Bank Equity Risk

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Motivation

- Stricter regulation in response to the Great Financial Crisis has led banks to increase their capitalization
- However, several studies suggest that more capital has not led to a decrease in banks' equity risk
- For example, Sarin and Summers (2016) examine bank risk using a range of financial market data and find little support that major institutions are safer now

This paper

- The degree to which banks hold capital *in excess* of regulatory capital is a key determinant of equity risk
- We show in a simple Merton style model, that lower excess capitalization can undo the effect of higher capitalization
- We confirm empirically that this effect can explain preserved equity risk
- Higher capitalization does seem to have reduced the total cost of debt

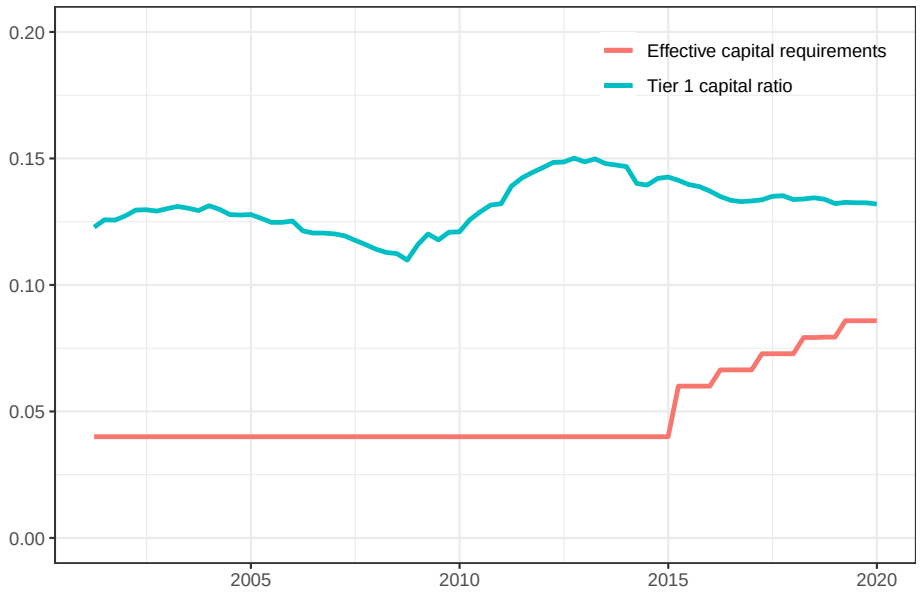


Figure: The excess capital is decreasing.

Risk tolerance and skydiving

- "The safer skydiving gear becomes, the more chances skydivers will take, in order to keep the fatality rate constant".
- Quote of skydiving icon Bill Booth (source: Wikipedia)

Literature

- Banks voluntarily hold excess capital, and actively manage the capital ratios by setting a target on capital ratio (Berger et al., 2008; Flannery and Rangan, 2002; Barth et al., 2008)
- Target capital ratios are affected by the capital requirements. Banks do not distinguish the soft buffer requirement from the hard requirement (Couaillier, 2021)
- Banks adjust capital structure partially and by changing RWA (Gropp et al., 2019; Couaillier, 2021)
- Regulatory default boundary reflecting both debt and regulatory requirement (Chan-Lau and Sy, 2007; Glasserman and Nouri, 2012)
- Banks have incentives to lever up (Hanson et al., 2011; Admati et al., 2018)

Model - assumptions

- The market asset of a bank, V_t, follows a Geometric Brownian motion with drift μ and volatility σ:

$$dV_t = \mu V_t d_t + \sigma V_t dW_t$$

- We assume the market value of a bank's assets is equal to the book value, and there is only one risky asset class
- The bank issues zero-coupon debt with time to maturity T and the face value is D
- Risk-weighted assets (RWA) of a bank is αV where α denotes the bank's risk density

Model - default boundary

- The bank's capital ratio is the book value of equity $(V_T - D)$ divided by the risk-weighted assets αV
- We assume the bank enters resolution when its capital ratio reaches the regulatory capital requirement ρ

$$\frac{V_T - D}{\alpha V_T} = \rho \tag{1}$$

- The solution of V_T of this equation defines the regulatory default boundary D_B:

$$D_B = \frac{D}{1 - \alpha\rho} > D \tag{2}$$

- Bankruptcy costs are large enough to **fully wipe out** the equity when insolvency happens

The default boundary - a reality check

- Having equity wiped out in default - or in resolution - is a realistic assumption
- Conservative valuation principles reduce asset value significantly
- We do not model the dialogue with regulators and corrective measures that would be applied as a bank gets near its boundary
- We treat the buffers as 'hard' requirements
- In practice, corrective measures would include restricting dividend payments and new engagements
- Equity prices would suffer - and this is what our model captures qualitatively

Model - results

- From option pricing theory, the equity price is:

$$E_0 = V_0 \Phi(d_1^{D_B}) - De^{-rT}\Phi(d_2^{D_B})$$

$$\text{where } d_1^{D_B} = \frac{\log \frac{V_0}{D_B} + (r + \frac{\sigma^2}{2})T}{\sigma\sqrt{T}} \text{ , and } d_2^{D_B} = d_1^{D_B} - \sigma\sqrt{T}$$

- The equity volatility is:

$$\sigma_E = \left[\Phi(d_1^{D_B}) + (\alpha\rho)\ \varphi(d_1^{D_B})\frac{1}{\sigma\sqrt{T}}\right]\frac{V_t}{E_t}\sigma$$

