

Systemic risk: Applications for investors and policymakers

Will Kinlaw

Mark Kritzman

David Turkington

Outline

The absorption ratio as a measure of implied systemic risk

The absorption ratio and the pricing of risky assets

The absorption ratio as a measure of intrinsic systemic risk

Centrality as a measure of systemic importance

Summary

**The absorption ratio as a measure of
implied systemic risk**

Why we cannot observe systemic risk directly

- Securitization obscures connections among stakeholders.
- Private transacting leads to opacity.
- Complexity reduces clarity.
- “Flexible accounting” also hides financial linkages.
- Even if we could identify the relevant linkages, they do not remain constant.

The absorption ratio

- The absorption ratio equals the fraction of the total variance of a set of assets explained or “absorbed” by a finite number of eigenvectors.
- A high absorption ratio implies that markets are compact or tightly coupled.
- Compact markets are relatively fragile in that shocks propagate more quickly and broadly than when markets are loosely linked.

The absorption ratio

$$AR = \frac{\sum_{i=1}^n \sigma_{E_i}^2}{\sum_{j=1}^N \sigma_{A_j}^2}$$

AR: Absorption ratio

N: number of assets

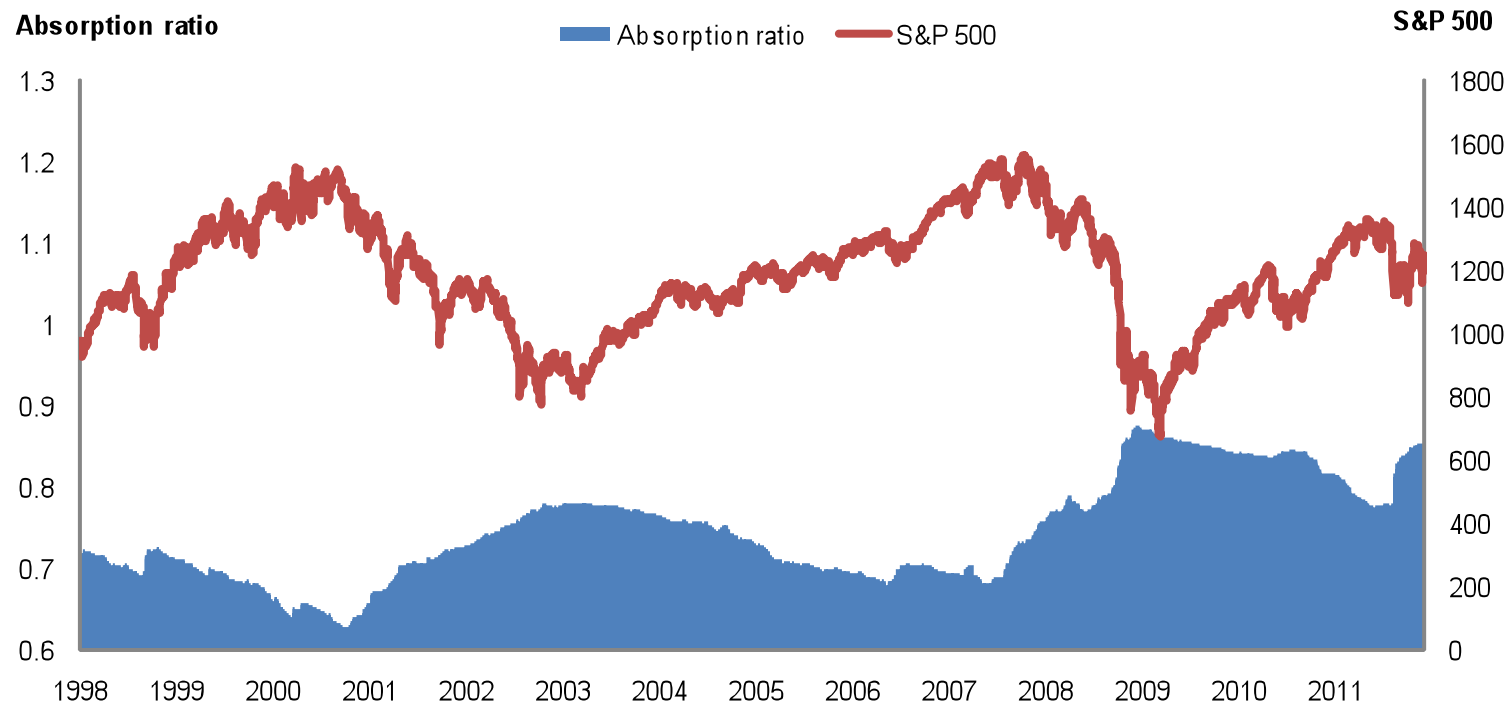
n: number of eigenvectors used to calculate AR

