How Connected is the Global Sovereign Credit Risk Network?

Görkem Bostancı
University of Pennsylvania

Kamil Yılmaz
Koç University

Third Economic Networks and Finance Conference
London School of Economics and Political Science
December 11, 2015

Motivation

- The last decade of financial crises has shown us that sovereign debt problems in one country can be followed by many others
- While some of the sovereigns are directly affected by the event, some are relatively unaffected.
- It would be useful to be able to predict the spillovers just after a sovereign debt problem occurs.

Main Approach

- Credit Default Swaps (CDS) are used as insurance against an institutional default.
- As the credit risk of the institution increases, issuers of CDSs require a higher premium (spread) to insure the credit holder.
- We can exploit the information in sovereign CDS (SCDS) spreads to measure the interconnectedness of credit risks of sovereigns.

Literature Review

The Determinants of Sovereign Credit Risk

- Hilscher and Nosbusch (2010), Aizenman et al. (2013), Beirne and Fratzscher (2013) show the effect of country-specific fundamentals on SCDS spreads.
- Pan and Singleton (2008), Longstaff et al. (2011), Wang and Moore (2012), Ang and Longstaff (2013) show how variations and principal components of SCDS spreads are highly correlated with U.S. financial data.

Literature Review

The Determinants of Sovereign Credit Risk

- Hilscher and Nosbusch (2010), Aizenman et al. (2013), Beirne and Fratzscher (2013) show the effect of country-specific fundamentals on SCDS spreads.
- Pan and Singleton (2008), Longstaff et al. (2011), Wang and Moore (2012), Ang and Longstaff (2013) show how variations and principal components of SCDS spreads are highly correlated with U.S. financial data.

Measurement of Financial Network Structures

- Alter and Beyer (2014), Heinz and Sun (2014), Cho et al. (2014) and Adam (2013) use Diebold-Yilmaz connectedness index framework to analyze the connectedness of smaller sets of sovereign CDSs.

Our Contribution

- Our study overcomes the dimensionality problem experienced by many of the previous empirical studies.

Our Contribution

- Our study overcomes the dimensionality problem experienced by many of the previous empirical studies.
- We are able to produce a dynamic network structure, i.e. at any point in time, we can observe the full network and analyze the changes in connectedness between any two sovereigns throughout the whole sample period.

Our Contribution

- Our study overcomes the dimensionality problem experienced by many of the previous empirical studies.
- We are able to produce a dynamic network structure, i.e. at any point in time, we can observe the full network and analyze the changes in connectedness between any two sovereigns throughout the whole sample period.
- We use high frequency (daily) financial data on SCDS rather than monthly or quarterly data on country economic fundamentals.

Methodology

Diebold-Yilmaz Connectedness Measures

What fraction of the H-step-ahead prediction-error of variable i is due to shocks in variable j, $j \neq i$?

Methodology

Diebold-Yilmaz Connectedness Measures

What fraction of the H-step-ahead prediction-error of variable i is due to shocks in variable j, $j \neq i$?

Variance Decomposition / Connectedness Table

	$\mathbf{x_1}$	$\mathbf{x_2}$	...	$\mathbf{x_N}$	From Others
$\mathbf{x_1}$	d_{11}^H	d_{12}^H	$\cdots$	d_{1N}^H	$\sum_{j \neq 1} d_{1j}^H$
$\mathbf{x_2}$	d_{21}^H	d_{22}^H	$\cdots$	d_{2N}^H	$\sum_{j \neq 2} d_{2j}^H$
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$
$\mathbf{x_N}$	d_{N1}^H	d_{N2}^H	$\cdots$	d_{NN}^H	$\sum_{j \neq N} d_{Nj}^H$
To Others	$\sum_{i \neq 1} d_{i1}^H$	$\sum_{i \neq 2} d_{i2}^H$	$\cdots$	$\sum_{i \neq N} d_{iN}^H$	$\sum_{i \neq j} d_{ij}^H$

Connectedness Measures

- Pairwise Directional: $C^{H}_{j \leftarrow i} = d^{H}_{ij}$

Connectedness Measures

- Pairwise Directional: $C^H_{j \leftarrow i} = d^H_{ij}$
- Net Pairwise Directional: $C^H_{ij} = C^H_{j \leftarrow i} - C^H_{i \leftarrow j}$

Connectedness Measures

- Pairwise Directional: $C^H_{j \leftarrow i} = d^H_{ij}$
- Net Pairwise Directional: $C^H_{ij} = C^H_{j \leftarrow i} - C^H_{i \leftarrow j}$
- Total Directional:
  - **From others** to i: $C^H_{i \leftarrow \bullet} = \sum_{\substack{j=1 \\ j \neq i}}^{N} d^H_{ij}$
  - From j **To others**: $C^H_{\bullet \leftarrow j} = \sum_{\substack{i=1 \\ i \neq j}}^{N} d^H_{ij}$

