Cross-Border Interbank Networks, Banking Risk and Contagion

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Motivation: International banking exposures

- Increase in foreign interbank asset (liability) positions since 1980s.

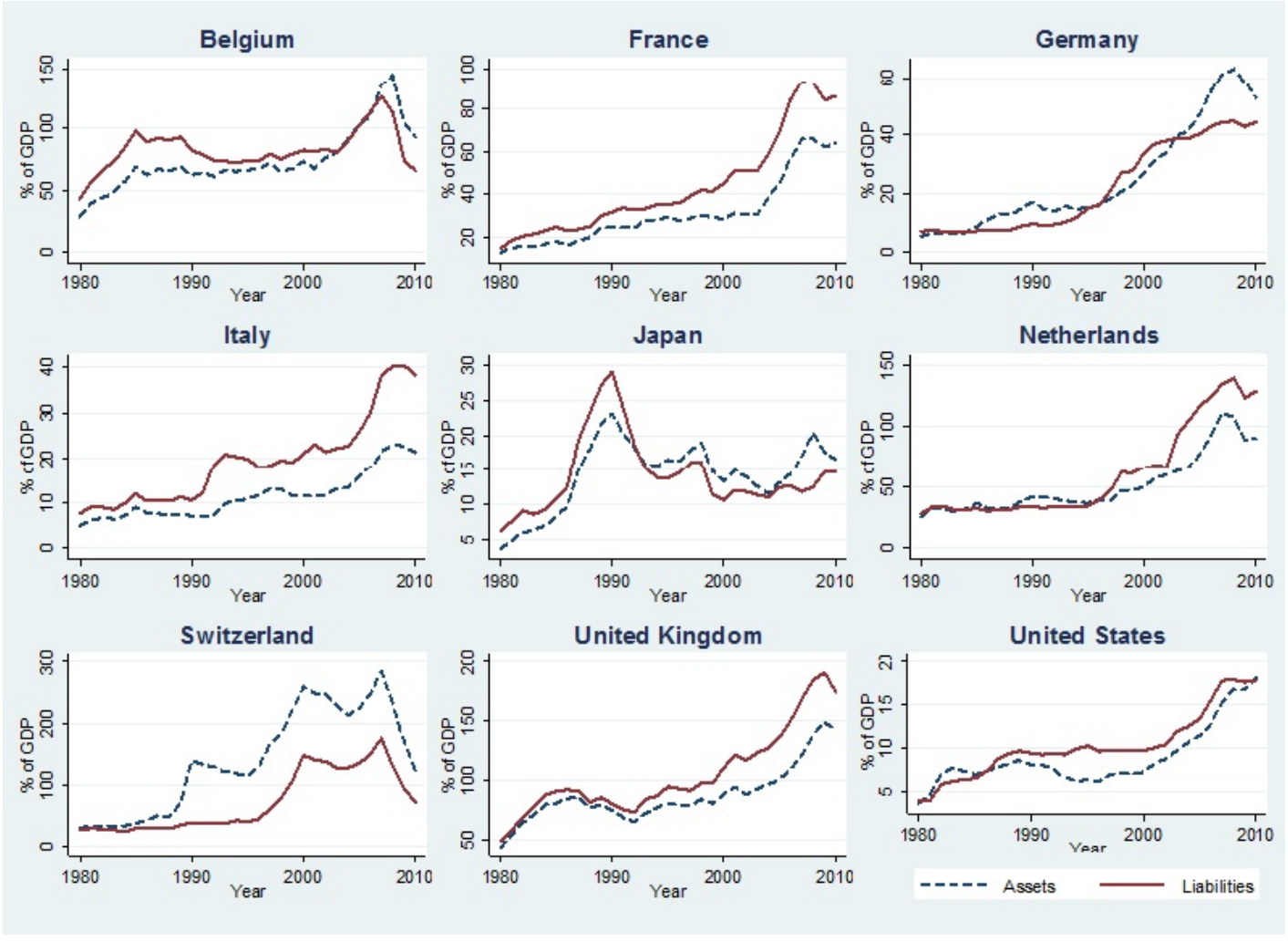

Figure: Cross-Border Interbank Exposures (% of GDP)

Network models and banking stability: What theory would tell...

