Earnings smoothing and its effect on banks' other actions

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Motivation

- Accounting noise due to earnings smoothing. Bank executives control the earnings smoothing.
- Shareholders control dividends and equity issuances.
- Shareholders observe accounting values that are noisy (uncertainty in the book values). How does this noise affect shareholders' optimal dividend and recapitalization policy?

Main result

- Optimal policy:
  (1) When capital buffer (equity over debt) is bigger than the dividend barrier, bank pays dividends.
  (2) When capital buffer is smaller than the equity issuance barrier, new equity is sold.
  (3) Once capital buffer hits the default barrier, bank defaults.
  (4) Bankers use earnings smoothing to maximize market equity value.

- Calibration result (22 US banks, from 1993 to 2014):
  (1) Small banks use more earnings smoothing.
  (2) In out-of-sample test, our partially observed model fits banks' realized actions well.
  (3) Most banks used earnings smoothing during the latest financial crisis.

Related papers

- Empirical papers on earnings smoothing:
  - Bhat (1996)
  - Ahmed, Takeda, Thomas (1999)
  - Goel and Thakor (2003)
  - Anandarajan, Hasan, Lozano-Vivas (2005)
- Theoretical bank models:
  - Milne and Roberson (1996)
  - Milne and Whalley (2001)
  - Cadenilla, Choulli and Taksar (2006)
  - Peura and Keppo (2006)
  - Huang and Liu (2007)
  - Sotomayor and Cadenillas (2013)
- Mathematical methods:
  - Bensoussan (2004)
  - Dai and Zhong (2008)
  - Durbin and Koopman (2012)

Fully observed benchmark model - Shareholders

Shareholders optimize dividend and equity issuances. Market value of bank equity as a percentage of the debt:

$$\max_{\pi\in\Pi}\mathbb{E}^{X_0}\left[\int_0^{\tau^\pi} e^{-(\delta-\mu)t}dL_t^\pi - \sum_i e^{-(\delta-\mu)(t_i^\pi+\Delta)}\left(s_i^\pi+K\right)\mathbf{1}_{\{t_i^\pi+\Delta<\tau^\pi\}}\right],$$

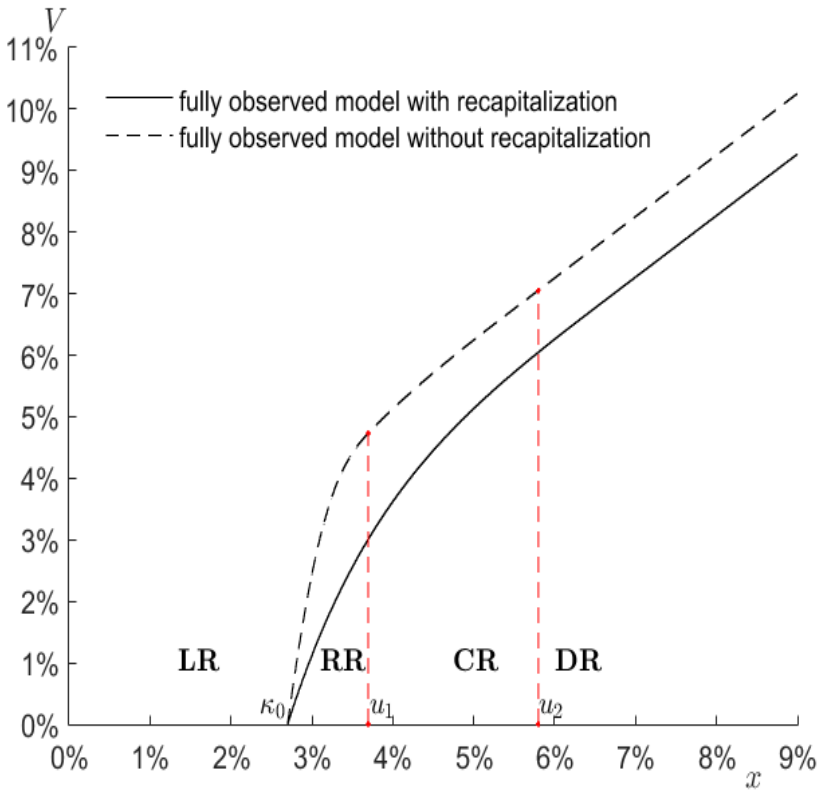
$$X_t^\pi = X_0 + \int_0^t (X_u^\pi+1)(\alpha-\mu)du + \int_0^t (X_u^\pi+1)\sigma dW_u - L_t^\pi + \sum_i s_i^\pi \mathbf{1}_{\{t_i^\pi+\Delta\le t\}},$$

