

ONLINE APPENDIX

Not for publication

This appendix provides supplementary material for “Banks Funding, Leverage and Investment”.

A Further properties of the banking equilibrium

We explore further quantitative properties of the banking equilibrium. We do so in a version of the model where the expected returns on core investment and core liabilities are exogenous. Still, the price q_t is endogenously determined to clear the market for non-core liabilities (banking industry equilibrium).¹ We assume away the presence of learning about the probability of a crisis. The parameter values are reported in Table 1 in the paper.

A.1 Proposition 2.1 with aggregate uncertainty

We show here that the results proved in proposition 2.1 hold in the calibrated version of the model with aggregate uncertainty. The top panels of Figure A-1 plots leverage and NCF for different values of R^k and, therefore, different values of the return spread R^k/R^l (since R^l is fixed). The bottom panels plot the same variables but for different values of χ . The continuous lines show that a higher return spread between core investments and core liabilities is associated with higher NCF and leverage. Although not shown, this also increases the price of non-core liabilities q_t but less than R^k so that its expected return R^k/q_t also increases. A higher R^k implies a higher incentive to invest and, therefore, a higher supply of non-core liabilities. In order for banks to purchase the extra supply of these liabilities, the expected return has to increase.

The increase in the issuance cost has the opposite effect on NCF and leverage. With a higher cost, banks have less incentive to insure the idiosyncratic risk. Since they face higher risk, it is optimal for them to leverage less. This implies that the supply of non-core liabilities declines which leads to an increase in their price q_t and a decline in their expected return.

To illustrate the importance of the NCF for the choice of leverage, we conduct the following exercise. We force banks to choose $\alpha_t = 0$ so that there is no core-funding. We then recompute the optimal portfolio choice subject to this constraint. The dashed lines in Figure A-1 plots the NCF and leverage when banks cannot diversify. As can be seen, in absence of the non-core market, the equilibrium is characterized by much smaller leverages.

The importance of non-core funding for the choice of leverage can be explained as follows. When the return spread increases, banks would choose to become more leveraged even if

¹To compute the banking equilibrium for given R^k/R^l , we solve the system of nonlinear equations (4), (7), (8), (9), (10), (11), (12) in the paper, together with the market clearing condition for non-core liabilities $F_{t+1} = \alpha_t K_{t+1}$.

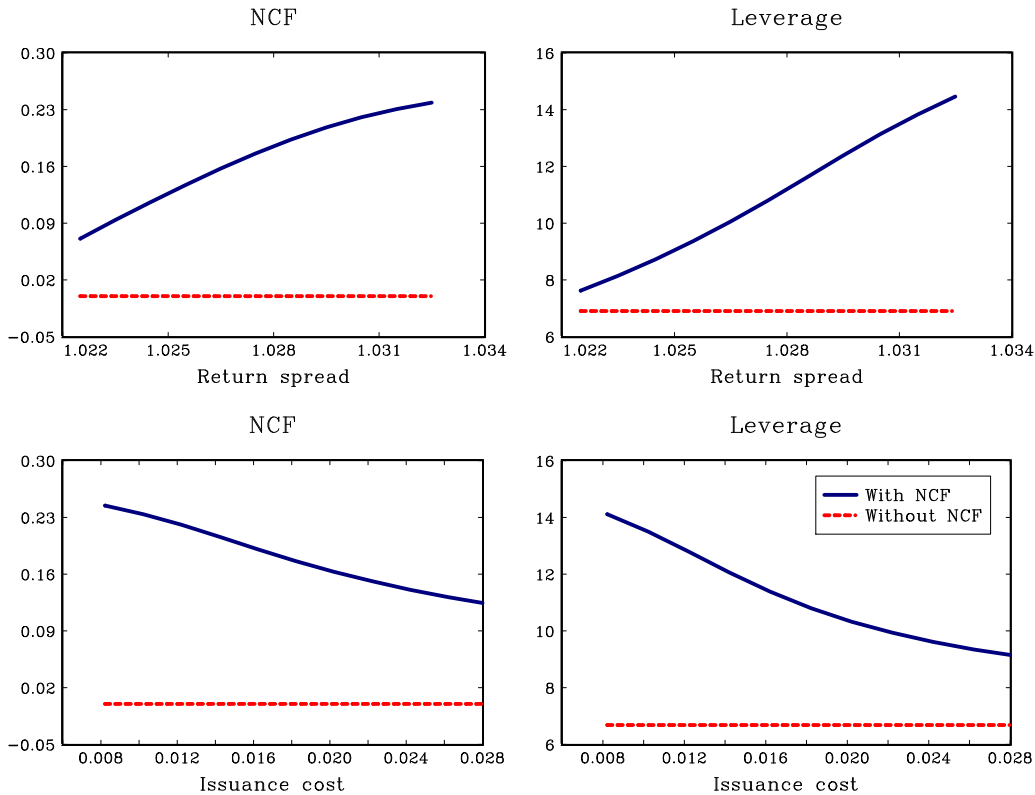


Figure A-1: Sensitivity of NCF and leverage to return spread and issuance cost. The sensitivity is performed by changing R^k or χ . Parameters values are reported in Table 1 in the paper.

they could not diversify through the issuance of non-core liabilities. However, since leverage increases the risk faced by banks, the ability to issue non-core liabilities reduces the risk, which further encourages leverage.² Therefore, when the return spread increases, non-core funding ‘amplifies’ the impact of the higher return spread on leverage. When the issuance cost declines, banks expand non-core funding because it is less costly. Since non-core funding reduces the idiosyncratic risk, banks are more willing to leverage. In summary, non-core funding creates the conditions for banks to become more leveraged.

A.2 Change in the volatility of the idiosyncratic shock

We show how NCF and leverage respond to a change in the volatility of the idiosyncratic shock, z_{t+1} . This is related to the recent literature on time-varying volatility. As Figure A-2 shows, higher idiosyncratic risk increases the incentive of banks to diversify (higher NCF). However, since diversification does not completely offset the higher risk, banks choose lower leverage. This exercise shows that the positive co-movement between the NCF and leverage

²Higher leverage means that a negative realization of z_{t+1} has a larger percentage effect on the equity of the bank and, therefore, on dividend payments.

is not simply the result of an accounting identity. The two indices could be either positively or negatively correlated. It depends on the dominant force underlying their change.