Allen and Gale 2000, Freixas et al. 2000, Cifuentes et al. 2005, Nier et al. 2007, Gai and Kapadia 2010, Upper and Worms 2004, Degryse and Nguyen 2007, Degryse et al. 2010...

Testable hypotheses:

- **H1:** Interconnections in banking allow for risk-sharing possibilities. At the same time, they can transmit shocks.
- **H2:** The trade-off between risk-sharing possibilities and contagion risk can be affected by the degree of diversification or interconnectedness.
- **H3:** Stronger links taking the form of larger interbank exposures tend to increase contagion risk.

... but implemented empirically?

Descriptive statistics of the international banking network

- Minou and Reyes (2011) study characteristics of the network structure in global banking using various network measures.

Determinants and effects of cross-border exposures

- Cetorelli and Goldberg (2011) analyze determinants of changes in cross-border lending during the crisis.
- Lane and Milesi-Ferretti (2010) examine if changes in foreign net lending affect economic stability.

Simulation studies

- Spillover of shocks between banks/ banking systems through linkages analyzed (Upper and Worms 2004, Degryse et al. 2010).
- Drawback: non-availability of bank-to-bank exposures, simulated bilateral links based on assumption of equally distributed interbank positions across counterparties, country-specific studies.

This paper

- Question
  - Does the stability of a country's banking system affect the soundness of a banking system in another but interlinked country?
  - And which role plays the underlying network structure?
- Data
  - Confidential data on bilateral cross-border exposures between banking systems obtained from the Bank for International Settlements.
  - Measure for bank risk from the Financial Structure Database, Bankscope.
- Approach
  - Spatial modeling approach allows evaluating feedback effects in a network of intertwined banking systems.
- Contribution
  - Network topology and implications for stability merely considered in the international banking literature.
  - Impacts however visible at least since 2007 and further evidence necessary for (international coordination of) regulation.

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The network in matrix notation

The $n \times n$ network matrix at time t consists of bilateral foreign claims (assets or liabilities or both) x_{ijt} between country pair ij:

$$\begin{bmatrix} 0 & x_{12t} & \cdots & x_{1nt} \\ x_{21t} & 0 & \cdots & x_{2nt} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1t} & x_{n2t} & \cdots & 0 \end{bmatrix}.$$

Network measures:

- Herfindahl index: $HHI_{it} = \sum_{j=1\setminus i}^{n} \omega_{ijt}^2$ where $\omega_{ijt} = \frac{x_{ijt}}{\sum_{j=1\setminus i}^{n} x_{ijt}}$.
- HHI $\in \left(1/(n-1), 1\right)$ with lower values indicating a higher degree of interconnectedness and more equally distributed exposures.
- Node-in strength: $\frac{liabilities_{it}}{\sum_{j=1}^{n} liabilities_{jt}}$
- Node-out strength: $\frac{assets_{it}}{\sum_{j=1}^{n} assets_{jt}}$

Cross-border interbank network I

- No obvious relationship between openness and diversification.

Figure: Openness versus Diversification

Cross-border interbank network II

Table: Distribution of Cross-Border Assets between Banking Systems (2008)