- Note the contribution to vol from $\alpha\rho = \frac{D_B - D}{D_B}$

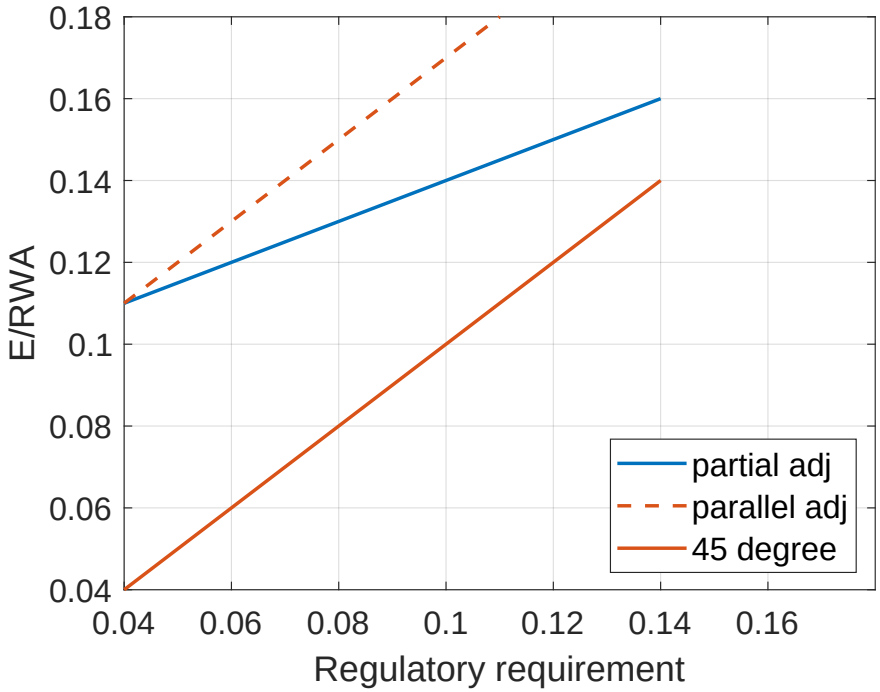
Model - in a figure

- With fixed asset volatility, the equity volatility depends on:
  - Leverage
  - Distance between asset V and regulatory boundary D_B

Figure: Illustration of the basic intuition. Bank B has more capital but its equity vol is larger due to less excess capital.

Capital target and equity vol

- Consider a bank with target capital ratio $= 0.09 + 0.5\rho$, a partial (50%) adjustment when there is stricter regulation
- Equity volatility need not decrease when bank has better capitalization



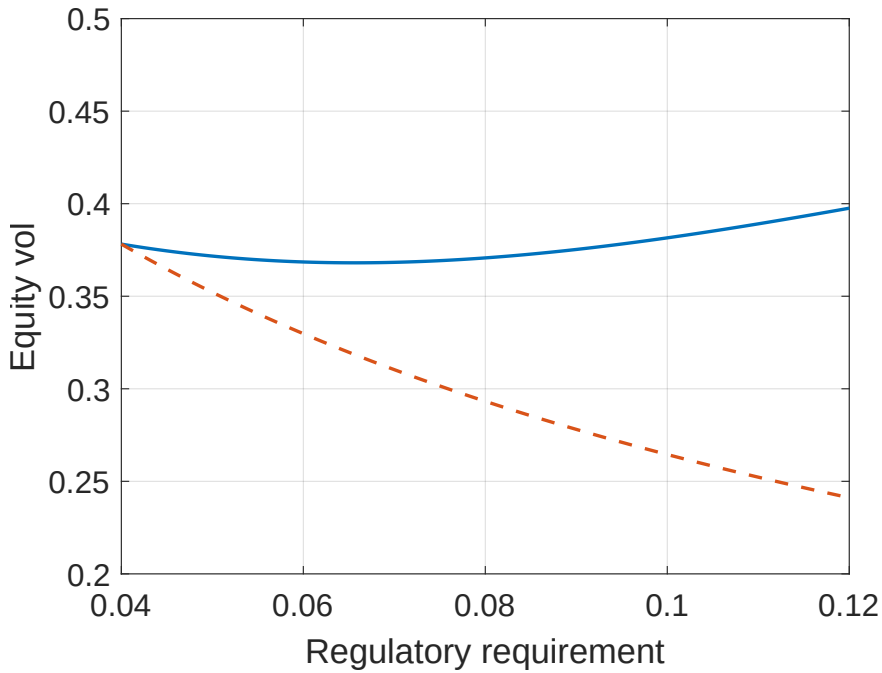
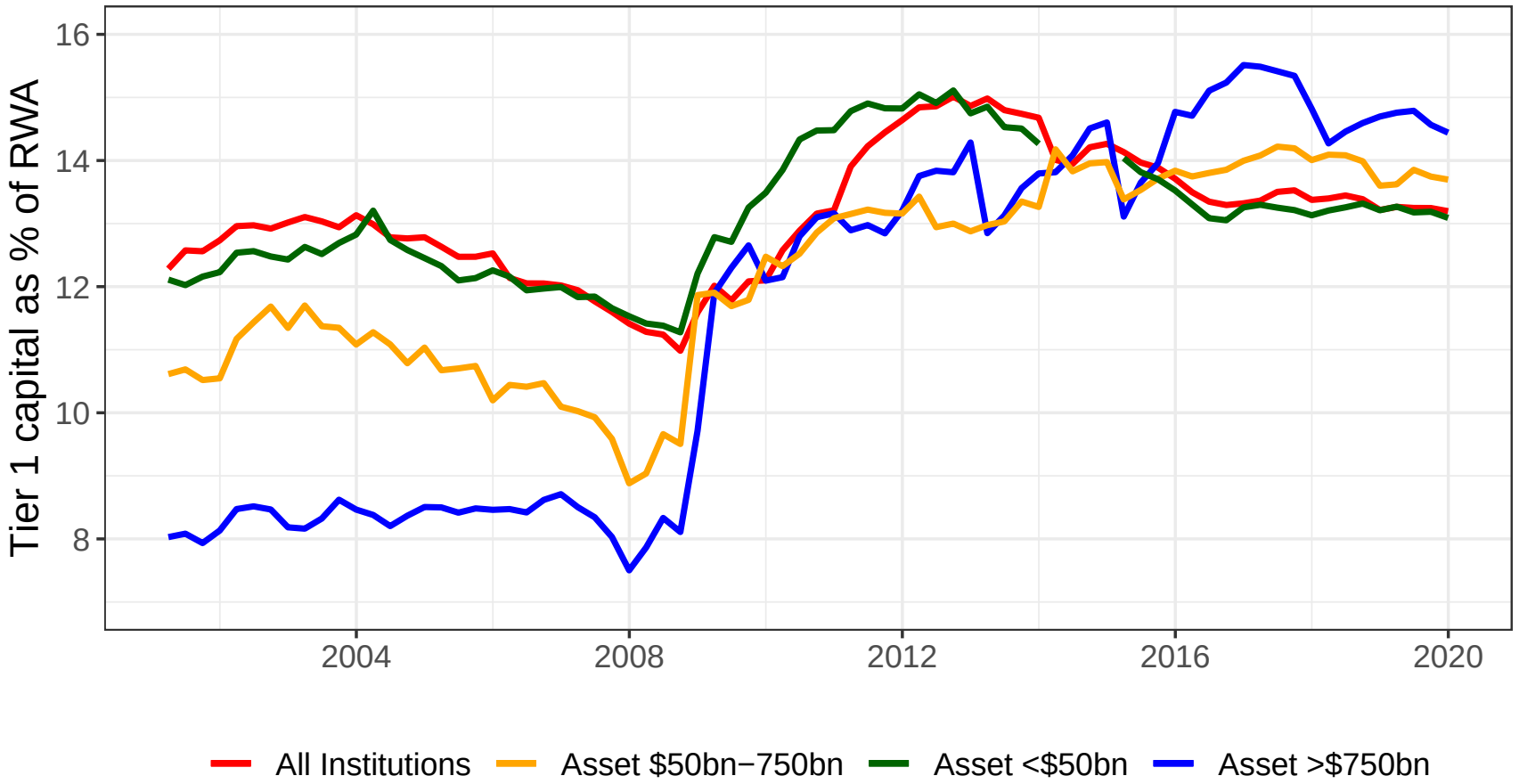


