Supplementary Material for "Measuring the frequency dynamics of financial connectedness and systemic risk"*

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1 Supplementary Tables and Figures

1.1 Including Fannie Mae (FNM) and Freddie Mac (FRE)

As suggested in the data section, FRE and FNM were, for a substantial portion of the period, part of the US financial system. Hence, as a robustness measure, we compute the overall connectedness with the same specification over the shorter dataset when both FRE and FNM are publicly traded and compare the overall connectedness of the two systems to see how the results change. The result is shown in Figure 1. We can see that most of the time, the system that includes the FRE and FNM was more connected than was the restricted system. The difference peaks at approximately 6% in mid-2006, which is a relatively high number due to the nature of the connectedness, which is a mean of shares of variances created by shocks to other variables. Hence, including FRE and FNM in the system increases the systemic risk although the dynamics do not substantially differ from the analysis that omits FRE and FNM.

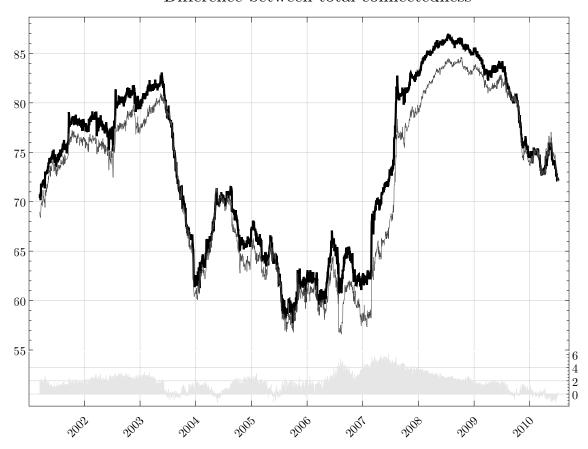
Difference between total connectedness

Figure 1: Time dynamics of connectedness of the US financial sector for system with and without FNM and FRE. The top part shows the level of connectedness and the bottom part shows the difference. The horizontal axis shows time. A positive difference indicates that the system including FNM and FRE is more connected than the system without those two stocks.

1.2 Supplementary Tables and Figures

β_1	β_2	s	ρ	Connectedness				Connectedness without correlation			
				Total	$(\pi/2, \pi)$	$(\pi/4, \pi/2)$	$(0, \pi/4)$	Total	$(\pi/2, \pi)$	$(\pi/4, \pi/2)$	$(0, \pi/4)$
0.40	-0.40	0.00	0.00	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
				(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
0.40	-0.40	0.00	0.90	44.77	44.77	44.78	44.78	0.01	0.01	0.01	0.01
				(0.11)	(0.11)	(0.11)	(0.12)	(0.01)	(0.01)	(0.01)	(0.01)
0.40	-0.40	0.20	0.00	3.35	3.39	3.33	3.31	3.35	3.34	3.34	3.35
				(0.23)	(0.31)	(0.26)	(0.36)	(0.23)	(0.24)	(0.22)	(0.22)
0.40	-0.40	0.20	0.90	45.00	43.50	45.62	46.28	3.37	3.37	3.38	3.38
				(0.11)	(0.14)	(0.10)	(0.09)	(0.19)	(0.17)	(0.20)	(0.22)
0.40	-0.40	0.59	0.00	23.10	23.11	23.09	23.08	23.10	23.11	23.09	23.08
				(0.27)	(0.54)	(0.36)	(0.59)	(0.27)	(0.35)	(0.28)	(0.34)
0.40	-0.40	0.59	0.90	46.87	41.00	47.87	48.64	23.06	23.06	23.06	23.06
				(0.09)	(0.20)	(0.05)	(0.04)	(0.35)	(0.27)	(0.42)	(0.54)
0.40	-0.40	-0.20	0.00	3.34	3.33	3.35	3.35	3.33	3.34	3.33	3.33
				(0.19)	(0.29)	(0.22)	(0.34)	(0.19)	(0.19)	(0.19)	(0.19)
0.40	-0.40	-0.20	0.90	45.02	46.05	44.27	43.01	3.33	3.33	3.33	3.33
				(0.12)	(0.10)	(0.13)	(0.16)	(0.18)	(0.20)	(0.17)	(0.15)
0.40	-0.40	-0.59	0.00	23.02	23.01	23.01	23.01	23.01	23.00	23.02	23.03
				(0.30)	(0.51)	(0.39)	(0.61)	(0.30)	(0.36)	(0.32)	(0.37)
0.40	-0.40	-0.59	0.90	46.86	48.51	45.09	38.80	23.02	22.99	23.02	23.04
				(0.10)	(0.04)	(0.11)	(0.26)	(0.31)	(0.50)	(0.24)	(0.23)

Table 1: Simulation results. The first three columns describe parameters for the simulation as described in Equation (**??**). The estimate is computed averaging over the 1000 simulations of VAR with length 10^4, and the standard error is the sample standard deviation.

