



# SYSTEMIC RISK 10 YEARS LATER

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Annual Review of Financial Economics, Vol 10. 11/9/18



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## V-Lab: Real-time Financial Volatility, Correlation, And Risk ...

<https://vlab.stern.nyu.edu/en/> ▼

The Volatility Laboratory (V-Lab) provides real time measurement, modeling and forecasting of financial volatility, correlations and risk for a wide spectrum of assets. V-Lab blends together both classic models as well as some of the latest advances proposed in the financial econometrics literature. The aim of the website is to ...

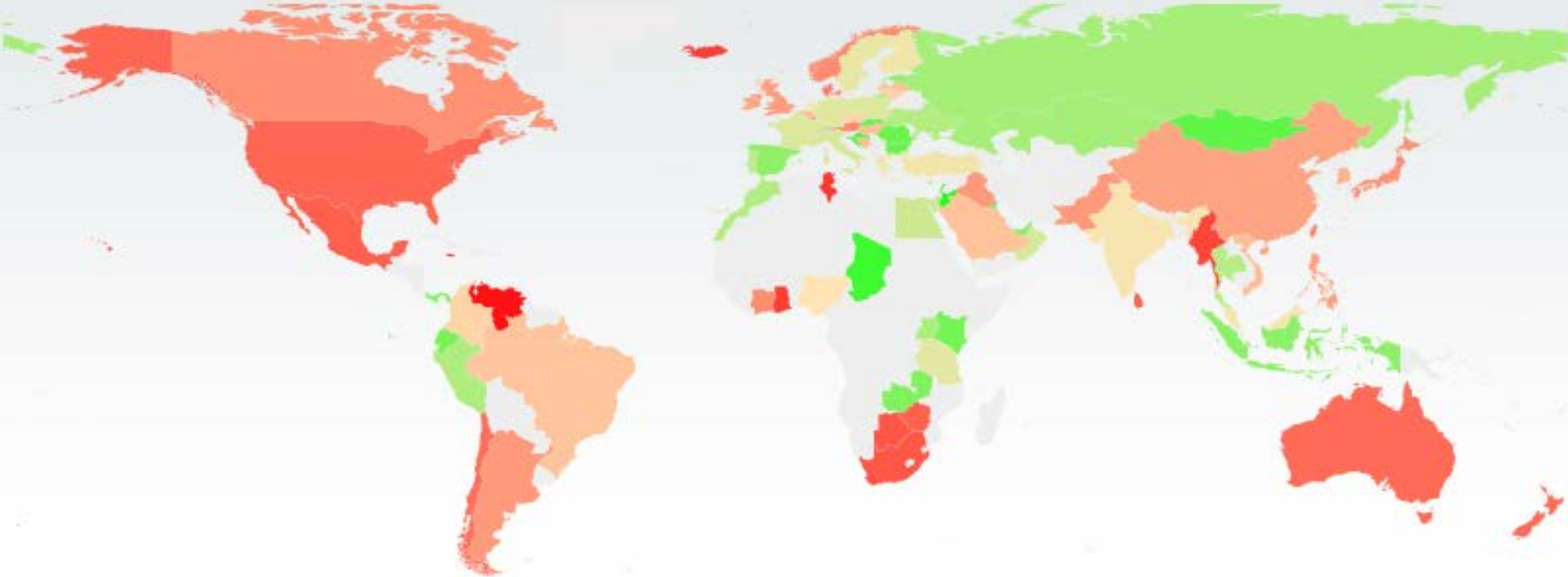
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11/7/18

