

Online Appendix

Accompanying “Syndication, Interconnectedness, and Systemic Risk”
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A1. Robustness Analysis of Section 5

A1.1 Robustness - Alternative industry aggregation levels

This section complements our findings on interconnectedness on financial institution's systemic risk measures in section 5 of the paper. In the paper, we show results of interconnectedness based on industrial aggregation along specializations based on borrower 2-digit SIC industry. Table A1 reports results based on specializations on more aggregated level (SIC division) and a finer aggregation level (4-digit SIC industry¹). We find that all of our results and conclusions also hold along different industrial aggregation levels.

A1.2 Robustness - Alternative regional aggregation levels

This section continues to complement our findings on interconnectedness on financial institution's systemic risk measures in section 5 of the paper. In the paper, we show results of interconnectedness based on regional aggregation along specializations based on borrower's headquarter U.S. state. Table A2 reports results based on specializations on more aggregated level (U.S. region²) and a finer aggregation level (3-digit ZIP code). We find that all of our results and conclusions also hold along different regional aggregation levels.

¹ 3-digit SIC industry level results are very similar to 4-digit SIC industry level as the correlation among the interconnectedness measures is very high (>0.99). This partially stems from missing information on the fourth digit of the SIC industry, so that by mapping the 3-digit SIC industry to a 4-digit industry we potentially miss granularity of industry specializations.

² Federal regions according to the Office of Management and Budget Circular A-105 "Standard Federal Regions" in April 1974. E.g. region 1 contains CT, ME, MA, NH, RI, and VT.

Table A1: Alternative aggregation levels of specialization along industries

This table reports coefficient estimates from three regressions relating a financial institution's SRISK, DIP, and CoVaR to its interconnectedness in the U.S. syndicated loan market. The three dependent variables are systemic capital shortfall (SRISK) in billions of U.S. dollars, distress insurance premium (DIP) in billions of euro, and the opposite of 1% CoVaR in billions of U.S. dollars. Across all three regressions, the independent variable of interest is the interconnectedness of a lead arranger, which is computed based on its distance from all the other lead arrangers in specializations with regard to SIC division and 4-digit SIC industry and can be equal-, size-, or relationship-weighted. Recession is an indicator variable equal to 1 if a month falls into the recession periods identified by the NBER. Expansion is an indicator variable equals to 1 if a month falls not into the recession periods identified by NBER. Interconnectedness \times Expansion is the interaction term of Interconnectedness and Expansion. Interconnectedness \times Recession is the interaction term of Interconnectedness and Recession. Control variables include the financial institution's total assets, market share as a lead arranger in the U.S. syndicated loan market during the previous twelve month, market size measured as syndicated loan originated during the previous twelve months in the U.S. syndicated loan market (in billion U.S. dollar), and one-month lagged systemic risk measure (SRISK, DIP, or CoVaR). All regressions include lead arranger fixed effects. Control variables are not reported for brevity. Robust standard errors allowing for clustering by lead arranger are in parentheses. The bottom part of each systemic risk measure regression shows the hypothesis test (H_0 : $Interconnectedness \times Recession - Interconnectedness \times Expansion = 0$) and the hypotheses test's p-values. * indicates that the estimated coefficient is significantly different from zero at the 10% level, ** at the 5% level, and *** at the 1% level.

	Industry Aggregation (SIC division)			Industry Aggregation (4-digit SIC industry)		
	equal- weighted	size- weighted	relationship- weighted	equal- weighted	size- weighted	relationship- weighted
SRISK						
Interconnectedness \times Expansion	-0.005 (0.012)	-0.007 (0.009)	-0.003 (0.009)	0.000 (0.014)	0.000 (0.012)	0.005 (0.012)
Interconnectedness \times Recession	0.063** (0.027)	0.052** (0.020)	0.053** (0.020)	0.070*** (0.023)	0.062*** (0.021)	0.058*** (0.019)
H_0	0.068**	0.059***	0.056***	0.069***	0.062***	0.054***
p-value	0.011	0.006	0.008	0.002	0.002	0.004
DIP						
Interconnectedness \times Expansion	-0.012 (0.015)	0.010 (0.013)	0.007 (0.013)	0.005 (0.016)	0.021 (0.017)	0.012 (0.015)
Interconnectedness \times Recession	0.146** (0.051)	0.121** (0.044)	0.107** (0.038)	0.130*** (0.039)	0.130*** (0.036)	0.105*** (0.031)
H_0	0.158***	0.110**	0.100**	0.125***	0.109***	0.093***
p-value	0.007	0.018	0.013	0.003	0.004	0.004
CoVaR						
Interconnectedness \times Expansion	0.019 (0.024)	-0.004 (0.018)	0.006 (0.019)	0.001 (0.024)	0.003 (0.020)	0.013 (0.020)
Interconnectedness \times Recession	0.139* (0.076)	0.091 (0.056)	0.105* (0.061)	0.114* (0.067)	0.101 (0.061)	0.100* (0.058)
H_0	0.120	0.095	0.098	0.113	0.099	0.087
p-value	0.140	0.150	0.130	0.155	0.157	0.159