Default time: $\tau^\pi = \inf\{t : X_t^\pi < \kappa_0\}$.

- μ is the growth rate of debt D_t: $dD_t = \mu D_t dt$.
- α and σ are the drift and volatility of total asset Y_t: $dY_t = \alpha Y_t dt + \sigma Y_t dW_t$.
- X_t: the capital buffer (ratio) defined as equity over debt.
- L_t: cumulative dividends, control variable.
- s_i: amount of new equity injected. K is the cost.
- Δ: the delay of equity issuances. δ is the discount factor of dividends.
- κ_0: liquidation barrier. τ is the corresponding stopping time.

Fully observed benchmark model - Model analysis

- u_1: equity issuance barrier, when capital buffer falls lower than it, new equity is issued.
- u_2: dividend barrier, when capital buffer exceeds it, bank pays dividends.



Partially observed model - Shareholders

Due to accounting noise, book value of total assets Y_t is partially observed:

$$dZ_t = \log(Y_t)dt + mdW_z(t),\ \ \rho = \text{corr}(W_z(t), W(t))$$

Consider first two moments, the mean and variance of log total asset:

$$\hat{M}_t = \mathbb{E}[\log(Y_t)|\mathcal{G}_t],\ \ S_t = \mathbb{E}[(\log(Y_t) - \hat{M}_t)^2|\mathcal{G}_t].$$

The market value of bank equity for partially observed model:

$$\max_{\pi\in\Pi} \mathbf{E}^{\hat{X}_0,S_0}\left[\int_0^{\hat{\tau}^\pi} e^{-(\delta-\mu)}dL_t^\pi - \sum_i e^{-(\delta-\mu)(t_i^\pi+\Delta)}(s_i^\pi + K)\mathbf{1}_{\{t_i^\pi+\Delta<\hat{\tau}^\pi\}}\middle|\mathcal{G}\right]$$

$$\hat{X}_t^\pi = \mathbb{E}[X_t|\mathcal{G}_t] = X_0 + \int_0^t (\hat{X}_u^\pi + 1)(\alpha-\mu)du + \int_0^t (\hat{X}_u^\pi + 1)\left(\frac{S_u}{m} + \sigma\rho\right)d\widetilde{W}_z(u)$$
$$-L_t^\pi + \sum_i s_i^\pi \mathbf{1}_{\{t_i^\pi+\Delta\le t\}},$$

Default time: $\hat{\tau}^\pi = \inf\left\{t|\hat{X}_t^\pi < \frac{\kappa_0 - \Phi^{-1}(a)\sqrt{\exp(S_t)-1}}{1+\Phi^{-1}(a)\sqrt{\exp(S_t)-1}}\right\}.$

