Banks' Portfolio Similarity and Stress Testing

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Background

- After Financial Crisis, Dodd-Frank Act requires the Federal Reserve Board to implement enhanced prudential supervisory standards (including stress tests).

- Objective:
  - Mitigate threat to financial stability posed by large institutions
  - Assess firms' capital positions during times of economic and financial stress to ensure continued operations and lending to households and business.

Questions

1. Are banks converging to similar portfolios after the 2008 crisis?
   - Is it due to post-crisis Dodd-Frank Act Stress Testing?

2. Are there systemic or financial stability consequences?

3. What are the implications for credit supply and for macroprudential policies?

Dodd-Frank Act Stress Tests Primer

1. Banks submit quarterly detailed *loan-level portfolio information*.
2. Annually, the Federal Reserve forecasts *forward looking loss and revenue* under stressful economic scenarios using *internally developed models*, and capital under stress is calculated.
3. Decisions on capital policies (dividend distributions) are a function of stress capital ratios being above regulatory threshold.

Information structure is relevant for our purpose:

- Banks do not know the "Fed models".
- Loss forecasts are disclosed 2 quarters after the "as of date" exercise, at the bank/portfolio level.
- Dividend policies are determined after results are disclosed.

Data

We use two sources of data

- Publicly available from "call reports" (FR-Y9C) at the bank holding company level, with aggregate portfolio data.
- Confidential Supervisory Information from the FR-Y14Q schedule on Commercial and Industrial loans.
- Sample of Banks subject to Stress Testing ($250 billion or more in assets).
- 2011Q3 to 2017Q4 (last DFAST, 2016Q4).

Measuring Banks' Portfolio Similarity

- Characterize each bank i at quarter t based on relative asset composition ($\alpha_{i.t}$)
- We focus on portfolio shares along 5 dimensions, each dimension d characterized by a separate vector ($\alpha_{i.t}^{d}$)

  1. **Overall** portfolio composition (relative to total assets, Y-9C).
     - Cash, securities, CRE, C&I, etc.
  2. C&I loan portfolio by **sector** (relative to all C&I loans, Y-14Q).
     - 2-digit SIC industries.
  3. C&I loan portfolio by **region** (relative to all C&I loans, Y-14Q).
     - Census region.
  4. C&I loan portfolio by **rating** (relative to all C&I loans, Y-14Q).
     - S&P rating categories.
  5. C&I loan portfolio by **maturity** (relative to all C&I loans, Y-14Q).
     - Maturity buckets 0-1, 1-2, 2-5, etc.

Summary Statistics of Overall Portfolio Composition

	Portfolio Shares (% of Total Assets)					
	Mean	p10	p25	p50	p75	p90
Cash	8.97	2.09	3.08	6.06	9.91	23.35
Securities	18.57	8.65	13.92	18.72	21.06	28.24
Fed Funds/RRP	6.80	0.00	0.02	0.63	10.75	29.14
Trading Assets	7.67	0.24	0.68	2.01	13.00	29.61
CRE Loans	6.46	0.31	1.78	7.30	9.92	13.22
C&I Loans	12.29	2.05	6.05	10.81	19.02	24.15
Retail Loans	20.51	0.75	13.83	22.27	28.42	41.05
N	425					

Source: FR-Y9C (Call-Reports) data at the portfolio level for BHC with more than $50 billion in assets, 2011-2017.

Measuring Banks' Portfolio Similarity

- For each of the 5 portfolio dimensions, compute bank-pair (i, j) similarity based on Euclidean distance:

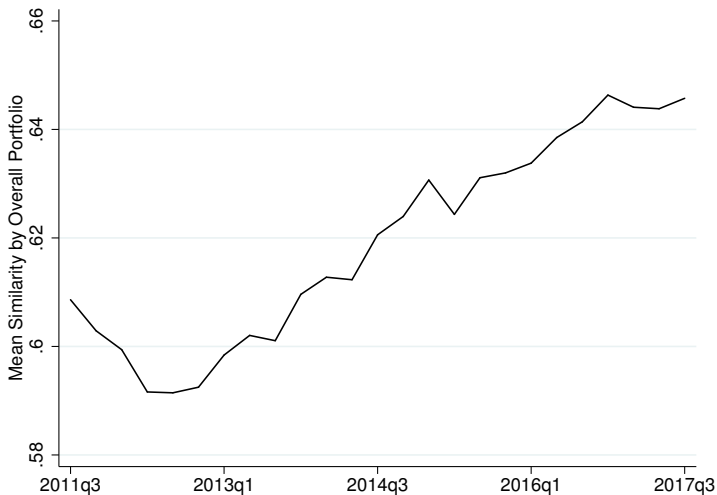$$ed_{i,j,t}^{d} = ||\alpha_{i.t}^{d} - \alpha_{j.t}^{d}||$$

- Euclidean distance normalized to give similarity measure:

$$similarity_{i,j,t}^{d} = 1 - \frac{ed_{i,j,t}^{d} - \min(ed_{i,j,t}^{d})}{\max(ed_{i,j,t}^{d}) - \min(ed_{i,j,t}^{d})}$$

- Caveat: no clear interpretation of units...
- To assess bank i's similarity to all other banks:
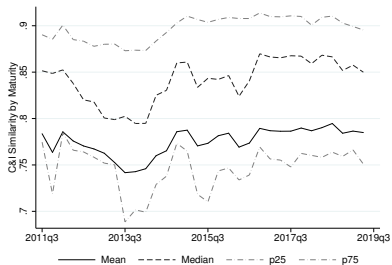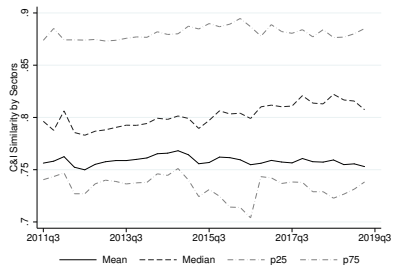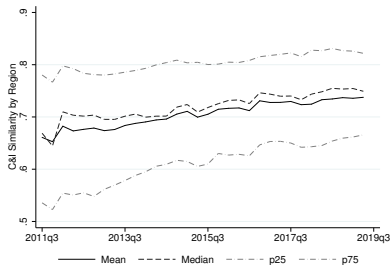
$$similarity_{i,t}^{d} = \sum_{j \neq i} similarity_{i,j,t}^{d} \quad \text{("degree centrality")}$$

Overall Portfolio Similarity (Mean)

$\rightarrow$ Relative increase in mean by about 6 percent

C&I Portfolio Similarity
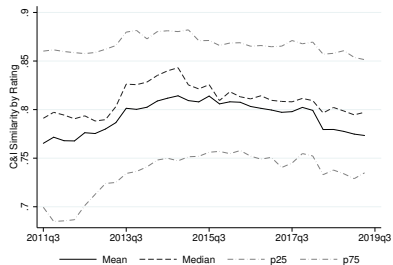
Does Regulation Drive Portfolio Similarity?

- We address two questions using the DFAST results and subsequent portfolio changes:

    1. Do banks with poor stress-test results (large capital shortfalls) subsequently adjust their overall portfolio to look more like the others (specifically like banks with low capital shortfalls)?

    2. Do banks with poor stress-test results for C&I portfolio subsequently adjust C&I portfolio to look more similar than others?