Figure: Effect of increased regulatory requirement on the capital ratio target and equity volatility.

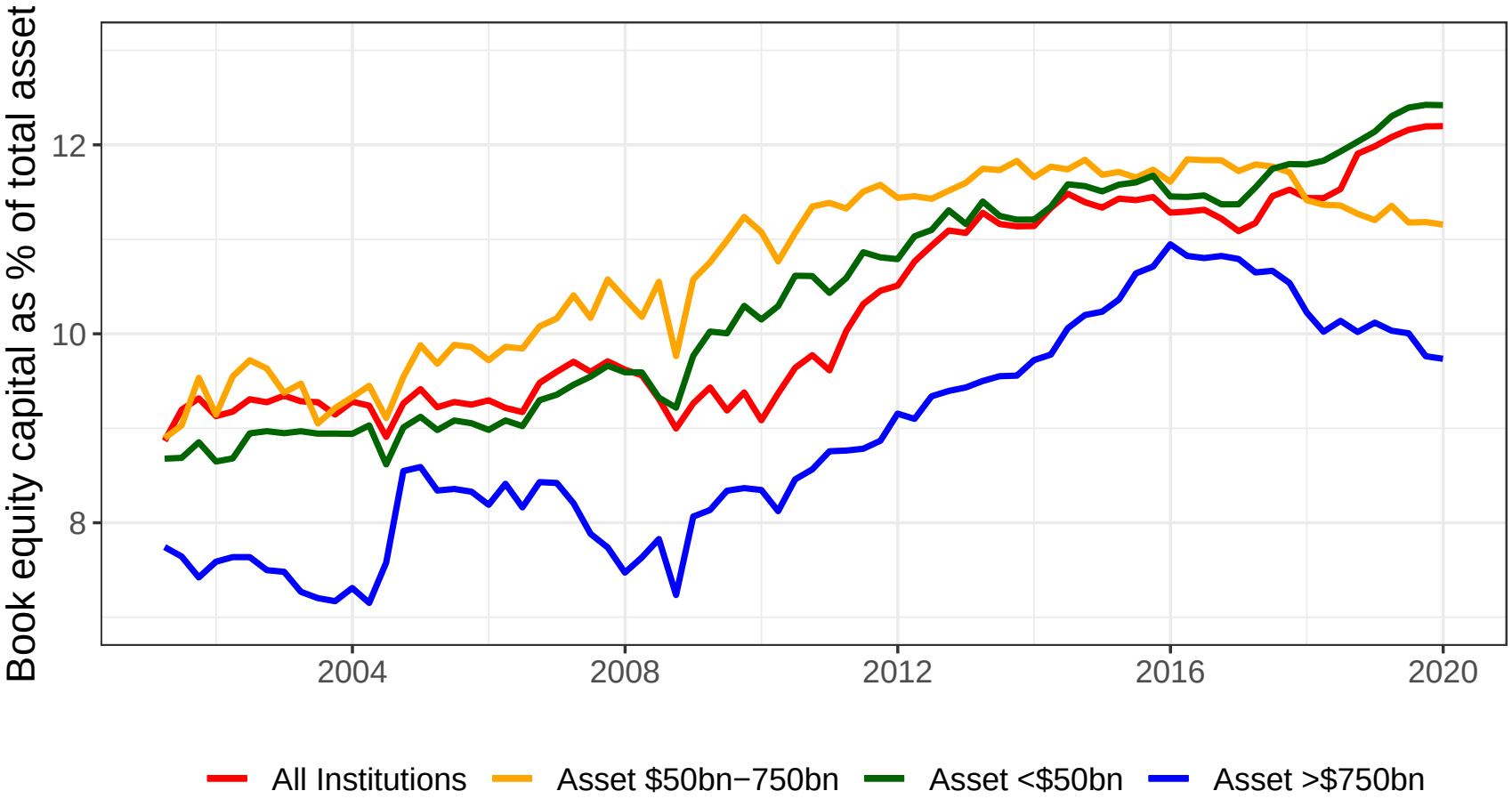
Data: Public US bank holding companies, 2012 - 2019

- Balance sheet data from FR Y-9C reports at consolidated level
- Effective capital requirement is the sum of:
  - Minimum capital requirement (4% before 2015 and 6% since 2015)
  - Capital conservation buffer (since 2015 with a phase-in schedule)
  - Individual capital requirements for G-SIBs (since 2015 with a phase-in schedule)