Global Volatility

Region: World

Now

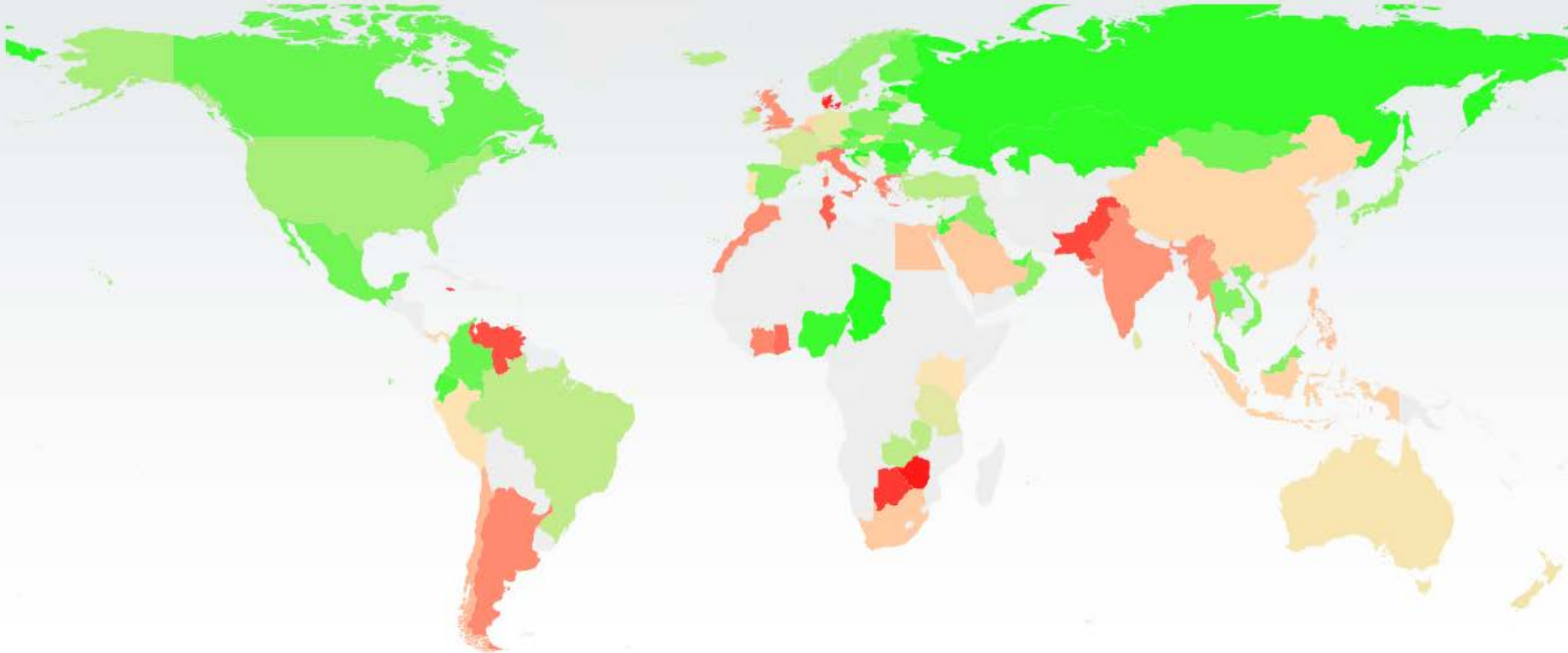


10/09/18

Global Volatility

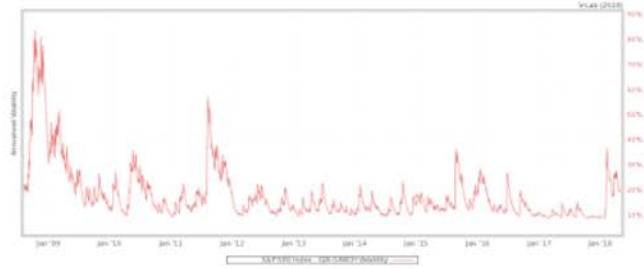
Region: World

4 Days Ago « [slider] »



## Volatility Analysis

There are few guarantees in financial markets. However, we do know that volatility clusters and mean-reverts. But how long will it take to mean revert and, on average, to what level? Where are the 'host spots' of volatility in the world and in what sectors? We attempt to answer these questions and more in our Volatility Analysis section of V-Lab. Come see the many models meant to explain volatility and explore volatility dynamics.



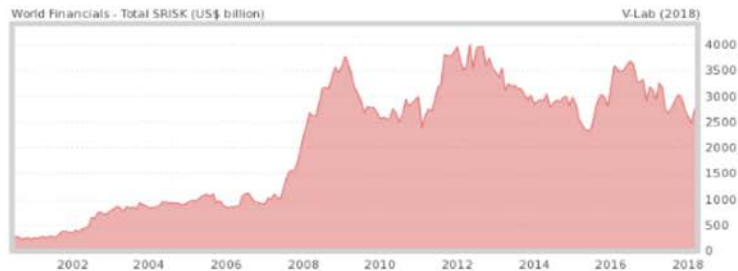
## Correlation Analysis

The co-movement of asset prices is important in many financial market decisions, such as portfolio allocation, diversification, and hedging. In our Correlation Analysis section, we use econometric models to determine how these time series co-move, which assets are particularly correlated, and which are diverging in direction.



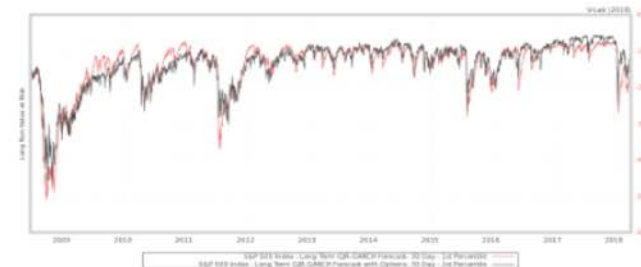
## Systemic Risk Analysis

The Global Financial Crisis of 2008 revealed the degree of interconnectedness and fragility of the global financial system at the time. How badly would the equity values of financial institutions decline if there were another crisis today? What degree of capital shortfall would financial institutions suffer? Our Systemic Risk Analysis section of V-Lab simulates crises in domestic markets, as well as another global financial crisis, in an attempt to answer these questions.



## Long-Run VaR Analysis

Often, volatility is assumed to grow with the square root of time. However, this assumes independence between observations each day (i.e. today's volatility has no bearing on what volatility will be tomorrow). Since this is not the case, one must defer to more sophisticated methods in order to estimate long-run volatility. Our Long-Run Value-at-Risk section simulates the 1 month and 1 year risk of holding financial assets, both using only returns and also conditioning average future volatility on current options market data.



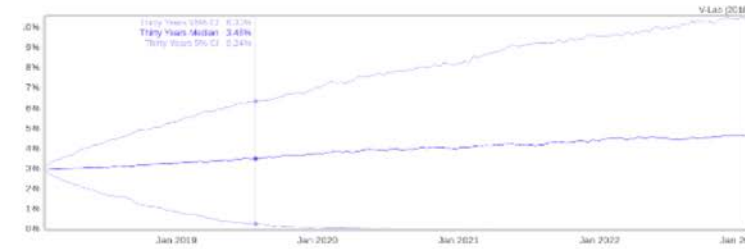
## Liquidity Analysis

The liquidity of a financial asset reflects transaction costs and the ability to unwind large trades at reasonable prices. 'Liquidity spirals' often exacerbate stock market declines, such as what we saw in the last Global Financial Crisis. In the liquidity section we estimate and forecast the liquidity of a broad spectrum of financial assets.



## Fixed Income Analysis

The future direction of interest rates has large implications for the the determination of discount rates, asset pricing, and firm capital structure. In addition, interest rates and their term structure are often used to infer economic forecasts of inflation, recession, and other key indicators. But where are rates headed in the long term? We forecast the distribution of treasury rates up to 5 years ahead from a 6-month bill to 30-year bond in the Fixed Income Section. We show upper and lower confidence intervals for future rates.



