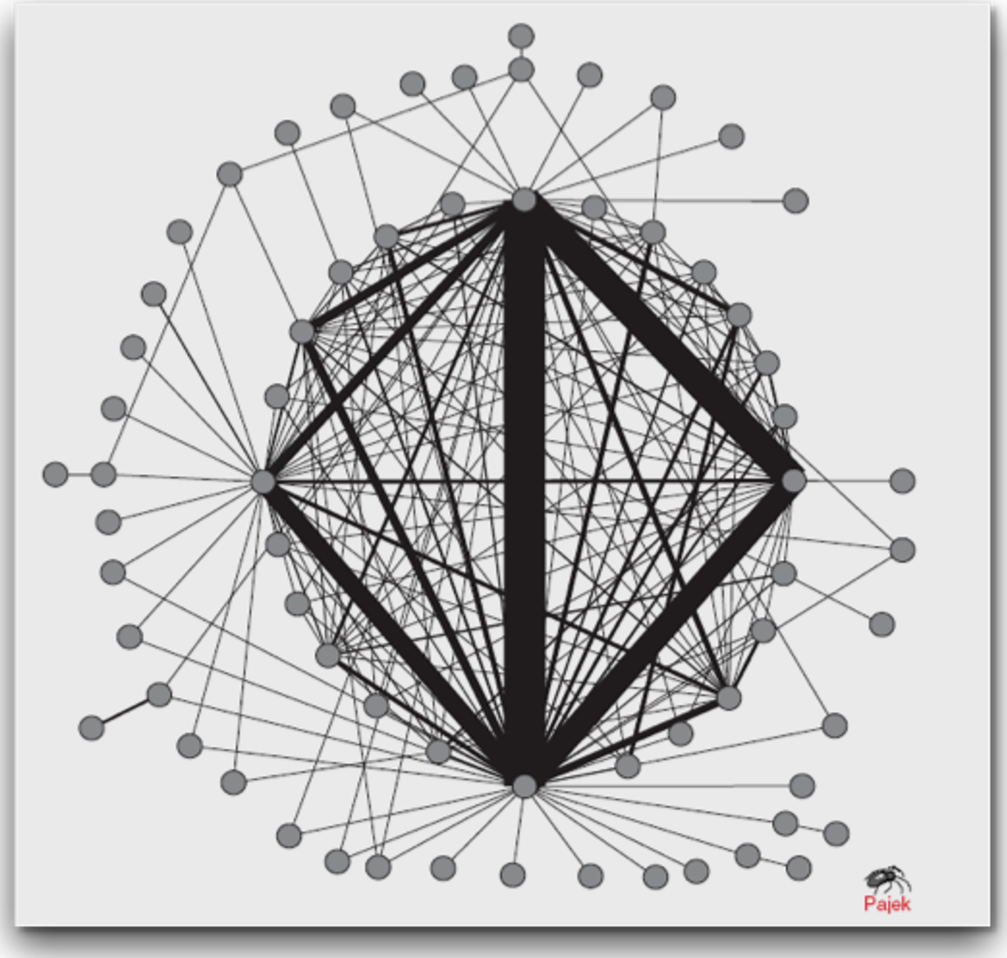
FNA

Exposure Networks

First Financial Networks



Fedwire Interbank Payment Network (Fall 2001) was one of the first network views into any financial system.

Of a total of around 8000 banks, the 66 banks shown comprise 75% of total value. Of these, 25 banks completely connected

The research was subsequently used e.g. in congressional hearings to showcase the type of information that should be collected by financial institutions after the financial crisis.

Soramaki, K. M Bech, J. Arnold, R.J. Glass and W.E. Beyeler, The Topology of Interbank Payment Flows, Physica A, Vol. 379, pp 317-333, 2007.

Recent Developments in Systemic Risk Analytics

Observation	Examples
Use of New Data Sets	• Loan-level Data Repositories • SST / CCAR • Derivatives Trade Repositories • SFTRs • Payments Data Repositories • Resolution & recovery data • Trade surveillance
Use of Old Data Sets for New Purposes	• Payments Data • Market Data & Trading Positions • Geospatial, Social...
Advanced Modelling of Interconnectedness	• Global lending flows • Global payments flows • Global CCP interconnectedness

Recent Developments in Systemic Risk Analytics

Observation	Examples
Increased Focus on Non-Financial Risks	• Cyber security • Cyber resilience • Climate change / disruption
Enhanced Collaboration	• FSB, BCBS, CPMI, IOSCO • CCP12 • Financial Systemic Analysis & Resilience Center (FSARC) • Euro Cyber Resilience Board (ECRB)
Regulator - FI Interoperability	• APIs • Stress testing • Model validation • FMI oversight

Use Case: Understanding Interconnectedness

Banking sector interconnectedness: what is it, how can we measure it and why does it matter?

By Zijun Liu of the Capital Markets Division, Stephanie Quiet previously of the Banking and Insurance Analysis Division and Benedict Roth of the International Banks Directorate.(1)

- Banks can be connected to each other in a number of ways. Greater interconnectedness means that stresses tend to spread more rapidly and extensively across the financial system.
- Various regulatory initiatives have been introduced to mitigate financial stability risks arising from interconnectedness. On some measures, such as interbank credit exposures, interconnectedness has decreased materially since the financial crisis.

Overview

During the 2008 financial crisis, many banks ran into difficulties as shocks spread rapidly across the financial system. One of the main reasons for this is that the global financial system had become highly interconnected in the run-up to the crisis.

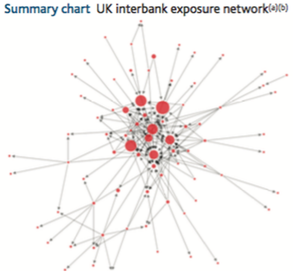
In a highly interconnected financial system, where banks are connected to each other both directly and indirectly, stresses in one part of the system are likely to be transmitted to other parts of the system, resulting in a reduction in the aggregate provision of financial services such as lending to the real economy.

Banks can be directly interconnected via bilateral transactions. The greater the degree of interconnectivity between banks, the greater the likelihood that a default by one bank could trigger contagion to other banks. The **summary chart** shows that UK interbank exposures are dominated by a small number of 'core' banks, whose distress could propagate extensively throughout the network.

Banks may also be interconnected through indirect channels: for example, fire sales by a distressed bank may lead to falls in asset prices and associated mark-to-market losses for other banks.

Broadly speaking, direct interconnectedness from interbank credit exposures has declined since the financial crisis, while other types of direct interconnectedness, such as banks' exposures to central clearing counterparties, have increased.

Summary chart UK interbank exposure network(a)(b)



Sources: Prudential Regulation Authority (PRA) and Bank calculations.