$\sigma_{E_i}^2$: variance of the i-th eigenvector, sometimes called eigenportfolio

$\sigma_{A_j}^2$: variance of the j-th asset

The absorption ratio and the pricing of risky assets

The absorption ratio for U.S. equities*



* We estimate the covariance matrix and eigenvectors of MSCI USA industry returns using a 500-day rolling window. Variances are estimated from exponentially decaying returns with a one-year half life. We set n equal to 10 eigenvectors. Results from 1/1/1998 through 11/30/2011.

Absorption ratio, drawdowns, and returns*

Fraction of drawdowns preceded by a spike in AR

	1% Worst	2% Worst	5% Worst
1 Day	70%	70%	62%
1 Week	73%	73%	67%
1 Month	92%	90%	75%

Annualized return after extreme AR

	1 Sigma Increase	1 Sigma Decrease	Difference
1 Day	-6.1%	7.5%	-13.6%
1 Week	-6.1%	7.5%	-13.5%
1 Month	-4.9%	5.7%	-10.6%

* Spike = 1 standard deviation outlier of (15-day moving average of AR minus 1-year moving average of AR) divided by standard deviation of 1-year AR. Results from 1/1/1998 through 11/30/2011.

Absorption ratio as a market timing signal*

Trading rule

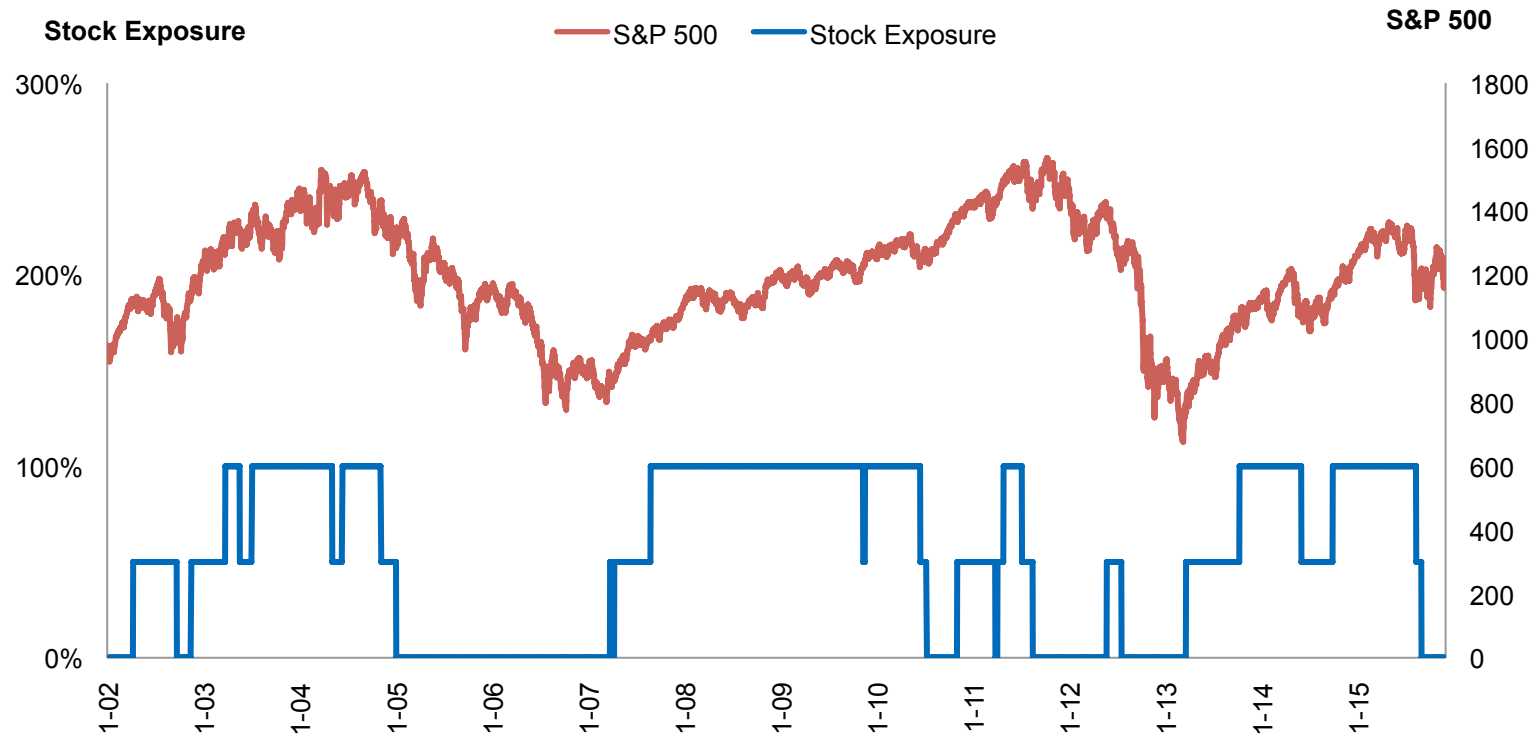
Systemic Risk Index	Stock/Bond Exposure
$-1\sigma \leq \Delta \text{Index} \leq +1\sigma$	50 / 50
$\Delta \text{Index} > +1\sigma$	0 / 100
$\Delta \text{Index} < -1\sigma$	100 / 0

