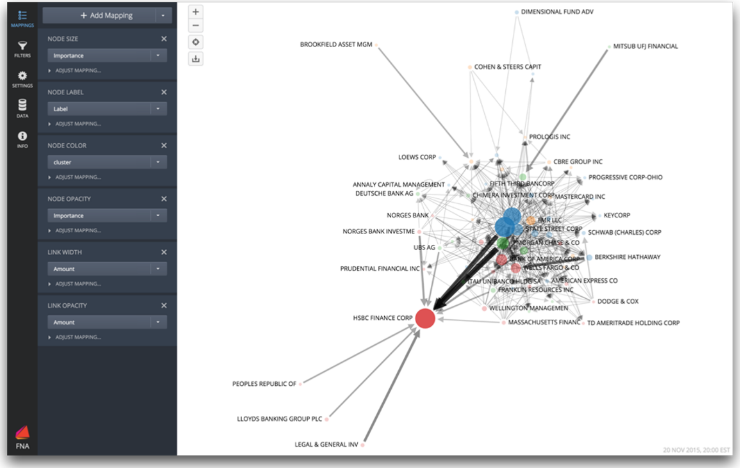
# FNA

Correlation Networks

# Transactions & Similarity Based Networks

**Transaction**: payment, trade, exposure, supply, flow, …




**Similarity**: correlation, partial correlation, granger causality, transfer entropy, …

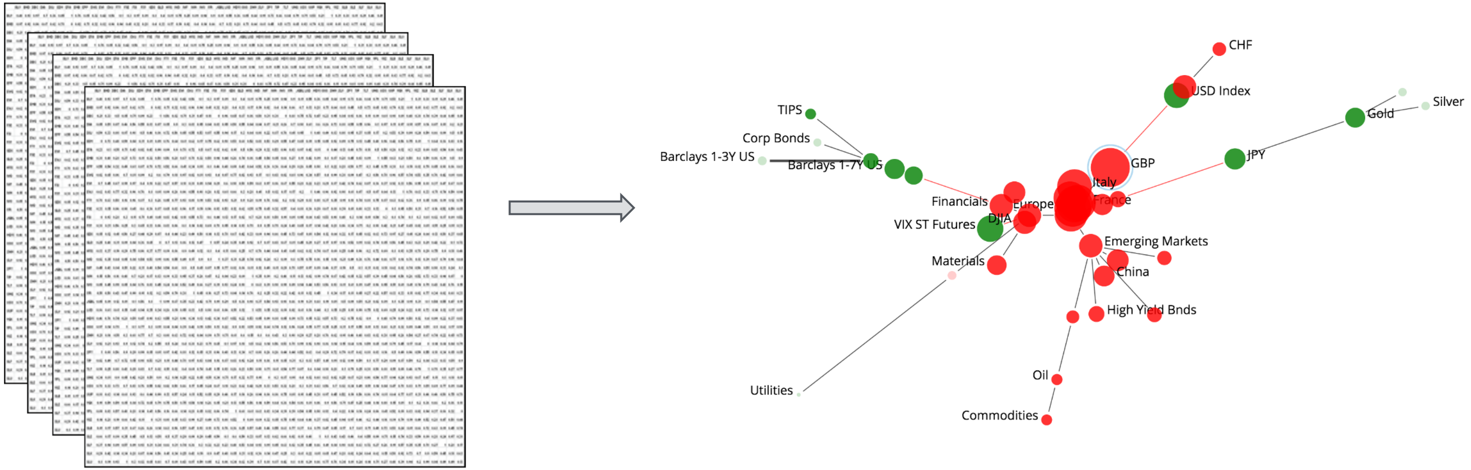

Stavroglou et al (2016)
[Causality Networks of Financial Assets]

# Correlation Networks

Interconnectivity of markets has increased

We need to be able to understand correlations structures of much larger scale.

Networks help develop intuition, and understand stress tests.



# Typical view of cross asset correlations

Correlation Matrix Over the Last 15 Years (2001-2015)

| | | Equity | | | | | Fixed Income | | | Alternative Strategies | | | | | Alternative Assets | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Large Cap | Mid Cap | Small Cap | Int'l | Emerging Mkts | Corp. | High Yield | Treas. | Long/ Short | Mkt Neutral | Event Driven | FI Arbitrage | Mgd Futures | Real Estate | Currency | Comm-odities |
| Equity | Large Cap | 1.00 | | | | | | | | | | | | | | | |
| | Mid Cap | 0.93 | 1.00 | | | | | | | | | | | | | | |
| | Small Cap | 0.88 | 0.96 | 1.00 | | | | | | | | | | | | | |
| | Int'l | 0.88 | 0.85 | 0.79 | 1.00 | | | | | | | | | | | | |
| | Emer. Mkts | 0.78 | 0.80 | 0.75 | 0.87 | 1.00 | | | | | | | | | | | |
| Fixed Income | Corp. | 0.17 | 0.20 | 0.13 | 0.30 | 0.31 | 1.00 | | | | | | | | | | |
| | High Yield | 0.66 | 0.71 | 0.66 | 0.69 | 0.71 | 0.52 | 1.00 | | | | | | | | | |
| | Treas. | -0.36 | -0.35 | -0.36 | -0.27 | -0.25 | 0.63 | -0.19 | 1.00 | | | | | | | | |
| Alt. Strategies | Long/Short | 0.75 | 0.79 | 0.72 | 0.84 | 0.80 | 0.27 | 0.61 | -0.28 | 1.00 | | | | | | | |
| | Mkt Neutral | 0.27 | 0.29 | 0.29 | 0.26 | 0.24 | -0.09 | 0.37 | -0.29 | 0.25 | 1.00 | | | | | | |
| | Event Driven | 0.64 | 0.70 | 0.64 | 0.71 | 0.70 | 0.23 | 0.67 | -0.34 | 0.83 | 0.32 | 1.00 | | | | | |
| | FI Arbitrage | 0.42 | 0.46 | 0.37 | 0.48 | 0.48 | 0.42 | 0.63 | -0.10 | 0.51 | 0.36 | 0.55 | 1.00 | | | | |
| | Mgd Futures | -0.13 | -0.10 | -0.12 | 0.00 | 0.01 | 0.19 | -0.12 | 0.29 | 0.19 | -0.01 | 0.09 | 0.00 | 1.00 | | | |
| Alt. Assets | Real Estate | 0.08 | 0.12 | 0.14 | 0.08 | 0.05 | -0.03 | 0.06 | -0.08 | 0.05 | 0.14 | 0.04 | 0.03 | 0.00 | 1.00 | | |
| | Currency | -0.03 | -0.02 | 0.01 | 0.02 | 0.01 | 0.11 | -0.07 | 0.13 | 0.13 | 0.02 | 0.03 | 0.00 | 0.61 | 0.07 | 1.00 | |
| | Commodities | 0.32 | 0.38 | 0.33 | 0.45 | 0.47 | 0.11 | 0.35 | -0.17 | 0.49 | 0.28 | 0.49 | 0.45 | 0.18 | 0.10 | -0.08 | 1.00 |

High (0.9-1.0) | Moderate High (0.7-0.9) | Moderate (0.3-0.7) | Low (0.0-0.3) | Negative (<0.0)

Low Diversification ⟷ High Diversification

# Universe of Global Assets (ETFs)

| | | | | | |
|---|---|---|---|---|---|
| **BND** | Total Bond Index | **FXC** | CAD | **USO** | Oil |
| **DBC** | Commodities | **FXE** | EUR | **UUP** | USD Index |
| **DIA** | DJIA | **FXI** | China | **VGK** | Europe |
| **DXJ** | Japan Stocks (in JPY) | **FXY** | JPY | **VPL** | Asia |
| **EEM** | Emerging Markets | **GDX** | Gold Miners | **VXX** | VIX ST Futures |
| **EFA** | EAFE | **GLD** | Gold | **XIU** | TSX 60 |
| **EMB** | EMBI | **IEF** | Barclays 1-7Y US | **XLB** | Materials |
| **EPP** | Asia ex Japan | **IYR** | Real Estate | **XLE** | Energy |
| **EWG** | Germany | **JNK** | High Yield Bonds | **XLF** | Financials |
| **EWI** | Italy | **LQD** | Corp Bonds | **XLK** | Tech |
| **EWJ** | Japan | **SLV** | Silver | **XLU** | Utilities |
| **EWQ** | France | **SPY** | S&P 500 | **CSJ** | Barclays 1-3Y US |
| **EWU** | UK | **TIP** | TIPS | **FXF** | CHF |
| **FXB** | GBP | **TLT** | 20Y+ Gov't | | |

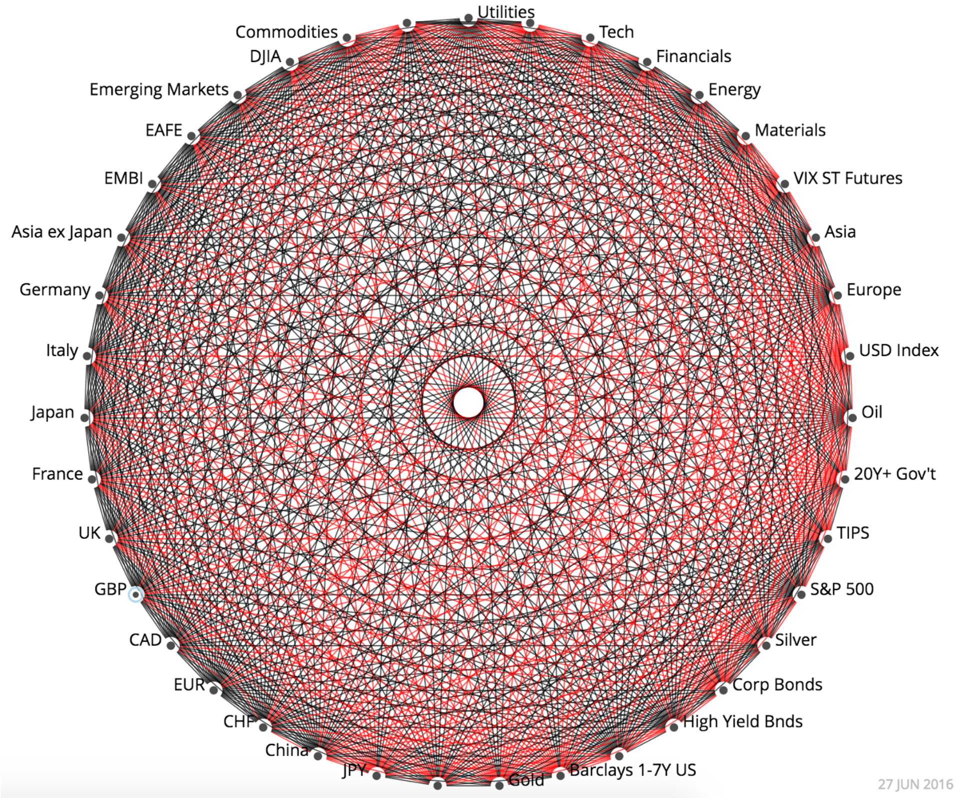
# Correlation Network of the Assets

We can view any matrix as a network.

We encode correlations as links between the correlated nodes/assets.

Red link = negative correlation
Black link = positive correlation

However, this simple encoding does not give us much.

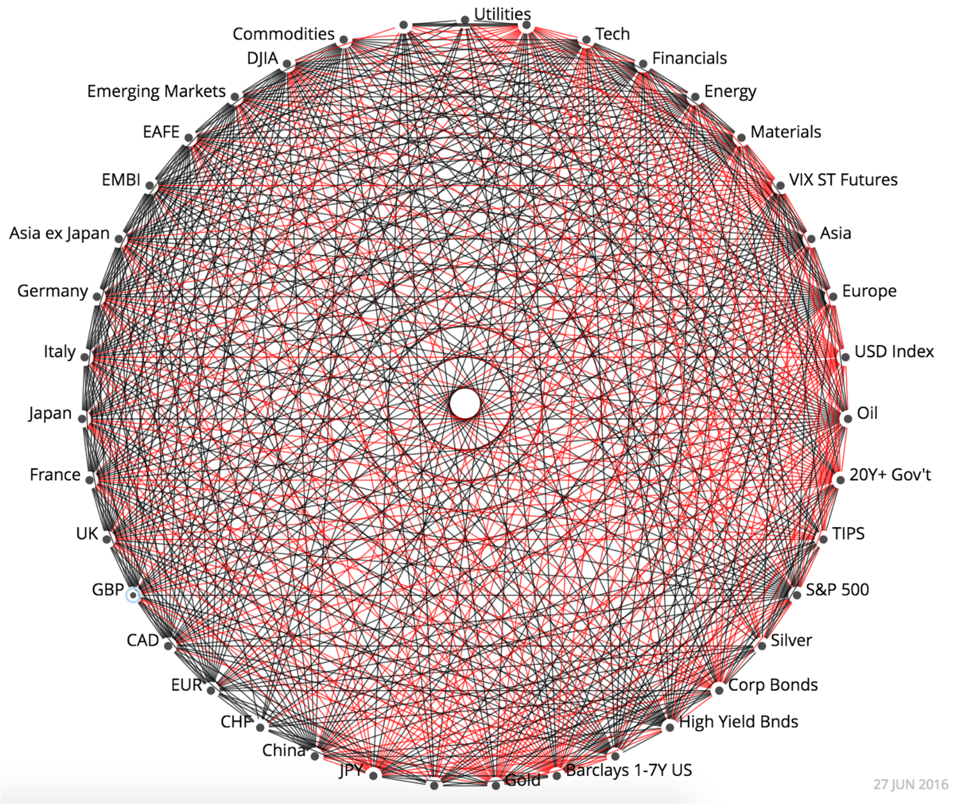


# Transactions & Similarity Based Networks

Not all correlations are statistically significantly different from 0.

Absence of link marks that asset is not significantly correlated (here at 95% level).

Due to the large number of estimates, we also need for multiple comparisons correction. Eg. Bonferroni or FDR.



# Network Layout

We can use network layouts to better detect patterns from noise.