Claims towards Reporting country	BE	CA	DK	FR	DE	IR	IT	JP	NL	PT	ES	SE	CH	UK	US
							(% of total)								
Belgium		0.4	0.7	**12.0**	7.6	19.5	2.3	0.6	**26.5**	0.8	5.8	0.6	1.0	18.9	3.2
Canada	0.1		0.1	1.3	0.2	4.7	0.0	0.1	1.7	0.0	0.3	0.0	0.3	18.3	**72.9**
Denmark	2.7	0.1		2.5	5.8	12.7	0.2	0.1	1.3	0.2	4.4	42.6	0.5	23.8	3.1
France	4.8	0.6	0.4		12.0	4.4	13.1	3.1	4.7	2.0	9.0	0.8	2.5	31.6	10.9
Germany	1.8	0.7	2.9	9.5		5.7	9.3	1.0	4.7	1.4	10.6	1.7	2.8	38.4	9.5
Ireland	1.8	1.2	2.5	5.5	7.7		15.3	0.4	4.6	0.5	6.2	0.7	1.5	46.5	5.7
Italy	4.1	0.0	0.3	**22.4**	**26.2**	5.6		0.2	2.4	0.4	**11.4**	0.1	1.8	22.3	2.8
Japan	3.8	1.0	0.3	7.3	6.0	1.1	0.6		2.7	0.0	0.5	0.4	2.8	40.1	33.5
Netherlands	14.5	0.4	1.3	7.9	5.1	3.0	3.4	1.3		0.1	6.6	0.6	1.8	49.4	4.5
Portugal	2.1	0.2	1.6	11.6	17.6	3.4	5.6	0.2	3.6		28.7	0.6	2.2	16.7	6.0
Spain	5.2	0.1	0.6	13.9	5.4	1.6	14.3	0.4	5.8	11.4		0.5	1.0	31.8	8.1
Sweden	0.4	0.8	30.6	5.9	15.1	2.3	0.9	0.2	1.8	0.0	2.8		1.3	32.4	5.5
Switzerland	6.0	0.2	1.0	10.6	9.5	2.1	0.6	6.4	14.0	0.1	0.4	0.2		45.7	3.1
United Kingdom	3.5	2.7	1.0	17.4	14.1	9.2	6.1	4.1	10.3	0.9	7.9	1.3	7.8		13.7
United States	1.4	6.7	0.1	11.2	3.6	3.5	3.6	5.1	1.6	0.1	3.3	0.5	8.6	50.8	

- Regional clusters and financial centers.