Overall Portfolio Similarity: DFAST vs nonDFAST Banks
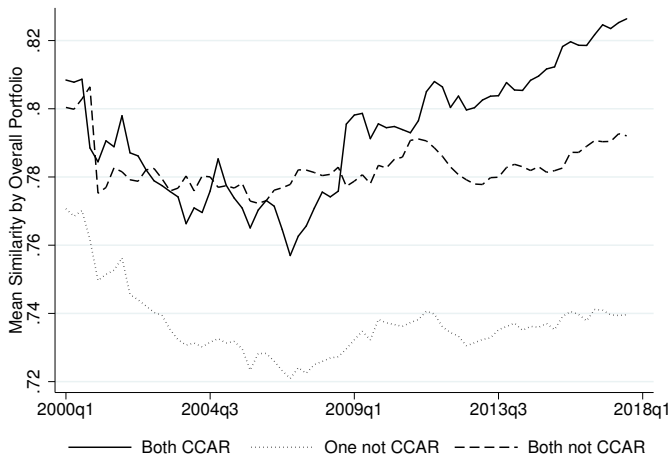
$$\Delta \log \text{Similarity}_{i,j,t} = \underset{(0.0014)}{0.0093} \cdot \text{Post-2011Q2} \times \text{CCAR Pairs} + \text{Quarter FE} + \text{Pair FE} + \epsilon_{i,j,t}$$

Overall Portfolio Similarity and Stress Test Outcome (SA) - Unconditional
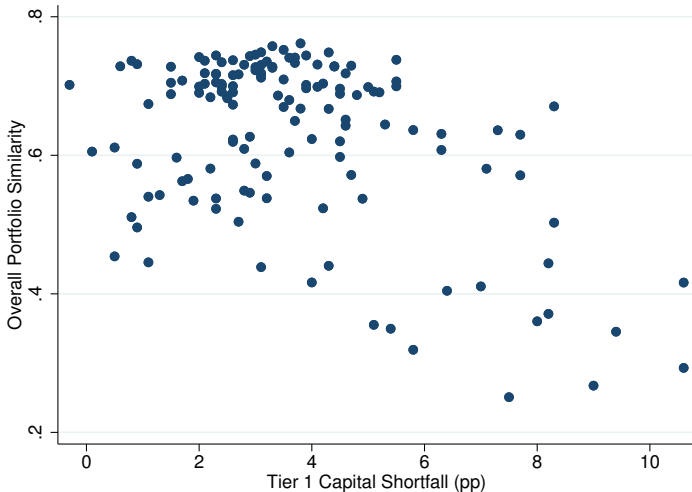
Bank-Level DFAST Outcome and Overall Portfolio Adjustment - FR-Y9C

Dep. Var: Change in Overall Portfolio Similarity to all banks				
	(1)	(2)	(3)	(4)
Tier 1 Ratio Loss	0.003***			
	(3.10)			
High Tier 1 Loss (p50)		0.015**		
		(2.66)		
High Tier 1 Loss (p75)			0.017***	
			(2.83)	
High Tier 1 Loss (p90)				0.025***
				(3.01)
Constant	-0.009**	-0.004	-0.001	0.000
	(-2.06)	(-1.53)	(-0.49)	(0.12)
Observations	108	108	108	108
R-squared	0.297	0.301	0.306	0.313
Quarter FE	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

$\rightarrow$ About 3 to 6 percentage points stronger increase in similarity to all banks.

Bank-Level DFAST Outcome and Overall Portfolio Adjustment toward "best performers" - FR-Y9C

Dep. Var: Change in Overall Portfolio Similarity to top 10th pctl.				
	(1)	(2)	(3)	(4)
Tier 1 Ratio Loss	0.006*			
	(1.82)			
High Tier 1 Loss (p50)		0.023		
		(1.35)		
High Tier 1 Loss (p75)			0.028	
			(1.21)	
High Tier 1 Loss (p90)				0.071**
				(2.46)
Constant	-0.030**	-0.018**	-0.013	-0.015*
	(-2.34)	(-2.42)	(-1.63)	(-1.75)
Observations	108	108	108	108
R-squared	0.158	0.153	0.155	0.190
Quarter FE	Yes	Yes	Yes	Yes
Robust t-statistics in parentheses				
*** $p<0.01$, ** $p<0.05$, * $p<0.1$				

$\rightarrow$ Up to 18 percentage points stronger increase in similarity to the top 10 percentile of better-capitalized banks post-stress.