(a) Data as at end-2013. Exposures are net of collateral.
(b) Each node represents a bank and the size of the node is scaled by the total amount of exposures to and from that bank. Each arrow points from one bank to another bank that it has exposure to. The layout is designed so that for any two banks in the network, the greater the exposures between them, the more closely they are positioned.

The analysis presented here suggests that correlations in banks' credit default swap premia increased since the crisis, which may reflect higher indirect interconnectedness, but is more likely to be driven by common reactions to shocks.

Since the financial crisis, a number of regulatory initiatives have been introduced in order to mitigate the financial stability risks posed by interconnectedness between banks. Bank interconnectedness is included in the set of core indicators used by the Financial Policy Committee to monitor risks to the UK financial system.

(1) The authors would like to thank Jamie Coen for his help in producing this article.

Bank of England maps Interbank Exposures in the United Kingdom

Background

During the 2008 financial crisis, many banks ran into difficulties at the same time as shocks spread rapidly across the financial system. One of the main reasons for this was that the global financial system had become highly interconnected.

Objective

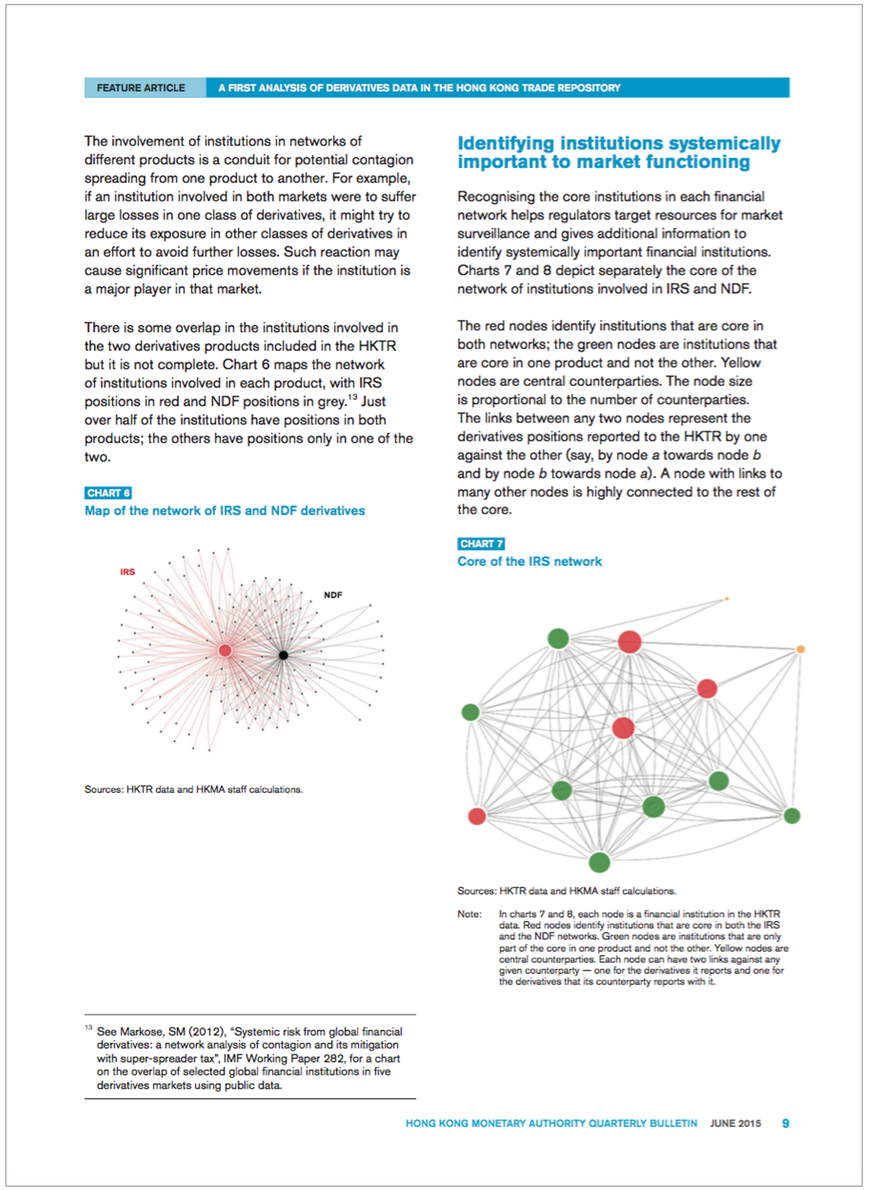
Measure bank interconnectedness and associated systemic risk in the UK.

Insights

Direct interconnectedness such as interbank credit exposures, have decreased materially since the financial crisis. On the other hand indirect interconnectedness such as correlations in banks' CDS premia remain elevated. The analysis helps to define the case for policy interventions to reduce the associated risks.

Bank of England: Banking sector interconnectedness: what is it, how can we measure it and why does it matter?
Research paper: Interbank Exposure Networks

Use Case: Understanding Interconnectedness



FEATURE ARTICLE A FIRST ANALYSIS OF DERIVATIVES DATA IN THE HONG KONG TRADE REPOSITORY

The involvement of institutions in networks of different products is a conduit for potential contagion spreading from one product to another. For example, if an institution involved in both markets were to suffer large losses in one class of derivatives, it might try to reduce its exposure in other classes of derivatives in an effort to avoid further losses. Such reaction may cause significant price movements if the institution is a major player in that market.

There is some overlap in the institutions involved in the two derivatives products included in the HKTR but it is not complete. Chart 6 maps the network of institutions involved in each product, with IRS positions in red and NDF positions in grey.[13] Just over half of the institutions have positions in both products; the others have positions only in one of the two.

CHART 6
Map of the network of IRS and NDF derivatives

Sources: HKTR data and HKMA staff calculations.

[13] See Markose, SM (2012), "Systemic risk from global financial derivatives: a network analysis of contagion and its mitigation with super-spreader tax", IMF Working Paper 282, for a chart on the overlap of selected global financial institutions in five derivatives markets using public data.

Identifying institutions systemically important to market functioning

Recognising the core institutions in each financial network helps regulators target resources for market surveillance and gives additional information to identify systemically important financial institutions. Charts 7 and 8 depict separately the core of the network of institutions involved in IRS and NDF.

The red nodes identify institutions that are core in both networks; the green nodes are institutions that are core in one product and not the other. Yellow nodes are central counterparties. The node size is proportional to the number of counterparties. The links between any two nodes represent the derivatives positions reported to the HKTR by one against the other (say, by node *a* towards node *b* and by node *b* towards node *a*). A node with links to many other nodes is highly connected to the rest of the core.