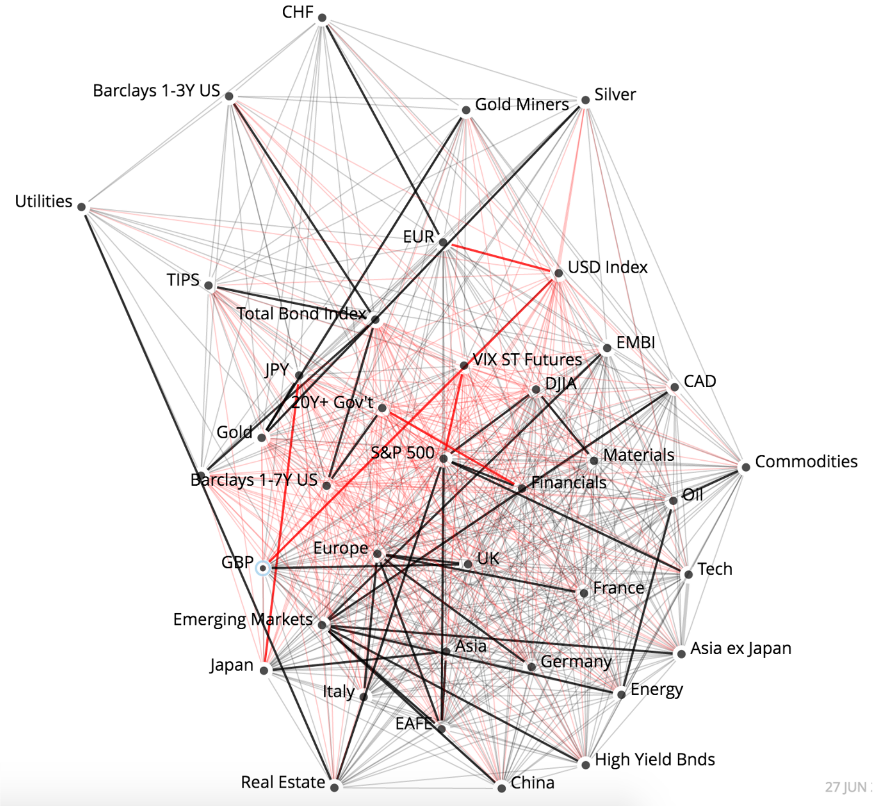
E.g. we can try a Force-Directed network layout to identify clusters.

# Filtering

Next, we identify the Minimum Spanning Tree and filter out other correlations (Mantegna, ‘99).

We need a distance function, here we look at maximum spanning tree with distance function: abs(cor)

This shows us the backbone correlation structure.

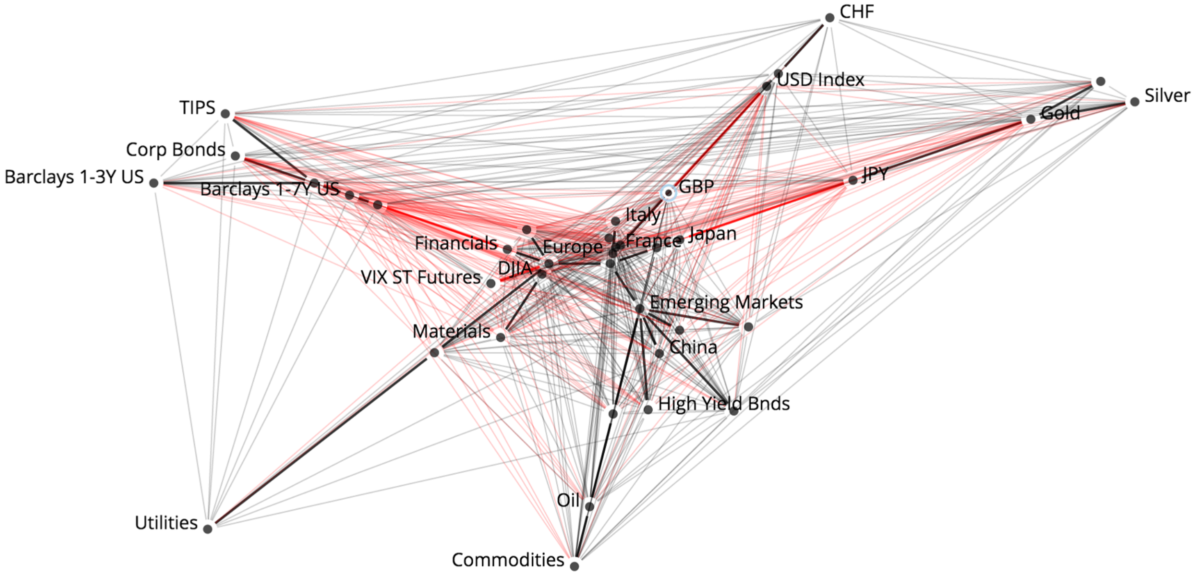


# Radial Tree Layout

We use a radial tree layout algorithm (Bachmeier et al. ‘05) that places the assets so that:

- Shorter links in the tree indicate higher correlations
- Longer links indicate lower correlations

As a result, we also see how the assets cluster by asset class.



# Radial Tree Layout

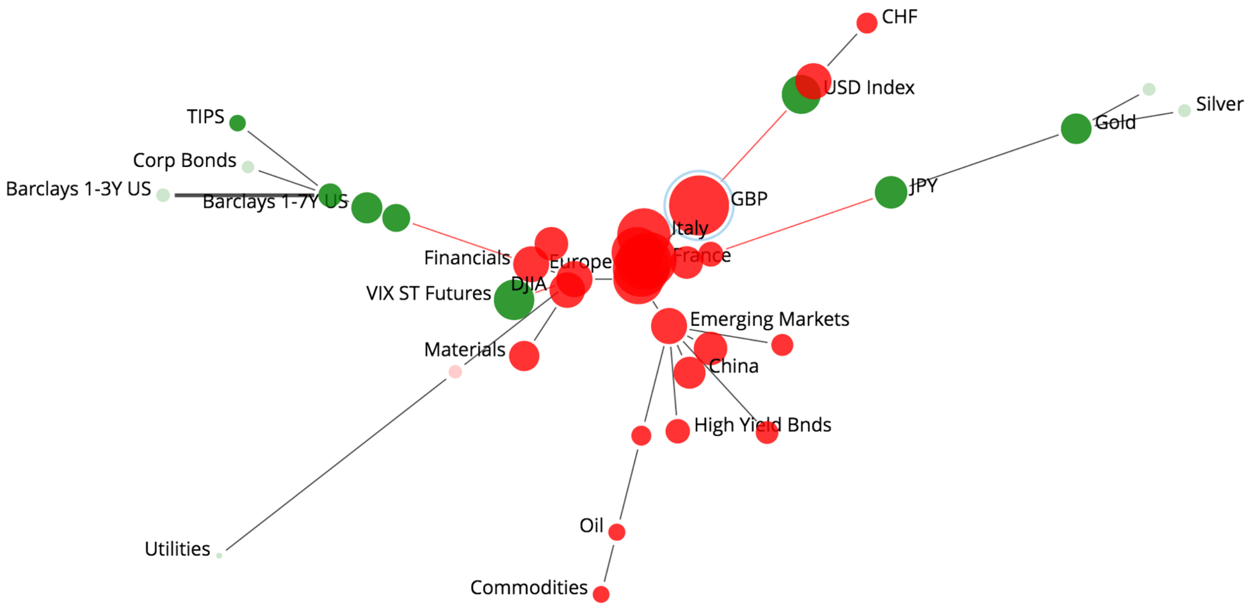
Focus on the links in the Spanning Tree to highlight clustering structure.

Node color indicates last daily return

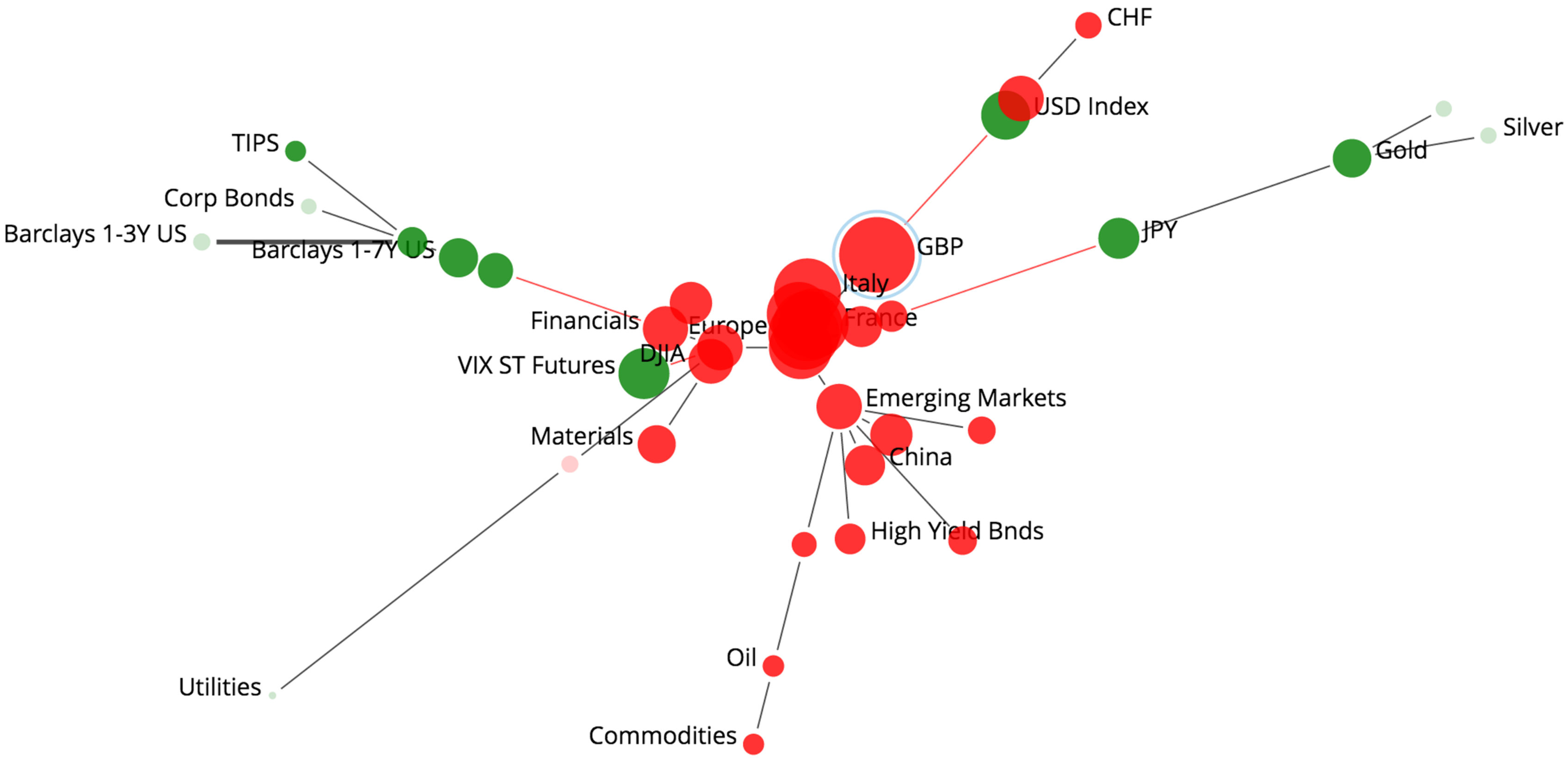
- Green = positive
- Red = negative

Node size indicates magnitude of return

Bright colors are VaR exceptions

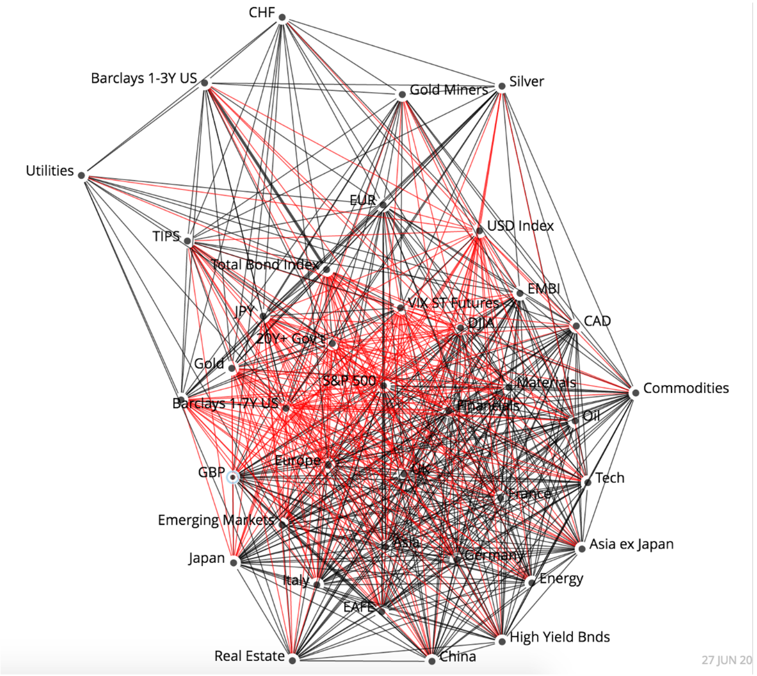


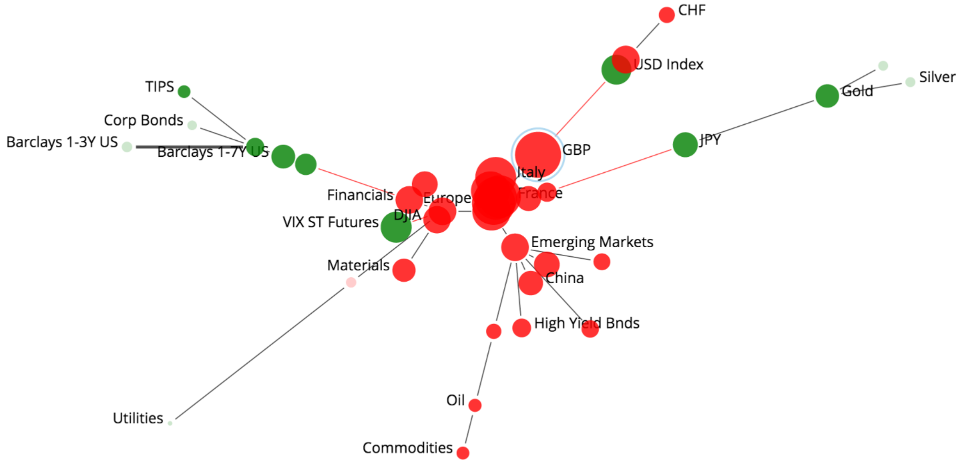
# Brexit, Friday 24 June 2016



# Network Analytics : Filtering

Often networks are large and complex and we want to filter out noise. Filtering techniques give solutions.