## Climate Risk Analysis

Climate change is effecting the world via stronger, more severe weather events, rising sea levels, and in many other ways. Are these events and the risks imposed by climate change properly reflected in asset prices? Environmental risks can be thought of as long run risks which influence portfolio decisions. In our Climate Risk Analysis section. We examine the performance of publicly traded environmental portfolios, which can serve as a measure of the new information on environmental risk and a mechanism to hedge these risks.



# EXCESSIVE CREDIT GROWTH

1. It is widely believed that excessive credit growth is the fundamental cause of financial crises.
2. See for example Reinhart and Rogoff(2009) “This Time Is Different” or Borio(2012)”the financial cycle”, Adrian and Shin(2011)”Leverage”
3. But credit growth is typically procyclical as increased credit is a natural component of growth.
4. Schularick and Taylor argue that a financial crisis is a “credit boom gone bust.” How can we see this in data?

# A MORTGAGE EXAMPLE

- Here is an example of excessive credit growth: A bank may issue mortgages to underqualified borrowers or overvalued houses.
- These mortgages will have market values that may be less than the accounting value and if the housing market declines, their market values will fall further as the collateral weakens.
- A portion of the bank's capital will be needed to cover these losses.
- If it does not have a sufficient capital cushion, then it will face bankruptcy or will seek a bailout.
- *Credit growth is excessive if the financial sector does not have sufficient capital to cover losses in a downturn.*



# DEFINITION of SRISK

*How much capital would a financial institution need to raise in order to function normally if we have another financial crisis?*

**Principle investigators:** Viral Acharya, Matt Richardson and me at the Volatility Institute at NYU's Stern School. Collaboration with HEC Lausanne and the Institute for Global Finance at University of New South Wales. Contributions by Christian Brownlees, Rob Capellini, Diane Perriet, Emil Siriwardane.

**References:** Acharya, Pedersen, Phillipon, Richardson "Measuring Systemic Risk (2010); Acharya, Engle, Richardson "Capital Shortfall, A New Approach to Ranking and Regulating Systemic Risks, AEAPP (2012), Brownlees and Engle, "Volatilities, Correlations and Tails for Systemic Risk Measurement" and "A conditional Capital Shortfall Measure of Systemic Risk," RFS(2017)

# SRISK or Systemic Risk

$$\text{Capital Shortfall} = k \left( \frac{\text{Debt} + \text{Equity}}{\text{QUASI ASSETS}} \right) - \text{Equity}$$

$$\text{SRISK} = \text{median}(\text{Capital Shortfall} | \text{Crisis})$$

$$\log(\text{Equity}_{t+n} / \text{Equity}_t) = \beta_t \log(\text{World Equity}_{t+n} / \text{World Equity}_t) + \varepsilon_{t+n}$$

$$\text{median} \left( \text{Equity}_{t+n} \left| \frac{\text{World Equity}_{t+n}}{\text{World Equity}_t} - 1 = \theta \right. \right) = \text{Equity}_t \exp(\beta_t \log(1 + \theta))$$

# ESTIMATE BETA WITH DCB

Beta is a correlation with the market times the ratio of the standard deviation of the firm over the market.

Dynamic Conditional Beta (DCB) estimates these inputs and adjusts for noise and for asynchronous returns.

Beta is different every day and is forecast from day  $t-1$ .

# MODELING THE COMPONENTS

We can construct DCB from

$$\beta_{i,m,t} = \rho_{i,m,t} \sqrt{\frac{h_{i,t}}{h_{m,t}}}$$

Estimation of Dynamic Conditional Beta involves

GJR GARCH model of the volatility of market returns

GJR GARCH model of the volatility of firm returns

DCC estimation of the correlation between these

# IS BETA CONSTANT?

Test beta=constant with artificially nested model

$$r_t^j = \phi r_t^m + \theta \left( \beta_t^j r_t^m \right) + \sqrt{h_t} \varepsilon_t^j$$

Use  $\hat{\phi} + \hat{\theta} \beta_t^j$  as the estimate of beta

# UNCERTAINTY IN SRISK MEASURES

- Sensitivity Analysis: SRISK is sensitive to the policy parameters. These results are for capital ratio = 8% and stress = 40% decline in global equities over six months. They can be changed on the web site to do sensitivity analysis.
- Econometric uncertainty is explored in the paper but is small since there are generally several thousand observations. Bootstrapped RMSE in beta are estimated to be less than 4%.
- Model Uncertainty: Several different versions of SRISK are presented on V-LAB and are compared in the survey.
- Measurement errors in the data are generally well recognized.

# BETA FOR CITIGROUP



# BETA FOR GOLDMAN SACHS

SRISK Graph

SERIES ▾ COPY GRAPH





# BETA FOR BNP PARIBAS



# BETA FOR BARCLAY'S





WHERE IS THE RISK?

# GLOBAL SRISK SINCE 2000

Risk Analysis Overview - All Financials Total SRISK (US\$ billion)