Bank-Level DFAST Outcome for C&I Portfolio and Subsequent C&I Portfolio Adjustment (Rating) - FR-Y14Q

Dep. Var: Change in C&I Portfolio Similarity by **Rating** to Best DFAST Performers			
	(1)	(2)	(3)
High C&I Loan Loss (p90)	-0.027	-0.129**	-0.078*
	(-0.63)	(-2.17)	(-1.99)
High Tier 1 Loss (p90)	-0.013	-0.037	-0.031
	(-0.74)	(-1.42)	(-1.31)
High C&I Loan Loss (p90) * High Tier 1 Loss (p90)		0.176**	0.120**
		(2.67)	(2.44)
Net Income Growth			-0.013***
			(-3.60)
Observations	107	107	107
R-squared	0.533	0.567	0.669
Quarter FE	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes

Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Bank-Level DFAST Outcome for C&I Portfolio and Subsequent C&I Portfolio Adjustment (Others) - FR-Y14Q

Dep. Var: Change in C&I Portfolio Similarity to Best Banks			
	by Region (1)	by Sector (2)	by Maturity (3)
High C&I Loan Loss (p90)	-0.092**	-0.013	-0.005
	(-2.11)	(-0.40)	(-0.07)
High Tier 1 Loss (p90)	-0.061	0.013	-0.006
	(-1.08)	(0.50)	(-0.32)
High C&I Loan Loss (p90)	0.168*	0.069**	0.048
$\times$ High Tier 1 Loss (p90)	(1.90)	(2.31)	(0.60)
Net Income Growth	0.010	-0.006	-0.006
	(0.54)	(-0.89)	(-0.97)
Observations	107	107	107
R-squared	0.269	0.326	0.606
Quarter FE	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes

# What Does it Mean for Financial Stability?

- Portfolios can become more similar either because ...
- ... each individual bank loads on a few similar exposures (concentration)
- ... or all banks converge to a similarly diversified portfolio

Question
Is the banking system more diversified on aggregate?

Bank- and System-Level Portfolio Diversification

- Example of diversification by region:
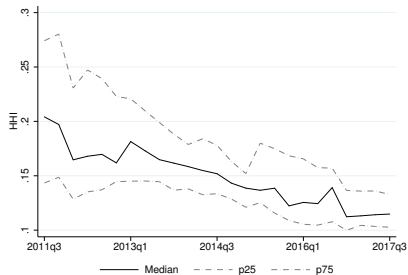
(a) Distribution of **bank-level** Herfindahl index measuring C&I portfolio concentration.

(b) HHI index measuring C&I concentration of a **DFAST-aggregate banking** portfolio.

The sample includes all banks participating in the five stress tests from 2011Q3 to 2016Q4.

Micro- vs. Macroprudential Concerns

- Microprudential gains:
  - Tier 1 capital has increased.
  - Capital shortfalls under stress have declined...
  - ... not at the cost of less severe scenarios.
  - Bank-level portfolio diversification increased.

- Aggregate concerns
  - Banks' portfolios become similarly diversified.
  - Banks' are loading similarly on the same risk factors (possibly *unobserved*.

- Are there any credit-supply effects of this portfolio reallocation resulting from regulation (DFAST in particular)?

Effects on Credit Supply

- Is this portfolio reallocation a result of **learning** about the sensitivity of portfolios to stress? *(regulatory supply-effect)*

- Or is the reallocation a result of **changes in the investment opportunity set**? *(demand)*

- We explore a learning model to estimate *credit supply* in those banks that:
  - Experience larger capital shortfalls in DFAST.
  - Have a higher sensitivity of their C&I portfolio to the stress scenarios.

- Khwaja-Mian bank/borrower identification approach allows us to identify whether stress testing has an effect on supply of credit.