Cross-border interbank network III

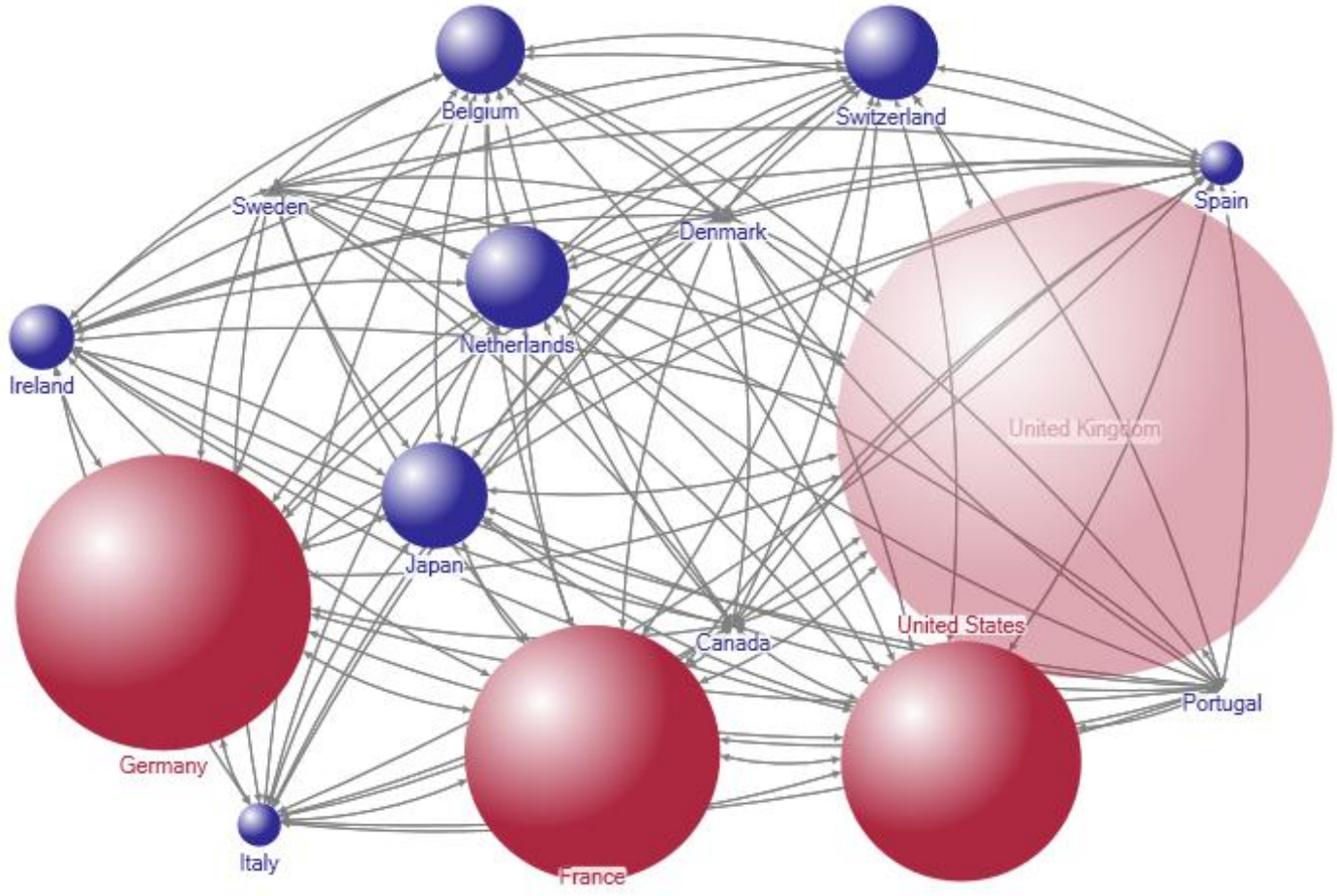

Figure: Relative Importance in the Network: Assets 2008

- Different importance of banking systems as lenders in the network.

Empirical analysis I

$\Rightarrow$ Spatial modeling approach to assess the link between cross-border network exposures and banking risk.

The sample covers 12 European countries, Japan, Canada and the United States, annual data for the period 1993-2009.

The dependent variable measures bank risk for the banking system in country *i* at time *t* and is defined as the average of

$$z - score_{kt} = \frac{ROA_{kt} + (E/A)_{kt}}{\sigma(ROA)_{kt}}$$

for all commercial banks *k* in country *i* whereas

- ROA_{kt} : return on assets,
- $(E/A)_{kt}$: equity to assets ratio,
- $\sigma(ROA)_{kt}$: standard deviation of return on assets.

(see *Financial Structure Database*, T. Beck et al. 2009)

Empirical analysis II

Model with **interaction term** (spatial interaction term):

$$y_{it} = \alpha_i^{country} + \sum_{c=1}^{C} \beta_c z_{it-1}^c + \sum_{b=1}^{B} \beta_b q_{it-1}^b + \phi \sum_{j=1}^{n} \omega_{ijt} y_{jt} + \varepsilon_{it}$$

- y_{it}: dependent variable measuring bank risk *ln(z-score$_{it}$)*,
- $\alpha_i^{country}$: country fixed effects,
- z_{it-1}^c : aggregate country and bank specific variables,
- q_{it-1}^b : change in cross-border asset (liability) positions,
- $\sum_{j=1\setminus i}^{n} \omega_{ijt} y_{jt}$: spatial autoregressive term with $\omega_{ijt} = \frac{x_{ijt}}{\sum_{j=1\setminus i}^{n} x_{ijt}}$ and x_{ijt} given by interbank asset (liability) positions of country $i's$ banking system towards banks in country j.

Empirical analysis III

Effects of **network exposures** and **diversification**:

- *HHI*: Herfindahl index measuring diversification of network exposures.
- *Network exposures*: cross-border lending or borrowing positions within the network of banking systems.
- *Node strength*: relative network importance as a lender or borrower.

Estimation approach:

- Control for country unobserved heterogeneity by including fixed effects.
- Adjust standard errors for heteroscedasticity.
- Lag control variables by one period to reduce simultaneity concerns.
- Spatial autoregressive term enters contemporaneously which raises endogeneity issues.
- Instrument network effect $\sum_{j=1\setminus i}^{n} \omega_{ijt} y_{jt}$ by its own lagged value.