# Example: US Presidential Election 2016

Soramaki et al (2016). 'A Network-Based Method for Visual Identification of Systemic Risks': Journal of Network Theory in Finance

# Use Case: Monitoring Housing Markets

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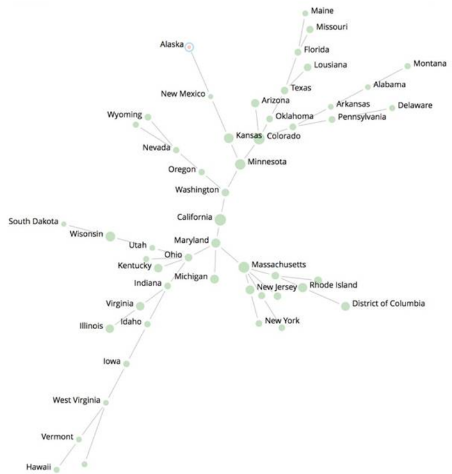
## New Tools Give Better Picture, Literally, of Financial-System Risk

Researchers are using network analytics and advanced data modeling to identify weak spots in the system that otherwise might go unnoticed




This sprawling tree shows housing prices in U.S. markets moving with little correlation in 2000. The tree has gotten shorter and shorter since, indicating higher correlation between markets.
PHOTO: FINANCIAL NETWORK ANALYTICS

Soramaki et al (2016). 'A Network-Based Method for Visual Identification of Systemic Risks': Journal of Network Theory in Finance

online | pdf

ASSET
NETWORK
STRESS
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ALERTS
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TOUR

# House Price Index Correlations

Correlations in changes of House Price Index by state. Data source: Quandl / Federal Reserve Economic Data.

The data displays a clear cascade of negative house price shocks starting in Q1 2007. Also notable is the increase in the overall level of correlations (and connectedness) from 2000 to 2014.

## How to read it

Nodes represent US States. Node color reflects change in price: green is positive, and red is negative. Node size scales with the magnitude of change, bigger nodes have larger price change. Outlier movements are marked with bright colors.

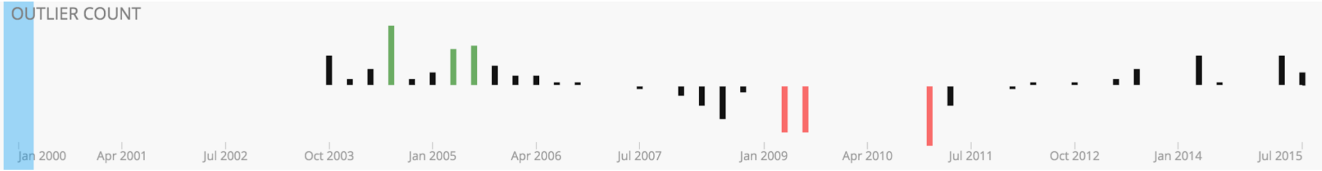
Links show strongest correlations. Among these correlations, shorter link means a stronger correlation.

In this example we look at US house prices across states. We see the US states as nodes and strong correlation between house prices as link. In 2000 the tree is very spread out and prices are going slightly up. This is a time when ABS are developed with the assumption that real-estate risk can be diversified across US states.