Effects on Credit - Results

VARIABLES	(1) Tier 1 Loss >p75 Credit Growth (%)	(2) Tier 1 Loss >p90 Credit Growth (%)	(3) Tier 1 Loss >p75 Credit Growth (%)	(4) Tier 1 Loss >p90 Credit Growth (%)
High Tier 1 Loss Bank	-1.544	-4.272**		
	(-1.12)	(-2.65)		
High Tier 1 Loss Bank $\times$ High Sensitivity (Rating)			-3.352**	-2.648
			(-2.76)	(-1.50)
High Tier 1 Loss Bank $\times$ High Sensitivity (Sector)			0.377	3.548
			(0.12)	(0.84)
Constant	2.948***	3.217***	2.877***	2.534***
	(6.87)	(11.39)	(12.02)	(10.16)
Observations	99,224	99,224	99,224	99,224
R-squared	0.608	0.608	0.610	0.610
Bank*Time FE	No	No	Yes	Yes
Borrower*Time FE	Yes	Yes	Yes	Yes
Borrower*Bank FE	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

High Sensitivity computed in a first stage, where we estimate the sensitivity of the C&I losses under the severely adverse scenario to different portfolio shares.

Effects on Credit - Borrower-level results

| VARIABLES	(1) Tier 1 Loss >p75 Credit Growth (%)	(2) Tier 1 Loss >p90 Credit Growth (%)	(3) Tier 1 Loss >p75 Credit Growth (%)	(4) Tier 1 Loss >p90 Credit Growth (%)
Exposure to Tier 1 Loss Banks	-3.102	-14.102***	-3.863***	-7.806***
	(-1.60)	(-4.71)	(-13.35)	(-19.58)
Constant	6.347***	7.374***	2.343***	2.362***
	(10.32)	(17.26)	(32.48)	(47.07)
Observations	16,750	16,750	352,678	352,678
R-squared	0.394	0.395	0.268	0.269
Bank FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Mean RHS	0.313	0.145	0.254	0.127
Std RHS	0.315	0.234	0.423	0.323

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Exposure defined as the share of credit obtained from an ex-post troubled bank over total loans from DFAST banks.

Conclusion

- Regulation had an impact on banks' portfolio allocation.

- Individual banks have become more diversified and hold more capital (*less microprudential concern*).

- But banks' portfolios have become more similar

- Moreover, aggregated banking system's portfolio has become more concentrated (*financial stability concern*).

- If stress test focuses on microprudential concerns, financial stability risks may arise from unintended exposures to unobserved systemic factors.

- Banks are reacting to sensitivity of their portfolio to stressed scenarios **and** reduce credit if portfolio too sensitive.

Appendix A: Number of Banks
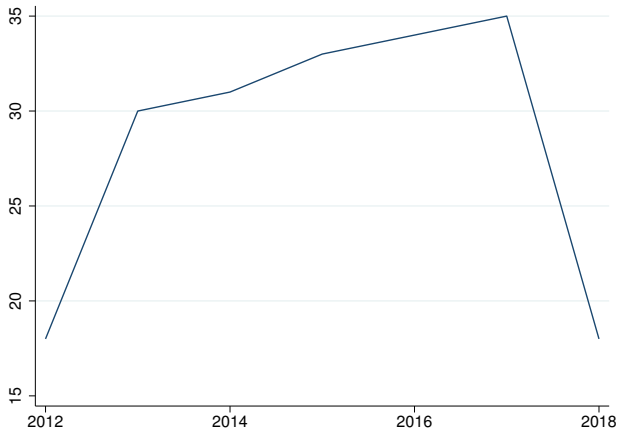
Appendix A: Summary Statistics of C&I Portfolio by Sector (Y-14Q)

	(1)					
	mean	p10	p25	p50	p75	p90
Financial & Insurance	17.94	6.08	10.98	16.28	24.46	33.80
Health Care & Social	4.18	0.00	1.25	4.18	6.72	7.86
Information	3.64	0.00	0.95	3.43	5.35	8.22
Manufacturing	15.72	3.19	12.39	17.09	21.54	24.26
Mining & Oil	4.66	0.64	2.74	4.28	5.81	8.15
Other Services	3.05	0.68	1.17	1.73	2.98	8.45
Public Administration	4.72	0.09	1.76	3.36	4.91	6.38
Real Estate	7.67	0.28	3.49	7.17	10.95	16.75
Retail Trade	12.00	2.64	4.95	7.04	8.74	14.62
Transportation	4.27	0.37	3.49	4.14	5.06	6.28
Utilities	4.53	0.59	3.00	4.01	5.20	9.49
Wholesale Trade	6.30	0.56	4.11	6.82	9.08	10.06
Other Sectors	9.83	0.00	0.00	12.41	15.57	16.57
N (Bank-Quarters)	425					