Performance (1/1/1998 through 11/30/2011)

	Dynamic	50/50
Return	9.15%	5.72%
Risk	11.30%	10.14%
Return/Risk	0.81	0.56
Max. Drawdown	12.83%	26.26%
Turnover	111%	n/a
Trades/year	2.2	n/a

* We compute a standardized shift to construct this trading rule. We first compute the moving average of the Systemic Risk Index over 15 days and subtract it from the moving average of the index over one year. We then divide this difference by the standard deviation of the index over the one-year time period.

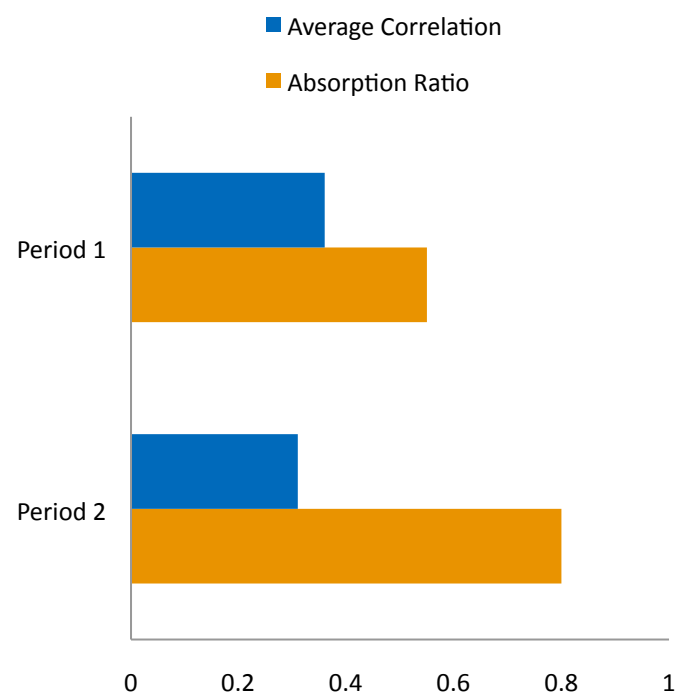