Table A2: Alternative aggregation levels of specialization along regions

This table reports coefficient estimates from three regressions relating a financial institution's SRISK, DIP, and CoVaR to its interconnectedness in the U.S. syndicated loan market. The three dependent variables are systemic capital shortfall (SRISK) in billions of U.S. dollars, distress insurance premium (DIP) in billions of euro, and the opposite of 1% CoVaR in billions of U.S. dollars. Across all three regressions, the independent variable of interest is the interconnectedness of a lead arranger, which is computed based on its distance from all the other lead arrangers in specializations with regard to U.S. region and 3-digit ZIP-code and can be equal-, size-, or relationship-weighted. Recession is an indicator variable equal to 1 if a month falls into the recession periods identified by the NBER. Expansion is an indicator variable equals to 1 if a month falls not into the recession periods identified by NBER. Interconnectedness \times Expansion is the interaction term of Interconnectedness and Expansion. Interconnectedness \times Recession is the interaction term of Interconnectedness and Recession. Control variables include the financial institution's total assets, market share as a lead arranger in the U.S. syndicated loan market during the previous twelve month, market size measured as syndicated loan originated during the previous twelve months in the U.S. syndicated loan market (in billion U.S. dollar), and one-month lagged systemic risk measure (SRISK, DIP, or CoVaR). All regressions include lead arranger fixed effects. Control variables are not reported for brevity. Robust standard errors allowing for clustering by lead arranger are in parentheses. The bottom part of each systemic risk measure regression shows the hypothesis test (H_0 : $Interconnectedness \times Recession - Interconnectedness \times Expansion = 0$) and the hypotheses test's p-values. * indicates that the estimated coefficient is significantly different from zero at the 10% level, ** at the 5% level, and *** at the 1% level.

	Regional Aggregation (U.S. region)			Regional Aggregation (3-digit ZIP-code)		
	equal- weighted	size- weighted	relationship- weighted	equal- weighted	size- weighted	relationship- weighted
SRISK						
Interconnectedness \times Expansion	0.007 (0.016)	0.003 (0.014)	0.007 (0.014)	-0.002 (0.013)	-0.002 (0.011)	0.001 (0.011)
Interconnectedness \times Recession	0.097*** (0.025)	0.076*** (0.020)	0.071*** (0.019)	0.077*** (0.020)	0.069*** (0.017)	0.065*** (0.016)
H_0	0.089***	0.073***	0.064***	0.079***	0.071***	0.064***
p-value	0.001	0.001	0.002	0.000	0.000	0.000
DIP						
Interconnectedness \times Expansion	-0.005 (0.020)	0.005 (0.017)	-0.001 (0.018)	-0.002 (0.017)	0.023 (0.018)	0.009 (0.016)
Interconnectedness \times Recession	0.120*** (0.035)	0.112*** (0.030)	0.081*** (0.027)	0.121*** (0.034)	0.125*** (0.034)	0.100*** (0.027)
H_0	0.126***	0.107***	0.083***	0.123***	0.102***	0.090***
p-value	0.004	0.004	0.006	0.002	0.003	0.003
CoVaR						
Interconnectedness \times Expansion	0.052 [*] (0.027)	0.029 (0.028)	0.037 (0.024)	0.013 (0.025)	0.010 (0.021)	0.015 (0.022)
Interconnectedness \times Recession	0.203 [*] (0.102)	0.157** (0.071)	0.153** (0.073)	0.125 [*] (0.068)	0.115 [*] (0.062)	0.103 [*] (0.056)
H_0	0.151	0.127	0.115	0.111	0.105	0.089
p-value	0.139	0.127	0.146	0.138	0.126	0.138

A2. List of Lead Arranger With Systemic Risk Measures

The following tables lists lead arrangers in the U.S. syndicated loan market for which various systemic risk measures are available. There are 58 lead arrangers with SRISK measures (Table A3), 19 with DIP measures (Table A4), and 36 with CoVaR measures (Table A5).