FNA

Sat, 1 Jan 2000 PLAY 1 Jul 1990 - 1 Jul 2015

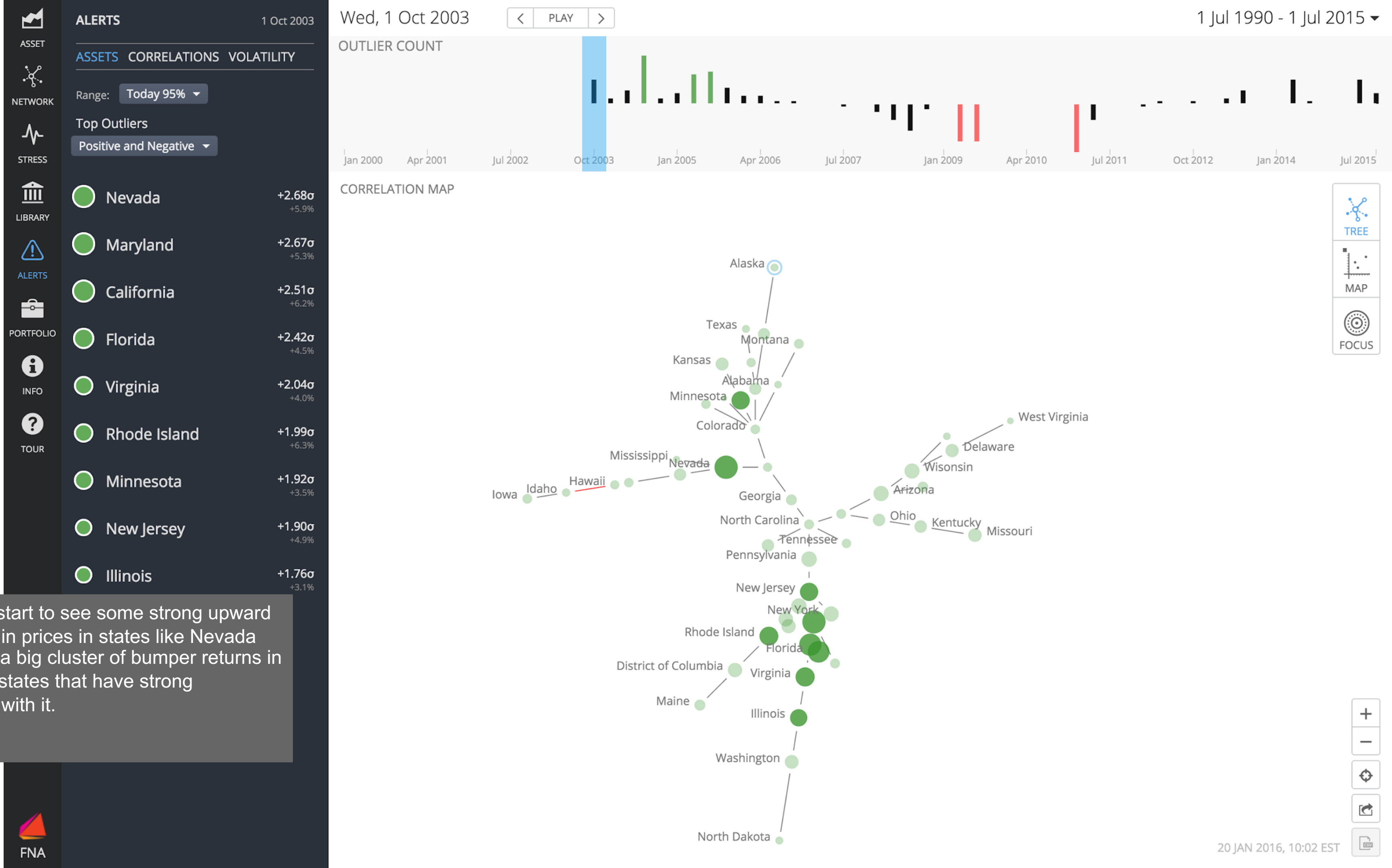
OUTLIER COUNT



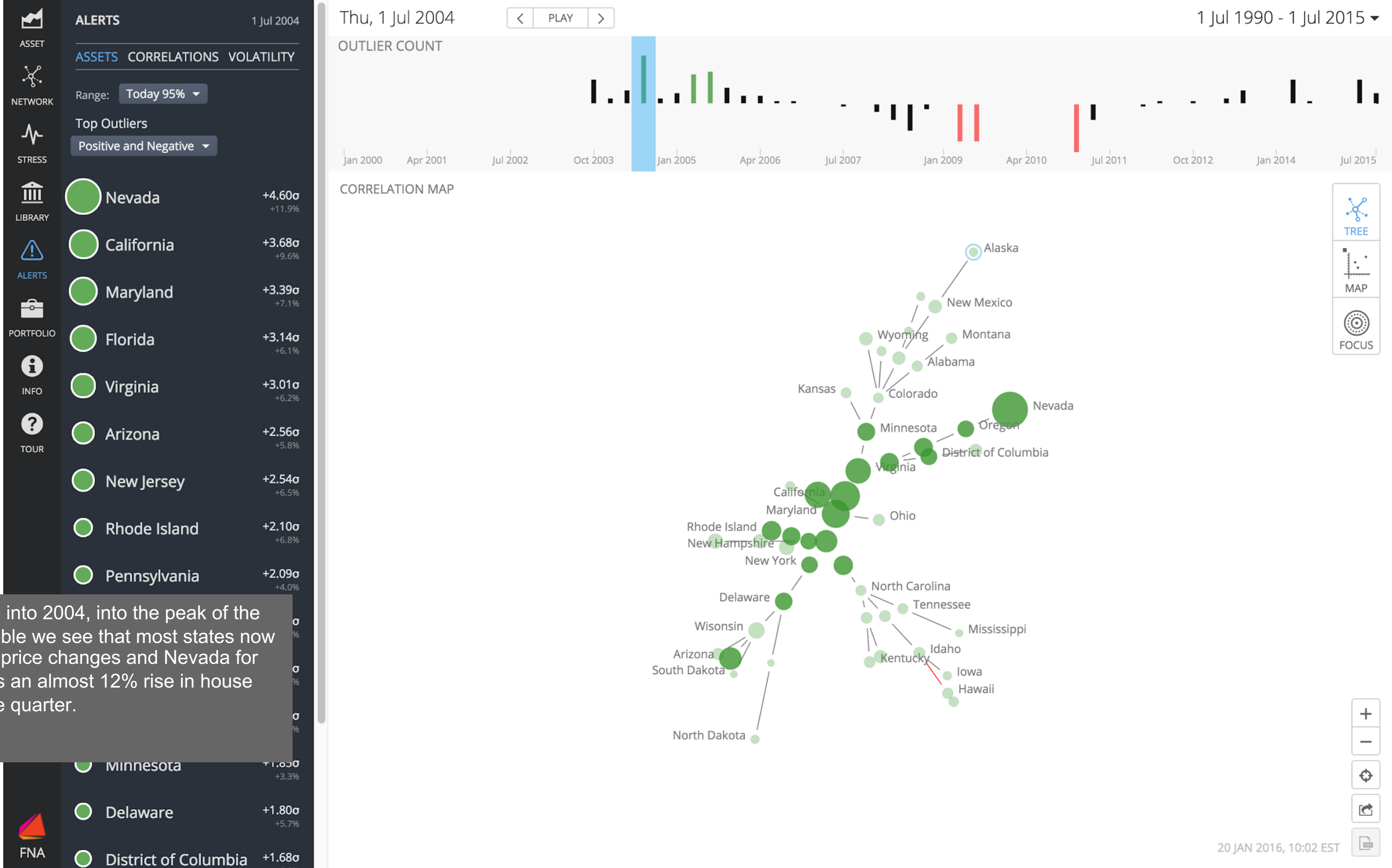

CORRELATION MAP

TREE
MAP
FOCUS

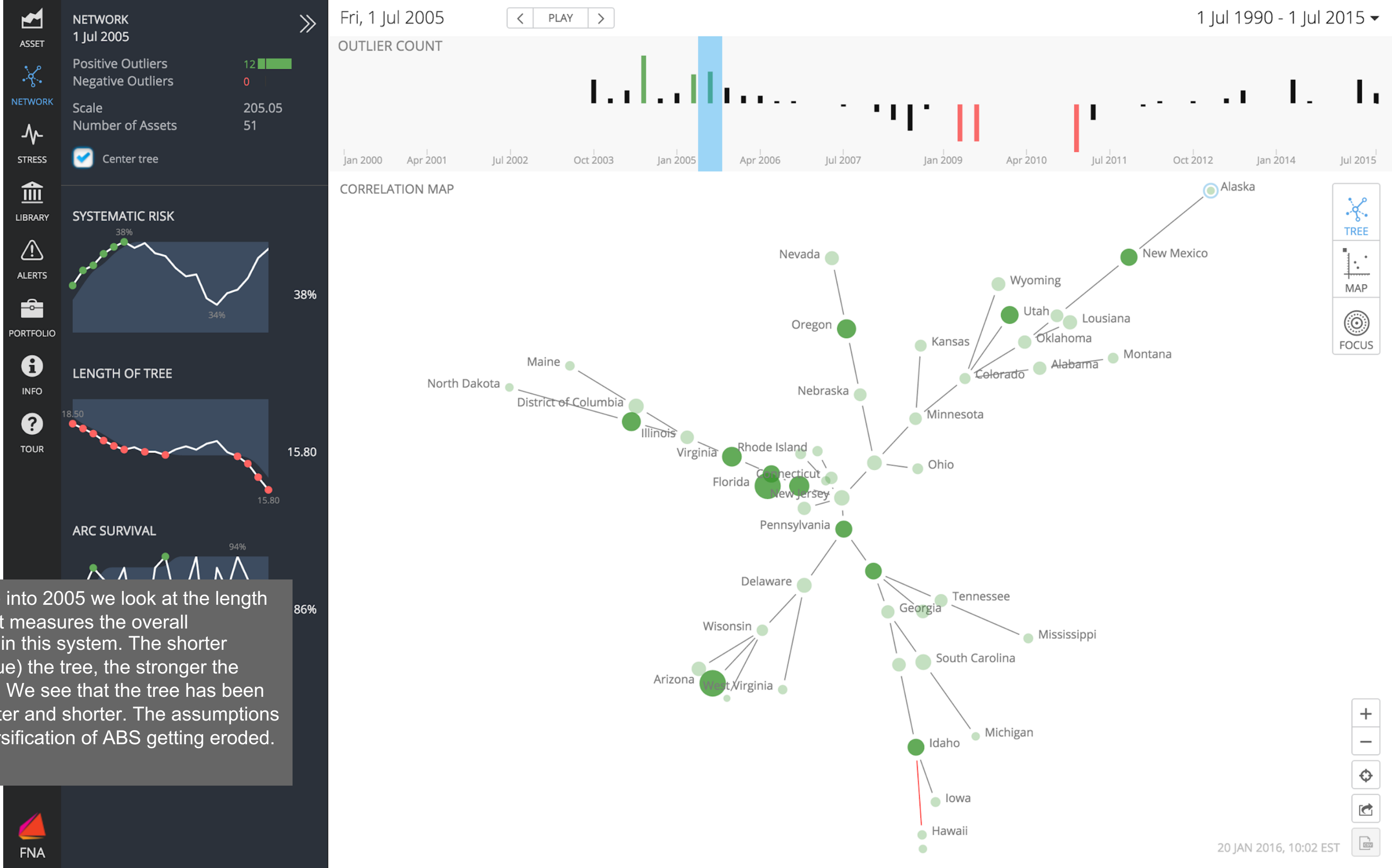

20 JAN 2016, 10:02 EST



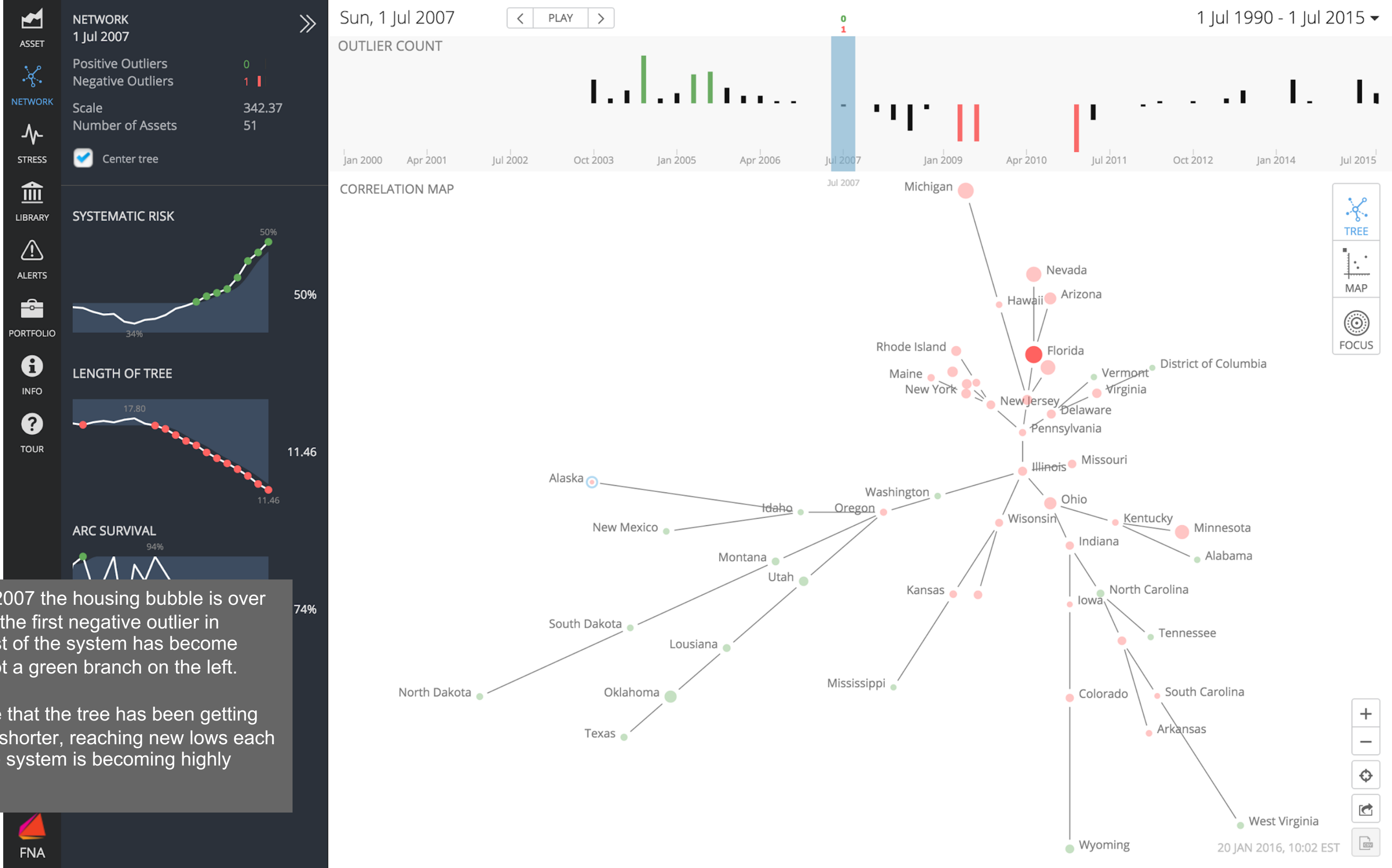

In 2003 we start to see some strong upward movements in prices in states like Nevada and we see a big cluster of bumper returns in Florida and states that have strong correlations with it.




As we move into 2004, into the peak of the housing bubble we see that most states now have outlier price changes and Nevada for example has an almost 12% rise in house prices in one quarter.

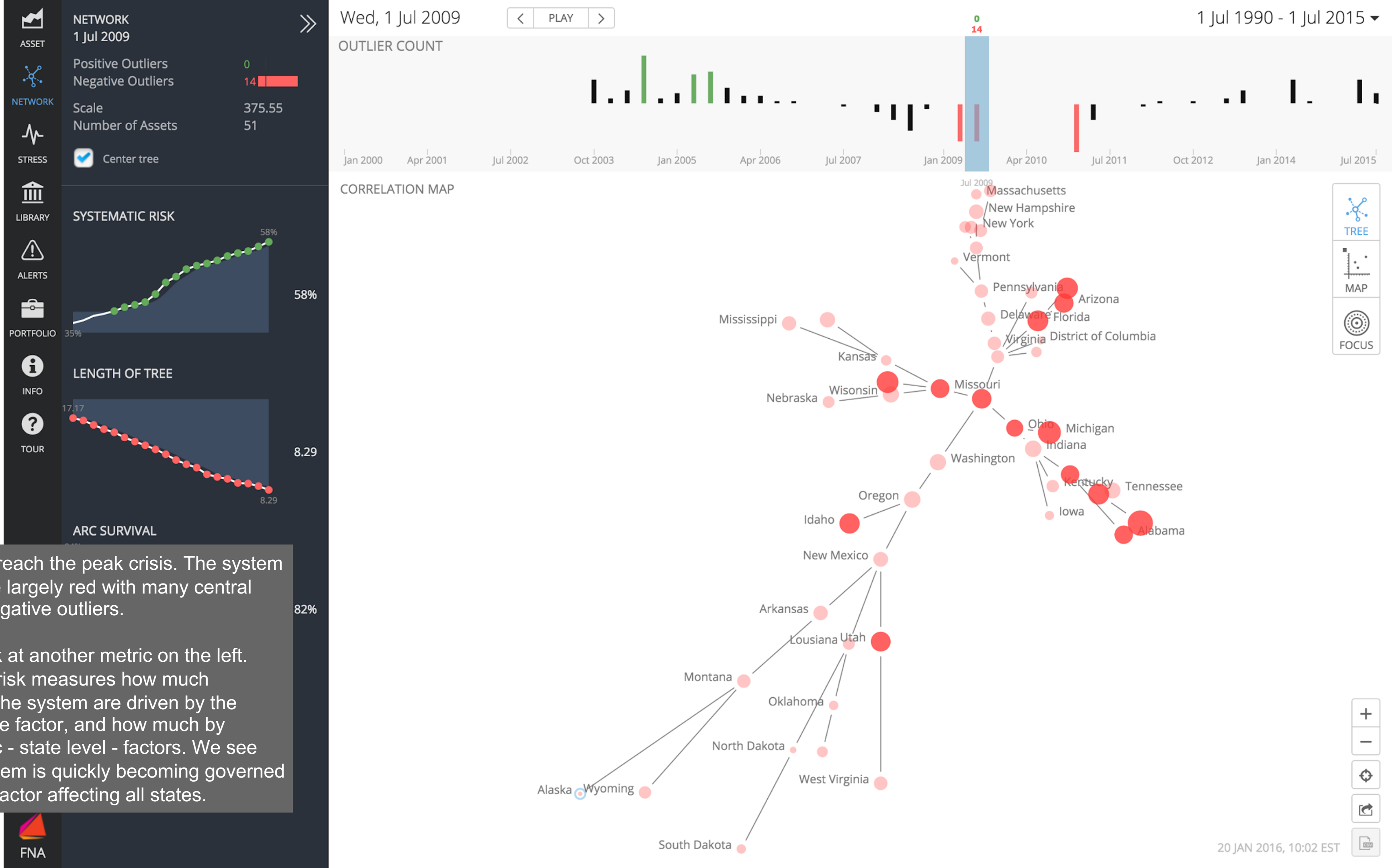



As we move into 2005 we look at the length of the tree. It measures the overall correlations in this system. The shorter (smaller value) the tree, the stronger the correlations. We see that the tree has been getting shorter and shorter. The assumptions behind diversification of ABS getting eroded.



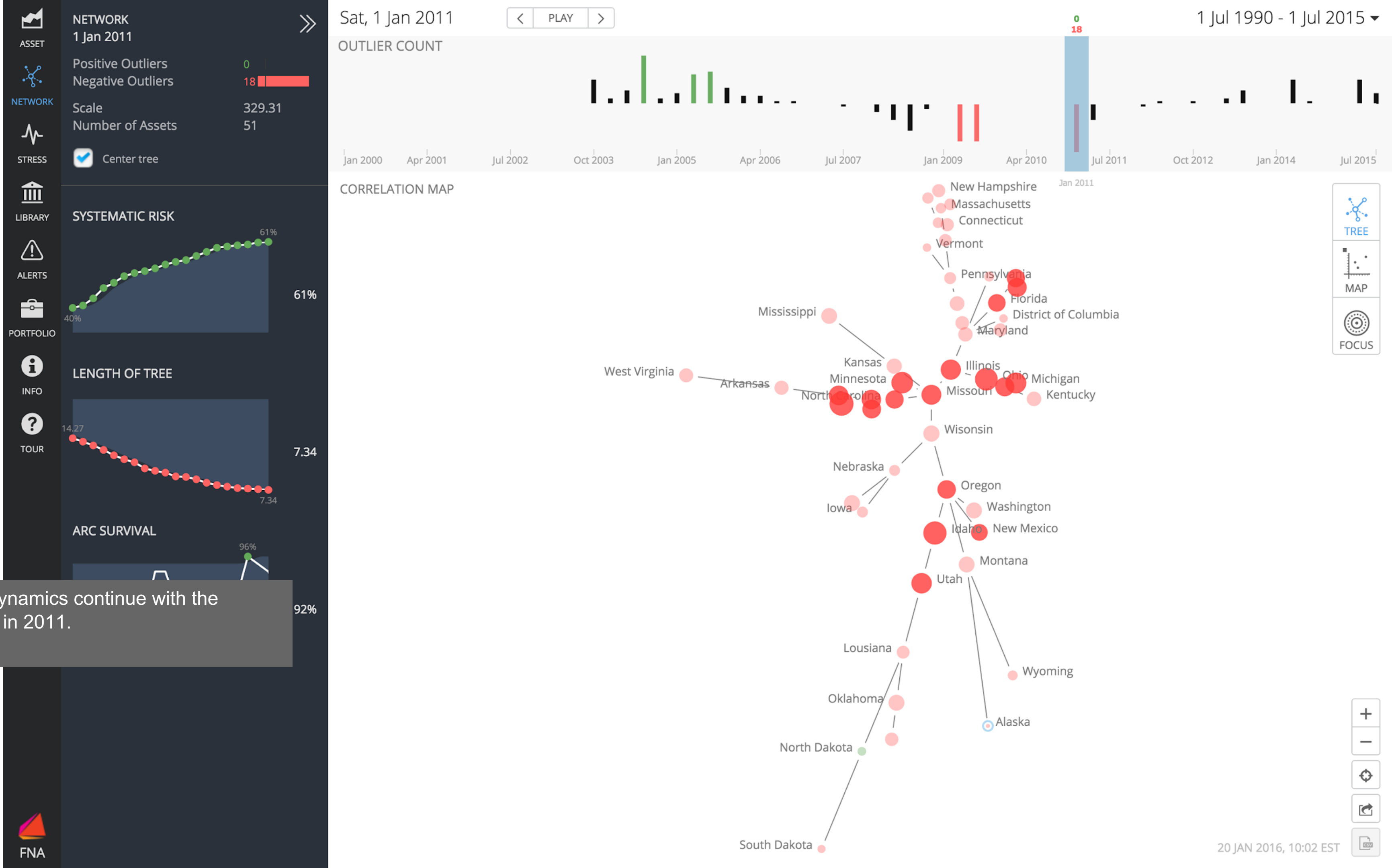

In summer 2007 the housing bubble is over and we see the first negative outlier in Florida. Most of the system has become redm, except a green branch on the left.

We also see that the tree has been getting shorter and shorter, reaching new lows each quarter. The system is becoming highly coupled.