Absorption ratio stock exposure



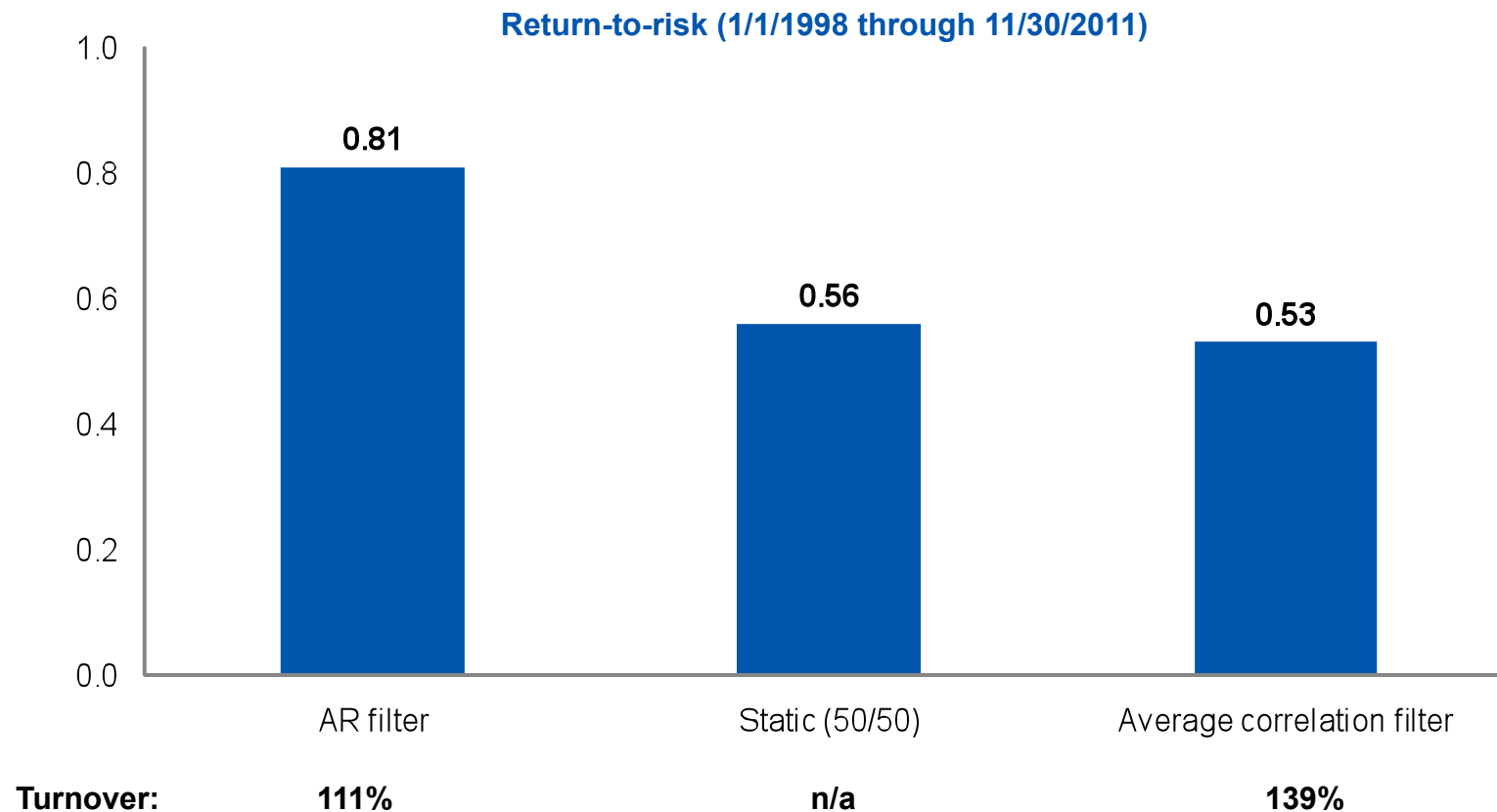
How is the absorption ratio different from average correlation?

Absorption Ratio versus Average Correlation					
Period 1	Correlations				Standard
Assets	1	2	3	4	Deviations
1	1.00	0.12	-0.01	0.01	35.16%
2	0.12	1.00	-0.04	-0.03	35.07%
3	-0.01	-0.04	1.00	0.82	4.95%
4	0.01	-0.03	0.82	1.00	5.02%

Period 2	Correlations				Standard
Assets	1	2	3	4	Deviations
1	1.00	0.64	-0.05	-0.01	34.46%
2	0.64	1.00	-0.05	-0.03	34.04%
3	-0.05	-0.05	1.00	0.03	4.92%
4	-0.01	-0.03	0.03	1.00	4.88%