Partially observed model - Bankers

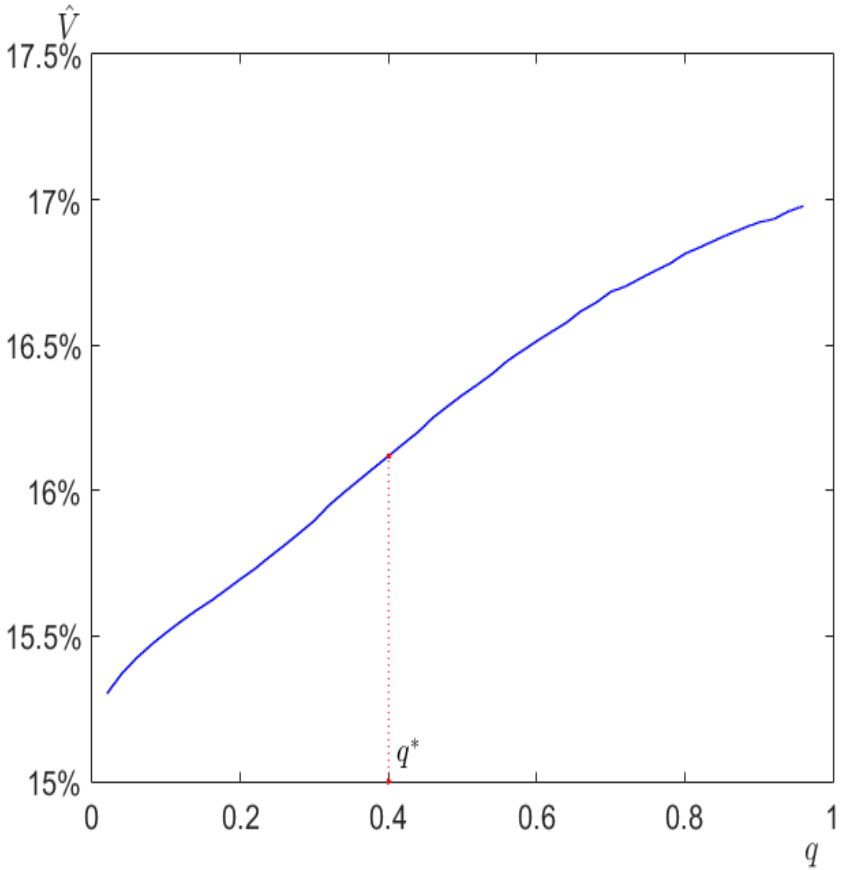
- We assume that bank executives are minority shareholders $\Longrightarrow$ they also maximize the market value of equity. However, there is a cost for earnings smoothing (e.g. regulation, monitoring by analysts):

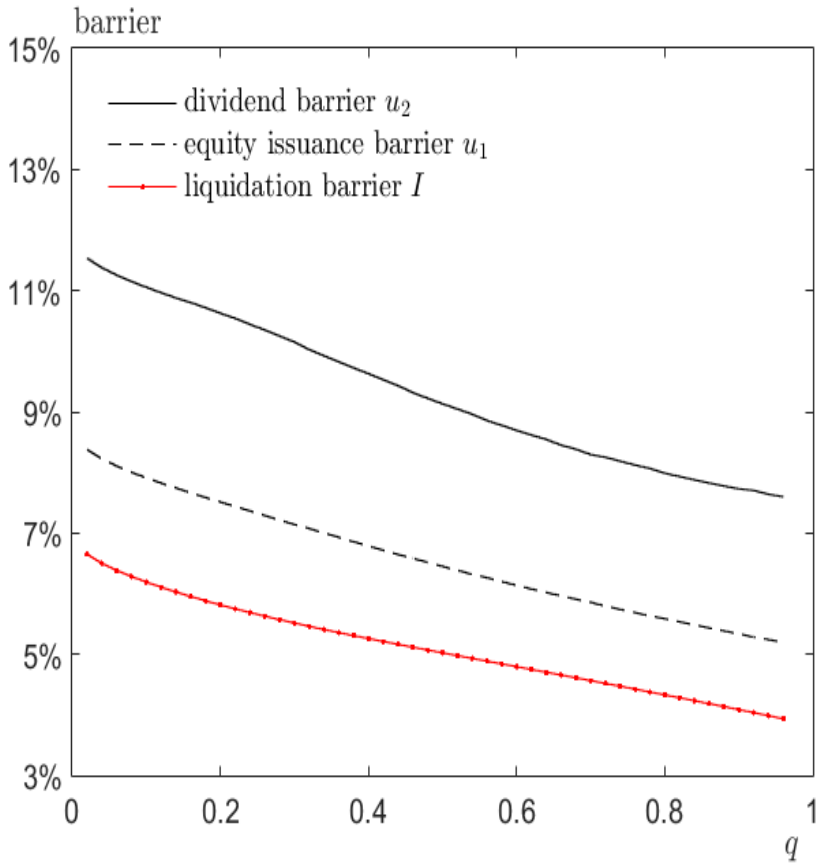
$$\max_{q\in[0,1]} \left\{ \hat{V}(\hat{X}, S; C_1, -q) - C_2 \hat{X} q \right\}$$