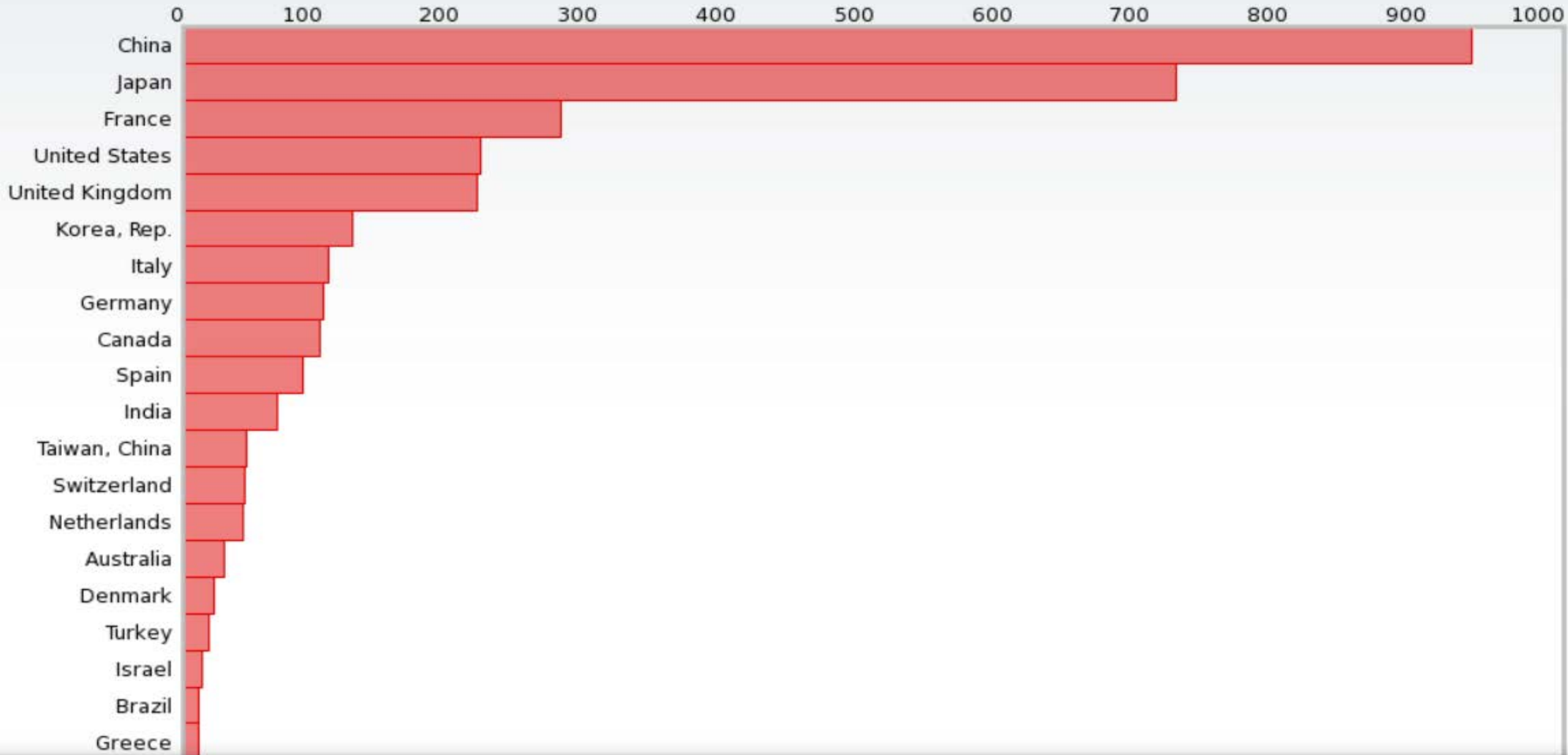
Date Range: from 6-2000 to 11-2018

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# Global Systemic Risk by Country

SRISK (USD billion)



# US SINCE 2000

Risk Analysis Overview - 2 Selected Countries Financials Total SRISK (US\$ billion)

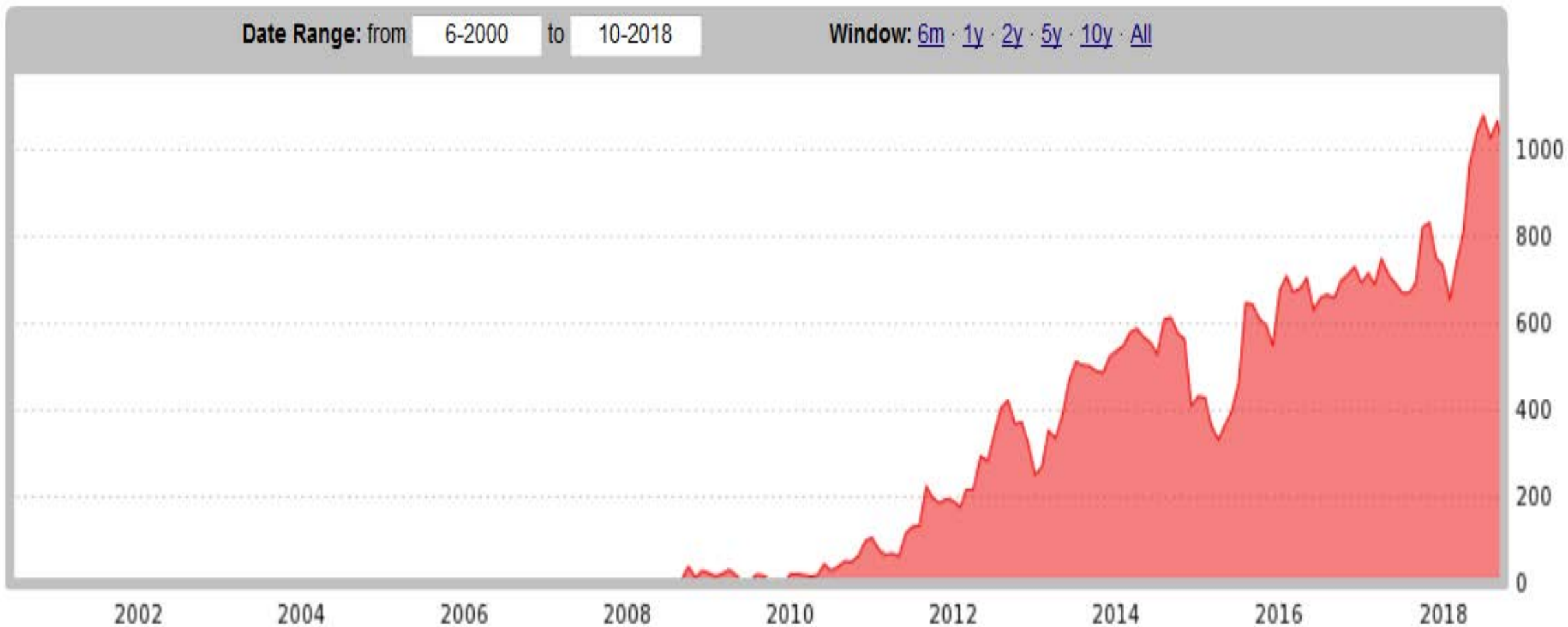


# CHINA SINCE 2000

Risk Analysis Overview - China Financials Total SRISK (US\$ billion)