Connectedness Measures

- Pairwise Directional: $C^H_{j \leftarrow i} = d^H_{ij}$
- Net Pairwise Directional: $C^H_{ij} = C^H_{j \leftarrow i} - C^H_{i \leftarrow j}$
- Total Directional:
  - **From others** to i: $C^H_{i \leftarrow \bullet} = \sum_{\substack{j=1 \\ j \neq i}}^{N} d^H_{ij}$
  - From j **To others**: $C^H_{\bullet \leftarrow j} = \sum_{\substack{i=1 \\ i \neq j}}^{N} d^H_{ij}$
- Net Total Directional: $C^H_i = C^H_{\bullet \leftarrow i} - C^H_{i \leftarrow \bullet}$

Connectedness Measures

- Pairwise Directional: $C^H_{j \leftarrow i} = d^H_{ij}$
- Net Pairwise Directional: $C^H_{ij} = C^H_{j \leftarrow i} - C^H_{i \leftarrow j}$
- Total Directional:
  - **From others to** i: $C^H_{i \leftarrow \bullet} = \sum_{\substack{j=1 \\ j \neq i}}^{N} d^H_{ij}$
  - From j **To others**: $C^H_{\bullet \leftarrow j} = \sum_{\substack{i=1 \\ i \neq j}}^{N} d^H_{ij}$
- Net Total Directional: $C^H_i = C^H_{\bullet \leftarrow i} - C^H_{i \leftarrow \bullet}$
- Total Connectedness: $C^H = \frac{1}{N} \sum_{\substack{i,j=1 \\ i \neq j}}^{N} d^H_{ij}$

Many Interesting Issues

- Approximating model: **VAR**? Structural DSGE?

Many Interesting Issues

- Approximating model: **VAR**? Structural DSGE?
- Identification of variance decompositions: Cholesky? **Generalized**? SVAR? DSGE?

Many Interesting Issues

- Approximating model: **VAR**? Structural DSGE?
- Identification of variance decompositions: Cholesky? **Generalized**? SVAR? DSGE?
- Time-varying connectedness: **Rolling estimation**? Smooth TVP's? Regime switching?

Many Interesting Issues

- Approximating model: **VAR**? Structural DSGE?
- Identification of variance decompositions: Cholesky? **Generalized**? SVAR? DSGE?
- Time-varying connectedness: **Rolling estimation**? Smooth TVP's? Regime switching?
- Estimation: Classical? Bayesian? **Hybrid**?
  - Selection: Information Criteria? Stepwise? **Lasso**?
  - Shrinkage: BVAR? Ridge? **Lasso**?

Methodology

Selecting and Shrinking the Approximating Model

- Correctly accounting for the origin of the shocks can help us identify the main channel in the propagation of shocks. However, increasing the number of variables, especially in a VAR setting, quickly consumes degrees of freedom.
- Increasing the rolling window size, on the other hand, precludes the correct estimation of the change in the coefficients over time.

$$\hat{\beta}_{en} = \mathrm{argmin}_{\beta} \left(\sum_{t=1}^{T} (y_t - \sum_{i} \beta_i x_{it})^2 + \lambda \sum_{i=1}^{K} (\alpha |\beta_i| + (1-\alpha)\beta_i^2) \right)$$

Data

- We get intraday SCDS spread data from the Bloomberg Database.
- We estimate daily range volatilities of SCDS spreads using the daily data on high and low spreads.
- Main dynamic and full sample analyses are conducted with 38 countries between February 2009 and April 2014.

Graphical Display

Graphical Display

- Node size: Credit Rating

Graphical Display

- Node size: Credit Rating
- Node color: Total directional connectedness “to others”

Graphical Display

- Node size: Credit Rating
- Node color: Total directional connectedness “to others”

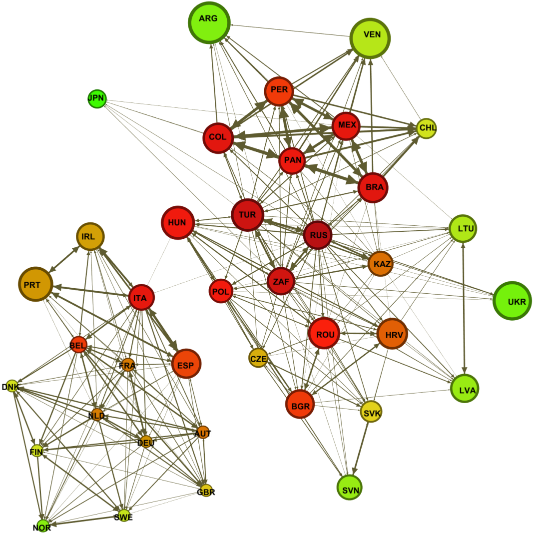
- Node location: Average pairwise directional connectedness (Equilibrium of repelling and attracting forces, where (1) nodes repel each other, but (2) edges attract the nodes they connect according to average pairwise directional connectedness “to” and “from.”)