  where $m = C_1 q^*$, $\rho = -q^*$
  and the cost of earnings smooth $=$ equity $\cdot\, C_2 q^*$ for the optimal q^*.
- The market equity value rises in m and falls in ρ $\Longrightarrow$ incentive for earnings smoothing (high m and highly negative rho).
- When calibrated to data:
  (1) All banks: $q^* = 0.40$ (so $\rho = -40\%$), $C_1 = 0.018$ (so $m = 0.72\%$), $C_2 = 1.21$.
  (2) Small banks: $q^* = 0.65$ (so $\rho = -65\%$), $C_1 = 0.016$ (so $m = 1.07\%$), $C_2 = 0.53$.
  (3) Thus, small banks have lower cost for earnings smoothing (less regulation, fewer analysts follow small banks etc) and they do more smoothing.

Partially observed model - Model analysis (Cont'd)

- The market equity value rises in q (the level of earnings smoothing).
- The dividend barrier u_2, equity issuance barrier u_1 and liquidation barrier I all fall in q.





Partially observed model - Estimation method

We estimate the dynamic error (due to business and economics uncertainties over time) and static error (uncertainty in the current accounting values, earnings smoothing if ρ negative) through Kalman filter recursion and corresponding likelihood function.

$$M_{t+1} = (1 - \sigma\rho)M_t + (\alpha - \frac{\sigma^2}{2}) + \sigma\rho M_t^{ac} + \sigma\sqrt{1-\rho^2}\eta_t,$$
$$M_t^{ac} = M_t + me_t,$$
$$\text{cov}(e_t, \eta_t) = 0, \ \eta_t \sim_{iid} \mathcal{N}(0,1), \ e_t \sim_{iid} \mathcal{N}(0,1).$$

- In our sample, 86% of the banks have negative ρ, which indicates earnings smoothing.

Partially observed model - Calibration

- Data set: accounting values of 22 banks in US from $1993Q1$ to $2014Q4$.

/ million dollars	book value of equity			book value of total asset			market capitalization		
Bank	max	min	average	max	min	average	max	min	average
JPMORAN	298,483	1,2171	125,021	2,573,126	149,888	1,192,990	216,725	8,690	88,230
BANK OF AMERICA	284,866	11,685	116,204	2,264,909	157,686	1,150,263	205,676	12,444	90,237
WELLS FARGO & CO	210,051	4,997	63,713	1,687,155	50,782	628,089	275,934	6,435	85,580
BBVA	93,117	6,443	41,240	840,983	80,532	440,627	84,879	5,071	35,270
US BANK CORP	45,486	763	17,515	402,529	7,636	179,728	78,358	1,030	33,402
PNC FINANCIAL SVCS GROUP	43,479	5,317	15,576	345,072	62,080	147,905	47,375	4,956	17,713
STATE STREET CORP	42,513	2,265	18,013	274,119	18,720	111,229	28,584	2,315	13,599
BB&T CORP	23,165	642	10,503	186,814	5,898	96,871	28,373	716	13,106
SUNTRUST BANKS INC	23,632	3,395	11,954	190,328	40,728	128,744	26,307	5,301	14,146
FIFTH THIRD BANCORP	15,474	1,365	8,555	138,706	11,966	77,673	33,908	2,163	14,477
NORTHERN TRUST CORP	14,512	1,574	6,396	109,947	16,903	54,598	15,127	1,887	8,829
KEY CORP	13,868	4,901	7,971	104,531	59,631	84,819	14,369	3,995	9,003
M&T BANK CORP	12,056	938	4,236	96,686	10,365	46,442	16,364	911	6,883
COMERICA INC	7,382	2,328	4,519	69,190	30,295	50,451	9,846	2,767	6,234
HUNTINGION BANCSHARES	7,624	1,635	3,728	66,298	17.619	37,593	7,794	992	4,151
ZIONS BANKCORPORATION	8,573	481	3,629	57,209	4,366	32,860	8,305	474	3,486
POPULAR INC	6,846	1,415	3,937	48,624	1,151	31,520	5,694	685	2,743
CITY NATIONAL CORP	3,189	488	1,489	32,610	3,013	14,120	4,134	303	2,007
BOKFINANCIAL NATIONAL CORP	3,878	252	1,648	29,090	2,917	15,111	4,614	334	2,053
FIRST HORIZON NATIONAL CORP	4,663	922	2,481	37,918	9,609	23,050	5,326	1,190	2,889
UMB FINANCIAL CORP	2,326	953	1,384	17,501	6,281	96,989	2,883	578	1,179
BANK OF HAWAII CORP	2,400	1,055	1,592	15,017	9,462	12,458	2,599	1,077	1,784