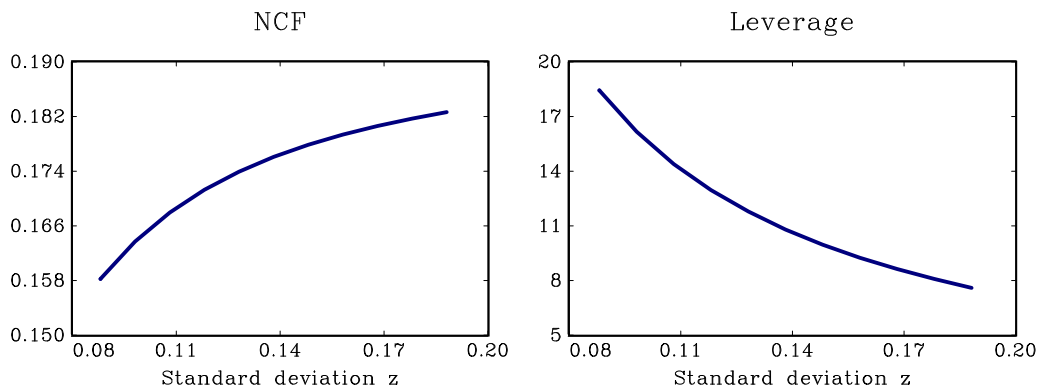


Figure A-2: Sensitivity of NCF and leverage to the standard deviation of the idiosyncratic shock. The sensitivity is performed by changing the low and high realizations of z . Parameters values are reported in Table 1 in the paper.

A.3 Sensitivity to low crisis probability, p^L

In order to calibrate the stochastic process for the probability of default, we need to pin down the following parameters: p^L , p^H , $\Gamma(p^L, p^L)$, $\Gamma(p^L, p^H)$. In addition, we need to set the initial value of the prior when we start the simulation, the variable θ_{1999} . In the calibration of the baseline model we pre-set $p^L = 0$ and $\Gamma(p^L, p^L) = 0.99$, and then we calibrated p^H , $\Gamma(p^H, p^H)$ and θ_{1999} jointly by using three targets: (i) The unconditional average probability of a banking crisis is 3%; (ii) The change in the expected losses induced by the 2008 crisis is equal to half the jump in credit default swaps rate observed in 2008 (about 0.9 percent); (iii) The initial prior, θ_{1999} , is set to the unconditional probability of p^H . In this section we conduct a sensitivity analysis with respect to p^L . When we change p^L we also change the other parameters so that the same calibration targets are met.

Figure A-3 plots the simulation of the model for three different calibrations of p^L . The continuous line is for the baseline calibration with $p^L = 0$. The other lines are for $p^L = 0.002$ and $p^L = 0.005$. As can be seen from the figure, different values of p^L affect the persistence of the response after the crisis. With higher values of p^L , the reversal after the crisis is faster. This is because a higher value of p^L must be associated to a lower persistence of p^H in order to match the calibration targets. This implies that the prior belief reacts less to a crisis as can be seen in the third panel and, therefore, the return of the economy to the pre-crisis period level is quicker. But besides the persistence after the crisis, the value of p^L does not change the main quantitative properties.