β_1	β_2	s	ρ	Connectedness	$(\pi/2, \pi)$	$(\pi/4, \pi/2)$	$(0, \pi/4)$
0.0	0.0	0.00	0.0	0.00	0.00	0.00	0.00
0.0	0.0	0.00	0.9	44.75	44.75	44.75	44.75
0.9	0.9	0.09	0.0	40.50	0.30	0.90	41.15
0.9	0.9	0.09	0.9	49.47	44.25	44.41	49.51
-0.9	-0.9	0.09	0.0	40.50	40.77	0.34	0.24
-0.9	-0.9	0.09	0.9	41.28	41.01	45.22	45.22
0.9	0.4	0.09	0.0	5.66	0.32	0.88	7.48
0.9	0.4	0.09	0.9	46.09	44.25	44.48	46.56
0.9	0.0	0.09	0.0	2.59	0.32	0.80	3.97
0.9	0.0	0.09	0.9	45.40	44.25	44.51	45.98
0.9	-0.9	0.09	0.0	0.45	0.45	0.45	0.45
0.9	-0.9	0.09	0.9	44.76	44.26	44.97	45.26
0.4	-0.4	0.00	0.0	0.00	0.00	0.00	0.00
0.4	-0.4	0.00	0.9	44.75	44.75	44.75	44.75
0.4	-0.4	0.20	0.0	3.33	3.33	3.33	3.33
0.4	-0.4	0.20	0.9	45.01	43.52	45.62	46.28
0.4	-0.4	0.59	0.0	23.08	23.08	23.08	23.08
0.4	-0.4	0.59	0.9	46.87	40.94	47.86	48.64
0.4	-0.4	-0.20	0.0	3.33	3.33	3.33	3.33
0.4	-0.4	-0.20	0.9	45.01	46.05	44.27	43.00
0.4	-0.4	-0.59	0.0	23.08	23.08	23.08	23.08
0.4	-0.4	-0.59	0.9	46.87	48.51	45.13	38.84

Table 2: The true values for connectedness in the VAR settings.

Institution	Ticker	No. of obs.	Mean	Median	St. dev.	Skewness	Kurtosis	Start date	End date
AIG	AIG	4216	2.14	1.46	2.82	10.17	202.03	2000-01-03	2016-11-30
American Express	AXP	4216	1.63	1.30	1.15	2.88	18.52	2000-01-03	2016-11-30
Bank of America	BAC	4216	1.76	1.36	1.84	14.12	448.59	2000-01-03	2016-11-30
Bank of New York Mellon	BK	4216	1.72	1.34	1.41	6.53	88.15	2000-01-03	2016-11-30
Citigroup	C	4216	2.11	1.47	12.85	62.32	3985.03	2000-01-03	2016-11-30
Fannie Mae	FNM	2617	3.11	1.52	4.19	4.82	40.03	2000-01-03	2010-07-07
Freddie Mac	FRE	2617	3.16	1.47	4.58	5.55	55.22	2000-01-03	2010-07-07
Goldman Sachs	GS	4216	1.70	1.36	1.13	4.26	38.42	2000-01-03	2016-11-30
J.P. Morgan	JPM	4216	1.74	1.41	1.21	3.19	20.82	2000-01-03	2016-11-30
Morgan Stanley	MS	4216	2.18	1.76	1.80	7.39	104.67	2000-01-03	2016-11-30
PNC Group	PNC	4216	1.58	1.19	1.32	4.21	33.57	2000-01-03	2016-11-30
US Bancorp	USB	4216	1.62	1.23	1.25	3.32	22.18	2000-01-03	2016-11-30
Wells Fargo	WFC	4216	1.62	1.25	1.67	17.55	653.86	2000-01-03	2016-11-30

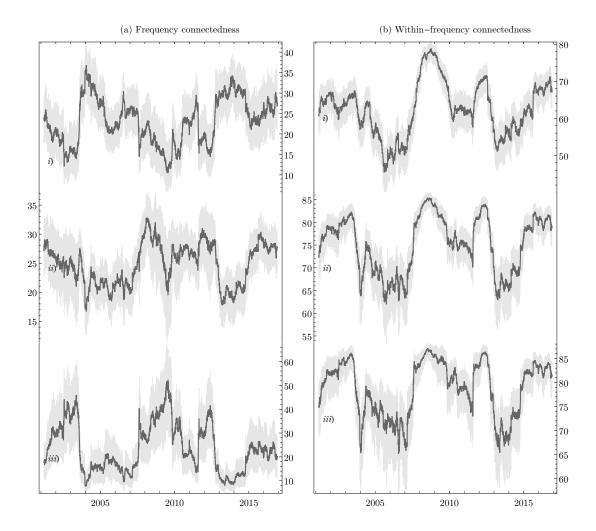**Table 3:** The descriptive statistics of the volatility data

Figure 2: The decomposition of connectedness with cross-sectional dependence. The individual lines represent connectedness measures at a given frequency band, more concretely: *i)* connectedness from one day to one week, *ii)* connectedness from one week to one month, and *iii)* connectedness from one month to 300 days. The shaded area represents the space between the 5% and 95% quantiles of the bootstrapped measure.

Figure 3: The decomposition of connectedness *without* cross-sectional dependence. The individual lines represent connectedness measures at a given frequency band, more concretely: *i)* connectedness from one day to one week, *ii)* connectedness from one week to one month, and *iii)* connectedness from one month to 300 days. The shaded area represents the space between the 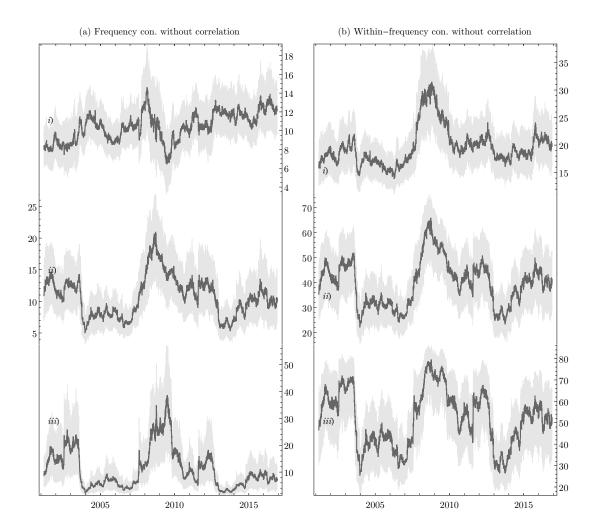5% and 95% quantiles of the bootstrapped measure.