Graphical Display

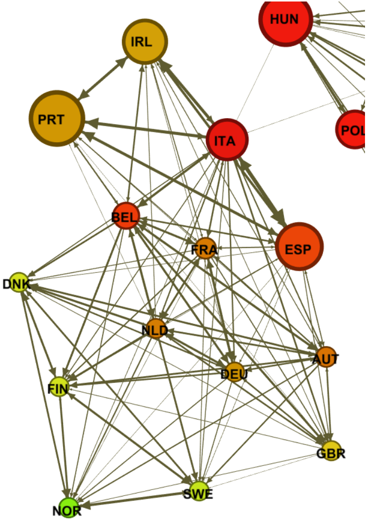
- Node size: Credit Rating
- Node color: Total directional connectedness "to others"

- Node location: Average pairwise directional connectedness (Equilibrium of repelling and attracting forces, where (1) nodes repel each other, but (2) edges attract the nodes they connect according to average pairwise directional connectedness "to" and "from.")
- Edge thickness: Average pairwise directional connectedness

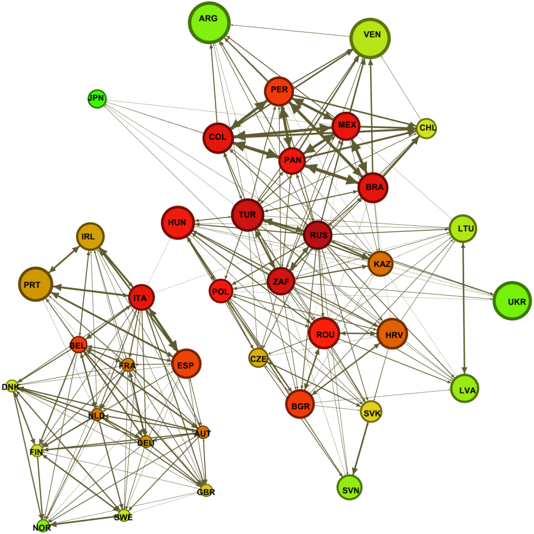
Static Estimation - Spreads



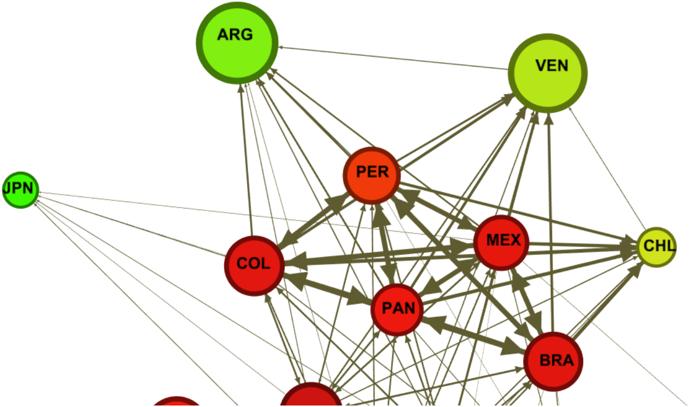
Static Estimation - Spreads



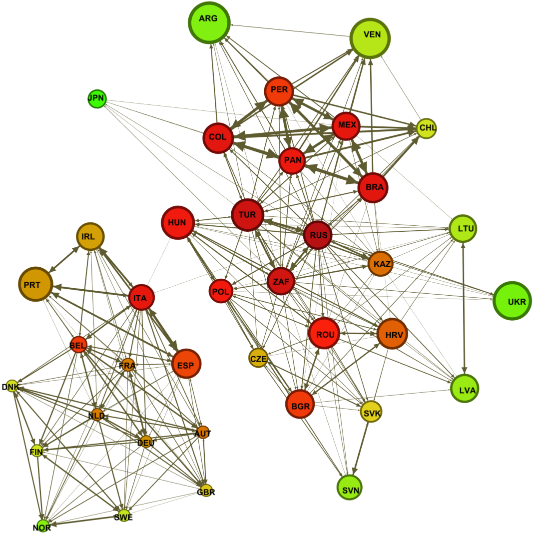
Static Estimation - Spreads



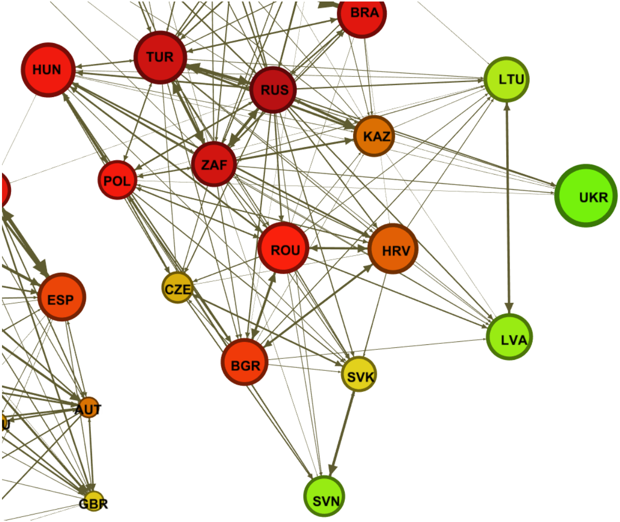