Date Range: from 6-2000 to 10-2018

Window: [6m](#) · [1y](#) · [2y](#) · [5y](#) · [10y](#) · [All](#)



# LOOKING BACK IN TIME:



# AUGUST 29, 2008 US

Systemic Risk Rankings for 2008-08-29  View changes

<u>Institution</u>	<u>SRISK%</u>	<u>RNK</u> ▲	<u>SRISK (\$ m)</u>	<u>LRMES</u>	<u>Beta</u>	<u>Cor</u>	<u>Vol</u>	<u>Lvg</u>
<u>Citigroup Inc</u>	12.79	1	138,091	80.00	2.61	0.79	63.4	19.99
<u>JPMorgan Chase &amp; Co</u>	10.14	2	109,492	82.00	2.42	0.74	62.9	13.42
<u>Bank of America Corp</u>	8.97	3	96,900	79.00	2.90	0.74	75.0	11.94
<u>Morgan Stanley</u>	6.51	4	70,259	77.24	2.09	0.74	53.7	23.01
<u>Freddie Mac</u>	6.38	5	68,874	85.00	5.01	0.44	221.2	297.76
<u>Merrill Lynch</u>	6.31	6	68,124	84.00	3.43	0.78	83.8	22.45
<u>Fannie Mae</u>	6.21	7	67,088	93.00	5.51	0.51	205.4	115.68
<u>American International Group Inc</u>	6.13	8	66,211	80.00	3.47	0.69	97.0	17.62
<u>Goldman Sachs Group Inc/The</u>	5.34	9	57,654	58.00	1.70	0.75	43.3	16.99
<u>Wachovia Bank</u>	5.00	10	54,008	85.00	3.06	0.66	87.3	22.40
<u>Lehman Brothers</u>	4.41	11	47,613	86.00	4.99	0.74	130.2	55.88
<u>MetLife Inc</u>	2.78	12	30,044	67.00	1.42	0.79	34.4	14.56
<u>Washington Mutual</u>	2.00	13	21,616	88.00	2.71	0.45	119.8	41.50
<u>Prudential Financial Inc</u>	1.99	14	21,476	49.00	1.35	0.72	36.1	15.39
<u>Hartford Financial Services Group Inc/The</u>	1.83	15	19,766	68.00	1.70	0.74	43.9	17.68
<u>Wells Fargo &amp; Co</u>	1.68	16	18,166	71.00	1.90	0.69	52.8	6.60

# FEB 28, 2007 US

Systemic Risk Rankings for 2007-02-28  View changes

<u>Institution</u>	<u>SRISK%</u>	<u>RNK</u> ▲	<u>SRISK (\$ m)</u>	<u>LRMES</u>	<u>Beta</u>	<u>Cor</u>	<u>Vol</u>	<u>Lvg</u>
<u>Morgan Stanley</u>	20.32	1	67,314	67.00	1.57	0.74	41.9	15.34
<u>Fannie Mae</u>	10.61	2	35,161	43.00	0.76	0.66	22.9	15.50
<u>Citigroup Inc</u>	9.01	3	29,843	51.00	0.91	0.70	26.0	8.15
<u>Merrill Lynch</u>	8.89	4	29,460	49.00	0.95	0.68	27.8	11.84
<u>Freddie Mac</u>	8.53	5	28,276	17.00	0.44	0.59	14.8	18.50
<u>Lehman Brothers</u>	8.49	6	28,125	57.00	1.35	0.70	38.1	15.06
<u>Goldman Sachs Group Inc/The</u>	8.44	7	27,975	46.00	1.54	0.87	35.0	11.42
<u>Bear Stearns</u>	6.93	8	22,950	55.00	1.06	0.68	30.2	21.91
<u>JPMorgan Chase &amp; Co</u>	5.15	9	17,065	48.00	0.71	0.71	19.6	8.23
<u>MetLife Inc</u>	4.29	10	14,222	43.00	0.88	0.64	27.5	11.26
<u>Hartford Financial Services Group Inc/The</u>	3.56	11	11,799	54.00	0.88	0.69	25.3	11.16
<u>Prudential Financial Inc</u>	2.42	12	8,009	33.87	0.58	0.58	19.9	10.90
<u>Lincoln National Corp</u>	1.55	13	5,137	53.00	1.10	0.75	29.2	9.80
<u>Washington Mutual</u>	0.64	14	2,123	38.00	0.57	0.48	23.9	8.78
<u>Countrywide Financial</u>	0.43	15	1,434	35.00	0.83	0.47	34.9	9.27
<u>Wachovia Bank</u>	0.39	16	1,279	49.00	0.87	0.66	26.5	7.02