CHART 7
Core of the IRS network

Sources: HKTR data and HKMA staff calculations.

Note: In charts 7 and 8, each node is a financial institution in the HKTR data. Red nodes identify institutions that are core in both the IRS and the NDF networks. Green nodes are institutions that are only part of the core in one product and not the other. Yellow nodes are central counterparties. Each node can have two links against any given counterparty — one for the derivatives it reports and one for the derivatives that its counterparty reports with it.

HONG KONG MONETARY AUTHORITY QUARTERLY BULLETIN JUNE 2015 9

Hong Kong Monetary Authority maps derivatives exposures based on TR data

Background

As part of global regulatory reforms, the Hong Kong Monetary Authority (HKMA) started in 2013 to collect derivatives data through the Hong Kong Trade Repository.

Objective

Bring more transparency to derivatives markets using the data collected by trade repositories.

Insights

Initial framework for analysing this new data source to assess the financial stability of the market and potential risks. This includes development of maps for the chain of exposures between institutions.

HKMA: A first analysis of derivatives data in the Hong Kong Trade Repository

Importance of Network Analytics for TR Analytics

- Understanding complex interconnections - across products & counterparties
- Gaining a clear view of risk concentrations, both through direct & indirect exposures
- Visualising changes in risk concentrations over time (using a time-series of graphs)
- Aggregating & dis-aggregating exposures (using multi-layer networks)

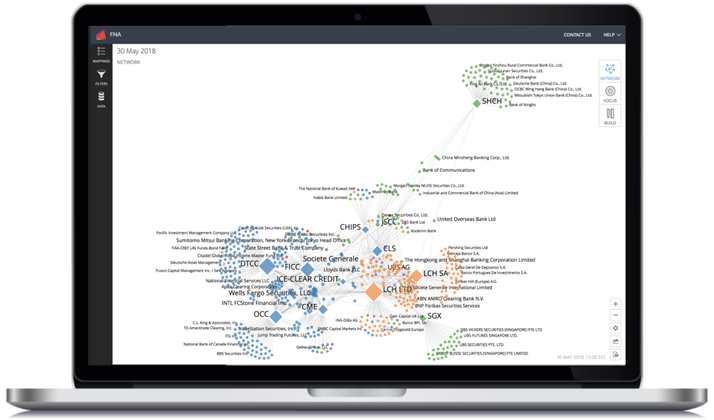
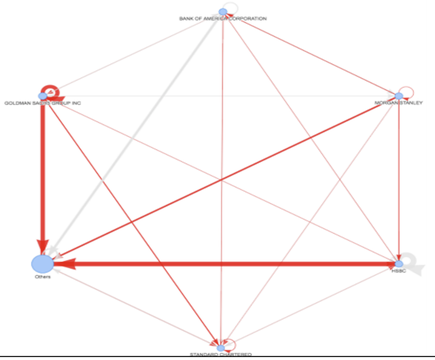
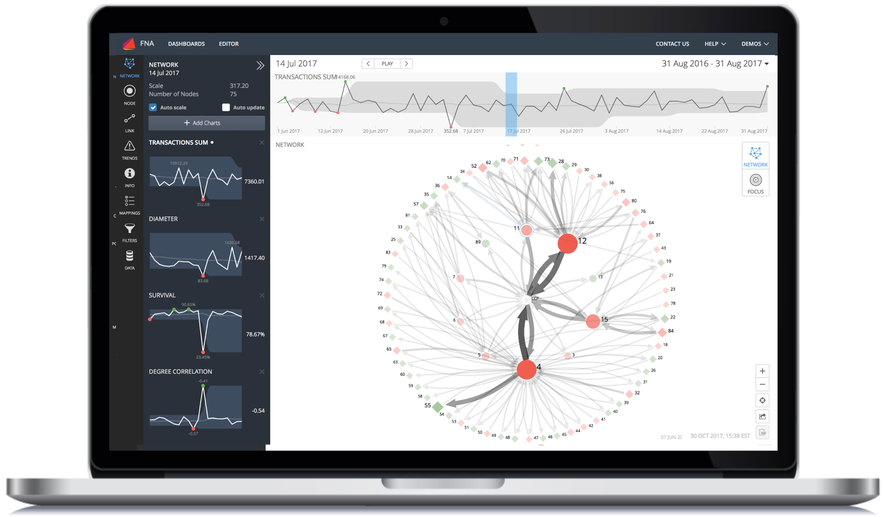


Chart 3: Network graph in free form – to visualise bilateral exposures of major entities

Chart 4: Circle layout – to visualise bilateral exposures of top entities by net notional value of outstanding positions



Use Case: Monitoring Risk Concentrations within FMIs



Chicago Mercantile Exchange identifies risk concentrations

Background

CCPs concentrate large amounts of risks by becoming seller to every buyer and buyer to every seller in the market. Their members play different roles of custody banks, liquidity providers and settlement members and it is not obvious how these roles are concentrated.

Objective

Identify risk concentrations across multiple roles members are playing in the system. Monitor changes over time and alert about outliers.

Outcomes

Proof-of-value project identifies previously unknown risk concentrations which prompt the development of a simulation model to evaluate impact of operational failures (e.g. cyber scenarios) on the CCP's ability to complete settlement.

BIS report (2017). Analysis of Central Clearing Interdependencies.

Loan-Level Data Repositories

Objectives

- Automation of reporting
- Real-time information
- Greater market coverage - atomic loan level data
- Automation of analytics
- Automation of monitoring
- Early warning mechanisms

Examples

- ECB's "AnaCredit"
- HKMA's "Granular Data Reporting"
- Bank of England

Analytics Focuses

- Banks & borrowers across products & facilities
- Banks' portfolios as they evolve from borrower, loan type, collateral type, and geographic perspectives
- Banks, borrower & guarantor relationships
- Systemic risk vulnerabilities, specific scenarios & impacts on individual borrowers and banks
- Regional economic variables & bank portfolios
- Credit quality dispersion across borrowers and borrower subtypes
- Concentration risk across categories and movement along a time series

Use Case: Understanding Foreign Banking Exposures

FNA R&D: BIS country exposures

Background

The BIS consolidated banking statistics provide internationally comparable measures of national banking systems' exposures to country risk. The statistics have been used to provide transparency into offshore banking in the 70' , the Asian Crisis 1997–98 and Global Financial Crisis 2007-08.

Objective

Develop an always up to date visual monitoring solution to assist measuring global financial contagion.

Outcome

Validation of available data and prototype for dashboards that enable systematic and transparent understanding of complex derivatives.