Static Estimation - Spreads



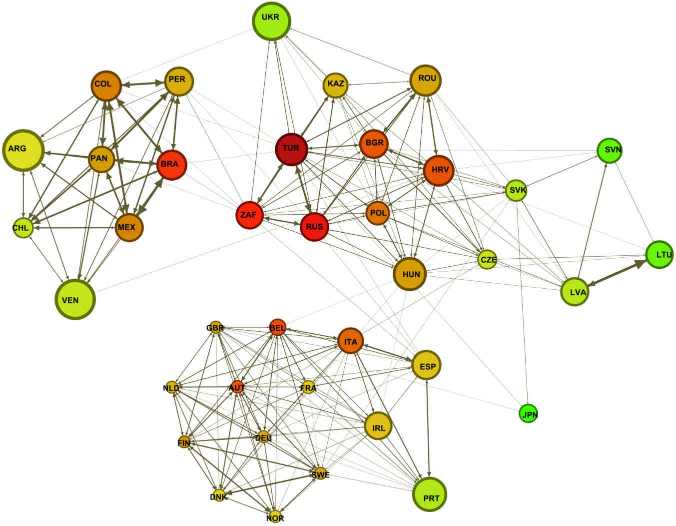
Static Estimation - Spreads



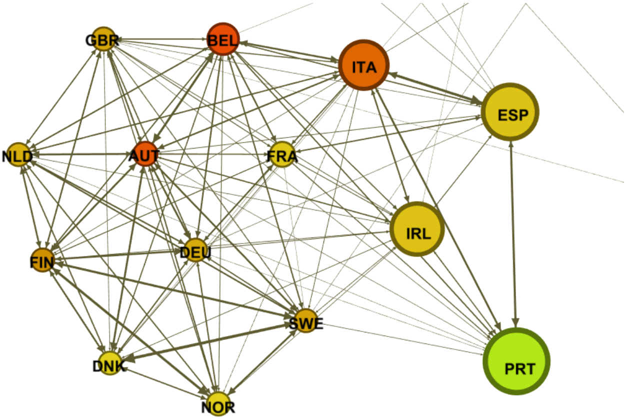
Static Estimation - Spreads



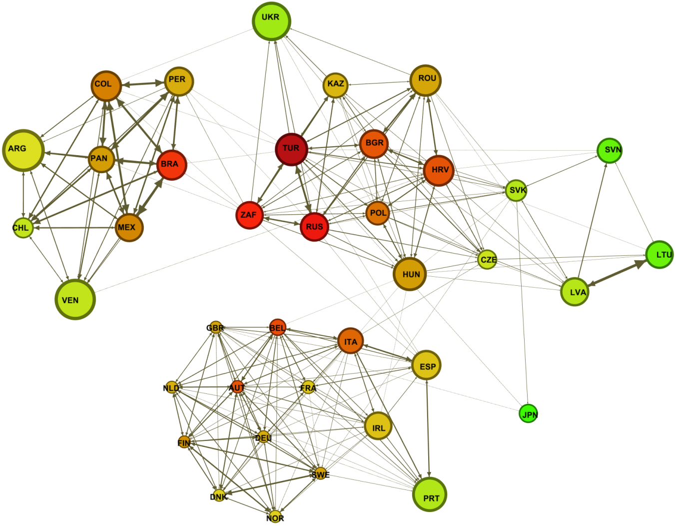
Static Estimation - Volatilities



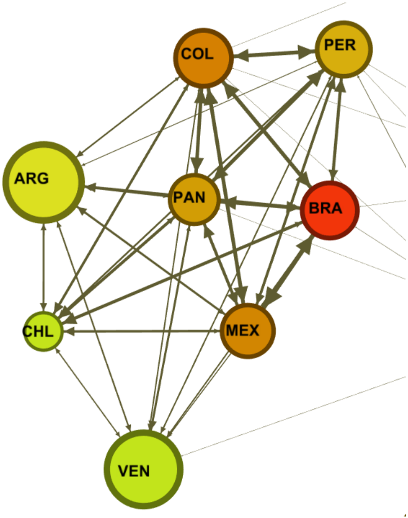
Static Estimation - Volatilities



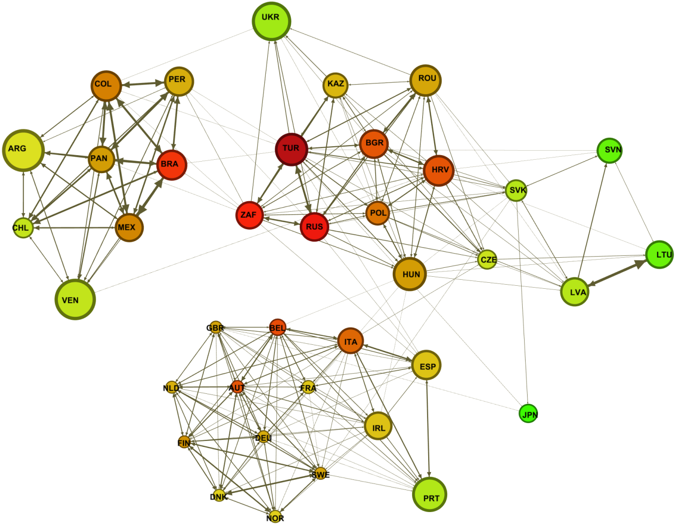
Static Estimation - Volatilities



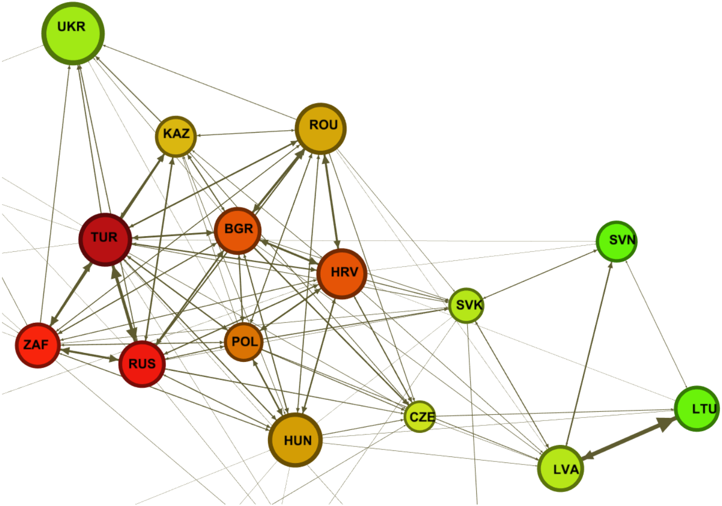
Static Estimation - Volatilities



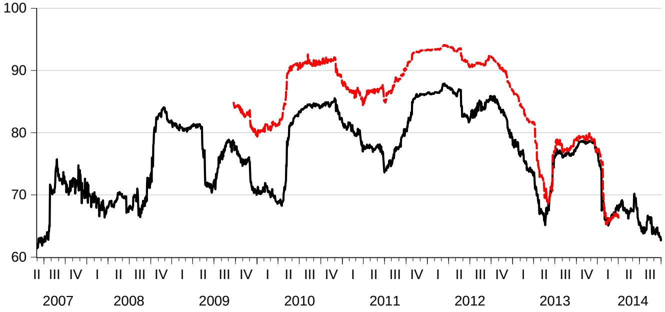
Static Estimation - Volatilities



Static Estimation - Volatilities

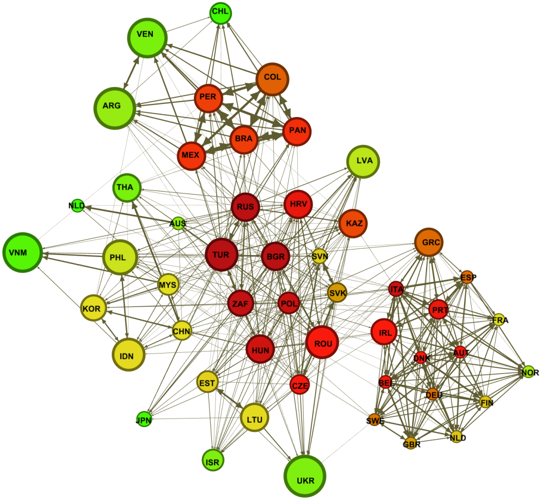


Dynamic Estimation - Spreads



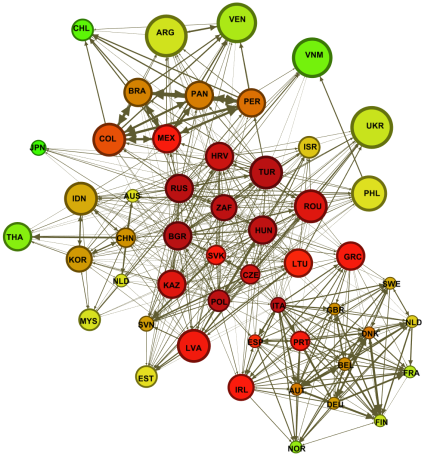