# JAN 31, 2005

Systemic Risk Rankings for 2005-01-31  View changes

<u>Institution</u>	<u>SRISK%</u>	<u>RNK</u> ▲	<u>SRISK (\$ m)</u>	<u>LRME S</u>	<u>Beta</u>	<u>Cor</u>	<u>Vol</u>	<u>Lvg</u>
<u>Fannie Mae</u>	19.60	1	49,242	49.00	1.02	0.43	25.9	16.72
<u>Morgan Stanley</u>	13.97	2	35,092	59.92	1.13	0.65	18.9	12.82
<u>Freddie Mac</u>	11.11	3	27,900	20.00	0.78	0.51	16.7	17.96
<u>JPMorgan Chase &amp; Co</u>	8.69	4	21,840	49.00	1.00	0.70	15.5	8.92
<u>Merrill Lynch</u>	7.53	5	18,913	44.00	1.14	0.73	17.2	11.67
<u>Lehman Brothers</u>	6.23	6	15,648	49.00	0.94	0.62	16.3	14.69
<u>Bear Stearns</u>	5.99	7	15,053	51.00	0.82	0.50	17.4	24.67
<u>Prudential Financial Inc</u>	5.98	8	15,013	40.00	0.98	0.58	18.6	14.69
<u>Hartford Financial Services Group Inc/The</u>	4.92	9	12,367	60.00	1.18	0.57	22.2	13.42
<u>MetLife Inc</u>	4.64	10	11,656	45.00	1.09	0.54	22.1	12.25
<u>Goldman Sachs Group Inc/The</u>	4.25	11	10,689	38.00	0.81	0.52	17.1	10.70
<u>Lincoln National Corp</u>	2.24	12	5,617	57.00	1.23	0.63	21.4	14.66
<u>Genworth Financial Inc</u>	1.77	13	4,456	21.00	0.54	0.29	20.6	24.42
<u>Washington Mutual</u>	1.38	14	3,463	40.00	0.75	0.45	18.0	9.13
<u>UNUM Group</u>	0.83	15	2,084	70.00	0.73	0.30	28.0	9.57
<u>State Street Corp</u>	0.40	16	1,013	56.25	1.15	0.49	26.0	6.88



**HOW MUCH SRISK IS TOO MUCH?**

# HOW MUCH SRISK IS TOO MUCH?

Engle and Ruan, 2018

When a country has a certain level of SRISK; what is the probability that it is in a crisis? **Probability of Crisis**

Can we identify a level of **SRISK\_Capacity** that keeps the probability of a crisis below 50%?

# MANAGING SRISK

If financial firms have high SRISK, they are vulnerable to external shocks and will be pressured by risk managers and regulators to reduce risk. The most common response is to sell assets and reduce debt.

If SRISK is a large fraction of Total Assets, then asset sales will be costly and will be likely to lead to a fire sale spiral. An appropriate risk measure is:

$SRISK/TA/k = \text{Total Assets for sale} / \text{Total Assets}$

# ROMER AND ROMER(2016) CRISIS INDICATOR

- For 24 industrial countries a semi-annual indicator of crisis intensity is extracted from OECD Reports 2000-2012.
- Measure ranges from 0 to 15 as a measure of credit disruption.
- Below 4 is called “minor credit disruption.”

# TOBIT ECONOMETRICS

- Panel regression with country and (in first model) time fixed effects.
- Model is fit by Tobit as there are many zeros in dependent variable.
- For each country and time, calculate the probability that
  - Crisis Indicator > "minor credit event"
- Calculate the Capacity which is the
  - SRISK that will bring the probability of a crisis above .5



Table 5: Equation 3c: Tobit Model (Using leave-one-out sum for world variables)  
 Standard errors are reported in parentheses. \*\*\*, \*\* and \* represent 1%, 5% and 10% significance, respectively.

	Dep Var: CRISIS			
	(1)	(2)	(3)	(4)
SRISK/(TA*k)	18.179*** (1.209)	12.997*** (1.375)	12.681*** (1.315)	15.398*** (1.392)
D.SRISK/(TA*k)	6.822*** (1.947)		4.118** (1.894)	
World SRISK/(TA*k)		14.300*** (2.413)		
D.World SRISK/(TA*k)		8.245*** (2.808)		
World SRISK/MV			9.921*** (1.551)	
World log SRISK				1.845*** (0.364)
D.World log SRISK				4.095*** (1.012)
var(e.CRISIS)	11.185*** (1.273)	9.964*** (1.123)	9.924*** (1.119)	10.716*** (1.214)
Country FE	Yes	Yes	Yes	Yes
Pseudo $R^2$	0.260	0.290	0.285	0.281
Observations	561	561	561	561

# MODEL FEATURES TWO EXTERNALITIES

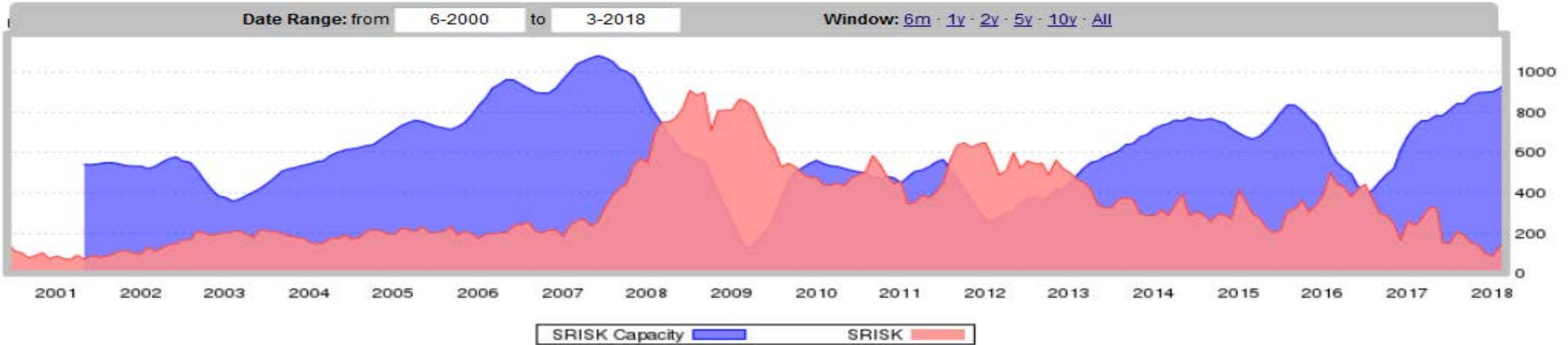
THE RISK OF AN UNDERCAPITALIZED FIRM DEPENDS  
UPON THE UNDERCAPITALIZATION OF OTHER  
FIRMS IN THE SAME COUNTRY