Use Case: Understanding Foreign Banking Exposures

Data: BIS Consolidated Banking Statistics, Table 9D

Contains exposures among reporting countries + exposures to non-reporting countries

These statistics measure banks' country risk exposures.

They capture the worldwide consolidated claims of internationally active banks headquartered in BIS reporting countries.

- Nodes = Banking sector of the country
- Directed Links = Value of loans to entities in the other country

Case Study: Eurozone Debt Crisis - Greece

Context

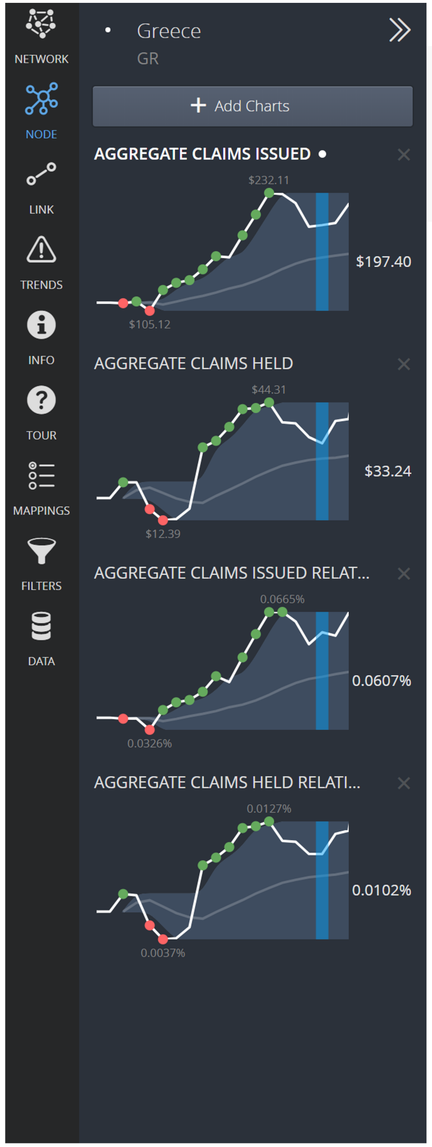
- Time frame: Early 2009 – Late 2018
- After the GFC, Greece and its banks found it increasingly difficult to sustain their positions and to access liquidity, which led to the beginning of the Euro Crisis.

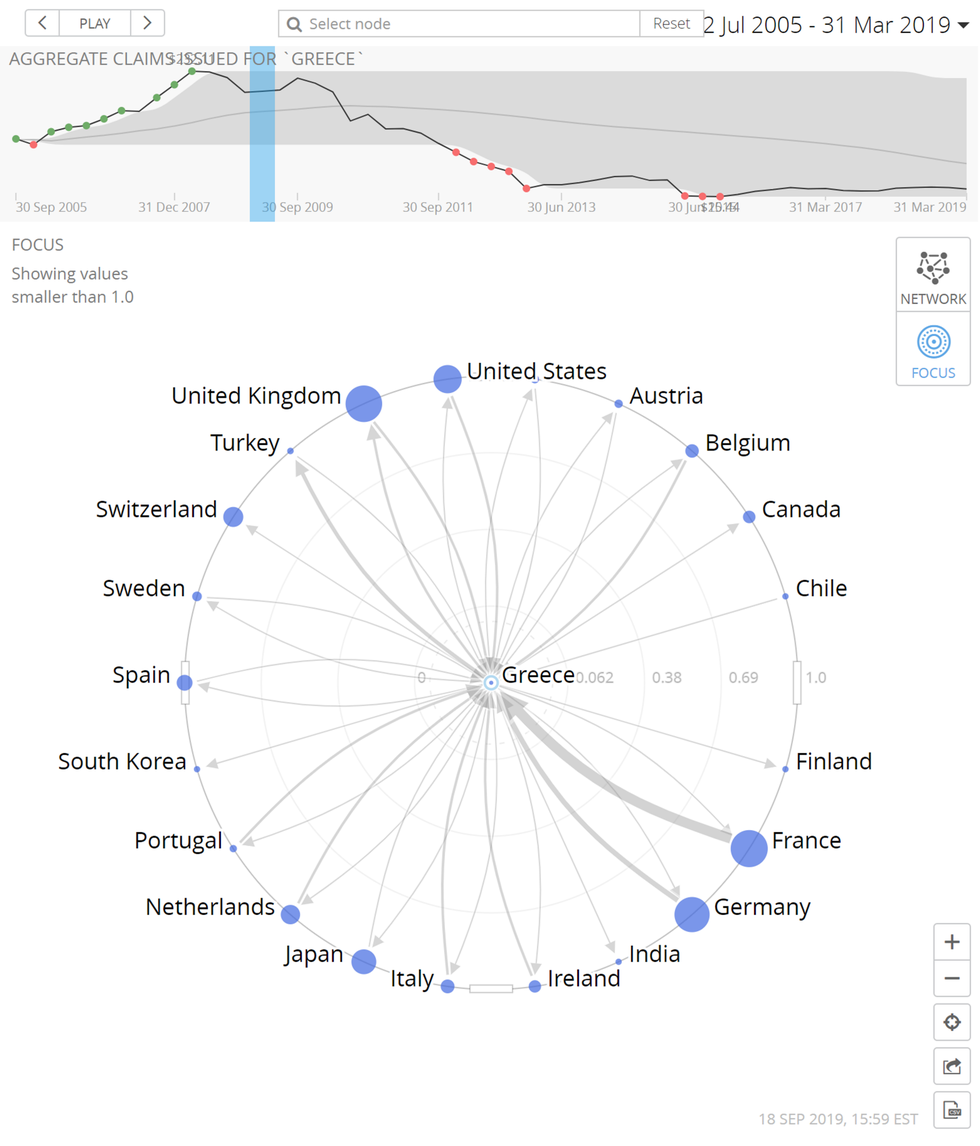
Visualization

- Greek banking exposure dynamics before and after the Eurozone debt crisis
- Prior to the crisis, Greek banks' aggregate claims held and issued grew steadily on a gross basis and relative to GDP

Insight

- French and German banks had the largest exposures to Greek banks, and they also have large overall exposures reflected in the node sizes
- This might explain why these two governments were keen to restructure Greek debt





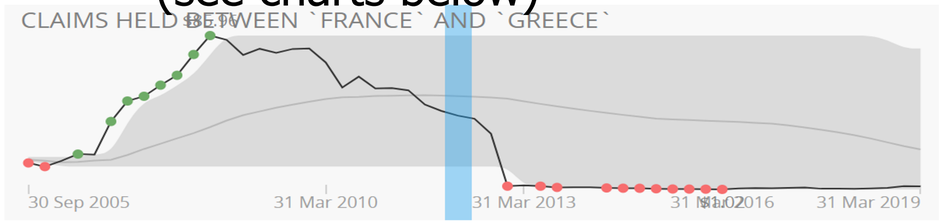
Case Study: Eurozone Debt Crisis - Greece