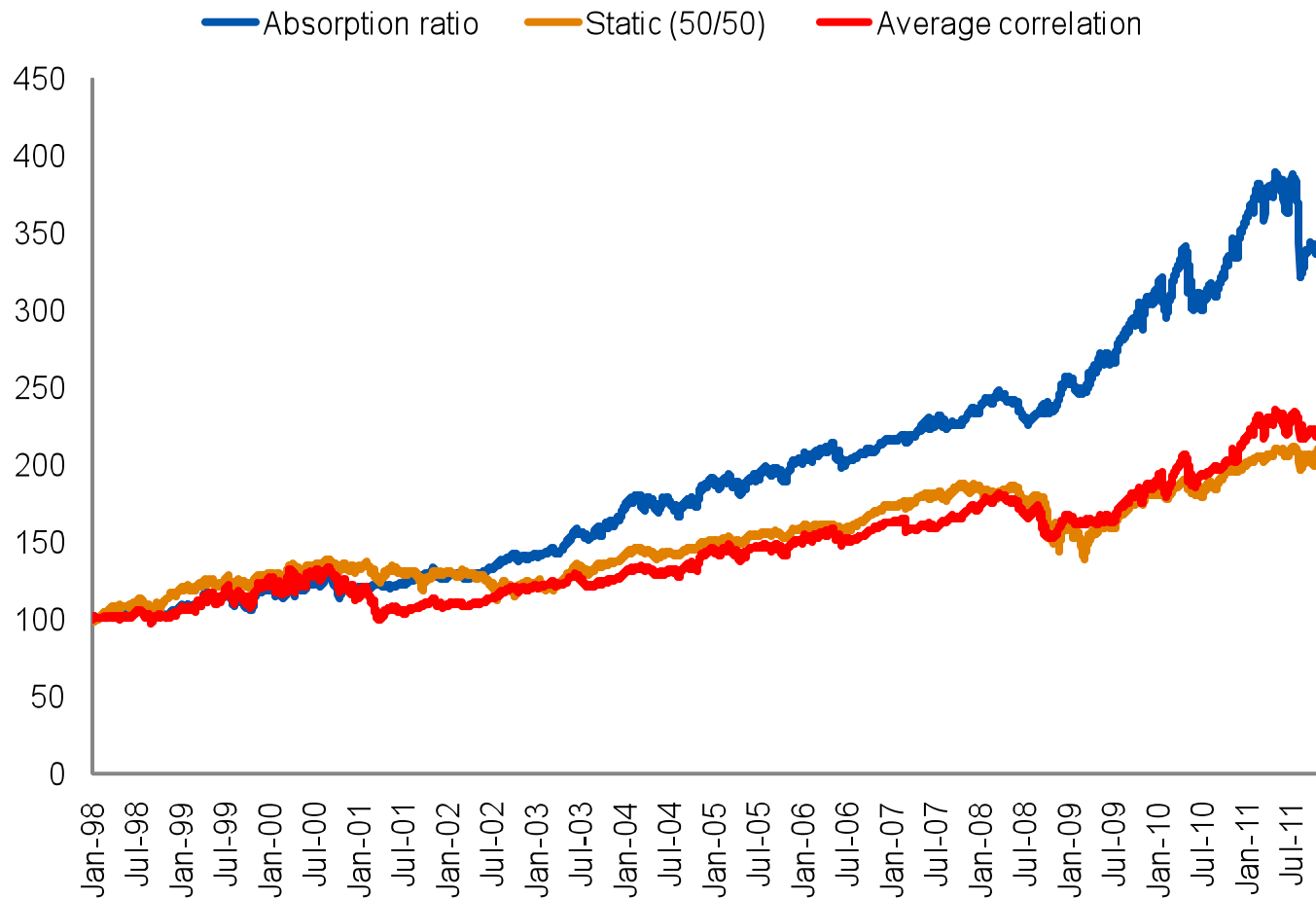


Absorption ratio performance versus average correlation

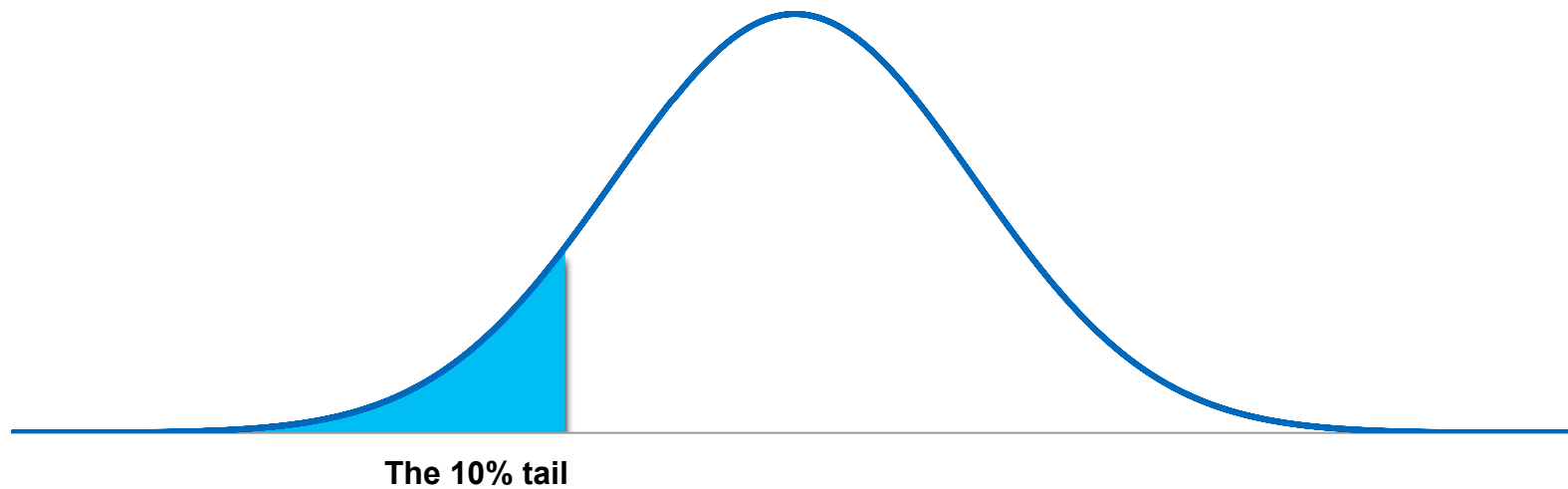


* We compute a standardized shift