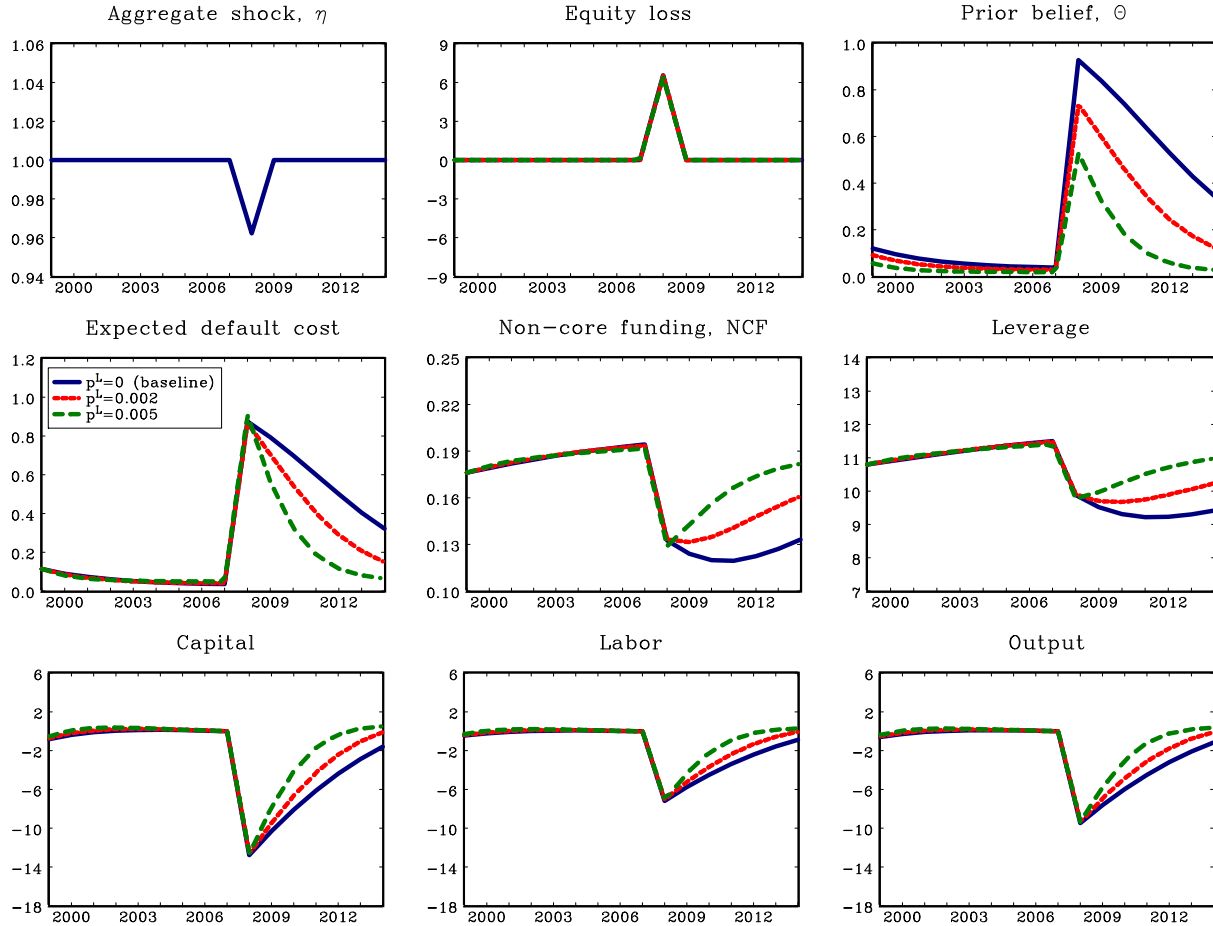


Figure A-3: Dynamics with Bayesian learning about the probability of crises. Different calibrations p^L .

B Non-Core Assets

We show that non-core assets follow in the data a dynamics similar to the one of the non-core funding (NCF). As in the paper, we use the Flow of Funds and consider three main actors in the US financial system: depository institutions, securities brokers and dealers and finance companies. We use as 'proxy' for non-core asset (NCA) the share of REPOs, MBS, commercial papers, corporate and foreign bonds and loans to other banks over total assets (See Table A-1 for the details of the series used).

Figure A-4 reports the evolution over time of the NCA. We also report the series for NCF used in Figure 2 in the paper. As the Figure shows, the two series display a very similar dynamics, with an increase before the crisis and a decrease after the crisis. The correlation between the two series is 0.9.

Since in the model presented in the paper NCF and NCA coincide, Figure A-4 implies that our model is able to broadly capture also the evolution of non-core assets.

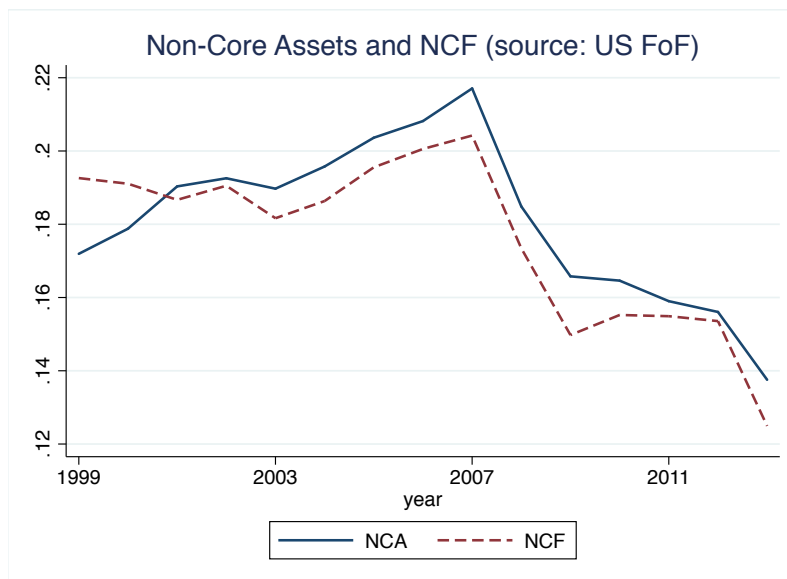


Figure A-4: NCA and NCF over time.

Table A-1: Data series from the US Flows of Funds.

US Depository Institutions	
764090760	Total Assets (Call report)
762050005	Federal funds and security repurchase agreements (REPOs); assets
763063605	Private MBS and CMOs; assets
763069175	Open market paper; assets
764035125	Loans to foreign banks; assets
Securities Brokers and Dealers	
664090663	Total Assets
662051003	Security repurchase agreements (REPO); assets
663063005	Corporate and foreign bonds; assets
663069103	Commercial paper; assets
663097005	Securities borrowed (net); assets
Finance Companies	
614090610	Total Assets
613063003	Corporate and foreign bonds; assets

C Empirical Evidence

C.1 Sample

Country	Obs.	Percent	Country	Obs.	Percent
AUT	4,143	1.61	ISR	203	0.08
BEL	1,314	0.51	ITA	11,205	4.36
CAN	1,348	0.52	JPN	11,596	4.51
CHE	6,965	2.71	KOR	860	0.33
CHL	565	0.22	MEX	1,442	0.56
CZE	545	0.21	NLD	1,072	0.42
DEU	28,729	11.17	NOR	2,018	0.78
DNK	1,786	0.69	NZL	307	0.12
ESP	2,830	1.1	POL	763	0.3
EST	126	0.05	PRT	1,007	0.39
FIN	421	0.16	SVK	307	0.12
FRA	6,420	2.5	SVN	310	0.12
GBR	6,751	2.63	SWE	1,680	0.65
HUN	590	0.23	TUR	1,055	0.41
IRL	693	0.27	USA	160,080	62.26
Total				257,131	100

Table A-2: Composition of the sample, by country. Data are from Bankscope. Sample period: 1999-2014 (pooled data).