Table: **Network spillovers and endogeneity**

Model	Benchmark		Spatial effect$_{t-1}$		IV (2SLS)	
Control variables						
GDP growth$_{t-1}$	0.006	0.009	0.018	0.015	0.016	0.019
	(0.025)	(0.025)	(0.026)	(0.026)	(0.029)	(0.029)
Real interest rate$_{t-1}$	0.013	0.009	0.003	-0.002	-0.001	-0.006
	(0.024)	(0.025)	(0.024)	(0.025)	(0.024)	(0.025)
Private credit$_{t-1}$	-0.433***	-0.416***	-0.461***	-0.453***	-0.138	-0.134
	(0.120)	(0.120)	(0.113)	(0.114)	(0.091)	(0.094)
Cost to income$_{t-1}$	-1.034***	-1.092***	-0.884***	-0.918***	-0.724**	-0.757**
	(0.339)	(0.351)	(0.337)	(0.345)	(0.333)	(0.363)
Banking variables						
IB Assets (Flow)$_{t-1}$	-0.375		-0.261		-0.296	
	(0.318)		(0.317)		(0.268)	
IB Liabilities (Flow)$_{t-1}$		-0.427		-0.269		-0.242
		(0.318)		(0.331)		(0.337)
Spatial effect (Assets)	*0.352****		*0.366****		*0.538****	
	(0.102)		(0.116)		(0.173)	
Spatial effect (Liabilities)		*0.358****		*0.386****		*0.500****
		(0.099)		(0.117)		(0.147)
R-squared	0.367	0.369	0.347	0.349	0.097	0.101
Observations	216	216	201	201	201	201
Endogeneity test					1.223	1.186
$p-value$					0.269	0.276

- Banking stability positively affected if linked to more stable partners.

Table: **Diversification and network exposure**

Model	Assets			Liabilities		
Control variables						
GDP growth$_{t-1}$	-0.005	0.006	-0.008	-0.001	0.010	0.002
	(0.025)	(0.026)	(0.025)	(0.025)	(0.026)	(0.025)
Real interest rate$_{t-1}$	0.020	0.021	0.021	0.004	0.010	0.006
	(0.025)	(0.024)	(0.025)	(0.024)	(0.024)	(0.024)
Private credit$_{t-1}$	-0.434***	-0.375***	-0.416***	-0.487***	-0.371***	-0.443***
	(0.115)	(0.110)	(0.117)	(0.112)	(0.110)	(0.119)
Cost to income$_{t-1}$	-1.032***	-0.868**	-1.036***	-1.022***	-0.918***	-1.024***
	(0.339)	(0.337)	(0.340)	(0.340)	(0.338)	(0.341)
Banking variables						
Spatial effect	0.302***	0.187	0.317***	0.305***	0.222*	0.320***
	(0.102)	(0.116)	(0.100)	(0.107)	(0.118)	(0.108)
HHI$_{t-1}$	-1.645*	-1.042	-1.508	-0.275	-0.020	-0.418
	(0.971)	(0.986)	(0.970)	(1.085)	(1.134)	(1.104)
Network exposures$_{t-1}$		-0.576***			-0.496***	
		(0.187)			(0.181)	
Node strength$_{t-1}$			-1.967			-1.399
			(1.558)			(1.502)
R-squared	0.389	0.406	0.388	0.385	0.396	0.383
Observations	204	204	204	204	204	204

- Banking stability negatively affected if larger and less diversified network exposures.

Robustness

- Change sample composition and estimation period.
  - If recent crisis years are omitted, results are not stable.
- Control for common time trends and crisis episodes.
  - Including OECD growth, spillover effects disappear.
- Control for further macroeconomic and institutional variables.
- Construct weighting matrix based on total/ non-bank exposures.
- Use standard spatial panel data estimation approach with constant weighting matrix.
  - Spillover effect remains significant unless distance weights are used.
- Analysis at the micro level using bank balance sheet data from Bankscope confirms the result.

Concluding remarks

- Banks are more engaged in *cross-border interbank activities*.
- Interconnections cause that not only *idiosyncratic risks*/ domestic factors affect banks' stability but also *spillover effects* through network links.
- Results suggest that these effects are of importance and imply:
  - Considering absolute magnitude of cross-border exposures in isolation ignores risks coming from characteristics of the banking network.
  - Interlinks can have positive effects which might, however, depend on the network topology.
  - Especially in crisis times when systemic stability is low, there is the risk of negative amplification effects.
  - Role for cross-border regulation and supervision?