Partially observed model - Model calibration

- The average capital buffer of sample is 11.8%. Perfectly observed model yields an average capital buffer 5.0% for the sample banks, while the partially observed model yields an average capital buffer 9.9%.

perfectly observed model with recaptalization										
All banks	μ	α	σ	δ	κ_0	u_1	u_2	u_0		
mean	7.56%	7.66%	0.70%	14.26%	3.50%	3.74%	5.01%	5.28%		
stdev	6.03%	6.00%	0.24%	3.19%	1.47%	1.38%	1.77%	2.14%		
partially observed model with recapitalization										
All banks	μ	α	σ	m	ρ	δ	κ_0	u_1	u_2	u_0
mean	7.56%	7.73%	1.40%	0.72%	−41.48%	9.33%	6.47%	5.68%	9.86%	12.65%
stdev	6.03%	5.99%	0.62%	0.45%	55.26%	5.90%	1.35%	1.33%	2.33%	5.68%
Correlation (p-value)										
μ	100%	96%	6%	−55%	43%	91%	−63%	−17%	−45%	−37%
α		100%	2%	−56%	40%	92%	−63%	−16%	−46%	−37%
σ			100%	89%	−12%	−35%	77%	−16%	34%	11%
m				100%	−19%	−43%	78%	−36%	17%	−2%
ρ					100%	36%	−40%	18%	8%	8%
δ						100%	−36%	−31%	−61%	−56%
κ_0							100%	−27%	9%	−8%

Partially observed model - Model calibration

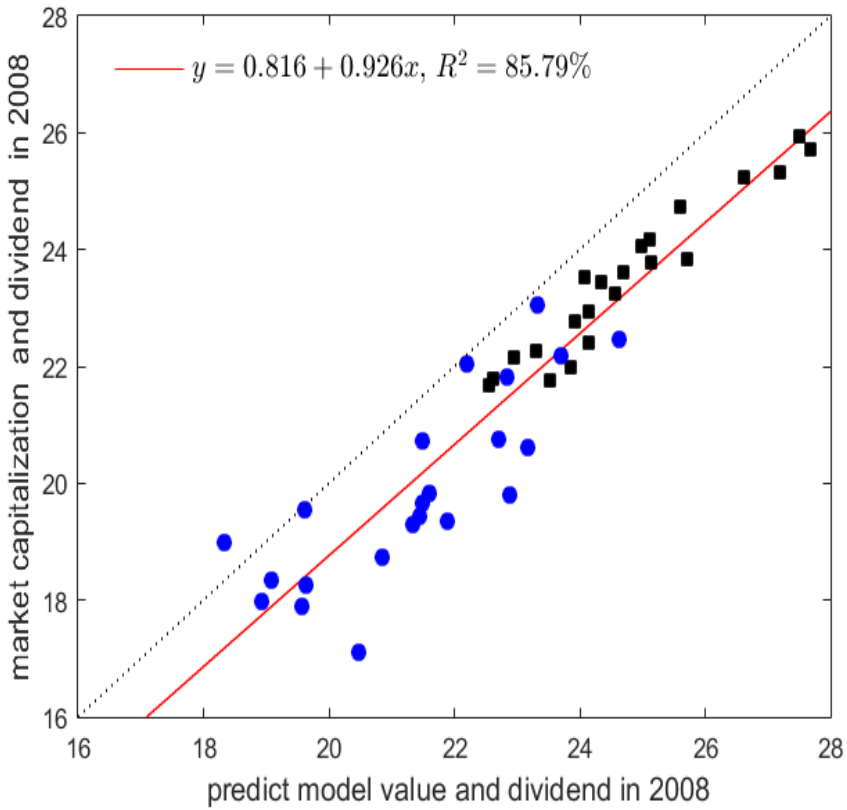
- Small banks have higher noise level and more negative correlation between asset value noise and earnings.