C.2 NCF and Leverage dynamics

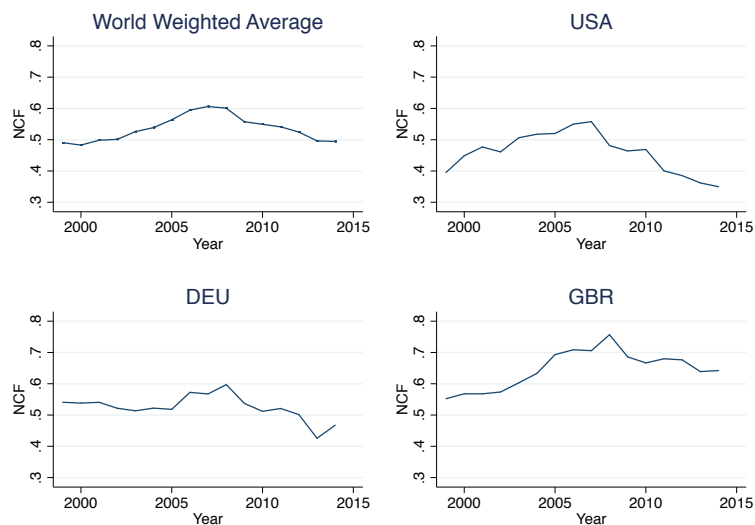


Figure A-5: NCF over time, selected countries. NCF is measured as the ratio of aggregate non-core liabilities to aggregate assets. Aggregate assets and liabilities are computed by summing the values of these variables for all Commercial and Savings Banks, Cooperative Banks, Investment Banks and Securities Firms, and Finance Companies. Assets and liabilities are in book values.

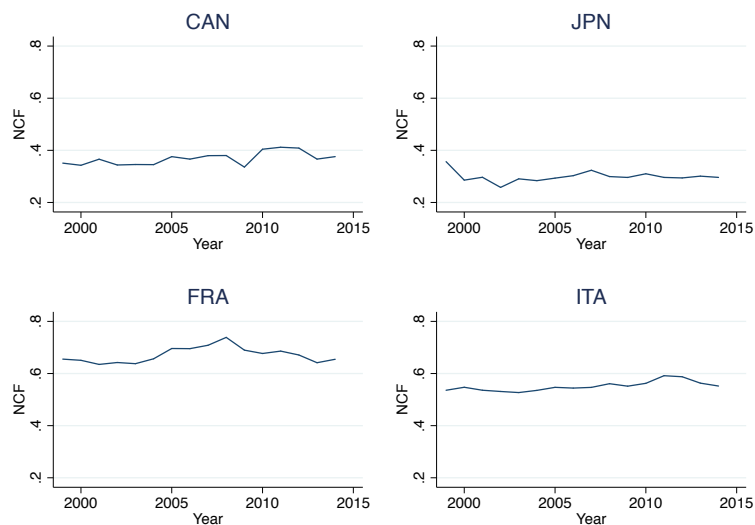


Figure A-6: NCF over time, selected countries. NCF is measured as the ratio of aggregate non-core liabilities to aggregate assets. Aggregate assets and liabilities are computed by summing the values of these variables for all Commercial and Savings Banks, Cooperative Banks, Investment Banks and Securities Firms, and Finance Companies. Assets and liabilities are in book values.

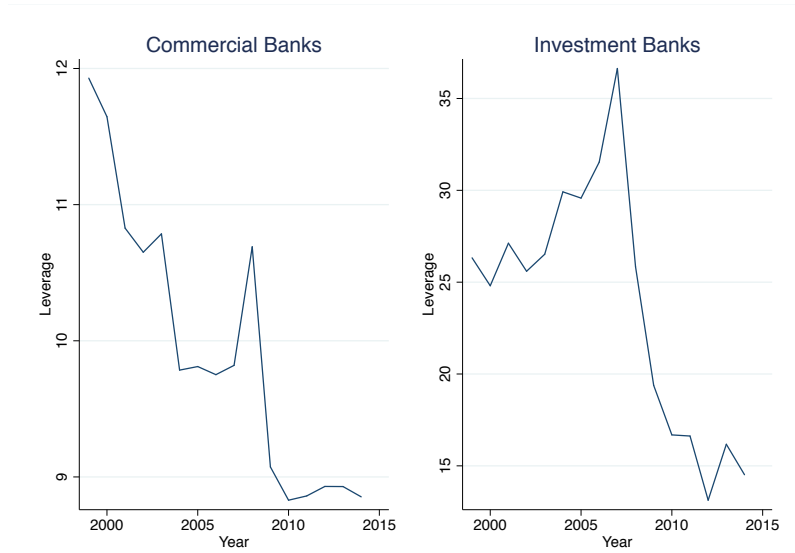


Figure A-7: Leverage over time, USA, Commercial and Investment Banks. Leverage is measured as total assets over total equity. Assets and equities are in book values.

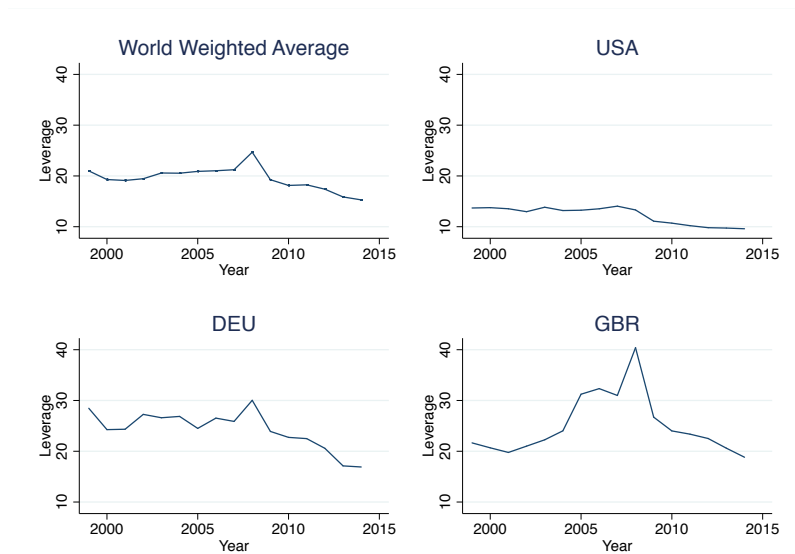


Figure A-8: Leverage over time, selected countries. Leverage is measured as the ratio of aggregate assets over aggregate equity. Aggregate assets, liabilities and equities are computed by summing the values of these variables for all Commercial and Savings Banks, Cooperative Banks, Investment Banks and Securities Firms, and Finance Companies. Assets and liabilities are in book values.