Appendix A: Summary Statistics of C&I Portfolio by Rating (Y-14Q)

	(1)					
	mean	p10	p25	p50	p75	p90
AAA	3.52	0.00	0.00	1.19	2.70	9.78
AA	6.15	0.00	0.67	6.26	9.84	12.85
A	17.47	1.45	11.09	19.23	24.40	28.25
BBB	32.14	19.61	27.57	33.13	37.34	42.73
BB	28.79	12.36	18.80	26.34	39.92	49.05
B	8.74	2.45	4.76	8.39	11.09	15.49
CCC	1.92	0.08	1.14	1.57	2.61	3.91
CC	0.38	0.00	0.00	0.00	0.05	1.25
C	0.03	0.00	0.00	0.00	0.00	0.00
D	0.32	0.00	0.01	0.13	0.44	1.03
NR	0.10	0.00	0.00	0.00	0.00	0.05
N (Bank-Quarters)	425					

Appendix A: Summary Statistics of C&I Portfolio by Region (Y-14Q)

| | (1) | | | | | |
	mean	p10	p25	p50	p75	p90
Foreign	14.36	0.22	2.00	5.95	26.73	32.23
West	17.92	7.63	10.37	14.01	26.74	32.57
Northeast	19.15	8.90	14.04	19.60	23.23	29.06
South	35.50	15.95	22.09	28.75	45.80	72.49
West	12.39	5.88	7.36	10.71	15.22	24.77
N (Bank-Quarters)	425					

Appendix A: Summary Statistics of C&I Portfolio by Maturity (Y-14Q)

	(1)					
	mean	p10	p25	p50	p75	p90
Maturity 0-1 Years	6.21	0.66	2.83	5.39	7.86	10.92
Maturity 1-2 Years	5.56	1.10	3.31	5.58	7.34	8.81
Maturity 2-5 Years	37.83	27.69	32.35	36.72	44.10	55.46
Maturity 5-6 Years	13.77	7.38	10.71	13.67	16.61	19.25
Maturity 6-11 Years	19.57	7.25	10.65	19.79	27.28	32.55
Maturity 11-31 Years	7.50	1.77	3.81	8.17	10.60	12.41
Maturity Callable	7.37	0.00	0.08	1.05	5.08	10.64
Maturity Unknown	1.97	0.01	0.14	0.43	1.39	6.68
N (Bank-Quarters)	425					

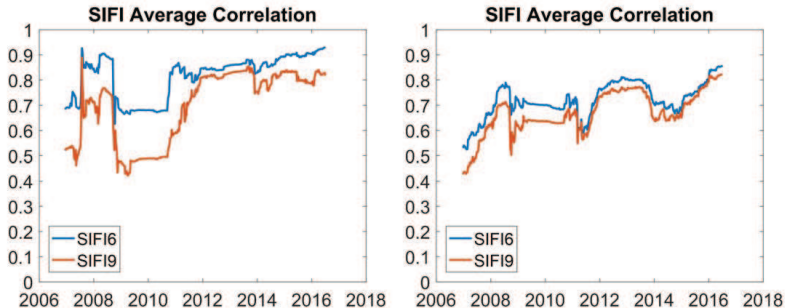# Appendix A: Overall Portfolio Similarity SIFI
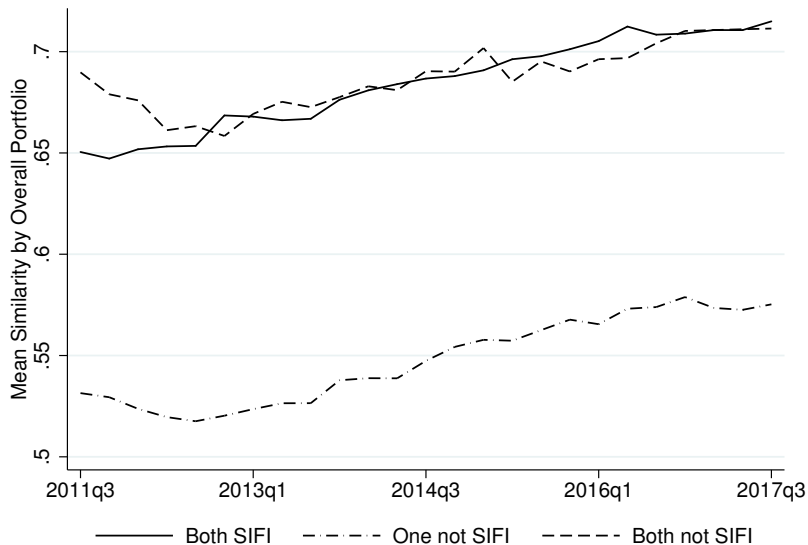
Figure: Average CDS and Equity Correlations 2007-2016: 6 largest SIFIs and 9 largest SIFIs in terms of assets.