Greece's Bailout Agreement - Spreads

May 3 2010



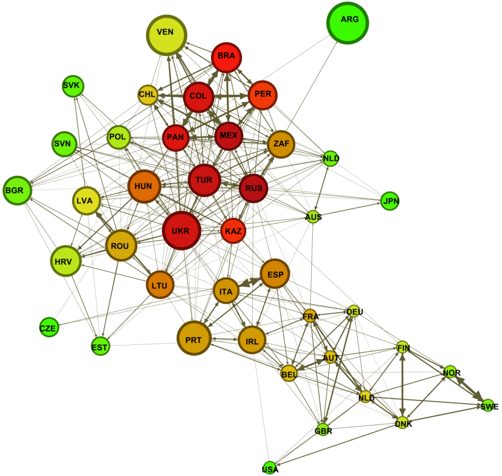
Greece's Bailout Agreement - Spreads

May 10 2010



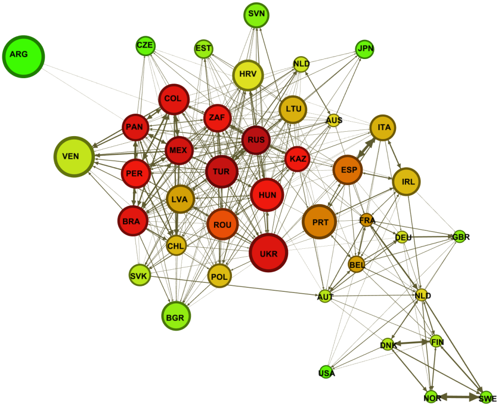
Greece's Bailout Agreement - Spreads

June 19, 2013



Greece's Bailout Agreement - Spreads

June 20, 2013



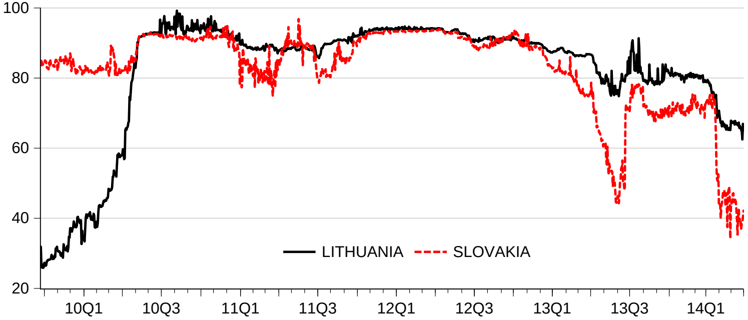
Sovereign Credit Risk Connectedness To Others (2009–14)

Sovereigns	Returns				Log Return Volatilities			
	Avg (%)	Min (%)	Max (%)	Net Avg (%)	Avg (%)	Min (%)	Max (%)	Net Avg (%)
Turkey	127.4	27.8	151.3	35.9	105.5	50	143.7	19.9
Russia	127	48.2	156.6	35.4	97.6	42.8	129.1	13
South Africa	114.7	44.8	143.8	24.2	89.1	42.8	139.4	4.6
Brazil	114.6	68	138	23.9	94	52	120.7	8.8
