-1.52)	(-2.59)	(-2.66)
NIM	3.955*	3.335*	3.165*	-1.570	-5.864 ♮	-6.243 ♮
	(1.71)	(1.76)	(1.67)	(-0.24)	(-1.25)	(-1.33)
LOAN	-0.001***	-0.001***	-0.001***	-0.001*	-0.003***	-0.003***
	(-2.77)	(-3.82)	(-3.90)	(-1.90)	(-3.91)	(-3.98)
SEC	0.373	0.468	0.602	-0.854	-0.0761	-0.143
	(0.39)	(0.64)	(0.85)	(-0.49)	(-0.07)	(-0.14)
LIQ_{t-1}	-0.067	-0.138***	-0.139***	-0.310*	-0.353***♮	-0.367***♮
	(-1.45)	(-4.44)	(-4.44)	(-1.68)	(-3.03)	(-3.15)
△RWATA	-0.943***	-0.995***	-0.994***	-0.841***	-0.743***♮	-0.728***♮♮
	(-14.53)	(-21.64)	(-21.61)	(-6.16)	(-6.02)	(-5.83)
△CAP	-0.217*	-0.266***	-0.273***	-0.461	-0.909***♮♮♮	-0.922***♮♮♮
	(-1.93)	(-2.84)	(-2.88)	(-1.45)	(-4.04)	(-4.13)
N	148167	148171	148171	52813	52857	52857
Hansen J-test	0.262	0.183	0.156	0.117	0.306	0.320
AR(1) test	0.000	0.000	0.000	0.000	0.000	0.000
AR(2) test	0.000	0.000	0.000	0.187	0.090	0.087
AR(3) test	0.105	0.163	0.166	0.554	0.289	0.225

***, ** and * are significance levels at 1%, 5%, and 10%, respectively.
♮♮♮, ♮♮ and ♮ are significance levels at 1%, 5%, and 10%, respectively for the differences in regression coefficients between two periods.

Results: **(3b) Liquidity Equation**

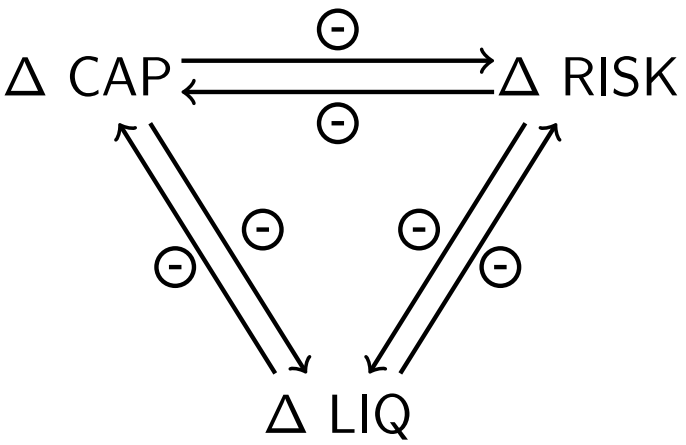
	Pre-crisis period (2001 Q1 - 2007 Q2)			Crisis period (2007 Q3 - 2009 Q4)		
	(1)	(3)	(4)	(5)	(7)	(8)
	△LIQ	△LIQ	△LIQ	△LIQ	△LIQ	△LIQ
Panel B: Risk is measured by NPL						
Core Deposits	0.072	0.060	0.061	1.062	-0.065	-0.050
	(0.63)	(0.54)	(0.55)	(1.52)	(-0.20)	(-0.15)
SIZE	-0.172***	-0.125**	-0.119**	0.267	-0.034	-0.032
	(-3.36)	(-2.27)	(-2.15)	(0.86)	(-0.38)	(-0.35)
NIM	8.831**	12.55***	12.43***	-5.889	0.763 ♮	0.794 ♮
	(2.26)	(3.05)	(3.02)	(-0.43)	(0.16)	(0.17)
LOAN	-0.003***	-0.002***	-0.002***	0.002	-0.003***	-0.003***
	(-4.38)	(-3.54)	(-3.49)	(0.60)	(-3.21)	(-3.20)
SEC	1.124	1.592	1.539	-9.347	1.157	1.292
	(0.57)	(1.07)	(1.03)	(-0.82)	(0.35)	(0.38)
LIQ_{t-1}	-0.439***	-0.598***	-0.613***	-0.418	-0.329***♮	-0.334***♮
	(-4.52)	(-5.48)	(-5.58)	(-1.47)	(-3.24)	(-3.32)
△NPL	-0.918	-1.057**	-1.067**	-2.047	-0.032	-0.023
	(-1.49)	(-2.18)	(-2.21)	(-0.99)	(-0.05)	(-0.03)
△CAP	-0.305**	-0.049	-0.046	-0.494	-1.712***♮♮♮	-1.68***♮♮♮
	(-2.25)	(-0.34)	(-0.32)	(-0.44)	(-5.28)	(-5.21)
N	148160	148164	148164	52811	52855	52855
Hansen J-test	0.002	0.460	0.438	0.399	0.316	0.273
AR(1) test	0.000	0.000	0.000	0.138	0.000	0.000
AR(2) test	0.000	0.074	0.099	0.477	0.857	0.859