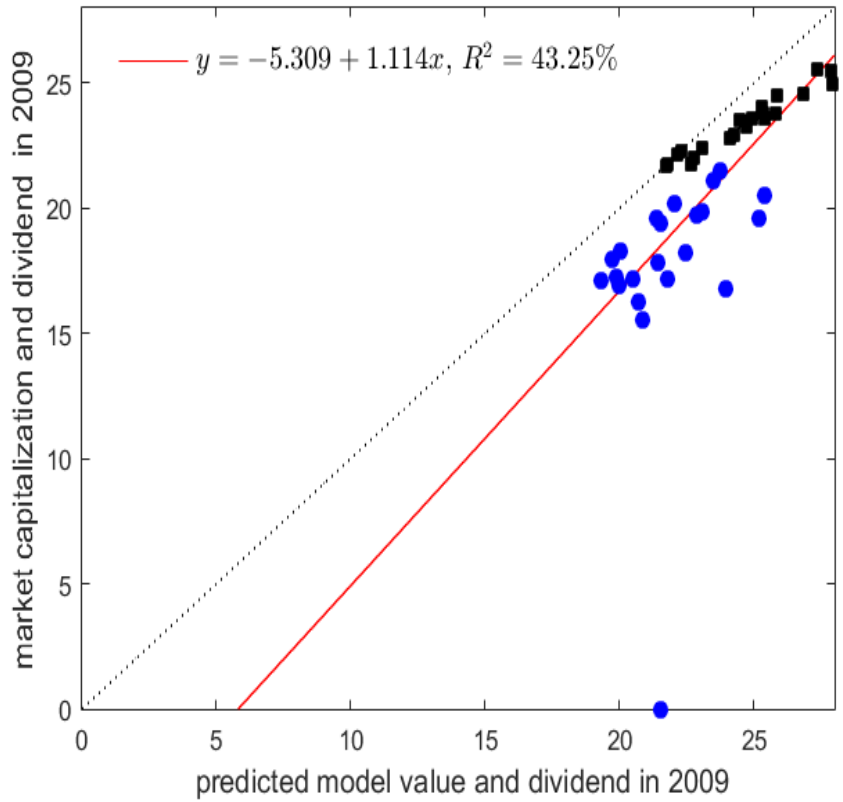
perfectly observed model with recaptalization										
All banks	μ	α	σ	δ	κ_0	u_1	u_2	u_0		
mean	7.56%	7.66%	0.70%	14.26%	3.50%	3.74%	5.01%	5.28%		
stdev	6.03%	6.00%	0.24%	3.19%	1.47%	1.38%	1.77%	2.14%		
partially observed model with recapitalization										
All banks	μ	α	σ	m	ρ	δ	κ_0	u_1	u_2	u_0
mean	7.56%	7.73%	1.40%	0.72%	−41.48%	9.33%	6.47%	5.68%	9.86%	12.65%
stdev	6.03%	5.99%	0.62%	0.45%	55.26%	5.90%	1.35%	1.33%	2.33%	5.68%
Perfectly observed model with recapitalization										
Small banks	μ	α	σ	δ	κ_0	u_1	u_2	u_0		
mean	4.69%	4.84%	0.87%	18.12%	3.86%	3.90%	4.97%	4.98%		
stdev	5.51%	5.49%	0.23%	12.15%	1.07%	1.23%	0.99%	1.00%		
partially observed model with recapitalization										
Small banks	μ	α	σ	m	ρ	δ	κ_0	u_1	u_2	u_0
mean	4.69%	5.00%	1.99%	1.11%	−67.46%	7.10%	6.97%	5.36%	10.98%	14.35%
stdev	5.51%	5.53%	0.68%	0.61%	22.19%	4.21%	1.84%	1.66%	1.98%	4.78%