on each metric, using the same parameters, to construct trading rules.

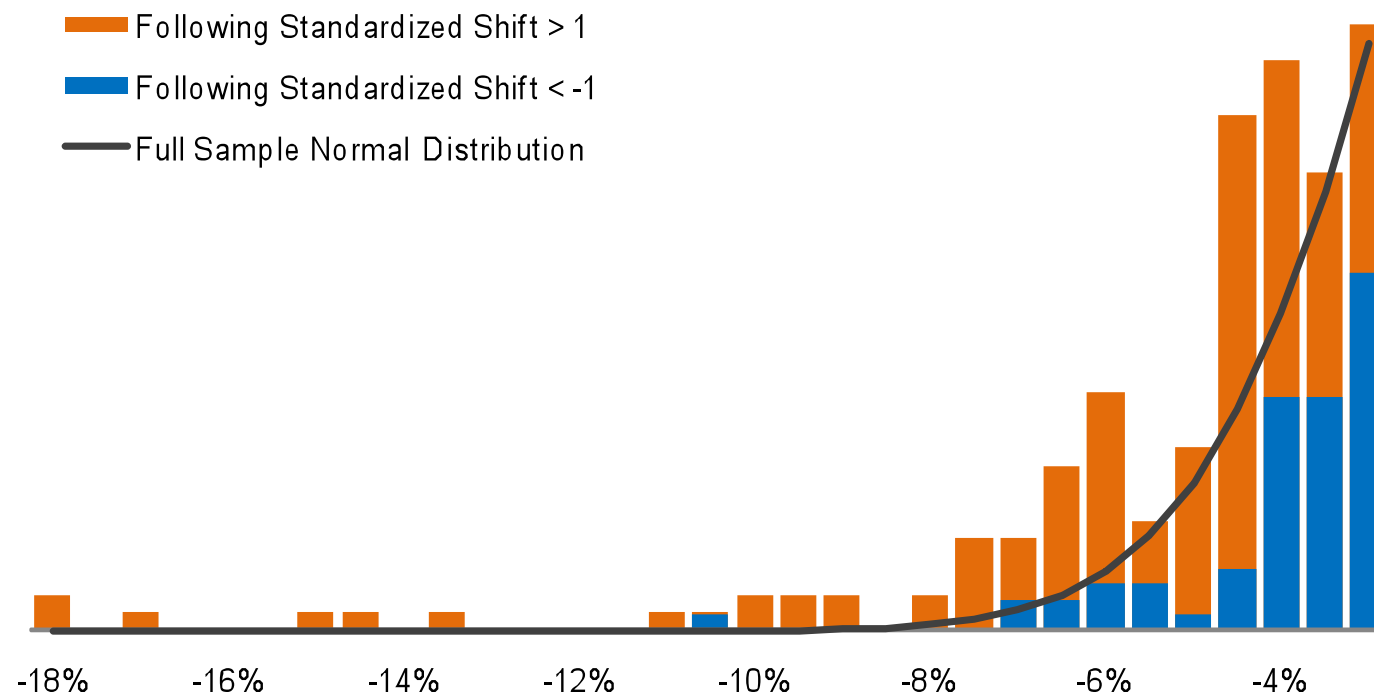
Absorption ratio performance versus average correlation