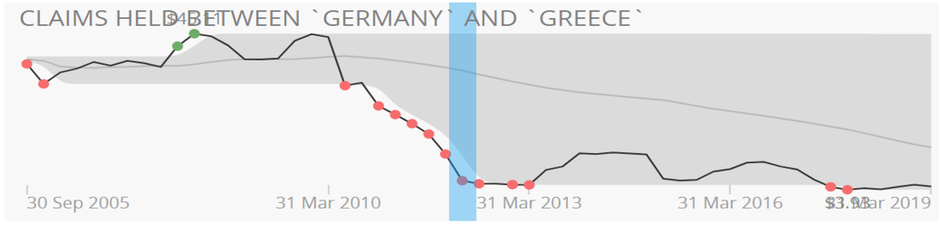
Visualization

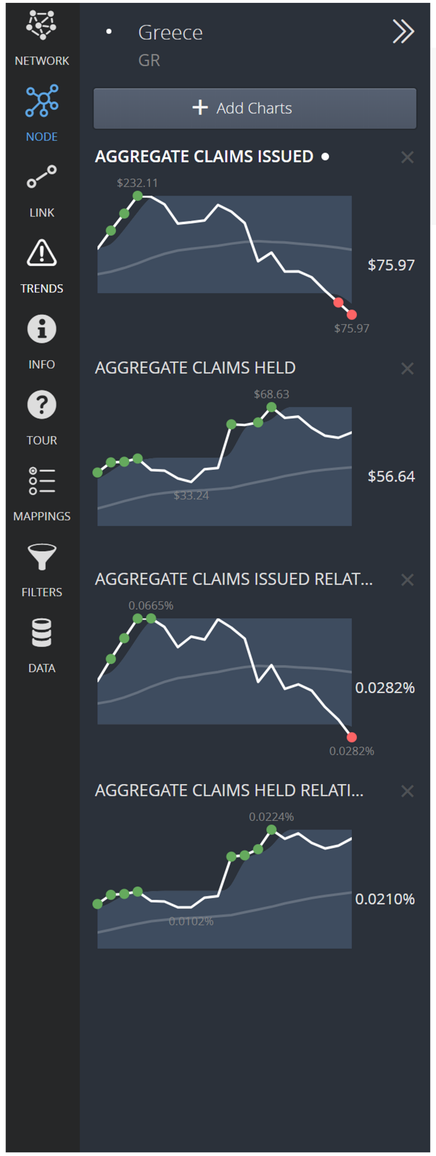
- Aggregate claims issued by Greek banks declined sharply
- Aggregate claims held by Greek banks kept rising

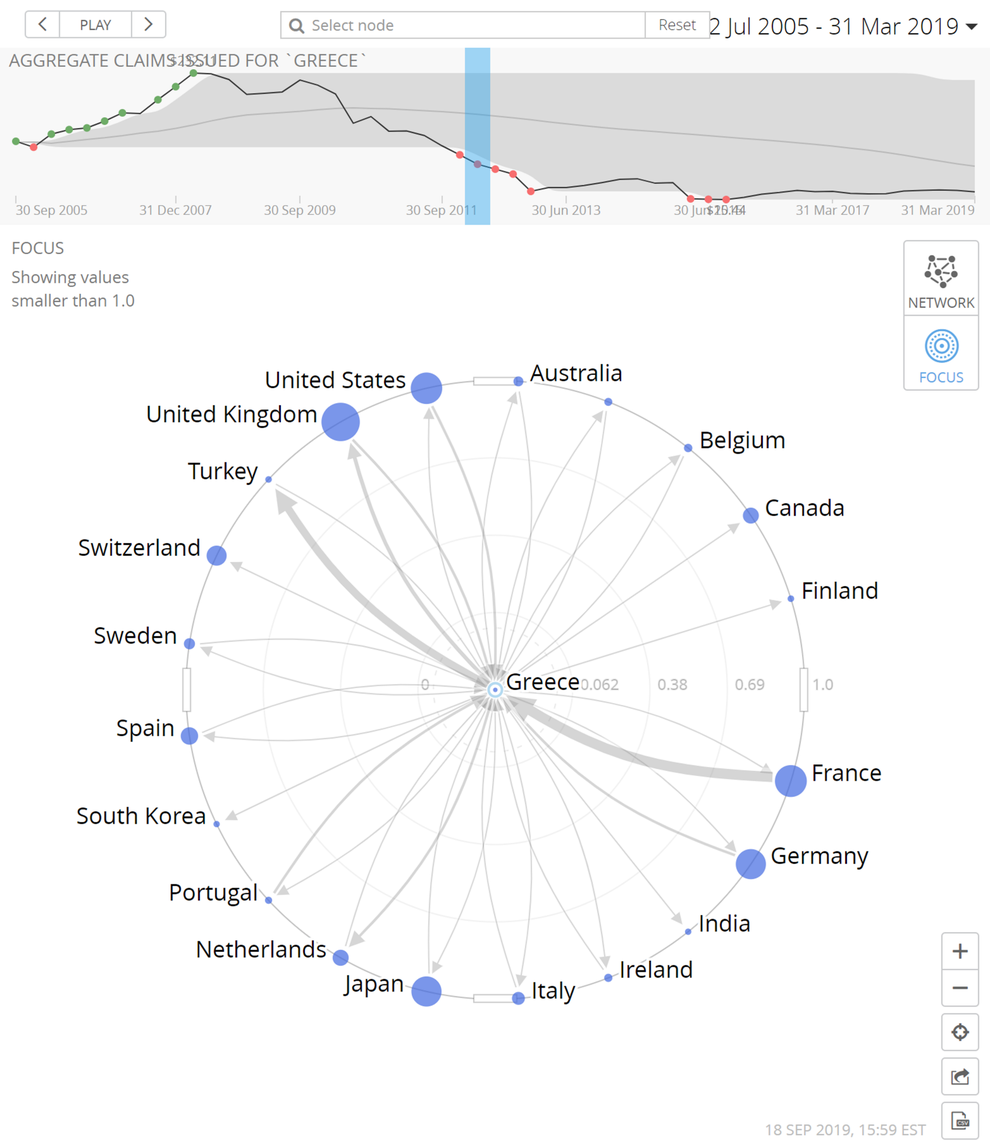
Insight

- Greek banks were lending more but borrowing less cross borders
- French and German banks were driving down their exposures to Greek banks (see charts below)