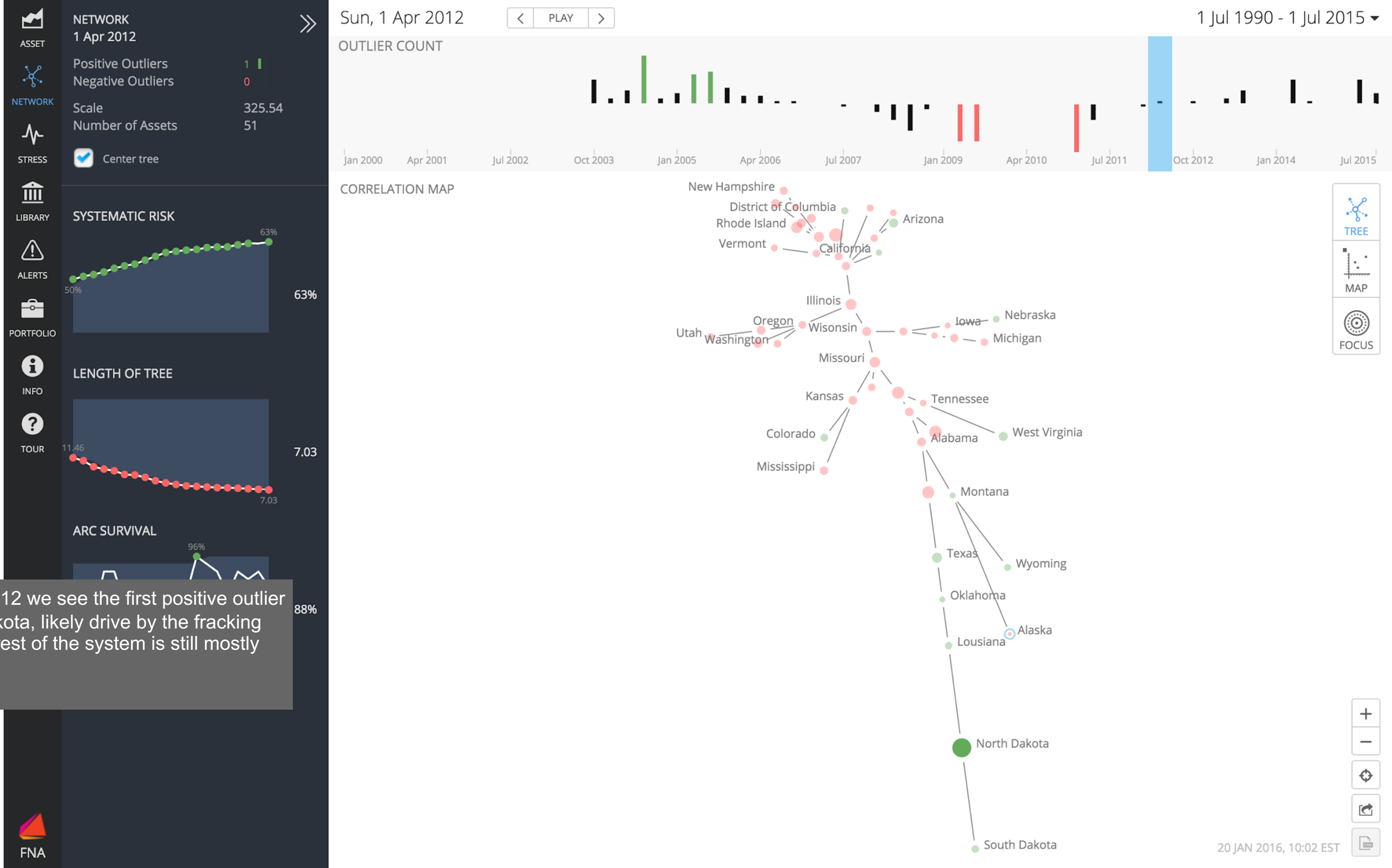



In 2009 we reach the peak crisis. The system has become largely red with many central states as negative outliers.

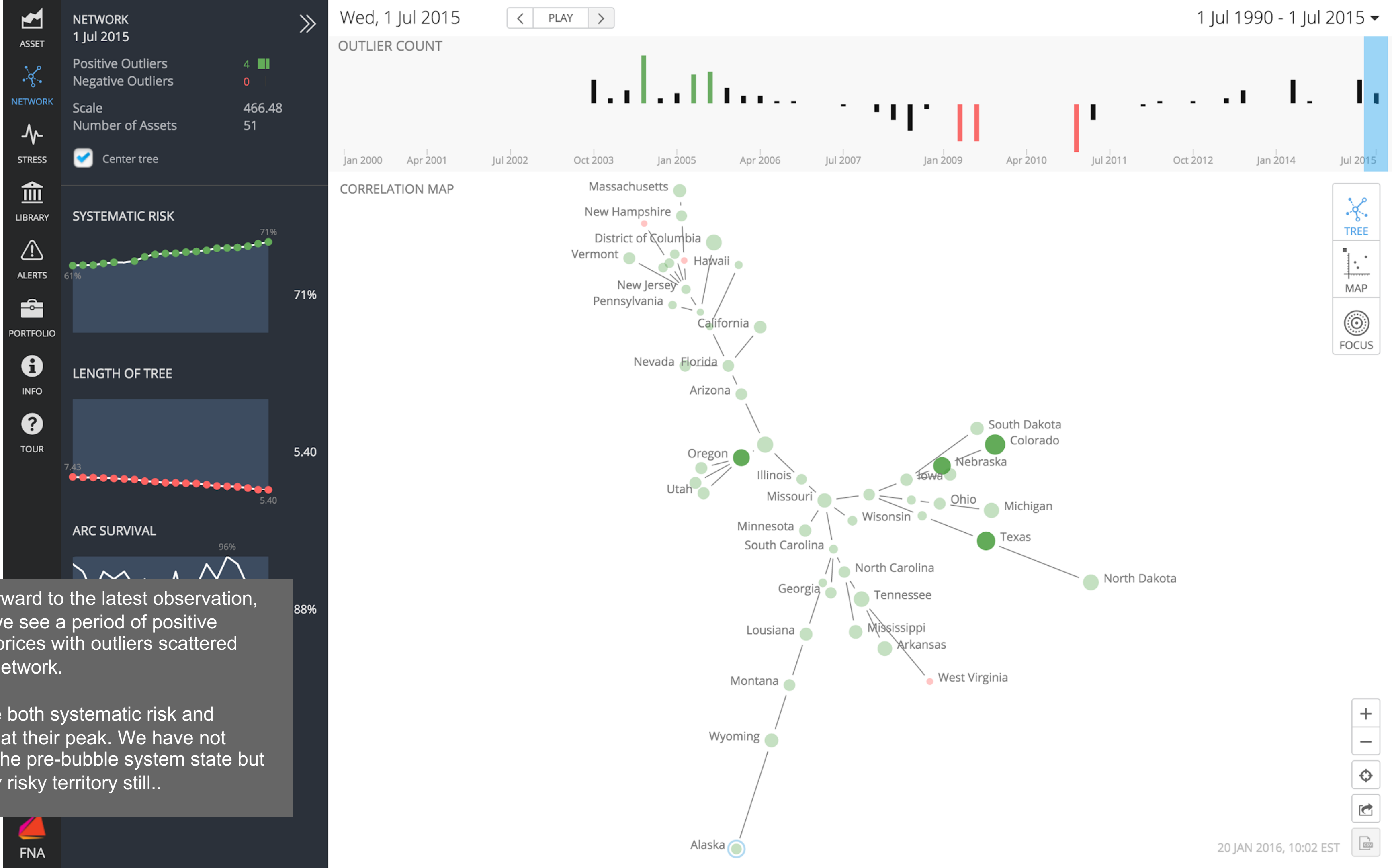
We can look at another metric on the left. Systematic risk measures how much changes in the system are driven by the largest single factor, and how much by idiosyncratic - state level - factors. We see that the system is quickly becoming governed by a single factor affecting all states.




The same dynamics continue with the “double dip” in 2011.




In Spring 2012 we see the first positive outlier in North Dakota, likely drive by the fracking boom. The rest of the system is still mostly negative.

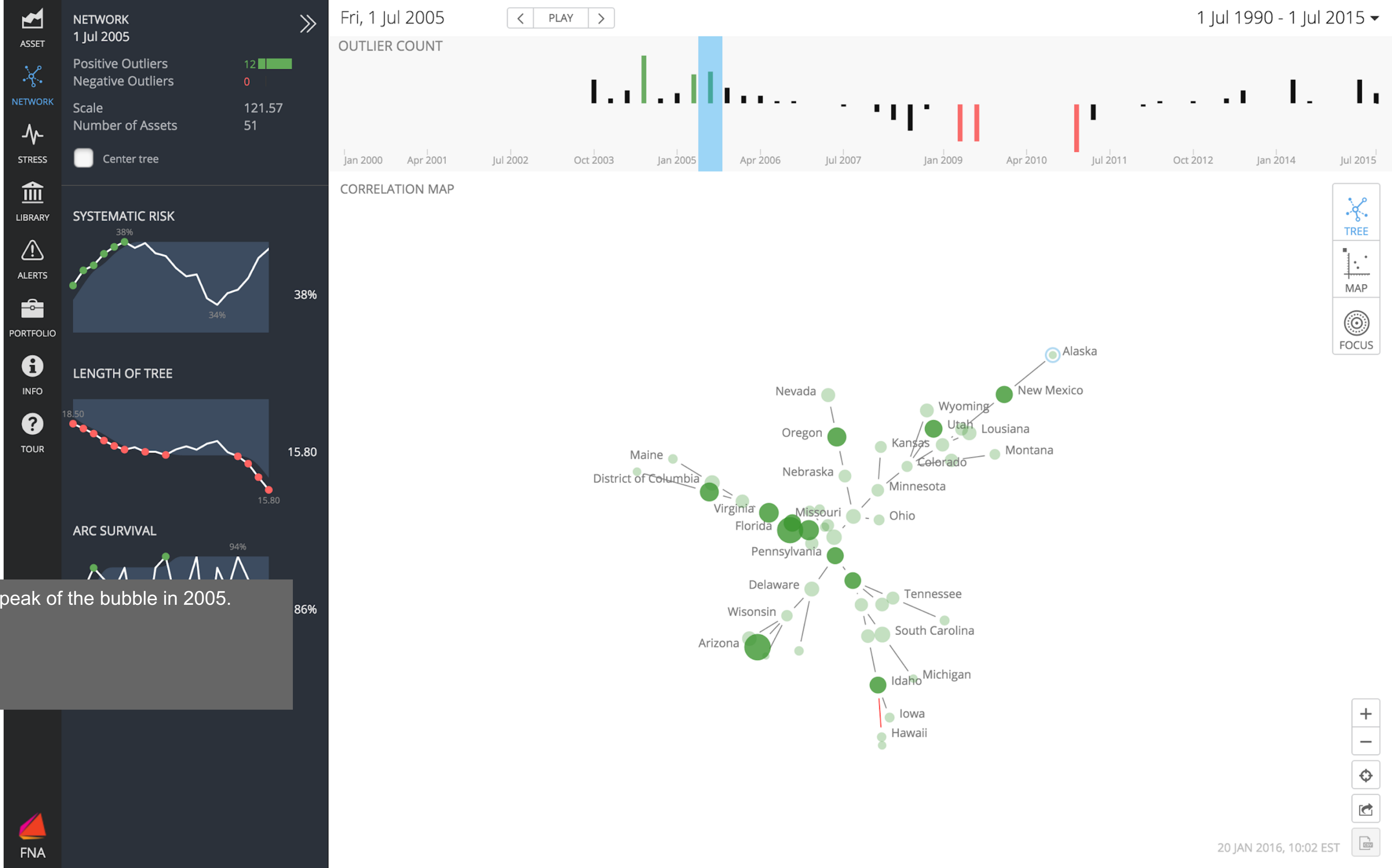



If we fast forward to the latest observation, July 2015, we see a period of positive changes in prices with outliers scattered across the network.

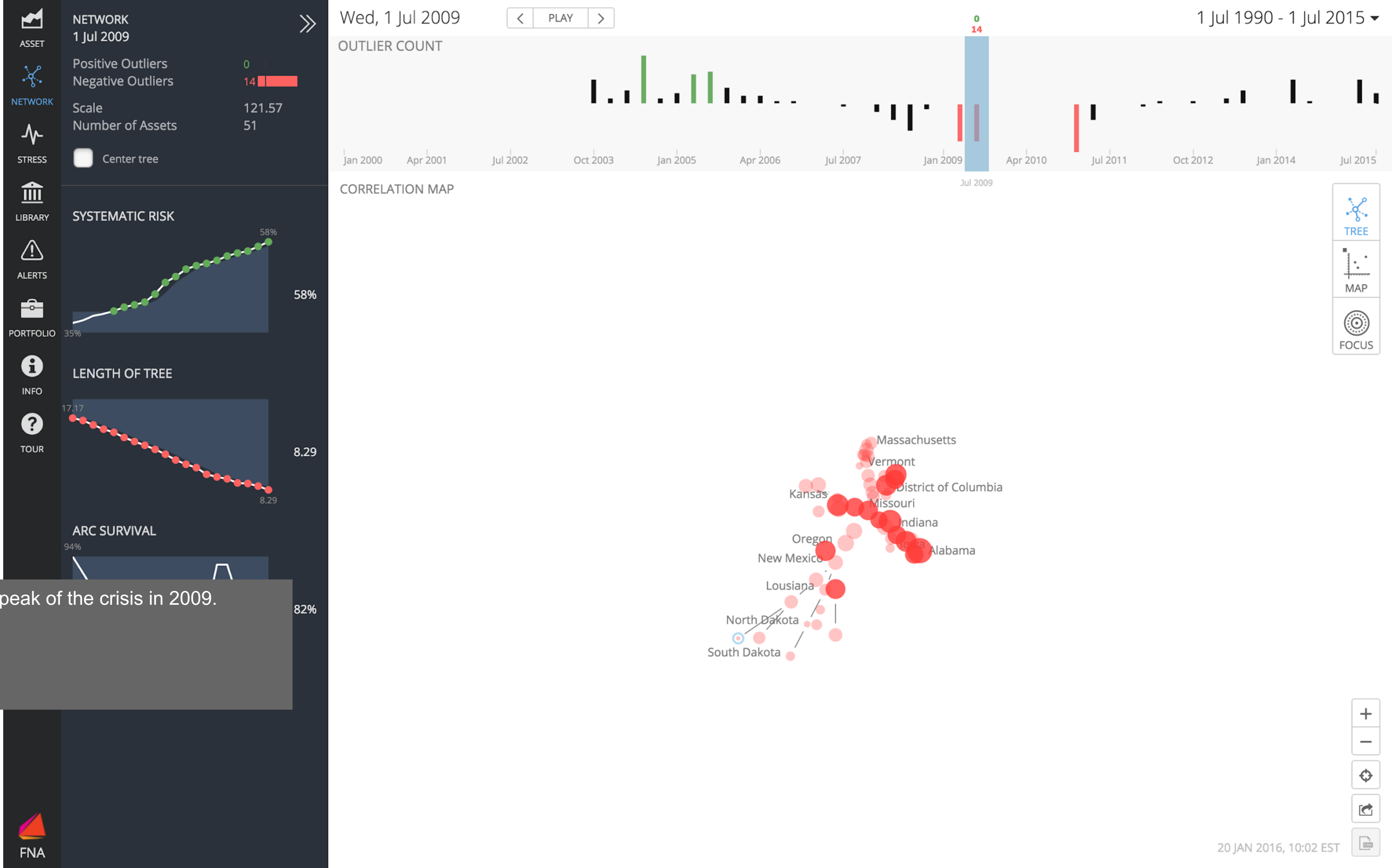
We also see both systematic risk and correlations at their peak. We have not returned to the pre-bubble system state but are in a very risky territory still..


We can see this clearly by looking at the size of the tree.