Mexico	114.5	60.6	140.7	23.6	89.7	50.3	116.7	5.9
Colombia	113.7	62.7	143.1	22.9	88.8	59.4	113.3	5
Italy	108.3	76	146.7	18.9	85	45.2	123.4	3.1
Panama	107.3	60.6	135.2	17	81.4	45.1	122.8	-1.5
Hungary	102.6	62.1	145	13.2	86.1	41.6	137.7	2.8
Romania	101.3	47.6	156.9	12.5	74.3	19.4	148.1	-5.1
Belgium	96.7	42.4	119.3	9.3	84.3	18	142.9	3.8
Poland	97.3	35.6	173.8	9.2	91.5	31.2	133.1	8
Kazakhstan	97.8	44.8	136.3	9.1	60.7	21.1	106.1	-18.9
Bulgaria	96.1	24.3	158.8	8.5	90.5	25	152.9	6.7
Croatia	96.5	40.1	148.5	8.5	86	28.2	138.2	2
Austria	94.2	32.6	126.5	8.1	86.1	50.9	120.9	4.5
Peru	96	17.7	138.5	7.6	70.3	7.1	110.6	-11.6
Spain	94.8	54.9	123.7	6.6	72.8	27.7	103.7	-7.3
Germany	84.8	19.6	116.6	0.2	78.1	48.3	119.4	-2.4