Tier 1 capital for different bank segments



Book equity over total assets for different bank segments



Measuring equity risk and cost of debt

- Equity risk:
  - Equity beta (CRSP, 252 daily forward looking returns)
  - Historical volatility (CRSP, 252 daily forward looking returns)
  - Implied volatility (OptionMetrics, at-the-money options on bank stocks)
  - Implied cost of equity capital (IBES, monthly analysts forecasts)
    - Idea: Equity value = F(future cash flows, cost of capital)
    - Future cash flows from analyst expectations of short and long term earnings growth rates
    - Find 'implied' cost of capital as solution to the valuation equation
- Cost of debt:
  - Ratio of interest expenses over total liability

Summary statistics

Time: 2002 - 07 (583 BHCs)	N(of bank-month)	Mean	S.D.	Min	1st Qu.	3rd Qu.	Max
Equity beta	29372	0.681	0.628	-1.97	0.12	1.178	3.262
Equity historical vol	29372	0.307	0.15	0.041	0.221	0.347	3.237
ICC (from analysts forecast)	14814	0.092	0.016	0.018	0.084	0.099	0.605
Implied volatility of equity	NaN	NaN	NaN	NaN	NaN	NaN	NaN
Cost of debt	30275	0.059	0.022	0.004	0.042	0.074	0.152
Time: 2010 - 14 (466 BHCs)							
Equity beta	20288	0.824	0.539	-1.404	0.321	1.219	2.968
Equity historical vol	20288	0.35	0.212	0.092	0.221	0.406	2.147
ICC (from analysts forecast)	7365	0.087	0.023	0.003	0.075	0.1	0.283
Implied volatility of equity	3221	0.287	0.132	0.07	0.208	0.323	1.736
Cost of debt	20326	0.025	0.016	0.001	0.013	0.033	0.23
Time: 2015 - 19 (381 BHCs)							
Equity beta	16494	0.989	0.447	-1.454	0.705	1.27	6.54
Equity historical vol	16494	0.299	0.162	0.087	0.223	0.299	5.286
ICC (from analysts forecast)	5754	0.088	0.018	0.006	0.077	0.097	0.189
Implied volatility of equity	5672	0.264	0.086	0.042	0.216	0.288	1.384
Cost of debt	17085	0.015	0.009	0.001	0.009	0.019	0.069
Reg sample: 2012 - 19 (466 BHCs)							
Equity beta	29129	0.893	0.476	-1.454	0.613	1.192	6.54
Equity historical vol	29129	0.288	0.155	0.087	0.215	0.296	5.286
ICC	10400	0.086	0.02	0.003	0.075	0.096	0.236
Implied volatility of equity	8191	0.263	0.095	0.042	0.211	0.289	1.736
Cost of debt	27576	0.016	0.01	0.001	0.009	0.02	0.209

Equity regression: decompose the total capitalization

- Univariate regressions confirm that equity risk goes up when leverage increases and when excess capitalization falls
- We want to understand the joint effect
- Taking logs of equity volatility:

$$\log(\sigma_E) = \log\left(\frac{V}{E}\right) + \log\left(\frac{\partial E}{\partial V}\right) + \log(\sigma)$$

- $\frac{\partial E}{\partial V}$ depends on $\alpha\rho = \frac{D_B - D}{D_B}$ which measures the minimum capitalization
- Regression with leverage, minimum capitalization, and bank fixed effects:

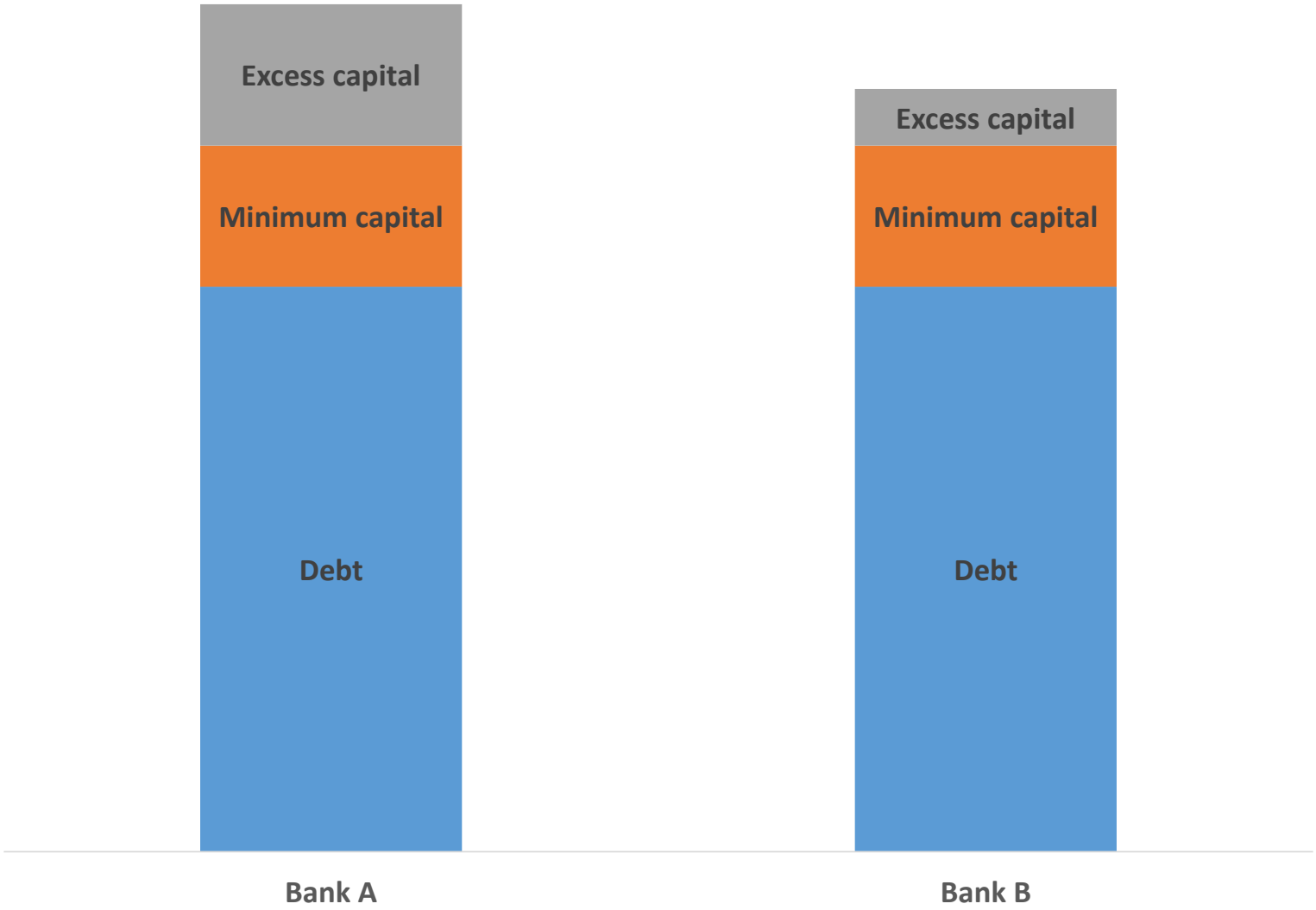
$$\begin{aligned}\log \text{Equity risk}_{i,t} = \beta_1 \log \text{Leverage}_{i,t} + \beta_2 \log \text{Minimum capitalization}_{i,t} \\ + \text{Bank FE}_i + \epsilon_{i,t}\end{aligned}$$