***, ** and * are significance levels at 1%, 5%, and 10%, respectively.
♮♮♮, ♮♮ and ♮ are significance levels at 1%, 5%, and 10%, respectively for the differences in regression coefficients between two periods.

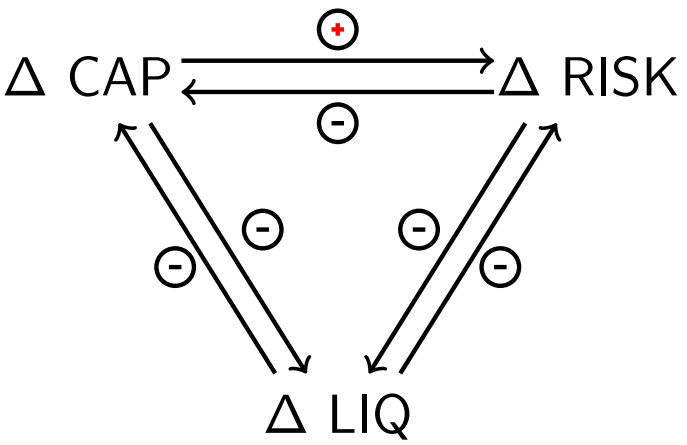
Results: Banks' coordination of capital, risk and liquidity

RWATA:

pre-crisis



crisis



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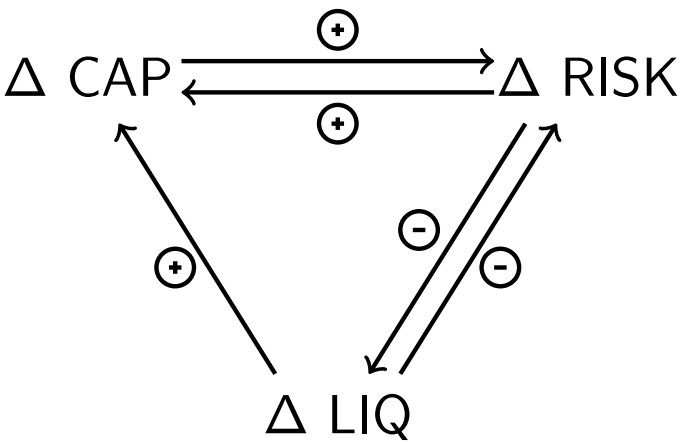
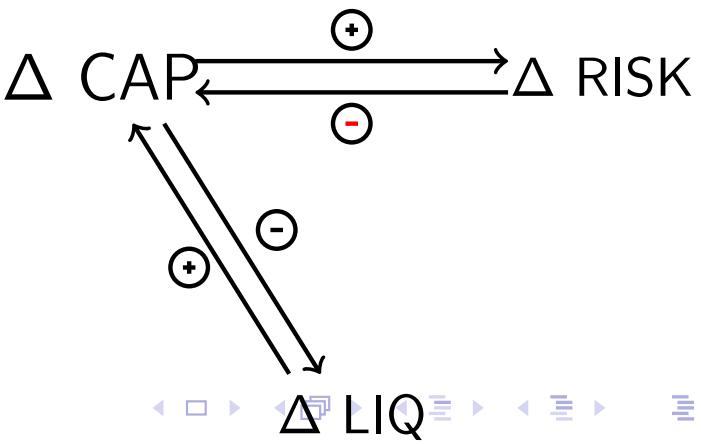


crisis



Conclusions

- show that banks simultaneously coordinate capital and liquidity levels, as well as their risk exposure
- empirically verify the theoretical predictions of Repullo (2005): an increase in capital induces banks to lower risk-taking and reduce liquidity position
- suggest that bank capital and liquidity ought to be regulated jointly:
    - emphasize the importance of liquidity buffer as regulatory tool and support an incorporation of liquidity requirements, in addition to capital requirements, into the Basel III accord