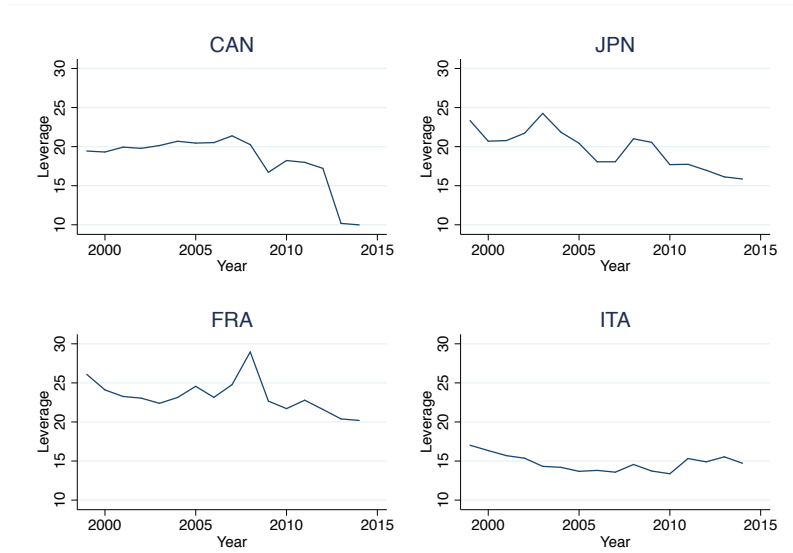


Figure A-9: Leverage over time, selected countries. Leverage is measured as the ratio of aggregate assets over aggregate equity. Aggregate assets, liabilities and equities are computed by summing the values of these variables for all Commercial and Savings Banks, Cooperative Banks, Investment Banks and Securities Firms, and Finance Companies. Assets and liabilities are in book values.

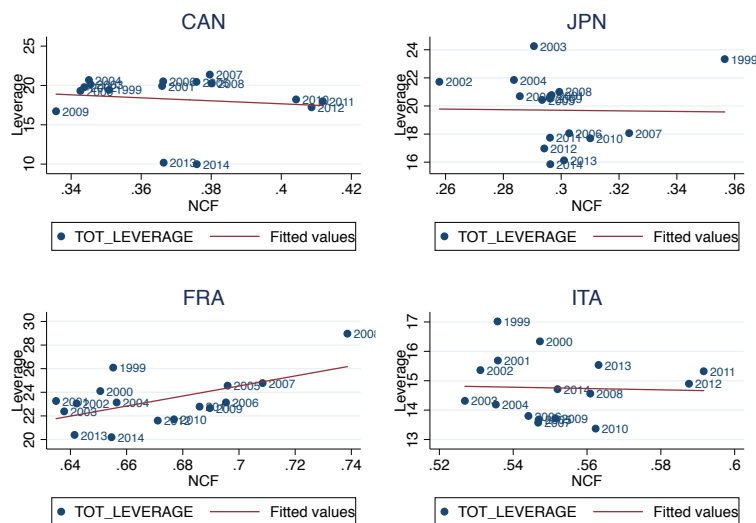


Figure A-10: Leverage and NCF, Across Time, Within Selected Countries. NCF is measured as the ratio of aggregate non-core liabilities to aggregate assets and Leverage as the ratio of aggregate assets over aggregate equity. Aggregate assets, liabilities and equities are computed by summing the values of these variables for all Commercial and Savings Banks, Cooperative Banks, Investment Banks and Securities Firms, and Finance Companies. Assets and liabilities are in book values.

C.3 NCF and Leverage: alternative samples

Table A-3: NCF and Leverage, Very Large Financial Institutions (1999-2007)

Dep Variable	A/E	A/E	A/E
NCF	38.234*** (2.418)	26.361*** (3.610)	20.406** (8.113)
size	0.823 (0.557)	-1.098* (0.627)	4.908** (2.256)
Specialisation FE	No	Yes	No
Country FE	No	Yes	No
Time FE	No	Yes	Yes
Banks FE	No	No	Yes
R-squared	0.386	0.578	0.118
N	710	710	710

Notes: unconditional and conditional correlations between leverage and NCF for financial institutions with balance sheets larger than 100 USD billions. Leverage is measured as total assets over total equity for each financial institution. NCF is measured as the ratio between non-core liabilities and total assets. Assets and liabilities are in book values. Standard Errors in Parenthesis. *, **, *** Statistically Significant at 10%, 5% and 1%.

Table A-4: NCF and Leverage, Very Large Financial Institutions (2003-2007)

Dep Variable	A/E	A/E	A/E
NCF	42.355***	25.640***	37.483***
	(3.254)	(5.112)	(14.135)
size	-0.168	-1.037	12.068***
	(0.822)	(0.794)	(3.954)
Specialisation FE	No	Yes	No
Country FE	No	Yes	No
Time FE	No	Yes	Yes
Banks FE	No	No	Yes
R-squared	0.401	0.625	0.205
N	399	399	399

Notes: unconditional and conditional correlations between leverage and NCF for financial institutions with balance sheets larger than 100 USD billions. Leverage is measured as total assets over total equity for each financial institution. NCF is measured as the ratio between non-core liabilities and total assets. Assets and liabilities are in book values. Standard Errors in Parenthesis. *, **, *** Statistically Significant at 10%, 5% and 1%.

Table A-5: NCF and Leverage: By Country, 1999-2011, FE

Dep Var: A/E	USA	CAN	GBR	JPN	DEU	FRA	ITA
NCF	5.299***	1.735	5.104**	-6.599	6.405***	10.581***	3.642**
	(0.368)	(1.785)	(2.292)	(4.993)	(1.441)	(3.275)	(1.185)
size	1.533***	3.244***	5.433***	6.880***	3.847***	8.443***	6.213***
	(0.073)	(0.646)	(0.620)	(0.960)	(0.542)	(0.987)	(0.778)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Banks FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.056	0.190	0.297	0.074	0.534	0.293	0.221
N	132945	1046	3400	10699	26534	5071	10438

Notes: correlations between leverage and NCF for different countries. Leverage is measured as total assets over total equity for each financial institution. NCF is measured as the ratio between non-core liabilities and total assets. Size is measured by the log of total assets. Assets and liabilities are in book values. Standard Errors in Parenthesis. *, **, *** Statistically Significant at 10%, 5% and 1%.