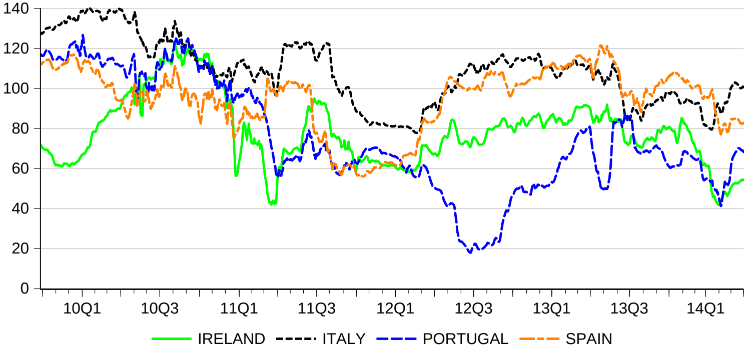
Sovereign Credit Risk Connectedness To Others (2009–14)

Sovereigns	Returns Avg (%)	Returns Min (%)	Returns Max (%)	Returns Net Avg (%)	Log Return Volatilities Avg (%)	Log Return Volatilities Min (%)	Log Return Volatilities Max (%)	Log Return Volatilities Net Avg (%)
France	86	30.9	126.6	-0.2	73.9	27.2	134.1	-3.9
Netherlands	84.8	37.3	109.4	-0.6	75	33.5	124.8	-4.7
Latvia	77.6	9.5	135.7	-2.7	75.2	20.8	122.7	-2.7
Denmark	77.7	27.9	123.1	-6.2	62.8	28.3	89.9	-14.9
Ukraine	76.5	11.2	136.2	-7.2	55	11.7	99.8	-18
Lithuania	74.1	10.4	120.3	-7.7	69.4	13.2	117.9	-4.2
Ireland	78.5	35.8	135.7	-7.7	74.7	40	103.2	-5.8
United Kingdom	74.9	28.4	127.5	-8	73.2	13.8	136.8	-4.6
Portugal	75.2	17	138	-9.3	54.4	4.2	96.2	-16.5
Finland	74.3	28.5	104	-9.4	75.1	32.2	138	-3.9
Czech Republic	68.9	7.7	152.8	-13.3	73.7	17.7	136.9	-5.6
Sweden	66.5	18.9	103.8	-13.9	75.1	23.7	120.1	-2.4
Chile	65.7	10.8	102.2	-19.1	42.2	13.5	68.2	-33.8
Slovakia	59	14	126.5	-23.6	57.5	14.9	90.5	-15.9
Argentina	52.8	7.9	97.9	-24	40.1	6.7	89.5	-35.6
Venezuela	56.6	19.4	89.3	-25.9	40.2	16	78.8	-33.1
Norway	46.3	26	72.3	-31.7	60.3	25.6	99	-16
Slovenia	42	9.6	89.6	-35.6	40.8	7.9	83.3	-29
Japan	22.8	5.6	58.8	-46	19.4	5.9	48	-37.6

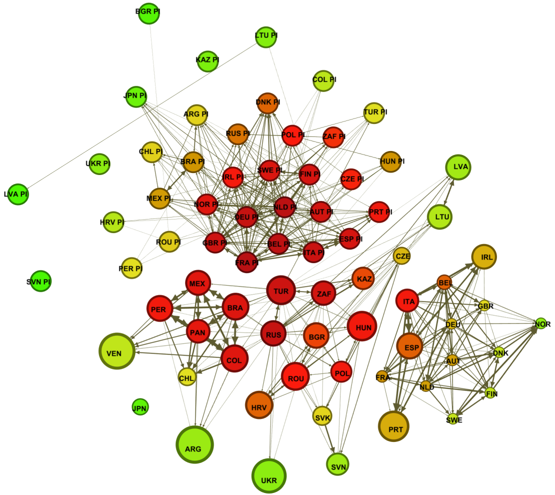
"From connectedness" of Lithuania and Slovakia



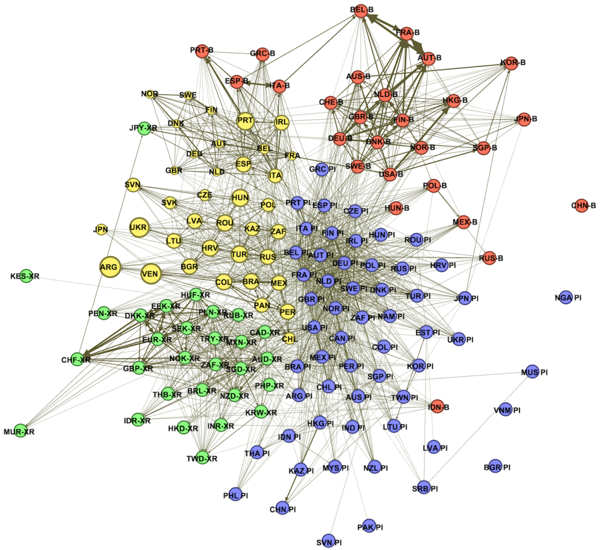
Sovereign Credit Risk Connectedness To Others