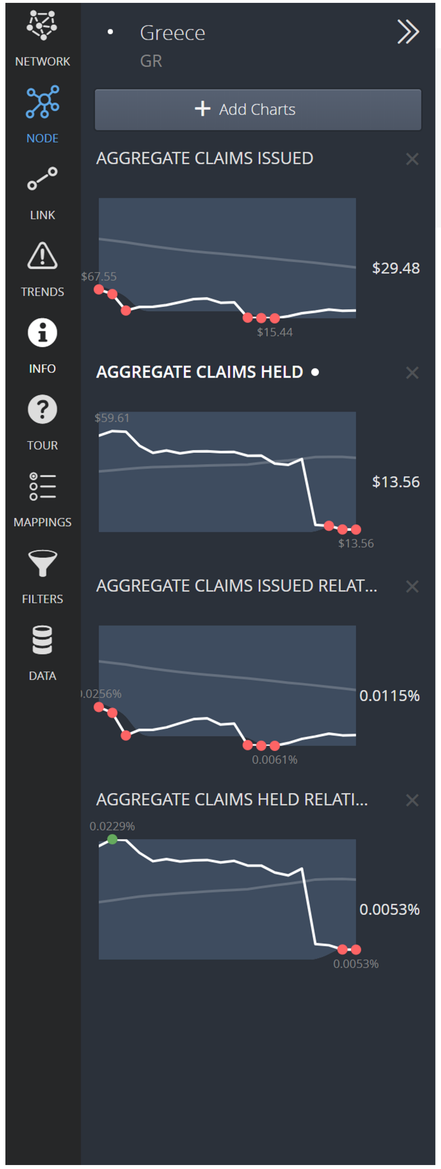
Case Study: Eurozone Debt Crisis - Greece

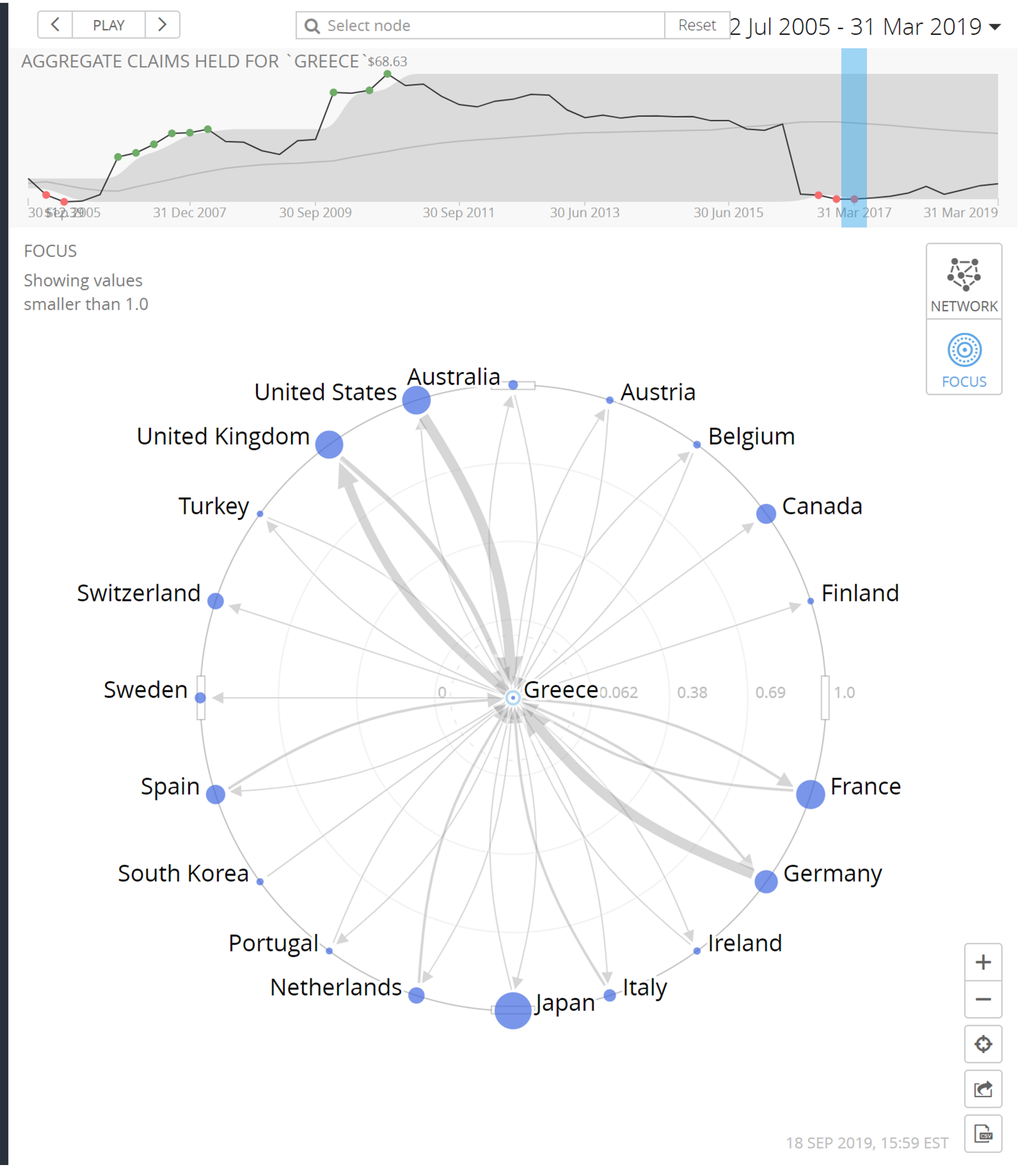
Visualization

- After the crisis, the aggregate claims held by Greek banks dropped abruptly
- Greece's aggregate claims issued, which means the total claims issued by its bank, stayed low

Insight

- British banks are among those whom Greek banks held a large portion of their claims on
- German and US banks became the main debtors of Greek banks
- This might signal a new paradigm after the crisis