Table A3. Lead Arrangers with SRISK Measures

	Financial Institution	Ticker		Financial Institution	Ticker
1	Allied Irish Banks	ALBK	30	Lloyds Banking Group	LLOY
2	Banco Bilbao Vizcaya Argentari	BBVA	31	Marshall & Ilsley	MI
3	Bank of America	BAC	32	Merrill Lynch	MER
4	Bank of Montreal	BMO	33	Mizuho Financial Group	F8411
5	Bank of New York Mellon	BK	34	Morgan Stanley	MS
6	Bank of Tokyo-Mitsubishi UFJ	F8306	35	National Bank of Canada	NA
7	Barclays	BARC	36	National City Corporation	NCC
8	BB&T Corporation	BBT	37	Natixis	KN
9	Bear Stearns	BSC	38	Nomura	F8604
10	BNP Paribas	BNP	39	Nordea Bank	NDA
11	Capital One Financial	COF	40	Northern Trust	NTRS
12	CIT Group	CIT	41	PNC Financial Services	PNC
13	Citigroup	C	42	Prudential	PRU
14	Comerica	CMA	43	Regions Financial Corp	RF
15	Commerzbank	CBK	44	Royal Bank of Canada	RY
16	Compass Bank	CBSS	45	Royal Bank of Scotland	RBS
17	Credit Agricole SA	ACA	46	Skandinaviska Enskilda Banken	SEBA
18	Credit Suisse	CSGN	47	Societe Generale	GLE
19	Crédit Lyonnais	FLY	48	Sovereign Bank	SOV
20	Deutsche Bank	DBK	49	State Street	STT
21	Fifth Third Bancorp	FITB	50	Suntrust Banks	STI
22	Goldman Sachs	GS	51	Toronto-Dominion Bank	TD
23	HSBC	HSBA	52	UBS	UBSN
24	Huntington Bancshares	HBAN	53	UniCredit SpA	UCG
25	ING Group	INGA	54	US Bancorp	USB
26	Intesa Sanpaolo SpA	ISP	55	Wachovia Bank	WB
27	JPMorgan Chase	JPM	56	Washington Mutual	WM
28	Keycorp	KEY	57	Wells Fargo	WFC
29	Lehman Brothers	LEH	58	Zions Bancorporation	ZION

Table A4. Lead Arrangers with DIP Measures

	Financial Institution	Ticker		Financial Institution	Ticker
1	Allied Irish Banks	ALBK	11	Intesa Sanpaolo SpA	ISP
2	Banco Bilbao Vizcaya Argentari	BBVA	12	Lloyds Banking Group	LLOY
3	Barclays	BARC	13	Natixis	KN
4	BNP Paribas	BNP	14	Nordea Bank	NDA
5	Commerzbank	CBK	15	Royal Bank of Scotland	RBS
6	Credit Agricole SA	ACA	16	Skandinaviska Enskilda Banken	SEBA
7	Credit Suisse	CSGN	17	Societe Generale	GLE
8	Deutsche Bank	DBK	18	UBS	UBSN
9	HSBC	HSBA	19	UniCredit SpA	UCG
10	ING Group	INGA			

Table A5. Lead Arrangers with CoVaR Measures

	Financial Institution	Ticker		Financial Institution	Ticker
1	Ares Capital Corp	ARCC	19	Keycorp	KEY
2	Bank of America	BAC	20	Marshall & Ilsley	MI
3	Bank of Hawaii	BOH	21	Mercantile Bank	MBWM
4	Bank of New York Mellon	BK	22	Morgan Stanley	MS
5	BB&T Corporation	BBT	23	Northern Trust	NTRS
6	Capital One Financial	COF	24	PNC Financial Services	PNC
7	CIT Group	CIT	25	PrivateBancorp Inc	PVTB
8	Citigroup	C	26	Prudential	PRU
9	City National Bank	CYN	27	Regions Financial Corp	RF
10	Comerica	CMA	28	State Street	STT
11	Cullen/Frost Bankers	CFR	29	Suntrust Banks	STI
12	Fifth Third Bancorp	FITB	30	UMB Financial Corp	UMBF
13	FINOVA Capital Corp	3FNVG	31	US Bancorp	USB
14	Goldman Sachs	GS	32	Webster Bank	WBS
15	Guaranty Bank	GBNK	33	Wells Fargo	WFC
16	Huntington Bancshares	HBAN	34	Whitney National Bank	WTNY
17	Jefferies Finance LLC	JEF	35	Wilmington Trust Corp	WL
18	JPMorgan Chase	JPM	36	Zions Bancorporation	ZION