Partially observed model - Out of sample

We use recession period (2008 – 09) as our out-of-sample period:

- log of market equity value
- log of dividends





Partially observed model - Out of sample

Out of sample	Year 2008	Year 2009	Year 2010	Year 2011
Bank	$(\hat{Y} - Y^{ac})/Y^{ac}$	$(\hat{Y} - Y^{ac})/Y^{ac}$	$(\hat{Y} - Y^{ac})/Y^{ac}$	$(\hat{Y} - Y^{ac})/Y^{ac}$
JPMORAN	-1.32%	$+0.66\%$	-1.04%	$+0.15\%$
BANK OF AMERICA	-2.01%	-0.12%	-0.73%	-0.99%
WELLS FARGO & CO	$+1.64\%$	-1.09%	-0.16%	$+0.29\%$
BBVA	-0.83%	-0.76%	-0.74%	$+0.55\%$
US BANK CORP	-1.17%	-0.10%	$+1.18\%$	$+1.58\%$
PNC FINANCIAL SVCS GROUP	$+0.64\%$	-1.20%	-1.89%	-0.34%
STATE STREET CORP	-2.69%	$+3.82\%$	$+3.03\%$	$+2.47\%$
BB&T CORP	-2.23%	-1.24%	-1.53%	-0.25%
SUNTRUST BANKS INC	-4.34%	-1.82%	$+0.77\%$	$+3.26\%$
FIFTH THIRD BANCORP	-3.15%	-2.91%	$+0.60\%$	$+2.37\%$
NORTHERN TRUST CORP	-3.89%	-2.89%	-2.15%	-0.23%
KEY CORP	-3.57%	-2.72%	-1.18%	$+1.86\%$
M&T BANK CORP	-2.81%	$+2.34\%$	-2.50%	$+1.62\%$
COMERICA INC	-2.06%	-3.86%	-1.04%	$+1.22\%$
HUNTINGION BANCSHARES	-1.93%	-3.22%	-2.49%	-0.94%
ZIONS BANKCORPORATION	-2.64%	-1.41%	-5.28%	-1.69%
POPULAR INC	-0.17%	$+0.70\%$	-5.06%	-2.94%
CITY NATIONAL CORP	-3.24%	-4.02%	-2.40%	-2.41%
BOKFINANCIAL NATIONAL CORP	-0.53%	-2.14%	-3.69%	-3.41%
FIRST HORIZON NATIONAL CORP	-7.48%	-0.99%	$+2.87\%$	$+0.33\%$
UMB FINANCIAL CORP	$+1.00\%$	-0.83%	$+2.63\%$	$+2.36\%$
BANK OF HAWAII CORP	-0.78%	-3.97%	-4.15%	$+1.76\%$
Average	-1.98%	-1.26%	-1.13%	$+0.30\%$
stdev	2.01%	1.99%	2.35%	1.83%

Partially observed model - Out of sample

- Model comparison by R^2: partially observed model fits banks' realized actions better in out-of-sample than the corresponding model without the noise.

R^2 of market capitalization and dividend	whole data: $1993-2014$	out of sample: 2008	out of sample: 2009
fully observed model with recapitalization	25.73%	54.96%	26.57%
partially observed model with recapitalization	36.08%	85.79%	43.25%