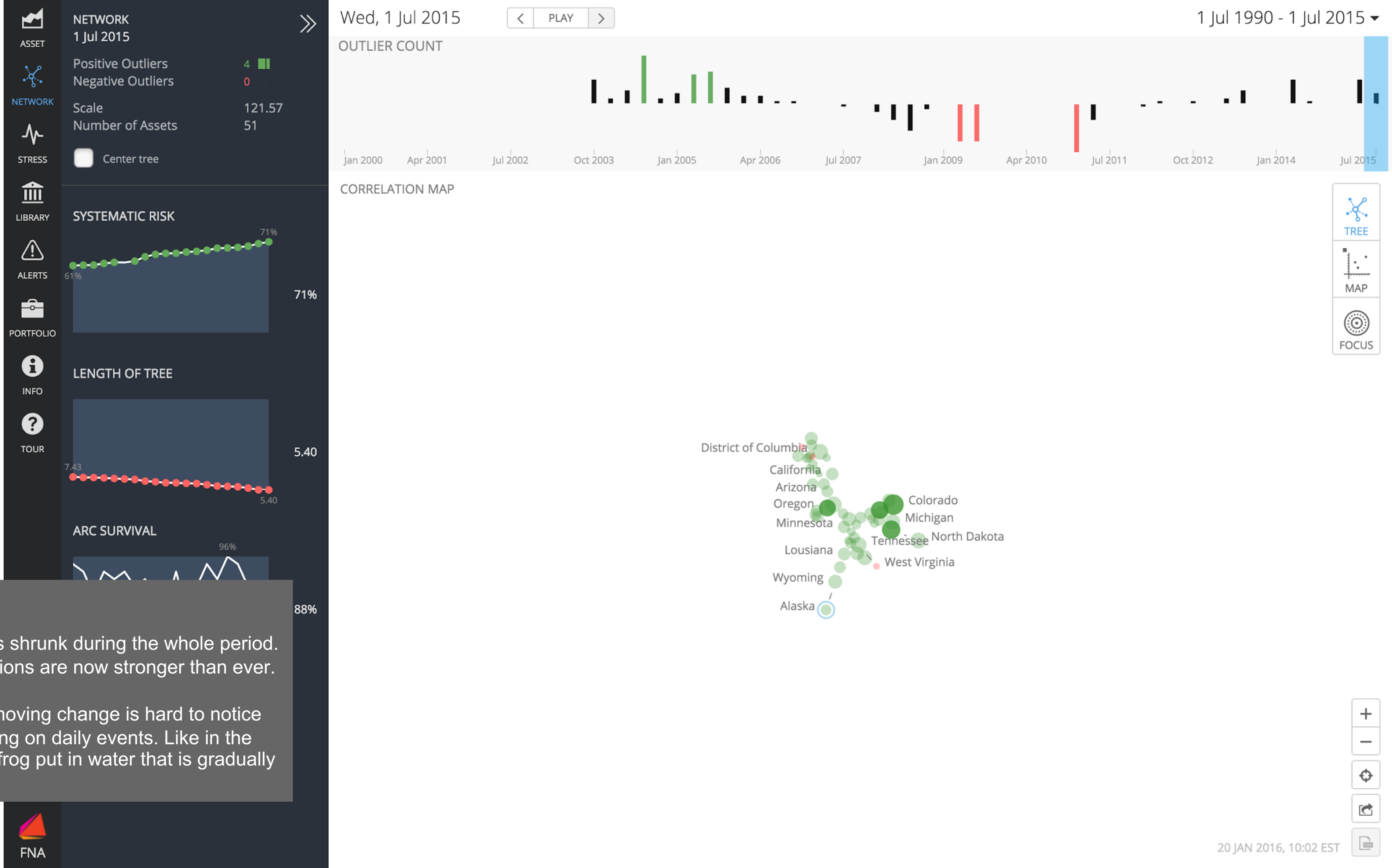
First in 2010.




Then at the peak of the bubble in 2005.




Then at the peak of the crisis in 2009.



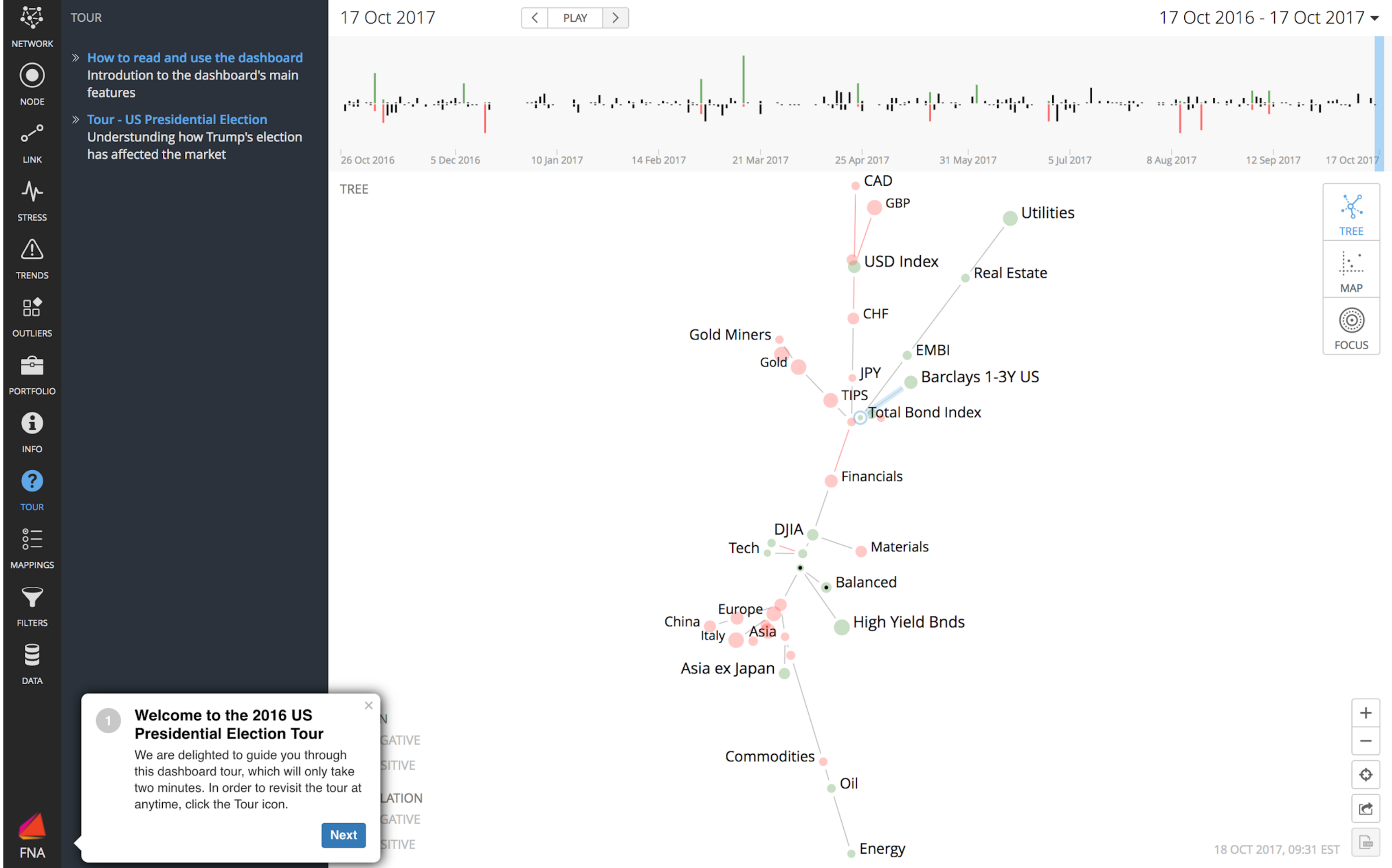

And now.

The tree has shrunk during the whole period.
The correlations are now stronger than ever.

Such slow moving change is hard to notice when focusing on daily events. Like in the story of the frog put in water that is gradually heated.