A3. Interconnectedness and Systemic Risk at the Market-Level

A3.1 A market-aggregate measure of systemic risk: CATFIN

While SRISK, DIP, and CoVaR measure the cross-sectional differences in banks' contribution to systemic risk (that is, micro- or bank-level measures of systemic risk), we also analyze an aggregate VaR measure of catastrophic risk in the financial sector, short CATFIN. CATFIN is constructed as an unweighted average of three (parametric and non-parametric) VaR measures using the historical distribution of equity returns. Allen et al. (2012) show that micro-level measures are helpful in explaining the cross-sectional variations in systemic risk contributions; however, they do a poor job in forecasting macroeconomic developments. Thus, they develop CATFIN to forecast potential detrimental effects of financial risk taking by the overall financial sector on the macroeconomy. The intuition is that banks do not internalize the costs on the society when making risk-taking decisions, and CATFIN is supposed to capture these externalities.

Data and Summary Statistics

The CATFIN data are monthly and available for the U.S. aggregate market level from January 1973 to December 2009.³ We match them with our monthly market-aggregate Interconnectedness Indices and obtain a matched sample of 252 months.

The market-aggregate CATFIN measure suggests that there is on average a 28% probability of a macroeconomic downturn (see Table A6).

Table A6. Summary Statistics

This table reports summary statistics of the CATFIN measure of 252 months.

	N =	Mean	SD	10 th	50 th	90 th
Systemic Risk Measures: CATFIN (%)	252	28.25	12.93	14.72	25.46	44.70

A3.2 Interconnectedness and CATFIN

SRISK, DIP, and CoVaR provide systemic risk measures for individual banks across time and thus allow us to assess the contribution of interconnectedness to systemic risk in a panel setting. In a next step, we are interested in how the effect of interconnectedness on systemic risk at the bank level aggregates to the market-level; that is, whether more interconnectedness in the overall financial sector increases the entire financial sector's systemic risk. To assess this, we use an aggregate systemic risk measure, called CATFIN, which has been shown to forecast recessions that arise from the excessive risk-taking of the U.S. banking sector using different VaR measures (L. Allen et al., 2012). Our CATFIN measure comprises monthly data ranging from 1989 until December 2009. To formally test the relationship between interconnectedness and CATFIN, we estimate the following regression:

³ The authors used return data on NYSE-, AMEX-, and NASDAQ-traded financial common stocks in the computation of the CATFIN measure.

$$\begin{aligned}
\text{CATFIN}_t &= \alpha + \beta_1 \cdot (\text{Interconnectedness Index}_t \times \text{Expansion}_t) \\
&+ \beta_2 \cdot (\text{Interconnectedness Index}_t \times \text{Recession}_t) + \beta_3 \cdot \text{Recession}_t \\
&+ \beta_4 \cdot \text{Market Size}_t + \beta_5 \cdot \text{Herfindahl}_t + \beta_6 \cdot \text{CATFIN}_{t-1} + e_t, \quad (\text{A1})
\end{aligned}$$

where the dependent variable CATFIN_t . The key independent variable is the $\text{Interconnectedness Index}_t$, the monthly market-aggregate $\text{Interconnectedness Index}$. We interact the $\text{Interconnectedness Index}_t$ with expansion periods, and separately with NBER recession periods. We further control for Market Size_t , the size of the U.S. syndicated loan market measured by the total amount of newly originated loans during the previous twelve months. Herfindahl_t is the Herfindahl index of the market as a measure of the competitiveness of the syndicated loan market as in equation (A2) below:

$$\text{Herfindahl}_t = \sum_i (y_{i,t})^2 \times 100, \quad (\text{A2})$$

where $y_{i,t}$ is the market share of bank i in the syndicated loan market based on the total loan amount the bank originated as a lead arranger during the twelve-month period prior to month t .⁴ In addition, we add one period lagged systemic risk measure (CATFIN_{t-1}) to control for the strong serial correlation. Standard errors are heteroscedasticity robust. Table A7 reports the results.