THE RISK OF AN UNDERCAPITALIZED COUNTRY  
FINANCIAL SYSTEM DEPENDS UPON THE  
UNDERCAPITALIZATION OF THE REST OF THE  
WORLD

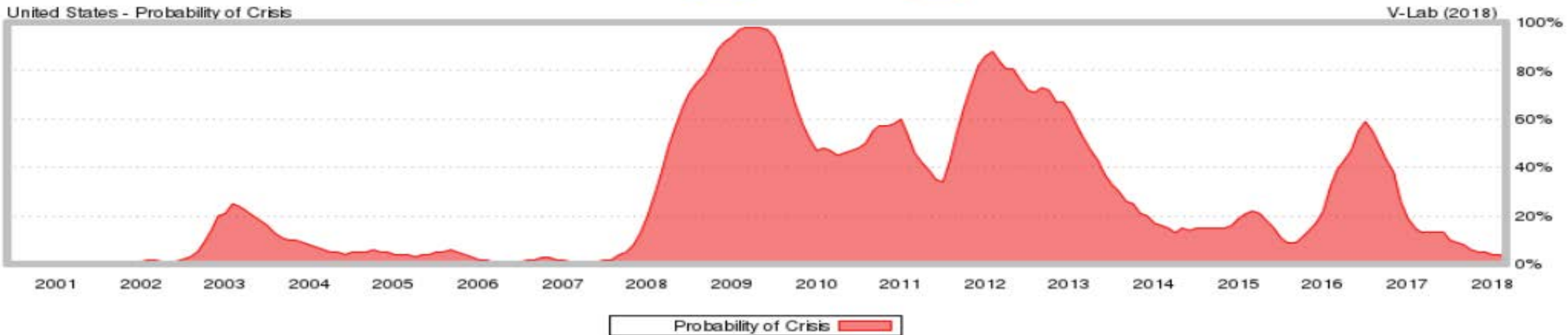
PROVIDES A MOTIVATION FOR COUNTRY AND  
GLOBAL COORDINATION AND REGULATION

# US SRISK Capacity and Probability of Crisis

Risk Analysis Overview - United States Financials Total SRISK (US\$ billion)

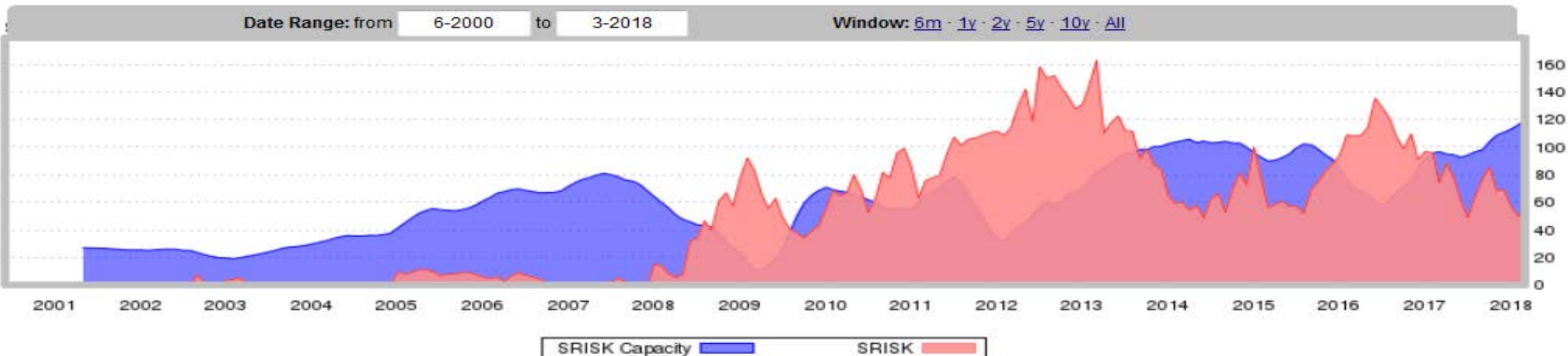


United States - Probability of Crisis



# SPAIN SRISK Capacity and Probability of Crisis

Risk Analysis Overview - Spain Financials Total SRISK (US\$ billion)



Spain - Probability of Crisis

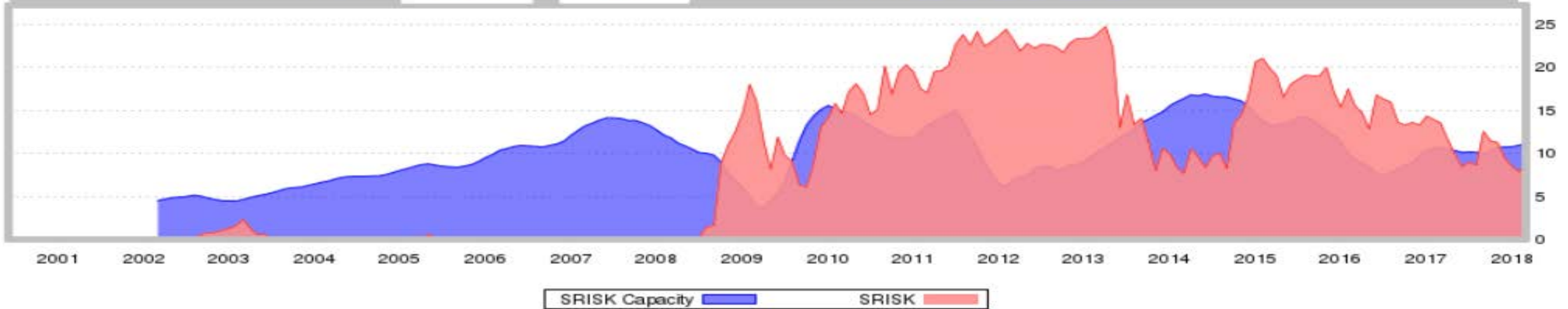


# GREECE SRISK Capacity and Probability of Crisis

Risk Analysis Overview - Greece Financials Total SRISK (US\$ billion)