Case Study: Eurozone Debt Crisis - Spain

Context

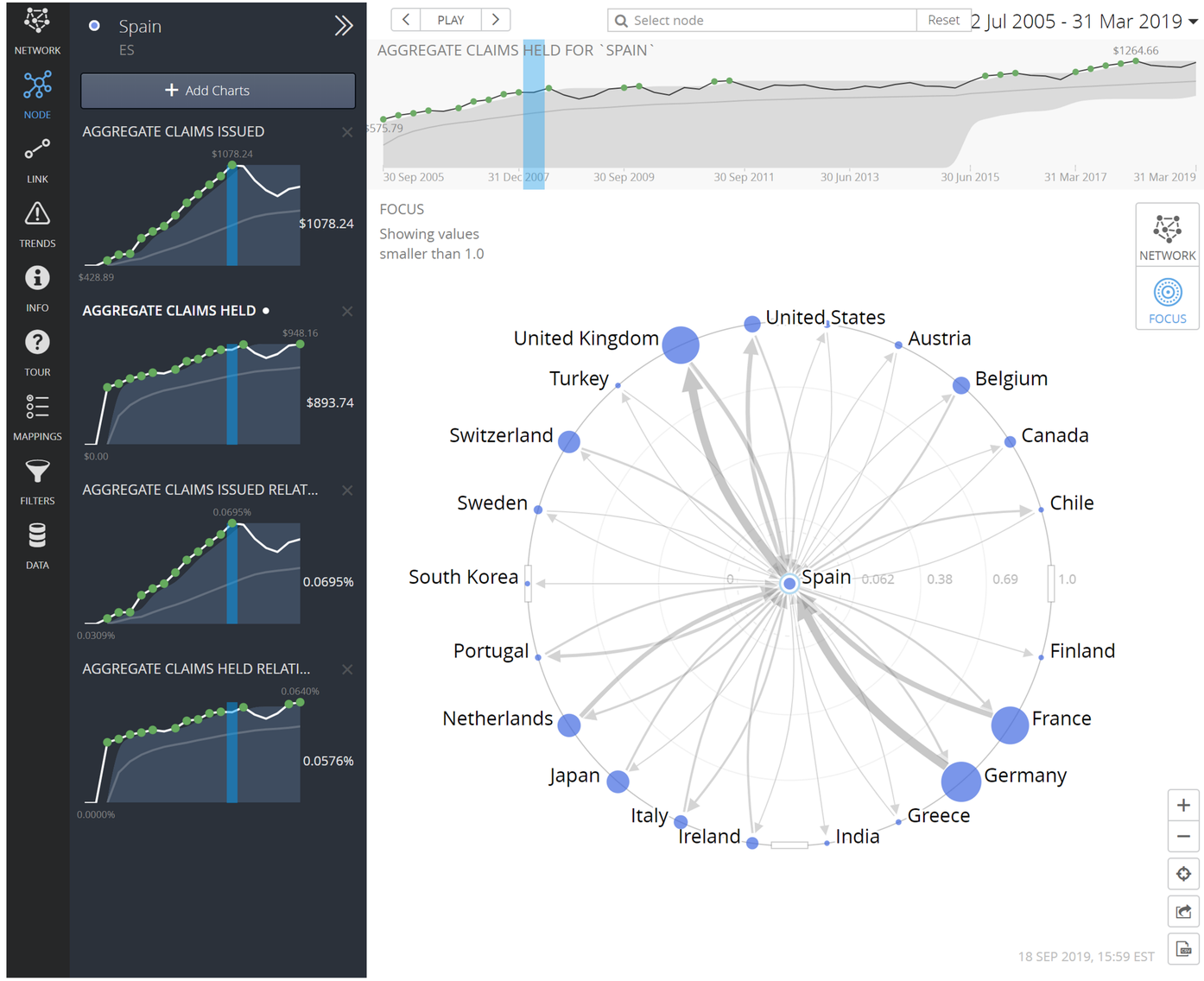
- Time frame: 2008 - 2014
- Spain was unable to bail out its financial sector after the 2008 financial crisis and had to apply for a €100 billion rescue package from the ESM
- Its 10-year bond interest rate spiked to 7% in 2012

Visualization

- Spain banking exposure dynamics before and after the Eurozone debt crisis
- Prior to the crisis, Spanish banks' aggregate claims held and issued grew steadily on a gross basis and relative to the country's GDP

Insight

- French and German banks had the largest exposures to Spanish banks, just like to Greek banks

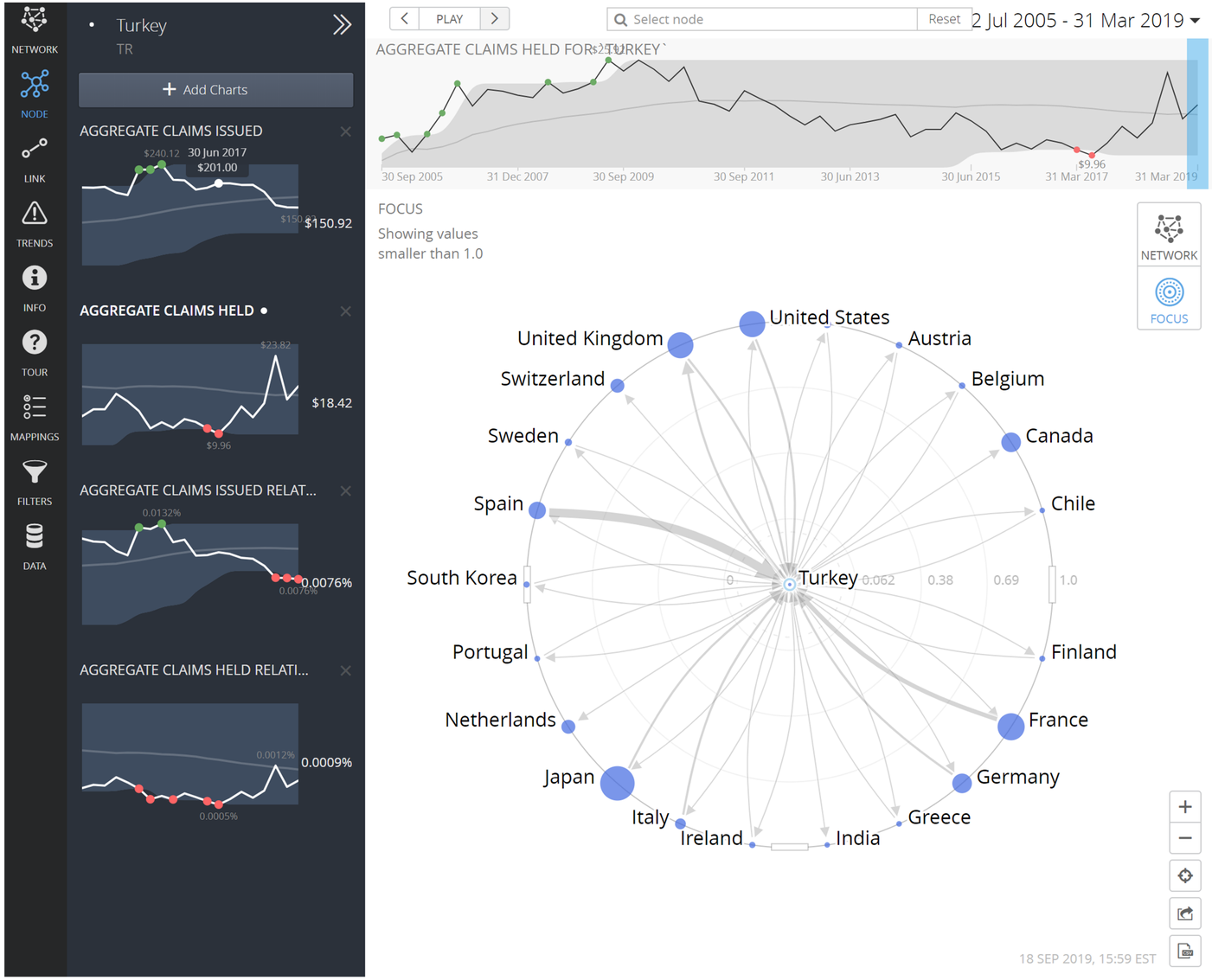


Case Study: Turkey - a Looming Problem?