Higher leverage with constant minimum capitalization increases risk

	Dependent variable:							
	Log beta	Log hist. vol	Log ICC	Log impl. vol	Log beta	Log hist. vol	Log ICC	Log impl. vol
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log book leverage	0.0564**	0.0712***	0.1215***	0.2088***				
	(0.0283)	(0.0168)	(0.0256)	(0.0326)				
Log risk leverage					0.1124***	0.1012***	0.1958***	0.0507
					(0.0282)	(0.0166)	(0.0247)	(0.0324)
Log mincap	0.2160***	0.2489***	0.0703***	0.0624***	0.1920***	0.2262***	0.0300***	0.0479***
	(0.0100)	(0.0060)	(0.0081)	(0.0100)	(0.0112)	(0.0067)	(0.0092)	(0.0108)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	23,378	23,889	8,821	7,166	23,378	23,889	8,821	7,166
R^2	0.6090	0.4110	0.3631	0.3401	0.6092	0.4115	0.3661	0.3364
Adjusted R^2	0.6014	0.3999	0.3452	0.3177	0.6016	0.4004	0.3482	0.3139
Note:								*p<0.1; **p<0.05; ***p<0.01

- Book leverage = Book assets/book equity
  Risk leverage = Total RWA/Tier 1 capital
- Fixing the minimum capital required, higher leverage implies higher risk