Market-aggregate interconnectedness reduces CATFIN under normal economic conditions. All coefficients in the industry aggregation specification are statistically significant at the 5% level. A one standard deviation increase of the market-aggregate interconnectedness index decreases CATFIN by 2.9% to 6.4% points. Interestingly, the coefficients are insignificant in the specifications with regional aggregation of our interconnectedness measure. We also find that the coefficients of interaction term of market-aggregate interconnectedness and recession are larger than the coefficients of the interaction term of market-aggregate interconnectedness and expansion. The difference even becomes positive in our specifications with regional specializations. While not statistically significant, the coefficients are economically meaningful. A standard deviation increase in the market-aggregate interconnectedness during recessions increases CATFIN in the range between 3.9% and 9.7% (the unconditional CATFIN is 28.3%) consistent with our findings using bank-level interconnectedness measures.

The difference between regional and industry aggregation is interesting, i.e. why does interconnectedness through industry portfolio overlap is associated with lower systemic risk compared to interconnectedness through regional portfolio overlap? One possible explanation of this result is that shocks might affect regions similarly, while the effect across industries is more heterogeneous (i.e. recession severity varies more across industries than across regions). Overall, the results from the market-aggregate systemic risk measure CATFIN are consistent to our analyses of bank-level systemic risk measures.

⁴ A more competitive syndicated loan market corresponds to a smaller Herfindahl index.

Table A7: Interconnectedness and CATFIN

This table reports coefficient estimates from regressions relating the aggregate U.S. financial sector's systemic risk, CATFIN, to the aggregate interconnectedness in the U.S. syndicated loan market. The dependent variable is the monthly CATFIN in percentage. The independent variable of interest is the market-aggregate Interconnectedness Index, an equal-weighted average of interconnectedness across all lead arrangers. Interconnectedness of a lead arranger is computed based on its distance from all the other lead arrangers in specializations with regard to 2-digit borrower SIC industry and borrower U.S. state and can be equal-, size-, or relationship-weighted. Recession is an indicator variable equal to 1 if a month falls into the recession periods identified by NBER. Expansion is an indicator variable equal to 1 if a month falls not into the recession periods identified by NBER. Interconnectedness Index \times Expansion is the interaction term of Interconnectedness Index and Expansion. Interconnectedness Index \times Recession is the interaction term of Interconnectedness Index and Recession. Control variables include the market size (measured by the total amount of newly originated loans in billions of U.S. dollars) and the Herfindahl index of the U.S. syndicated loan market, the one-month lagged CATFIN, and a constant. Robust standard errors are in parentheses. The bottom part of the table shows the hypothesis test (H_0 : $Interconnectedness \times Recession - Interconnectedness \times Expansion = 0$) and the hypothesis test's p-value. * indicates that the estimated coefficient is significantly different from zero at the 10% level, ** at the 5% level, and *** at the 1% level.

CATFIN	Industry Aggregation			Regional Aggregation		
	equal-weighted	size-weighted	relationship-weighted	equal-weighted	size-weighted	relationship-weighted
Interconnectedness Index \times Expansion	-0.539*** (0.184)	-0.384** (0.177)	-0.399** (0.170)	-0.313 (0.228)	-0.267 (0.207)	-0.185 (0.205)
Interconnectedness Index \times Recession	-0.166 (0.508)	-0.151 (0.338)	-0.096 (0.439)	0.325 (0.494)	0.078 (0.396)	0.423 (0.485)
Recession	-8.747 (17.024)	-5.216 (12.625)	-9.162 (18.512)	-17.648 (15.566)	-9.946 (13.920)	-23.258 (19.962)
Market Size	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)	-0.001 (0.002)	-0.000 (0.002)	-0.002 (0.002)
Herfindahl Index	-0.162 (0.230)	-0.024 (0.229)	-0.071 (0.227)	-0.048 (0.232)	-0.001 (0.242)	-0.040 (0.233)
Lagged CATFIN	0.664*** (0.070)	0.671*** (0.070)	0.671*** (0.069)	0.668*** (0.069)	0.676*** (0.069)	0.669*** (0.069)
Constant	29.156*** (7.445)	24.332*** (7.224)	27.037*** (7.693)	20.947*** (7.200)	20.045*** (7.271)	18.917** (7.990)
N =	251	251	251	251	251	251
R ²	0.6456	0.6420	0.6437	0.6436	0.6409	0.6432
H ₀	0.374	0.234	0.303	0.638	0.345	0.608
p-value	0.439	0.434	0.449	0.150	0.283	0.160