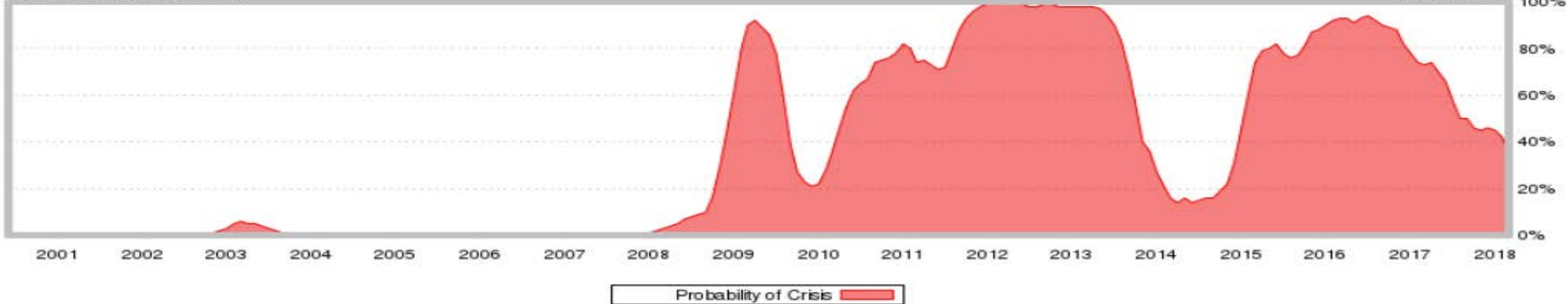
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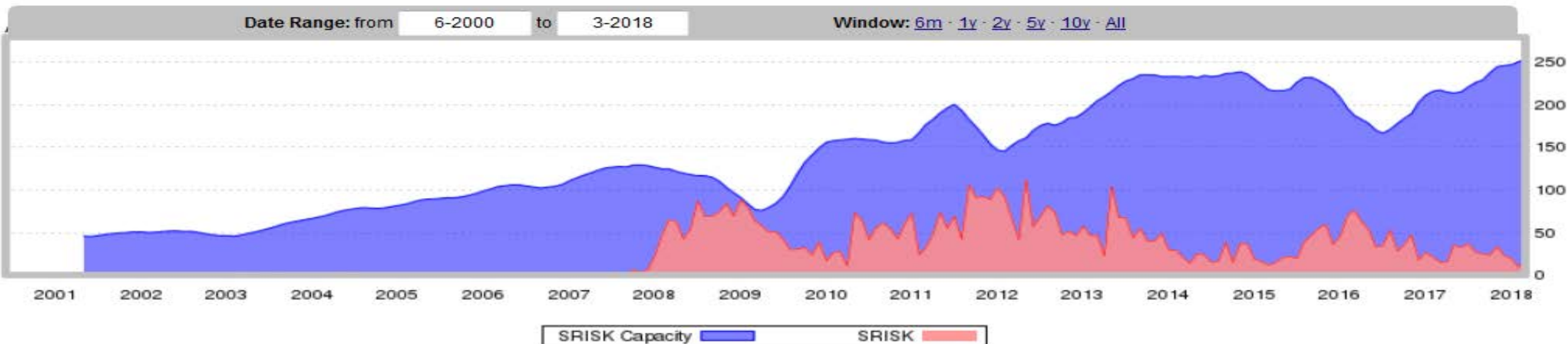
Greece - Probability of Crisis

V-Lab (2018)

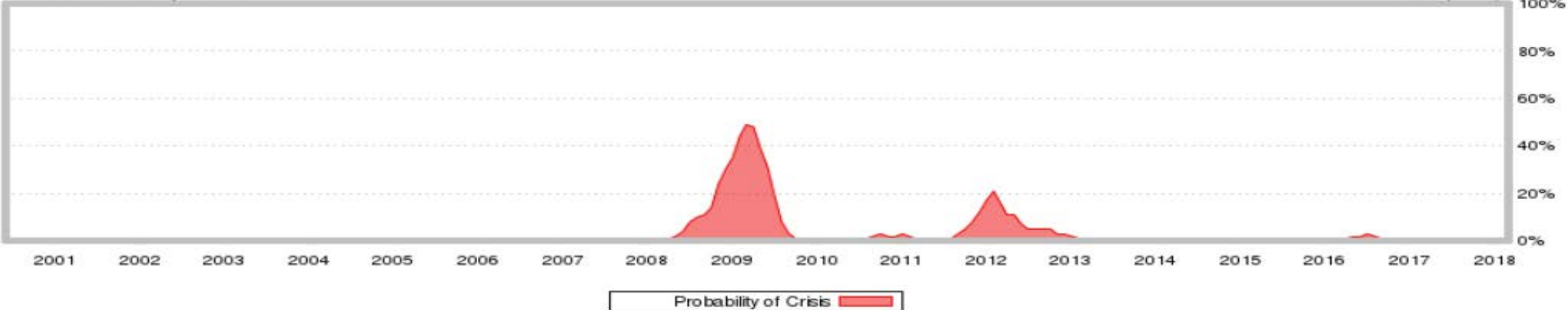


# AUSTRALIA SRISK Capacity and Probability of Crisis

Risk Analysis Overview - Australia Financials Total SRISK (US\$ billion)



Australia - Probability of Crisis



What is in their future?