C.4 Alternative measures of NCF: Non-core Liabilities over Total Liabilities (NCF2)

We present here the entire set of results obtained using an alternative measure for NCF:

$$NCF2 = \frac{LIABILITIES - DEPOSITS}{LIABILITIES} \quad (A-1)$$

The results obtained using this alternative measure of NCF are very similar to those presented in the paper.

Table A-6: NCF2 and Leverage: Cross-Country Evidence

Dep Variable	A/E	A/E	A/E
NCF2	20.474*** (1.365)	14.882*** (2.178)	16.809*** (2.200)
Country FE	No	Yes	Yes
Time FE	No	No	Yes
R-squared	0.320	0.777	0.841
N	480	480	480

Notes: unconditional and conditional correlations between leverage and NCF2 at country level. NCF2 is measured as the ratio of aggregate non-core liabilities to aggregate liabilities and Leverage as the ratio of aggregate assets over aggregate equity. Aggregate assets, liabilities and equities are computed by summing the values of these variables for all Commercial and Savings Banks, Cooperative Banks, Investment Banks and Securities Firms, and Finance Companies. Assets and liabilities are in book values. Standard Errors in Parenthesis. *, **, *** Statistically Significant at 10%, 5% and 1%.

Table A-7: **NCF2 and Leverage, Very Large Financial Institutions (1999-2014)**

Dep Variable	A/E	A/E	A/E
NCF2	32.688***	22.271***	26.062***
	(1.727)	(2.938)	(6.283)
size	-0.072	-1.009**	5.087***
	(0.385)	(0.453)	(1.766)
Specialisation FE	No	Yes	No
Country FE	No	Yes	No
Time FE	No	Yes	Yes
Banks FE	No	No	Yes
R-squared	0.309	0.489	0.194
N	1272	1272	1272

Notes: unconditional and conditional correlations between leverage and NCF2 for financial institutions with balance sheets larger than 100 USD billions. Leverage is measured as total assets over total equity for each financial institution. NCF2 is measured as the ratio between non-core liabilities and total liabilities. Assets and liabilities are in book values. Standard Errors in Parenthesis. *, **, *** Statistically Significant at 10%, 5% and 1%.

Table A-8: **NCF2 and Leverage, All financial institutions**

Dep Variable	A/E	A/E	A/E
Time Period	1999-2014	1999-2007	2003-2007
NCF2	2.999***	1.856***	1.434***
	(0.352)	(0.446)	(0.547)
size	2.873***	3.026***	3.240***
	(0.111)	(0.145)	(0.191)
Banks FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
R-squared	0.086	0.108	0.109
N	212962	125459	69476

Notes: conditional correlations between leverage and NCF2 for all financial institutions (two way fixed effect estimator). Leverage is measured as total assets over total equity for each financial institution. NCF2 is measured as the ratio between non-core liabilities and total assets. Size is measured as the log of total liabilities. Assets and liabilities are in book values. Standard Errors in Parenthesis. *, **, *** Statistically Significant at 10%, 5% and 1%.

Table A-9: **NCF2 and Leverage: By Country, 1999-2011, FE**

Dep Var: A/E	USA	CAN	GBR	JPN	DEU	FRA	ITA
NCF2	1.190*** (0.300)	0.485 (1.536)	2.157 (3.007)	-5.609 (6.005)	3.660*** (1.155)	5.304** (2.354)	-0.991 (1.236)
size	1.639*** (0.077)	4.188*** (0.712)	5.680*** (0.598)	6.599*** (0.906)	3.986*** (0.547)	8.432*** (0.830)	6.050*** (0.590)
hline Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Banks FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.048	0.239	0.285	0.075	0.517	0.273	0.233
N	132446	1040	3335	10699	26529	5069	10438

Notes: correlations between leverage and NCF2 for different countries. Leverage is measured as total assets over total equity for each financial institution. NCF2 is measured as the ratio between non-core liabilities and total liabilities. Size is measured by the log of total assets. Assets and liabilities are in book values. Standard Errors in Parenthesis. *, **, *** Statistically Significant at 10%, 5% and 1%.

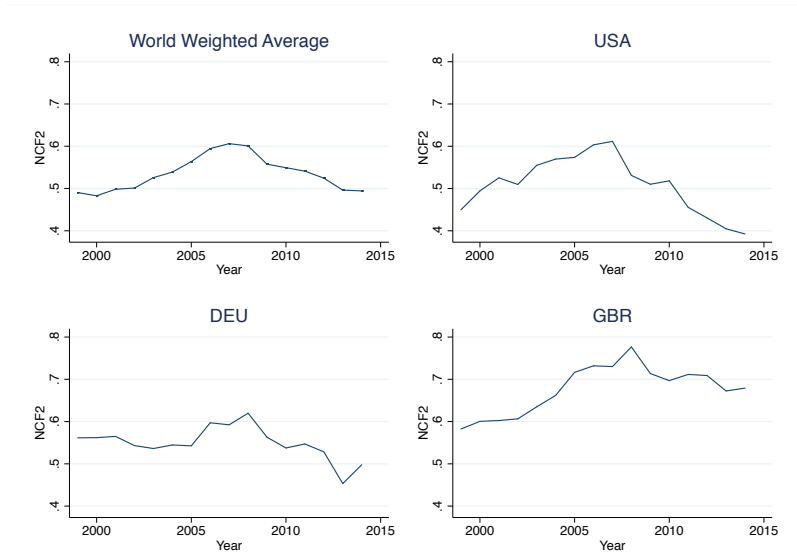


Figure A-11: NCF2 over time, selected countries. NCF2 is measured as the ratio of aggregate non-core liabilities to aggregate liabilities. Aggregate assets and liabilities are computed by summing the values of these variables for all Commercial and Savings Banks, Cooperative Banks, Investment Banks and Securities Firms, and Finance Companies. Assets and liabilities are in book values.