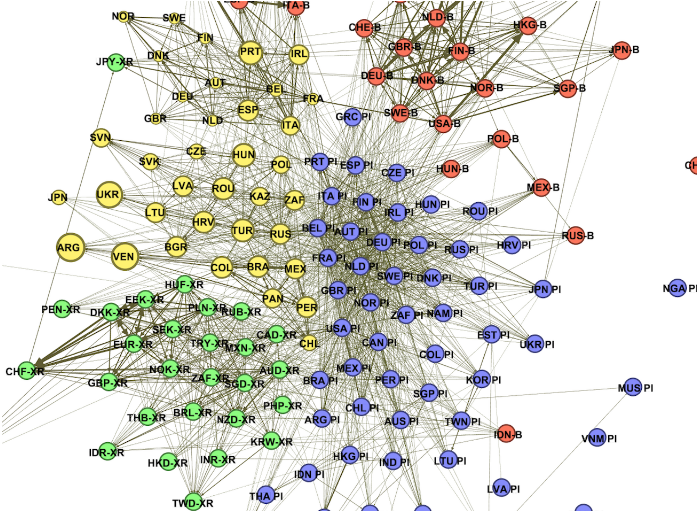
Network of 38 SCDSs and 35 Primary Stock Market Indices



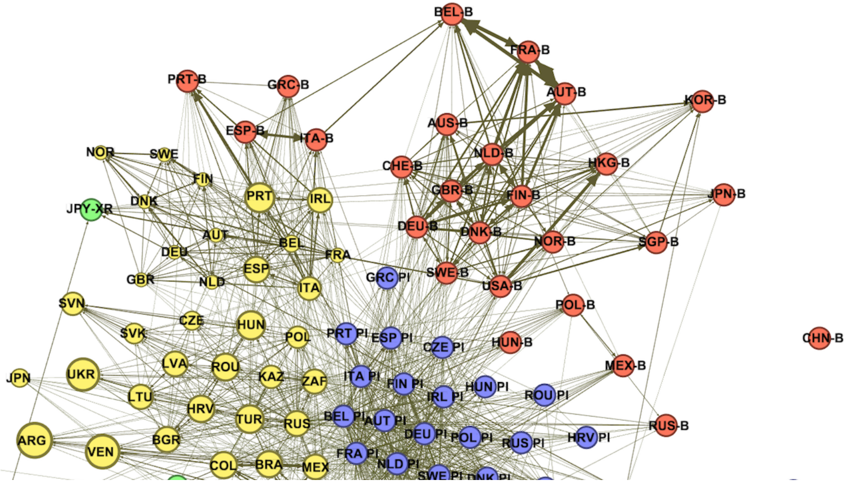
Network of SCDSs, Stocks, Bonds and FX Returns



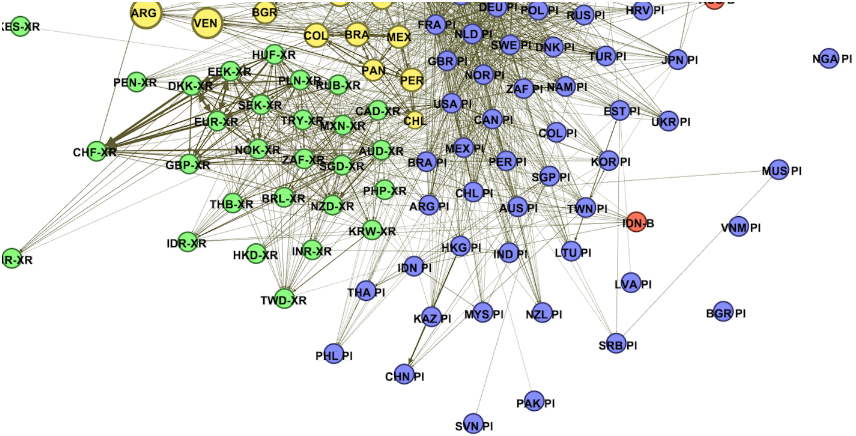
Network of SCDSs, Stocks, Bonds and FX Returns



Network of SCDSs, Stocks, Bonds and FX Returns



Network of SCDSs, Stocks, Bonds and FX Returns



Conclusions

- We used elastic-net method to estimate high-dimenional VARs and obtain measures of directional connectedness
- That help us identify how shocks to sovereign default risk in a country can spread across the globe.

- Connectedness of sovereign default risk across the globe changes substantially over time.
- Global sovereign risk factors are more important in the determination of SCDS spreads, even more so in times of crises.
- Safe haven countries do not generate sovereign default risk connectedness to other countries
- Severely problematic countries cease to be important generators of sovereign credit risk connectedness.