- **Context**
  - Time frame: 2018 - ?
  - Political instability in Turkey
  - The lira having fallen by over 40% against US$ since mid-2017
  - Moody's expecting a 2% economic contraction in 2019

- **FNA Visualization**
  - Turkish debt dynamics since 2017
  - Spanish banks have the largest exposure to Turkish banks, followed by French banks

- **FNA Insight**
  - Understand new potential systemic risk in the financial system
  - Could a Turkish banking default trigger a cascade that deteriorates the Spanish economy?

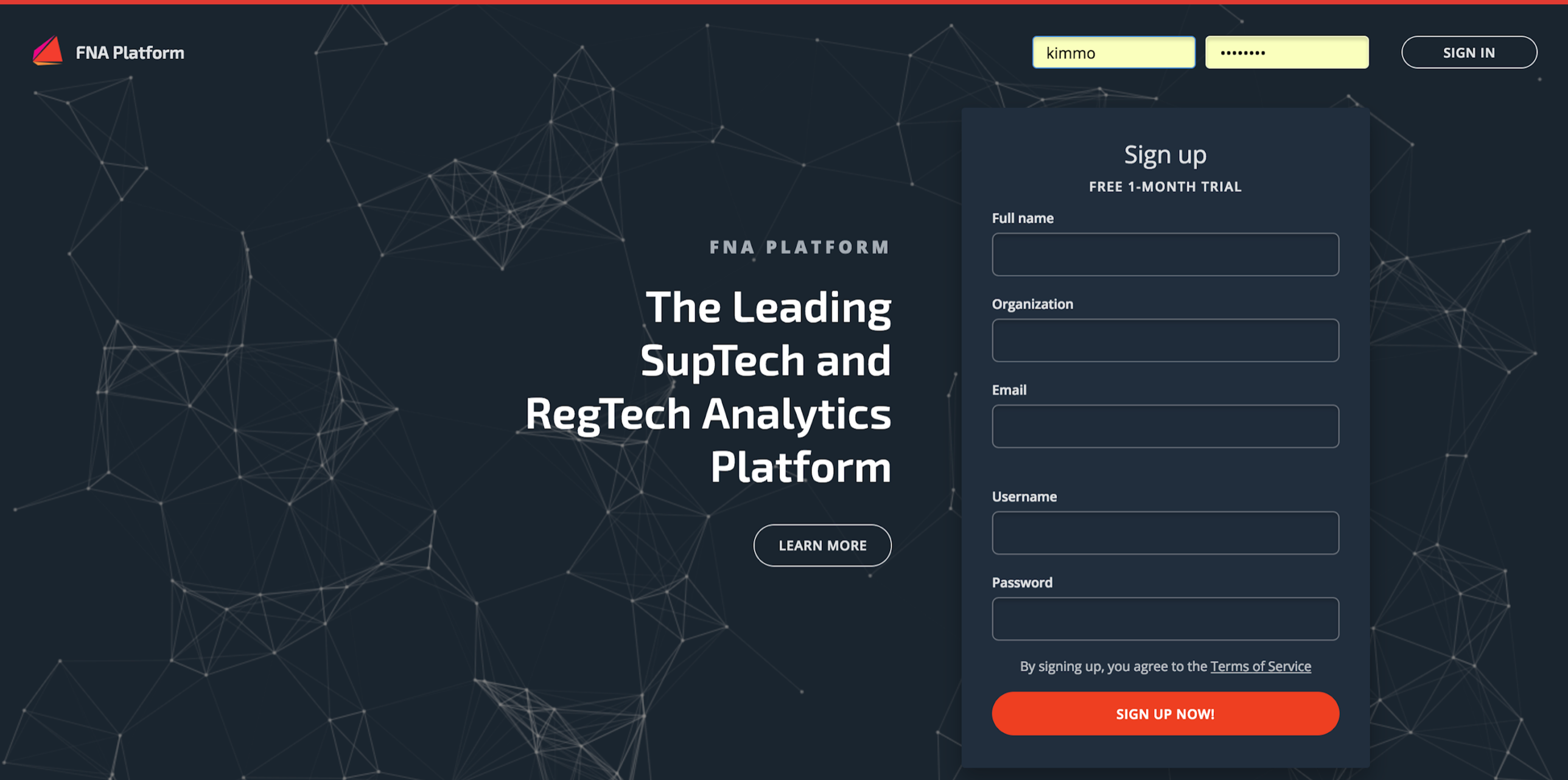


BIS & Beyond

- **By using the BIS Consolidated Banking Statistics we can**
  - Visualize **international credit exposures**
  - Gain a better understanding of **risk propagation** through the financial system
  - Improve policy decisions relating to **systemic risk** and **financial stability**
  - Identify **direct and indirect exposures**
  - Identify **opportunities for credit expansion**

- **The same type of analysis can be extended to other data sets (including national / intra-country data)**
  - Interbank lending
  - Other interbank credit exposures - direct & indirect
  - Bank <> corporate network monitoring

www.fnalab.com



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Exposure Networks - Scripting Example

www.fna.fi

Exposures - Create Network

```
system.reset_db

# import data
arc.property.define -property value -type numeric
arc.import -table bis_links.csv

# calculate degree
vertex.centrality.degree

# calculate layout for networks
vertex.layout.circle -sort_vertices vertex_id -correction false

# save series on file
series.save -file bis
```

Exposures - Create Dashboard

```
# create dashboard
dashboard.new
dashboard.view.network -x x -y y

# add mappings
dashboard.mappings.vertex -size degree -color :red
dashboard.mappings.arc -width value -opacity value
dashboard.mappings.vertex.label -text vertex_id

# show 10 years on time bar
dashboard.timebar -days 3650

# save dashboard
dashboard.save -file bis -series bis
```

FNA

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