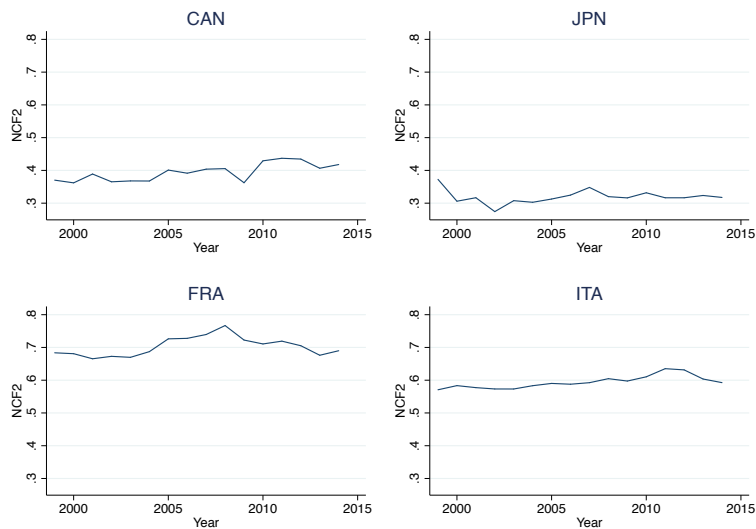


Figure A-12: NCF2 over time, selected countries. NCF2 is measured as the ratio of aggregate non-core liabilities to aggregate liabilities. Aggregate assets and liabilities are computed by summing the values of these variables for all Commercial and Savings Banks, Cooperative Banks, Investment Banks and Securities Firms, and Finance Companies. Assets and liabilities are in book values.

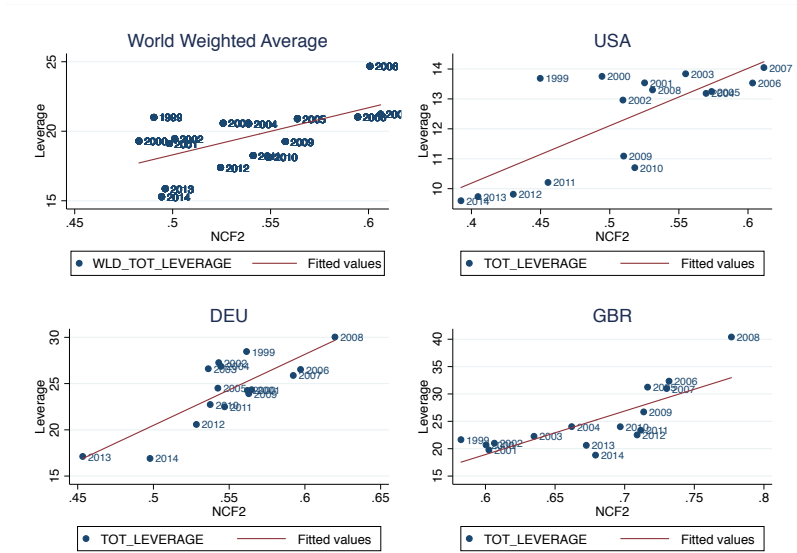


Figure A-13: Leverage and NCF2, Across Time, Within Selected Countries. NCF2 is measured as the ratio of aggregate non-core liabilities to aggregate liabilities and Leverage as the ratio of aggregate assets over aggregate equity. Aggregate assets, liabilities and equities are computed by summing the values of these variables for all Commercial and Savings Banks, Cooperative Banks, Investment Banks and Securities Firms, and Finance Companies. Assets and liabilities are in book values.

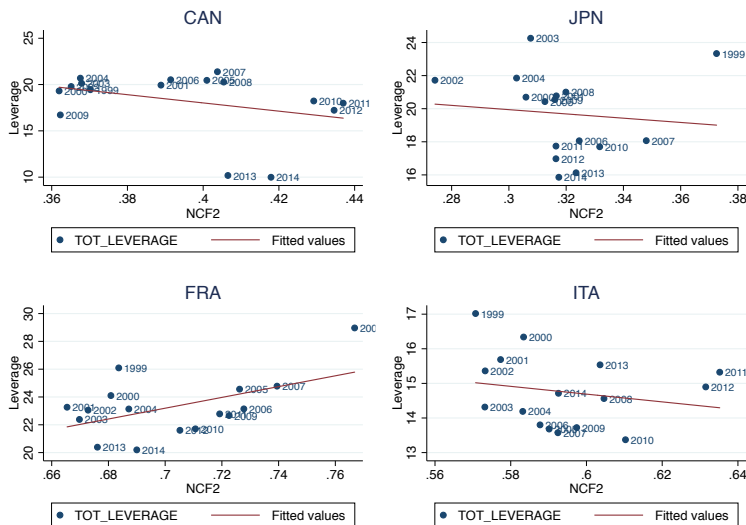


Figure A-14: Leverage and NCF2, Across Time, Within Selected Countries. NCF2 is measured as the ratio of aggregate non-core liabilities to aggregate liabilities and Leverage as the ratio of aggregate assets over aggregate equity. Aggregate assets, liabilities and equities are computed by summing the values of these variables for all Commercial and Savings Banks, Cooperative Banks, Investment Banks and Securities Firms, and Finance Companies. Assets and liabilities are in book values.