# Example: US Presidential Election 2016

Soramaki et al (2016). 'A Network-Based Method for Visual Identification of Systemic Risks': Journal of Network Theory in Finance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How to read and use the dashboard
Introdution to the dashboard's main features
Tour - US Presidential Election
Understunding how Trump's election has affected the market
17 Oct 2017
PLAY
17 Oct 2016 - 17 Oct 2017
26 Oct 2016
5 Dec 2016
10 Jan 2017
14 Feb 2017
21 Mar 2017
25 Apr 2017
31 May 2017
5 Jul 2017
8 Aug 2017
12 Sep 2017
17 Oct 2017
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CAD
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Utilities
USD Index
Real Estate
CHF
Gold Miners
EMBI
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Barclays 1-3Y US
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Total Bond Index
Financials
DJIA
Tech
Materials
Balanced
Europe
China
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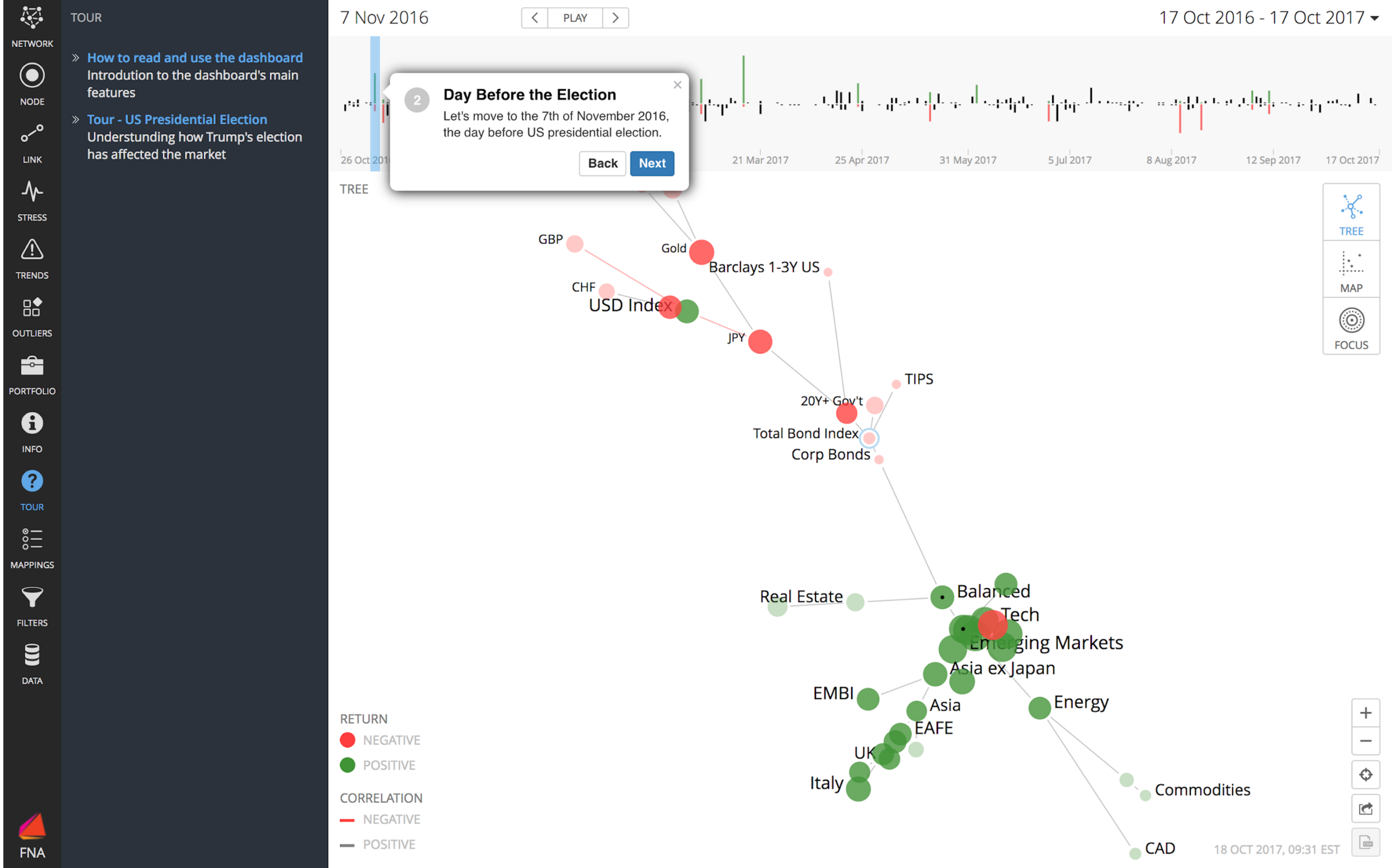
High Yield Bnds
Asia ex Japan
Commodities
Oil
Energy
TREE
MAP
FOCUS
1
Welcome to the 2016 US Presidential Election Tour
We are delighted to guide you through this dashboard tour, which will only take two minutes. In order to revisit the tour at anytime, click the Tour icon.
Next
18 OCT 2017, 09:31 EST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7 Nov 2016
PLAY
17 Oct 2016 - 17 Oct 2017
26 Oct 201
21 Mar 2017
25 Apr 2017
31 May 2017
5 Jul 2017
8 Aug 2017
12 Sep 2017
17 Oct 2017
2
Day Before the Election
Let's move to the 7th of November 2016, the day before US presidential election.
Back
Next
TREE
GBP
Gold
Barclays 1-3Y US
CHF
USD Index
JPY
TIPS
20Y+ Gov't
Total Bond Index
Corp Bonds
Real Estate
Balanced
Tech
Emerging Markets
Asia ex Japan
EMBI
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CORRELATION
NEGATIVE
POSITIVE
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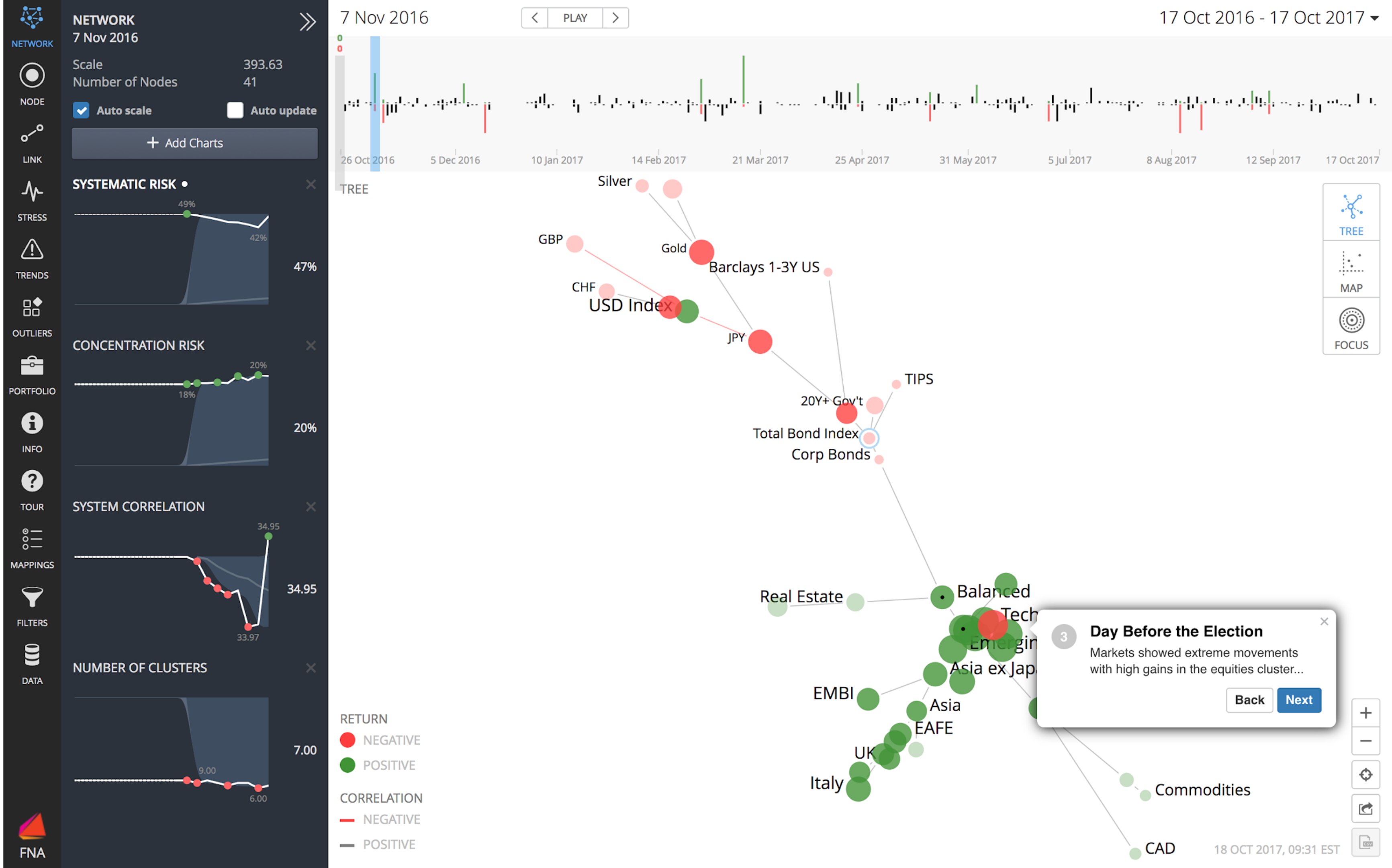
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7 Nov 2016
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Auto scale
Auto update
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CONCENTRATION RISK
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21 Mar 2017
25 Apr 2017
31 May 2017
5 Jul 2017
8 Aug 2017
12 Sep 2017
17 Oct 2017
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Barclays 1-3Y US
CHF
USD Index
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20Y+ Gov't
Total Bond Index
Corp Bonds
Real Estate
Balanced
Tech
EMBI
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UK
Italy
Commodities
CAD
Day Before the Election
Markets showed extreme movements with high gains in the equities cluster...
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NEGATIVE
POSITIVE
CORRELATION
NEGATIVE
POSITIVE
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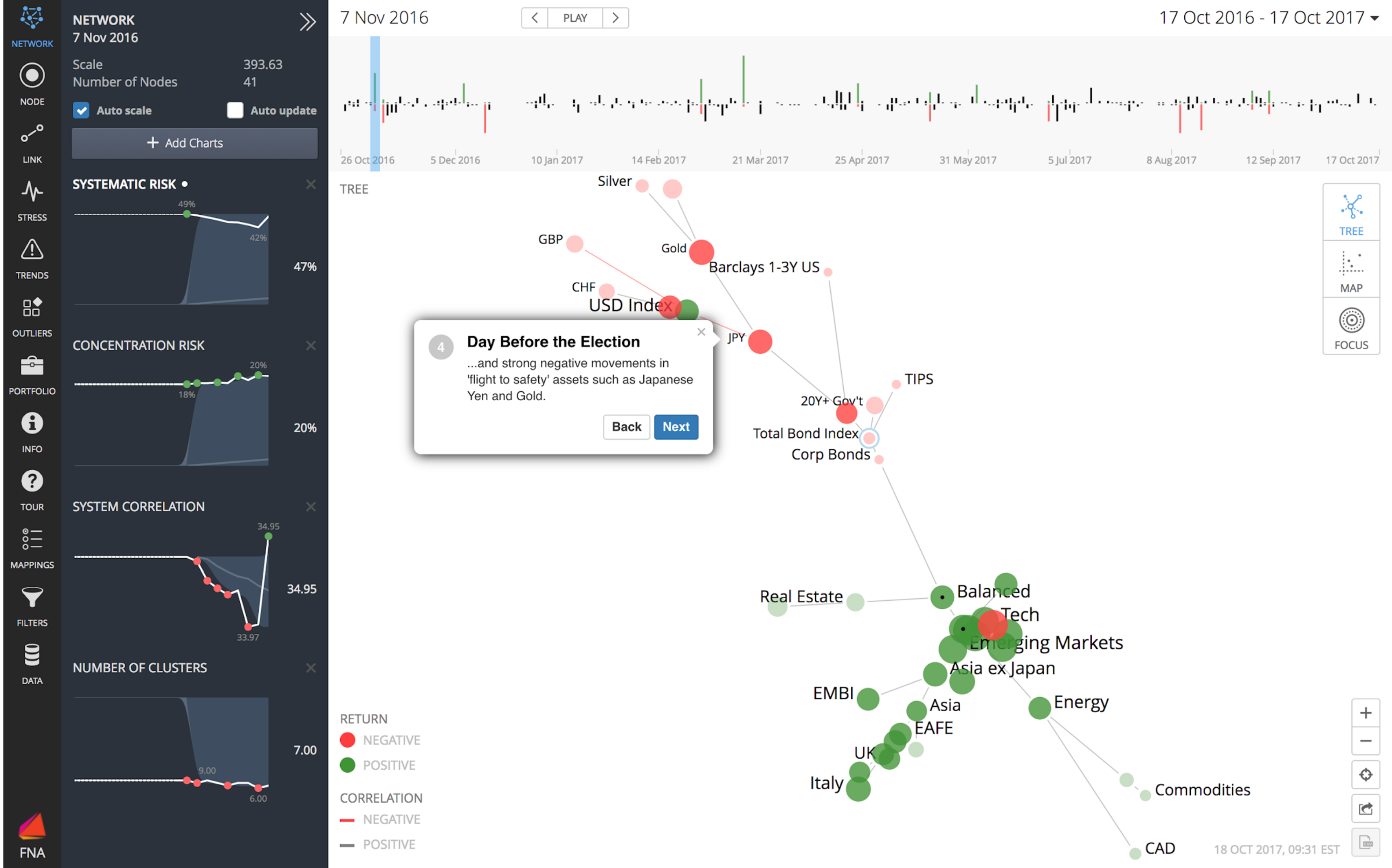
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17 Oct 2017
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Silver
GBP
Gold
Barclays 1-3Y US
CHF
USD Index
JPY
TIPS
20Y+ Gov't
Total Bond Index
Corp Bonds
4
Day Before the Election
...and strong negative movements in 'flight to safety' assets such as Japanese Yen and Gold.
Back
Next
Real Estate
Balanced
Tech
Emerging Markets
Asia ex Japan
EMBI
Asia
Energy
EAFE
UK
Italy
Commodities
CAD
RETURN
NEGATIVE
POSITIVE
CORRELATION
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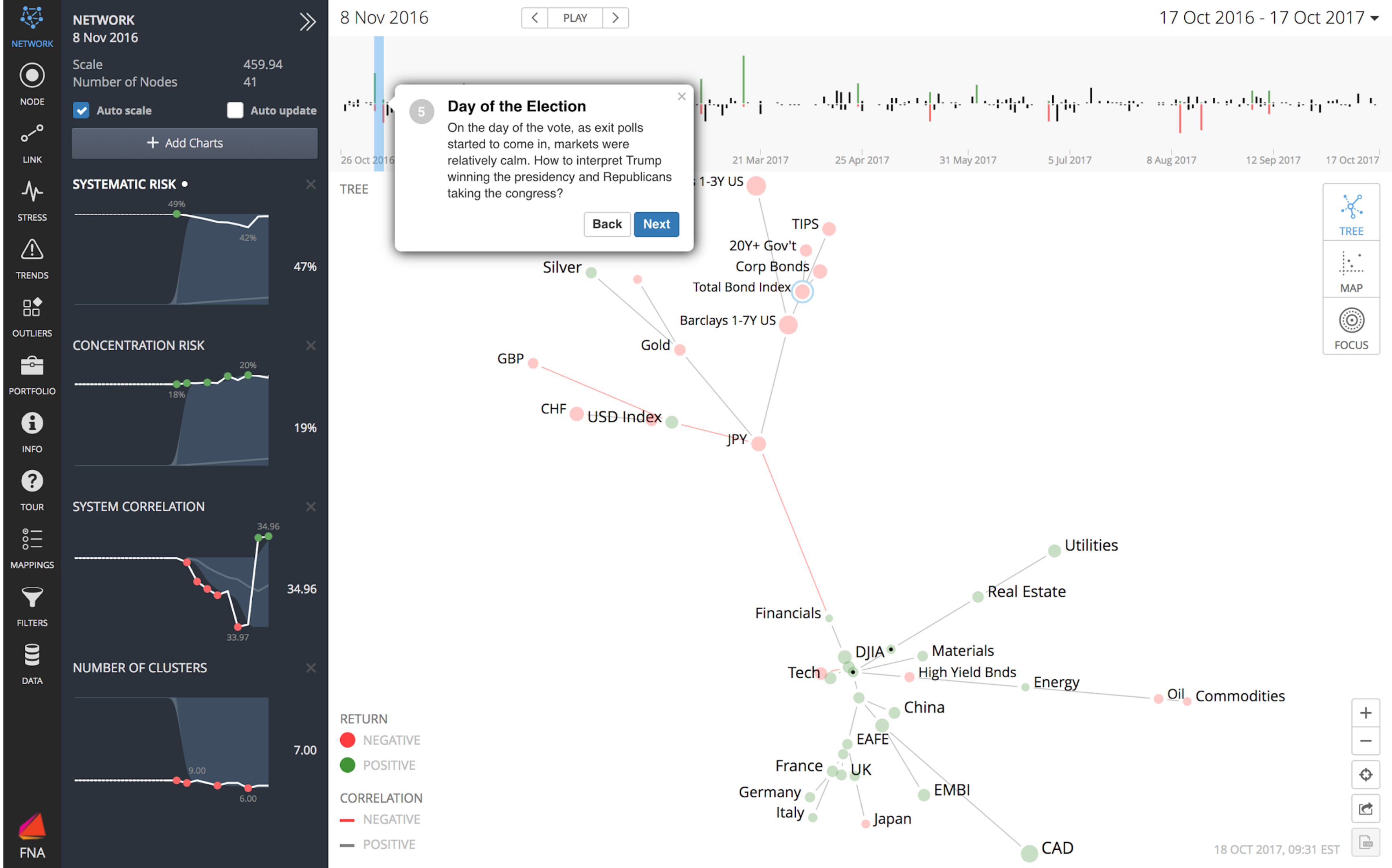

8 Nov 2016
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Scale 459.94
Number of Nodes 41
Auto scale
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CONCENTRATION RISK
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19%
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26 Oct 2016
21 Mar 2017
25 Apr 2017
31 May 2017
5 Jul 2017
8 Aug 2017
12 Sep 2017
17 Oct 2017
TREE
5
Day of the Election
On the day of the vote, as exit polls started to come in, markets were relatively calm. How to interpret Trump winning the presidency and Republicans taking the congress?
Back
Next
1-3Y US
TIPS
20Y+ Gov't
Corp Bonds
Total Bond Index
Barclays 1-7Y US
Silver
Gold
GBP
CHF
USD Index
JPY
Utilities
Real Estate
Financials
DJIA
Materials
Tech
High Yield Bnds
Energy
Oil
Commodities
China
EAFE
France
UK
Germany
Italy
EMBI
Japan
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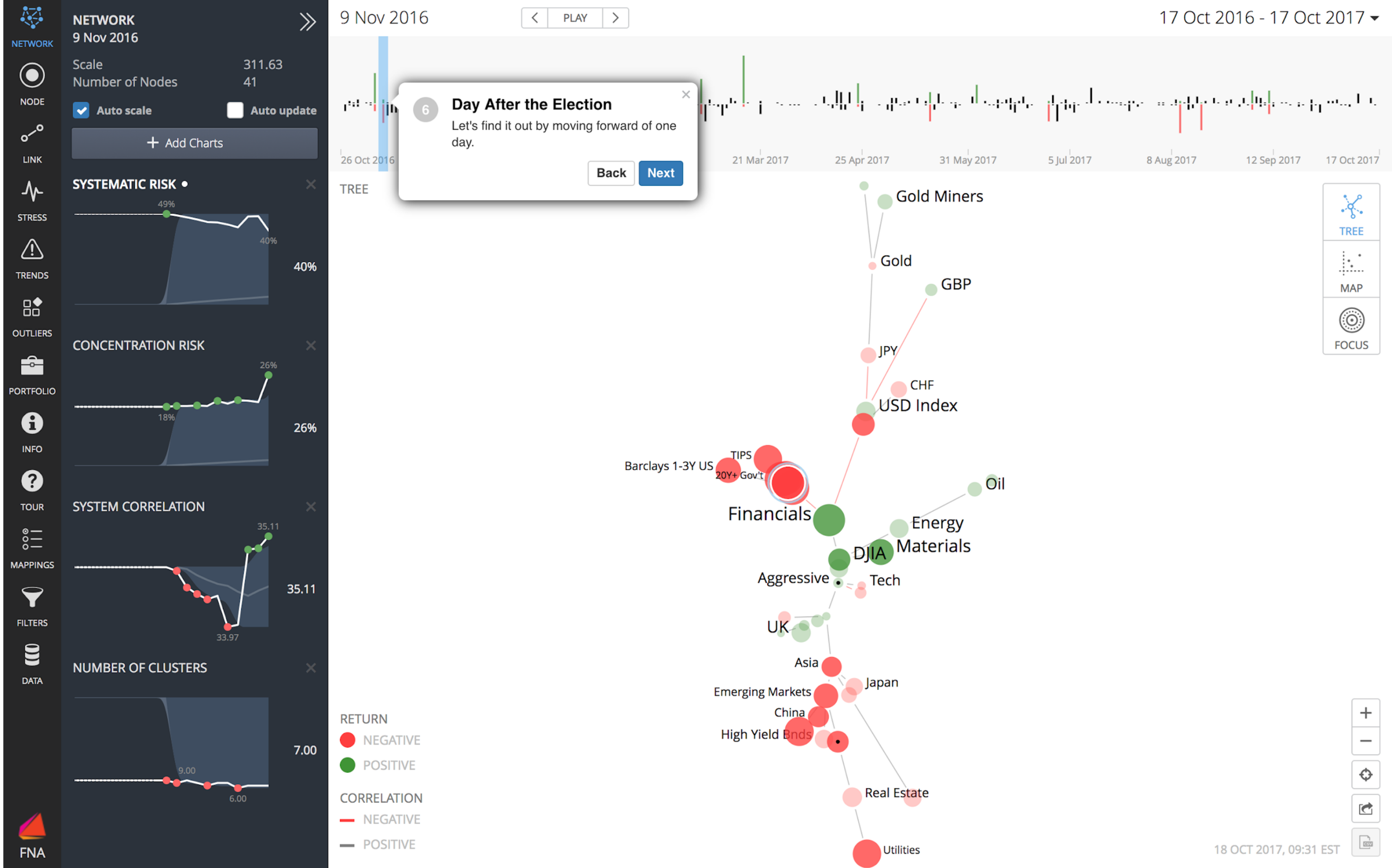
RETURN
NEGATIVE
POSITIVE
CORRELATION
NEGATIVE
POSITIVE
18 OCT 2017, 09:31 EST