Balance sheet visualization



Keeping leverage constant increasing minimum capitalization increases risk

	Dependent variable:							
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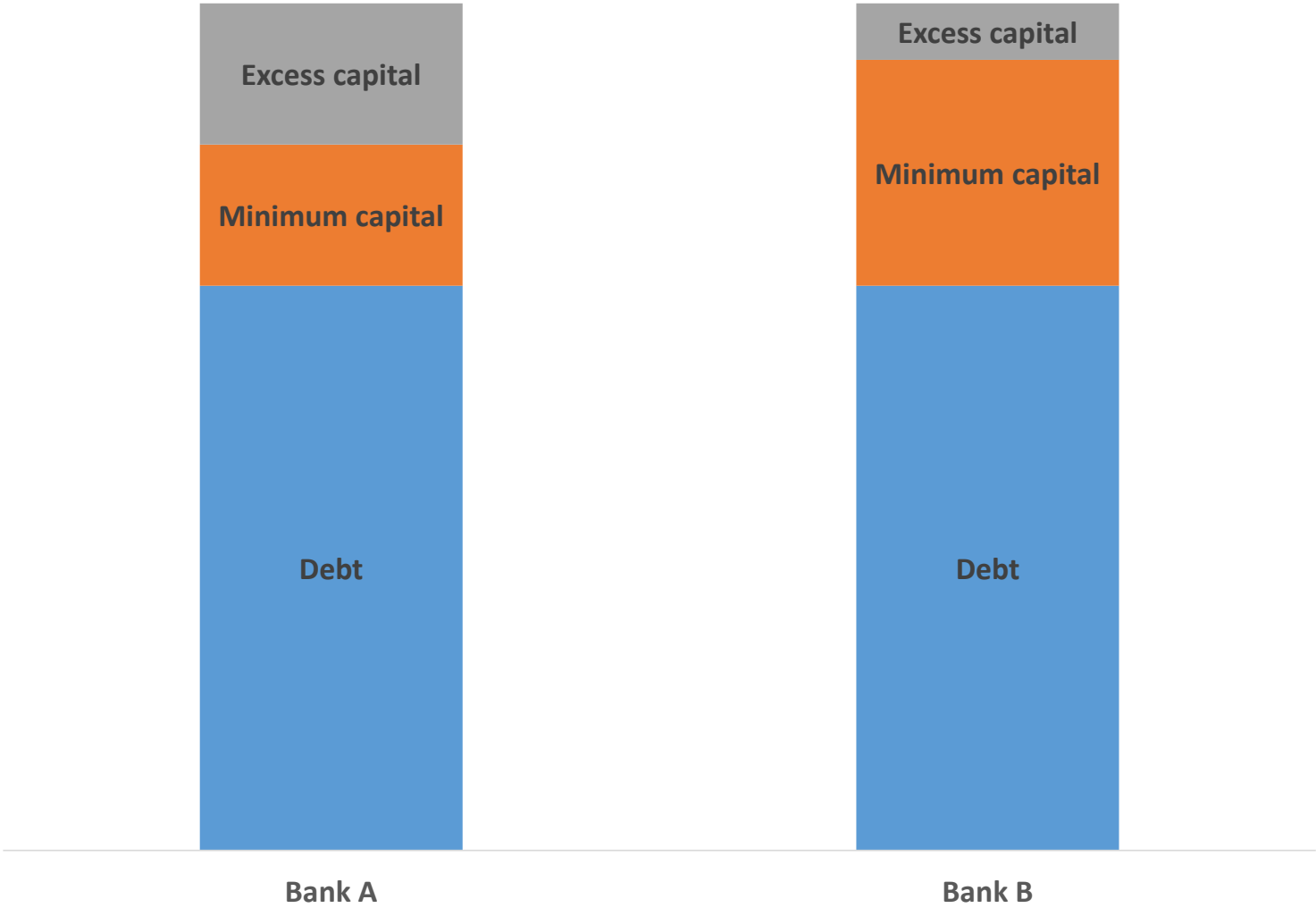
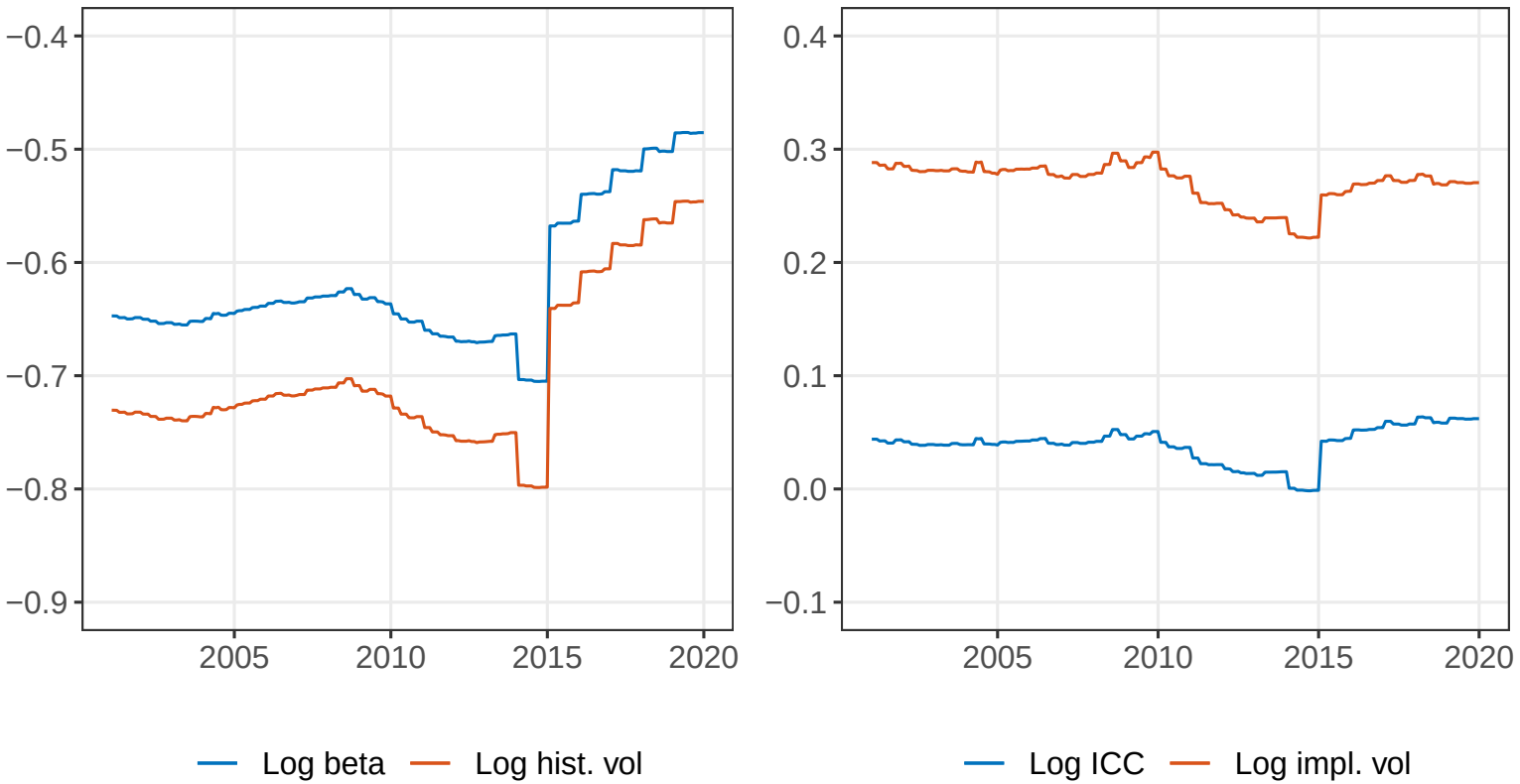
Note:								*p<0.1; **p<0.05; ***p<0.01

- Fixing the leverage, a higher minimum capitalization implies lower *excess* capitalization
- This increases risk

Balance sheet visualization



Effect is large enough to explain equity risk not falling



First compute cross-sectional average of log book leverage and log min capital. Then multiply by coefficients found in regression above at each time point to get time series showing effect is large enough to explain preservation or even increase of risk.