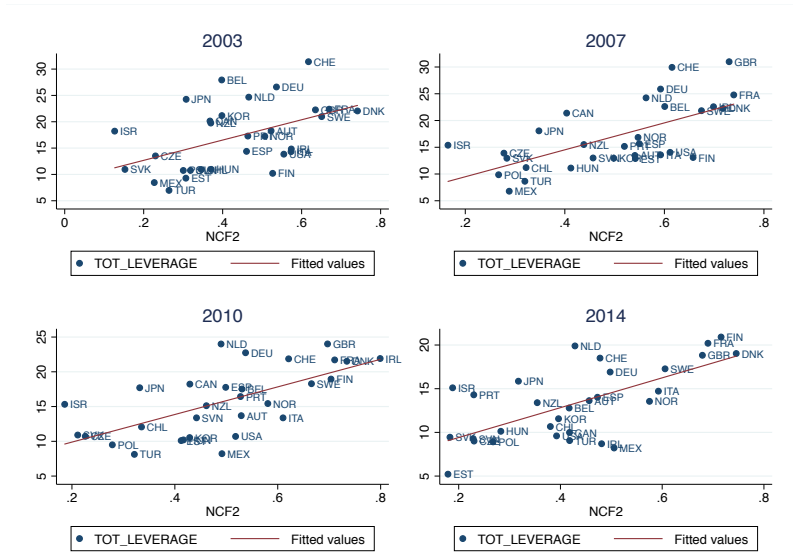


Figure A-15: Leverage and NCF2, Across countries, Selected Years. NCF2 is measured as the ratio of aggregate non-core liabilities to aggregate liabilities and Leverage as the ratio of aggregate assets over aggregate equity. Aggregate assets, liabilities and equities are computed by summing the values of these variables for all Commercial and Savings Banks, Cooperative Banks, Investment Banks and Securities Firms, and Finance Companies. Assets and liabilities are in book values.

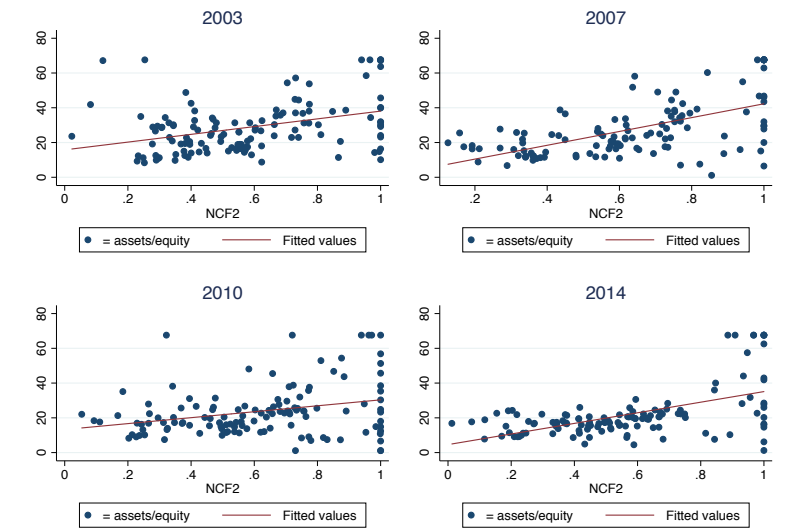


Figure A-16: Leverage and NCF2, Across Very Large Firms, Selected Years. Leverage is measured as total assets over total equity for each financial institution. NCF2 is measured as the ratio between non-core liabilities and total liabilities. Assets and liabilities are in book values.

C.5 Alternative measures of NCF: Inter Bank Deposits over Assets, Mega Banks (NCF3)

For a subset of the Mega Banks, we provide also the results obtained using a further measure of NCF:

$$NCF3 = \frac{INTERBANKDEPOSITS}{ASSETS} \quad (A-2)$$

Also in this case, we find a strong positive correlation between NCF and leverage.

Table A-10: **NCF3 and Leverage, Very Large Financial Institutions (1999-2014)**

Dep Variable	A/E	A/E	A/E
NCF3	44.524*** (3.726)	32.216*** (5.024)	14.204* (7.211)
size	1.698*** (0.411)	0.168 (0.468)	6.316*** (2.254)
Specialisation FE	No	Yes	No
Country FE	No	Yes	No
Time FE	No	Yes	Yes
Banks FE	No	No	Yes
R-squared	0.190	0.393	0.154
N	1103	1103	1103

Notes: unconditional and conditional correlations between leverage and NCF3 for financial institutions with balance sheets larger than 100 USD billions. Leverage is measured as total assets over total equity for each financial institution. NCF3 is measured as the ratio between Interbank deposits and total assets. Assets and liabilities are in book values. Standard Errors in Parenthesis. *, **, *** Statistically Significant at 10%, 5% and 1%.

Table A-11: **NCF3 and Leverage, Very Large Financial Institutions (1999-2007)**

Dep Variable	A/E	A/E	A/E
NCF3	38.842*** (4.713)	28.360*** (6.864)	35.726*** (12.971)
size	2.990*** (0.532)	0.324 (0.632)	6.775** (2.690)
Specialisation FE	No	Yes	No
Country FE	No	Yes	No
Time FE	No	Yes	Yes
Banks FE	No	No	Yes
R-squared	0.243	0.427	0.119
N	563	563	563

Notes: unconditional and conditional correlations between leverage and NCF3 for financial institutions with balance sheets larger than 100 USD billions. Leverage is measured as total assets over total equity for each financial institution. NCF3 is measured as the ratio between Interbank deposits and total assets. Assets and liabilities are in book values. Standard Errors in Parenthesis. *,**,*** Statistically Significant at 10%, 5% and 1%.

Table A-12: **NCF3 and Leverage, Very Large Financial Institutions (2003-2007)**

Dep Variable	A/E	A/E	A/E
NCF3	40.740*** (7.065)	25.270*** (9.296)	31.466** (15.034)
size	3.687*** (0.792)	0.990 (0.896)	26.292*** (4.973)
Specialisation FE	No	Yes	No
Country FE	No	Yes	No
Time FE	No	Yes	Yes
Banks FE	No	No	Yes
R-squared	0.232	0.473	0.322
N	309	309	309

Notes: unconditional and conditional correlations between leverage and NCF3 for financial institutions with balance sheets larger than 100 USD billions. Leverage is measured as total assets over total equity for each financial institution. NCF3 is measured as the ratio between Interbank deposits and total assets. Assets and liabilities are in book values. Standard Errors in Parenthesis. *,**,*** Statistically Significant at 10%, 5% and 1%.