# Appendix C: Changes in Overall Similarity by Bank Type

VARIABLES	(1) Changes in Similarity β	(2) Changes in Similarity $t-stat$
L.Tier 1 Loss	-0.001	(-0.22)
Custodian	0.033**	(2.11)
Foreign	0.010	(0.98)
Investment	0.213***	(10.42)
Large Noncomplex	0.011	(1.47)
Universal	0.025	(1.66)
Credit Card $\times$ Tier 1 Loss	0.006*	(1.89)
Foreign $\times$ Tier 1 Loss	0.003	(0.66)
Investment $\times$ Tier 1 Loss	-0.017***	(-4.63)
Large Noncomplex $\times$ Tier 1 Loss	0.002	(0.46)
Universal $\times$ Tier 1 Loss	0.000	(0.08)
Observations	108	
R-squared	0.445	
Quarter FE	Yes	

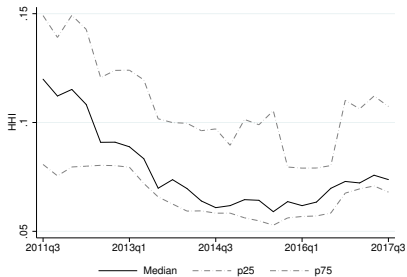Robust t-statistics in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Appendix D: Bank-Level Portfolio by Rating
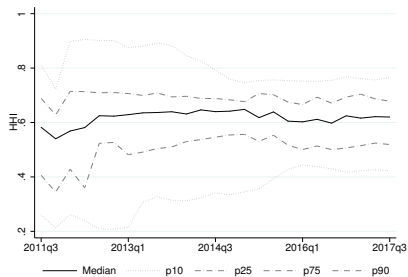
(a) IG Shares

(b) HHI (All Ratings)

Figure: Distribution of investment grade portfolio shares and Herfindahl index for all ratings. The sample includes all banks participating in the five stress tests from 2011Q3 to 2016Q4.

Computation of Portfolio Sensitivity

- We estimate equation (1) on an expanding window using all past and current information on all banks' portfolios
- Assumption: banks know peers past portfolios.

$$\text{Loss}_{i,t} = \sum_k \beta^{d,k} \text{Lending}_{i,t}^{d,k} + \epsilon_{i,t}, \tag{1}$$

- Then, we estimate (2) to asses the effects of sensitivity, especially on those banks who suffer higher tier 1 losses under stress:

$$\Delta\text{Credit}_{i,j,t} = \beta \cdot \text{Tier-1-Loss}_{i,t-1} + \alpha_{j,t} + \alpha_{i,j} + \epsilon_{i,t}, \tag{2}$$

- We then use the estimated β as an indicator of high sensitivity of the C&I losses to portfolio shares under the Severely Adverse scenario.