NETWORK
9 Nov 2016
Scale 311.63
Number of Nodes 41
Auto scale
Auto update
Add Charts
SYSTEMATIC RISK
49%
40%
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CONCENTRATION RISK
26%
18%
26%
SYSTEM CORRELATION
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NUMBER OF CLUSTERS
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17 Oct 2016 - 17 Oct 2017
26 Oct 2016
21 Mar 2017
25 Apr 2017
31 May 2017
5 Jul 2017
8 Aug 2017
12 Sep 2017
17 Oct 2017
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Day After the Election
Let's find it out by moving forward of one day.
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Japan
Emerging Markets
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Real Estate
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POSITIVE
CORRELATION
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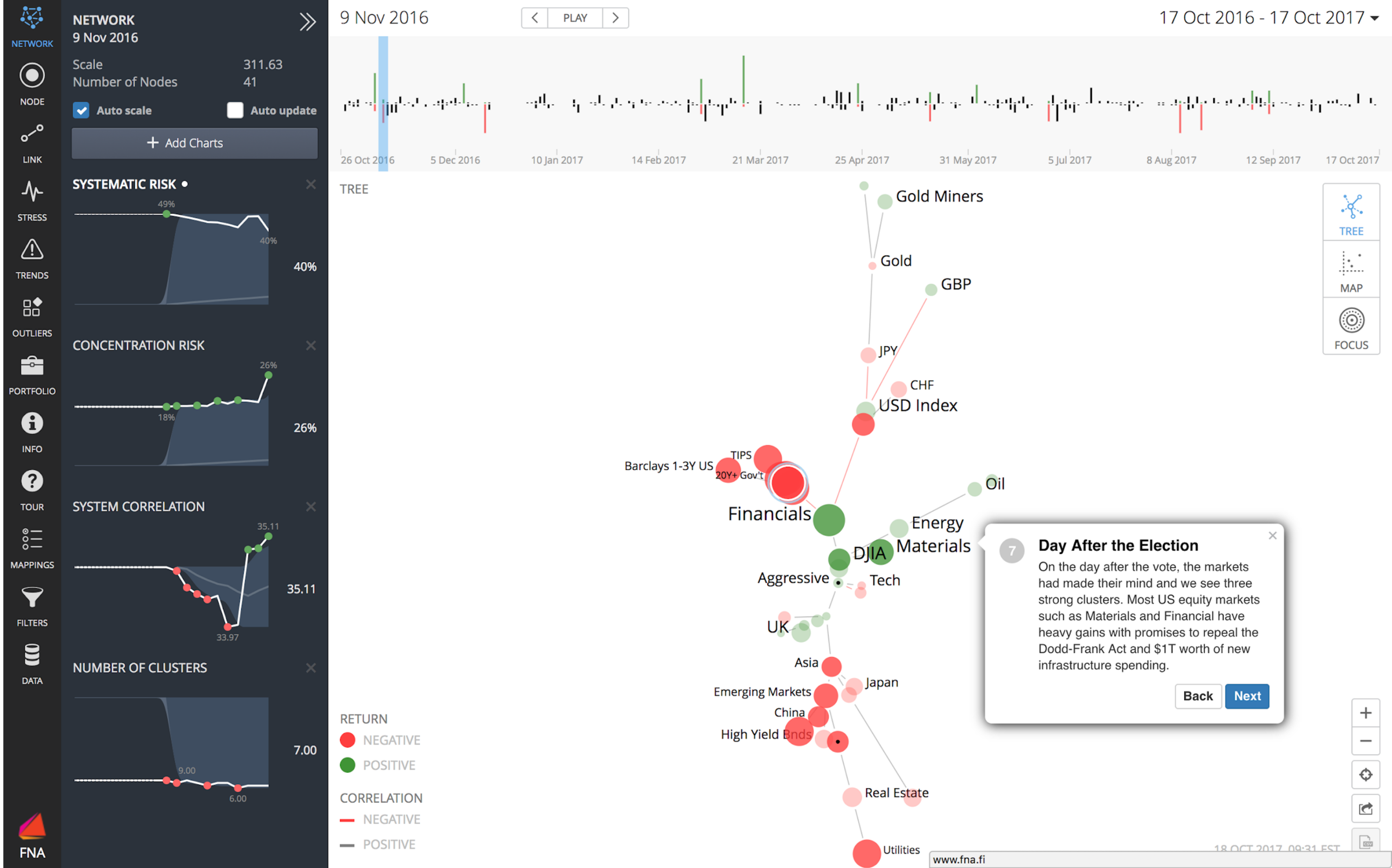
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Auto scale
Auto update
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Day After the Election
On the day after the vote, the markets had made their mind and we see three strong clusters. Most US equity markets such as Materials and Financial have heavy gains with promises to repeal the Dodd-Frank Act and $1T worth of new infrastructure spending.
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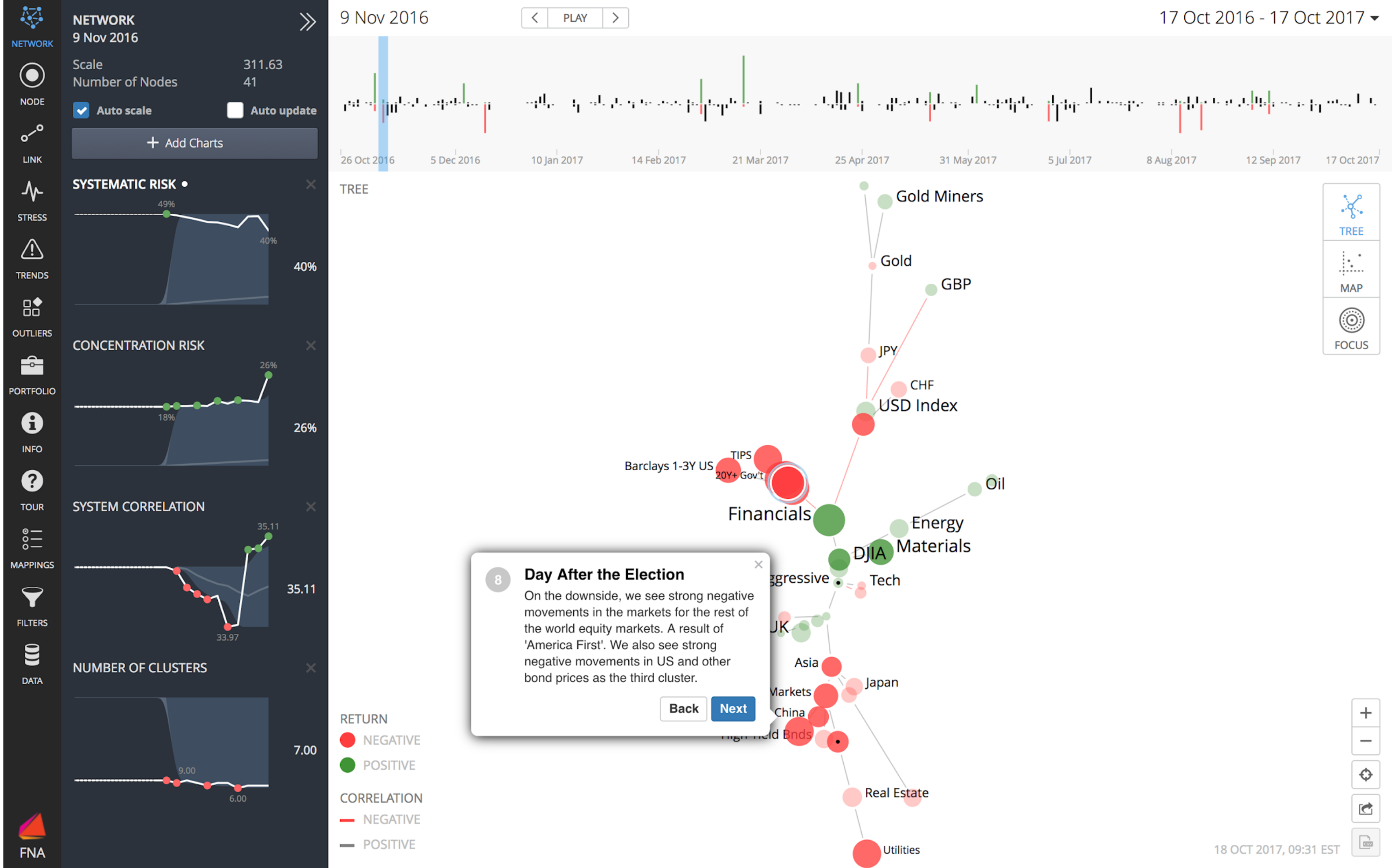
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Day After the Election
On the downside, we see strong negative movements in the markets for the rest of the world equity markets. A result of 'America First'. We also see strong negative movements in US and other bond prices as the third cluster.
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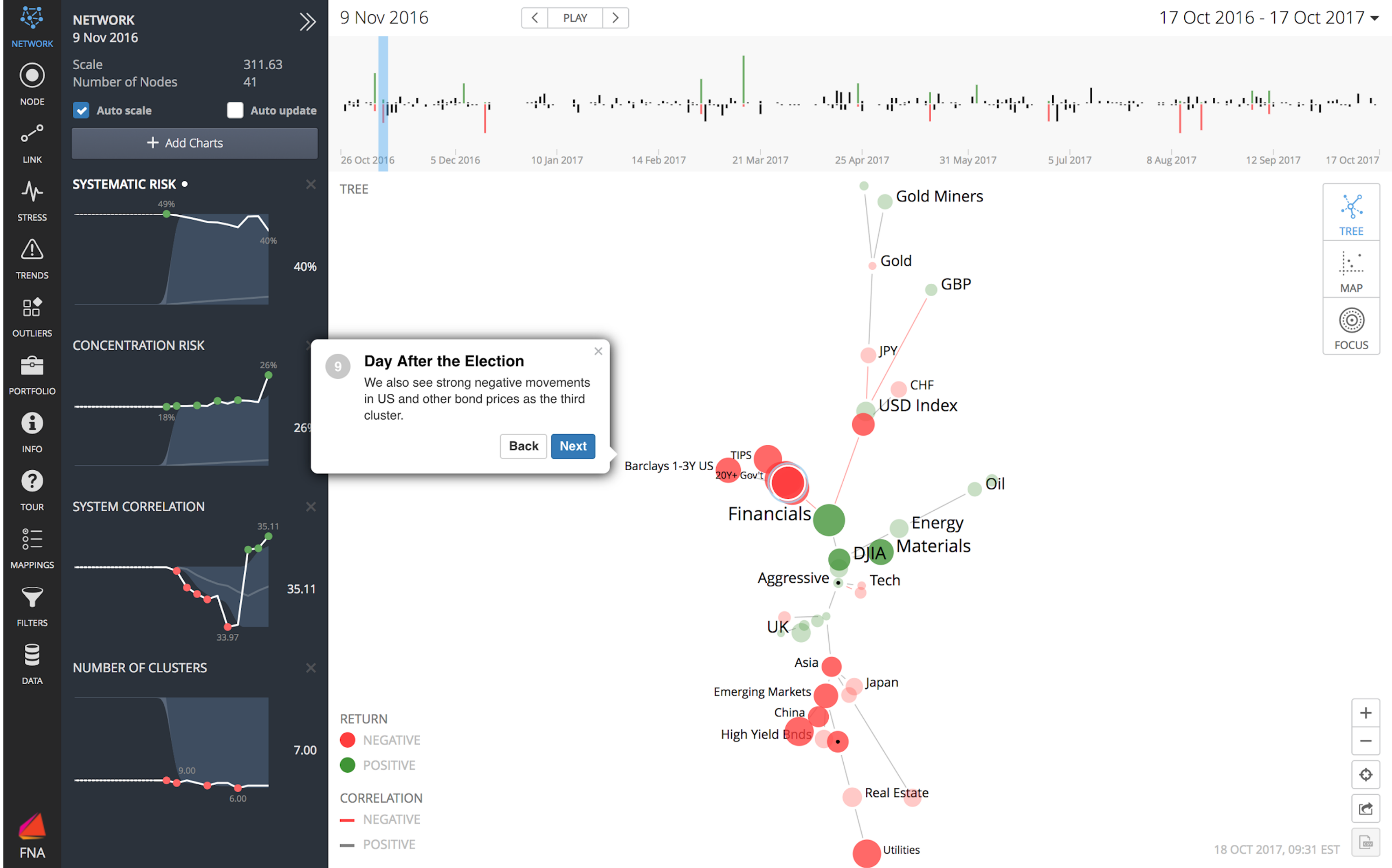
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Day After the Election
We also see strong negative movements in US and other bond prices as the third cluster.
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