Alternative equity regression: excess capital as residual

- We regress excess capitalization $\frac{V-D_B}{V}$ on total capitalization $\frac{V-D}{V}$
- Residual (orthogonal excess capital) removes correlation between total and excess capitalization
- Expect a negative effect of orthogonal excess capital on risk
- Regression with bank fixed effects:

$$\begin{aligned}\log \text{Equity risk}_{i,t} = \beta_1 \log \text{Leverage}_{i,t} + \beta_2 \text{Orthogonal excess capital}_{i,t} \\ + \text{Bank FE}_i + \epsilon_{i,t}\end{aligned}$$

Equity risk using orthogonalized excess capital

Panel A	*Dependent variable:*							
	Log beta	Log hist. vol	Log ICC	Log impl. vol	Log beta	Log hist. vol	Log ICC	Log impl. vol
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log book leverage	0.0695**	0.1049***	0.1365***	0.2091***				
	(0.0284)	(0.0166)	(0.0257)	(0.0327)				
Log risk leverage					0.1272***	0.0745***	0.1889***	0.0669**
					(0.0276)	(0.0161)	(0.0237)	(0.0317)
Orthogonal excesscapital	−5.5412***	−7.3004***	−1.9229***	−1.3643***	−4.8831***	−6.8099***	−1.0099***	−0.9670***
	(0.2531)	(0.1500)	(0.2010)	(0.2424)	(0.2750)	(0.1627)	(0.2177)	(0.2564)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	23,378	23,889	8,821	7,166	23,378	23,889	8,821	7,166
R^2	0.6092	0.4259	0.3643	0.3394	0.6095	0.4255	0.3669	0.3359
Adjusted R^2	0.6017	0.4151	0.3464	0.3170	0.6020	0.4146	0.3491	0.3134
Note:								*p<0.1; **p<0.05; ***p<0.01

Assets did not become more volatile

Average asset volatility of US banks measured by the implied volatility from the theoretical model in this paper

Assets did not become more volatile

Average asset volatility of US banks measured by the standard deviation of the quarterly percentage change of the book asset using 5 years' observations

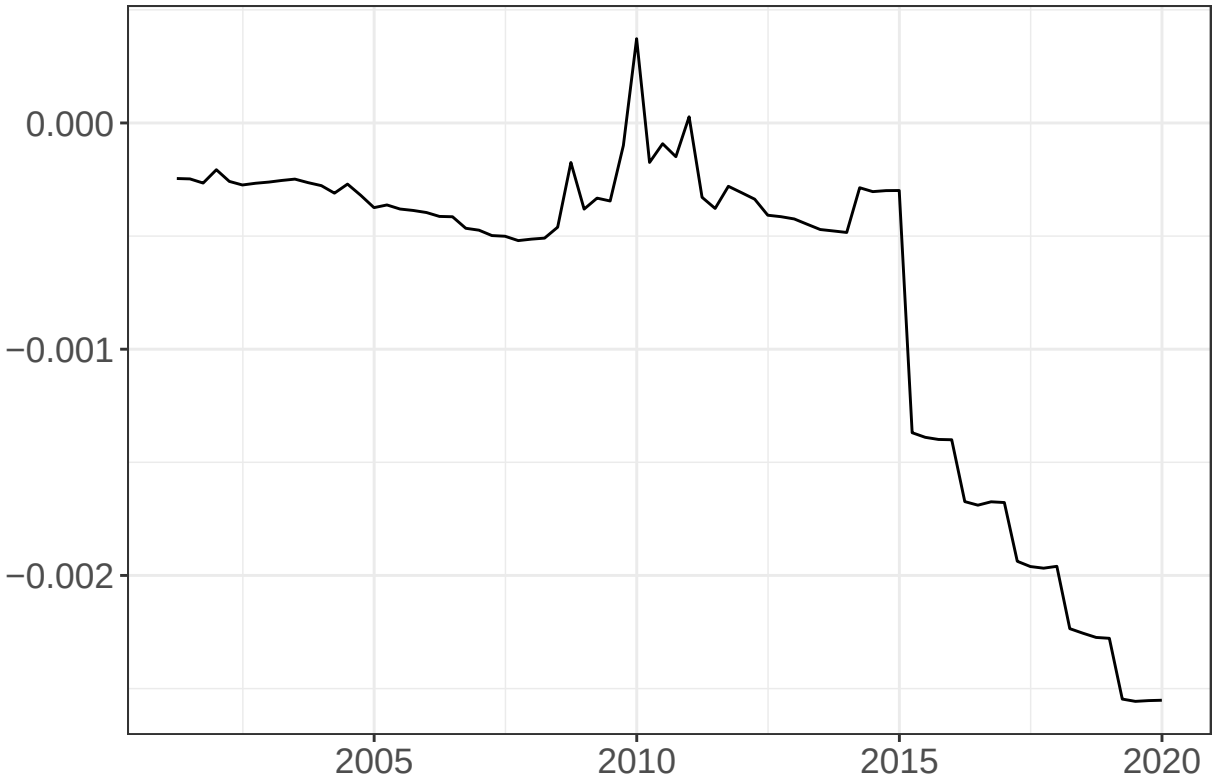
Cost of debt - two competing effects

- Two effects are at play: default probability and recovery
- A higher D_B leaves a larger recovery of debt in default
- However, a higher D_B (keeping asset value fixed) increases default probability
- In reality as bank approaches D_B, regulatory response favors debt over equity
- Our simplified model captures 'damage' to equity, but not attempts to favor debt before D_B is hit
- We test empirically whether debt is safer

Cost of debt (with bank FE)

	Dependent variable:			
	Cost of debt spread			
	(1)	(2)	(3)	(4)
Book leverage	0.0001***			
	(0.00004)			
Risk leverage		0.0002***		
		(0.00005)		
Excesscapital			−0.0126***	
			(0.0038)	
Mincapital	−0.0556***	−0.0630***	−0.0683***	−0.0559***
	(0.0107)	(0.0109)	(0.0114)	(0.0107)
Treasury yield 1Y	−0.5371***	−0.5324***	−0.5365***	−0.5399***
	(0.0164)	(0.0165)	(0.0164)	(0.0164)
Loan to asset ratio	0.0075***	0.0066***	0.0073***	0.0077***
	(0.0014)	(0.0014)	(0.0014)	(0.0014)
Deposit to liability ratio	−0.0420***	−0.0418***	−0.0421***	−0.0424***
	(0.0014)	(0.0014)	(0.0014)	(0.0014)
Cash to asset ratio	0.0113***	0.0119***	0.0113***	0.0122***
	(0.0022)	(0.0022)	(0.0022)	(0.0022)
Loan tightening index	−0.00003***	−0.00003***	−0.00003***	−0.00003***
	(0.00001)	(0.00001)	(0.00001)	(0.00001)
Interest rate margin	0.0118***	0.0118***	0.0119***	0.0119***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Bank FE	Yes	Yes	Yes	Yes
Observations	7,626	7,626	7,626	7,626
R^2	0.8603	0.8604	0.8604	0.8602
Adjusted R^2	0.8518	0.8519	0.8519	0.8517
Note:				*p<0.1; **p<0.05; ***p<0.01

Effect is large enough to explain falling cost of debt



We calculate cross-sectional average of book leverage and mincapital, multiply by regression coefficients and add up at each point in time.

Market-to-book ratio

- Sarin and Summers (2016) also note a declining ratio of market-to-book for banks
- They point to a falling franchise value, this leads to a lower equity valuation, higher leverage, and higher risk
- We argue that lower excess capital can help explain the declining market-to-book ratio
- When asset approaches default boundary, market value of equity goes to zero, book value remains larger than $D_B - D$

Market-to-book (with bank FE)

	Dependent variable:			
	Δ ME/BE ratio			
	(1)	(2)	(3)	(4)
ΔBook leverage	0.0226***		0.0329***	
	(0.0015)		(0.0015)	
ΔRisk leverage		0.0022*		0.0047***
		(0.0013)		(0.0014)
Δ Mincapital	−6.9377***	−6.8338***		
	(0.7188)	(0.7233)		
ΔOrthogonal excesscapital			10.2251***	10.7186***
			(0.3776)	(0.3826)
ΔLoan to asset ratio	0.2904***	0.2619***	0.5635***	0.5363***
	(0.0868)	(0.0873)	(0.0816)	(0.0825)
ΔDep. to liability ratio	−0.2124***	−0.2744***	−0.2128***	−0.3022***
	(0.0588)	(0.0590)	(0.0595)	(0.0600)
ΔCash to asset ratio	−0.3451***	−0.2213***	−0.2811***	−0.1146
	(0.0833)	(0.0834)	(0.0806)	(0.0811)
ΔLoan tight index	−0.0016***	−0.0016***	−0.0018***	−0.0018***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
ΔInterest margin	0.0864***	0.0829***	0.1732***	0.1792***
	(0.0186)	(0.0187)	(0.0152)	(0.0154)
Bank FE	Yes	Yes	Yes	Yes
Observations	24,221	24,221	24,478	24,478
R^2	0.0308	0.0212	0.0751	0.0558
Adjusted R^2	0.0118	0.0021	0.0573	0.0376
Note:				*p<0.1; **p<0.05; ***p<0.01

Conclusion

- Our model suggests: distance from the regulatory boundary, not just the amount of capital, is a critical determinant of bank equity risk
- We test the key implication and confirm that equity risk increases as the excess capitalization decreases
- Cost of debt (as measured through actual interest paid by banks) does go down with more capital
- Our model can also explain why market-to-book is reduced for riskier equity

Appendix: Robustness test - using bank variables instead of FE

	Dependent variable:							
	Log beta	Log hist. vol	Log ICC	Log impl. vol	Log beta	Log hist. vol	Log ICC	Log impl. vol
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log book leverage	−0.6255***	0.2782***	0.0149	0.0144				
	(0.0206)	(0.0096)	(0.0135)	(0.0161)				
Log risk leverage					0.1178***	0.0853***	0.0171	−0.2611***
					(0.0251)	(0.0118)	(0.0158)	(0.0185)
Orthogonal excess capital	−6.2492***	−5.5206***	−2.5721***	−1.3168***	−6.8420***	−4.6421***	−2.5012***	−2.5243***
	(0.3582)	(0.1708)	(0.2045)	(0.2591)	(0.3782)	(0.1790)	(0.2172)	(0.2685)
Asset return s.d.	0.2441***	0.3735***	0.3851***	0.3881***	0.5473***	0.1966***	0.3738***	0.4405***
	(0.0737)	(0.0351)	(0.0400)	(0.0550)	(0.0750)	(0.0357)	(0.0396)	(0.0533)
Loan to asset ratio	−0.6074***	−0.1971***	0.0796***	−0.0207	−0.6828***	−0.2230***	0.0714**	0.1160***
	(0.0457)	(0.0218)	(0.0271)	(0.0309)	(0.0480)	(0.0228)	(0.0279)	(0.0319)
Deposit to liability ratio	−0.7017***	0.3025***	−0.5234***	0.3132***	−0.7478***	0.3342***	−0.5222***	0.2991***
	(0.0417)	(0.0200)	(0.0227)	(0.0271)	(0.0426)	(0.0203)	(0.0227)	(0.0267)
Cash to asset ratio	−0.3556***	0.4326***	−0.1728***	−0.0241	−0.6928***	0.5798***	−0.1670***	0.0356
	(0.1050)	(0.0501)	(0.0558)	(0.0806)	(0.1067)	(0.0507)	(0.0554)	(0.0784)
Loan tightening index	0.0152***	0.0095***	0.0009**	0.0028***	0.0154***	0.0094***	0.0009**	0.0026***
	(0.0006)	(0.0003)	(0.0004)	(0.0005)	(0.0006)	(0.0003)	(0.0004)	(0.0005)
Interest rate margin	0.0438	0.7684***	0.1164***	−0.0975***	0.0745**	0.7670***	0.1182***	−0.1468***
	(0.0328)	(0.0156)	(0.0210)	(0.0265)	(0.0335)	(0.0159)	(0.0210)	(0.0263)
Constant	2.1273***	−4.5088***	−2.5214***	−4.0358***	0.4891***	−4.0649***	−2.5249***	−3.3969***
	(0.1195)	(0.0565)	(0.0747)	(0.0971)	(0.1232)	(0.0581)	(0.0763)	(0.0978)
Bank FE	No	No	No	No	No	No	No	No
Observations	20,869	21,288	7,929	6,612	20,869	21,288	7,929	6,612
R^2	0.1275	0.1925	0.1093	0.0655	0.0898	0.1629	0.1093	0.0929
Adjusted R^2	0.1272	0.1922	0.1084	0.0643	0.0895	0.1626	0.1084	0.0918

Note: *p<0.1; **p<0.05; ***p<0.01

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