The normal distribution: one-week U.S. equity returns

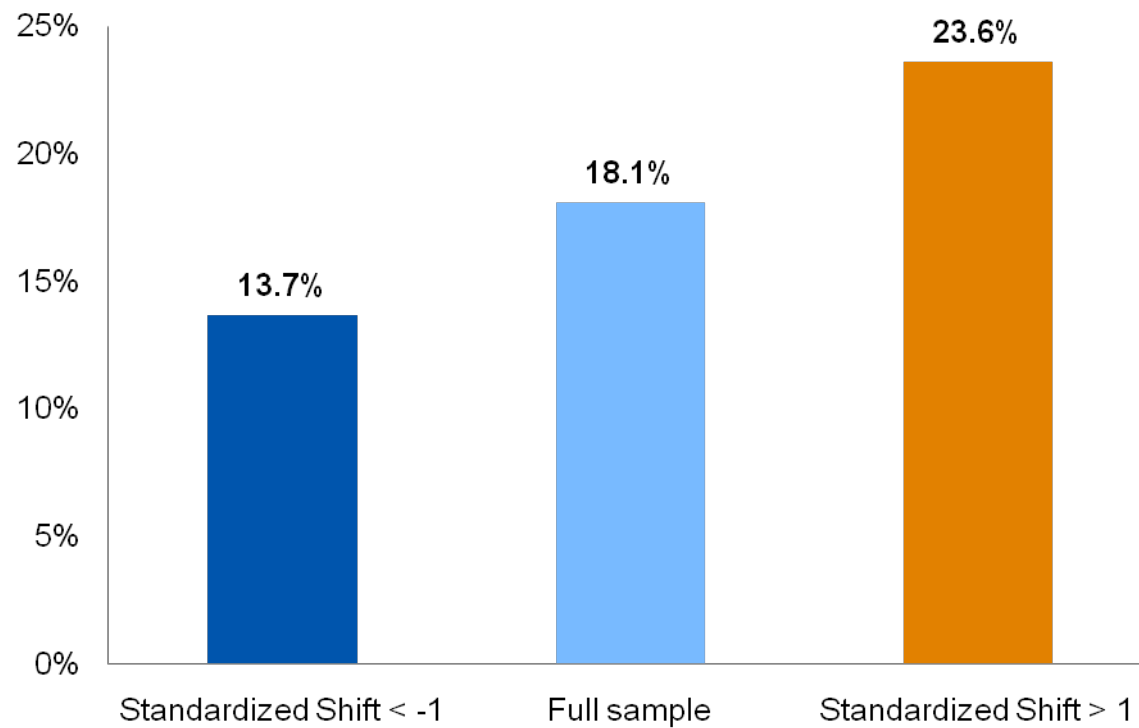


The normal distribution: one-week U.S. equity returns

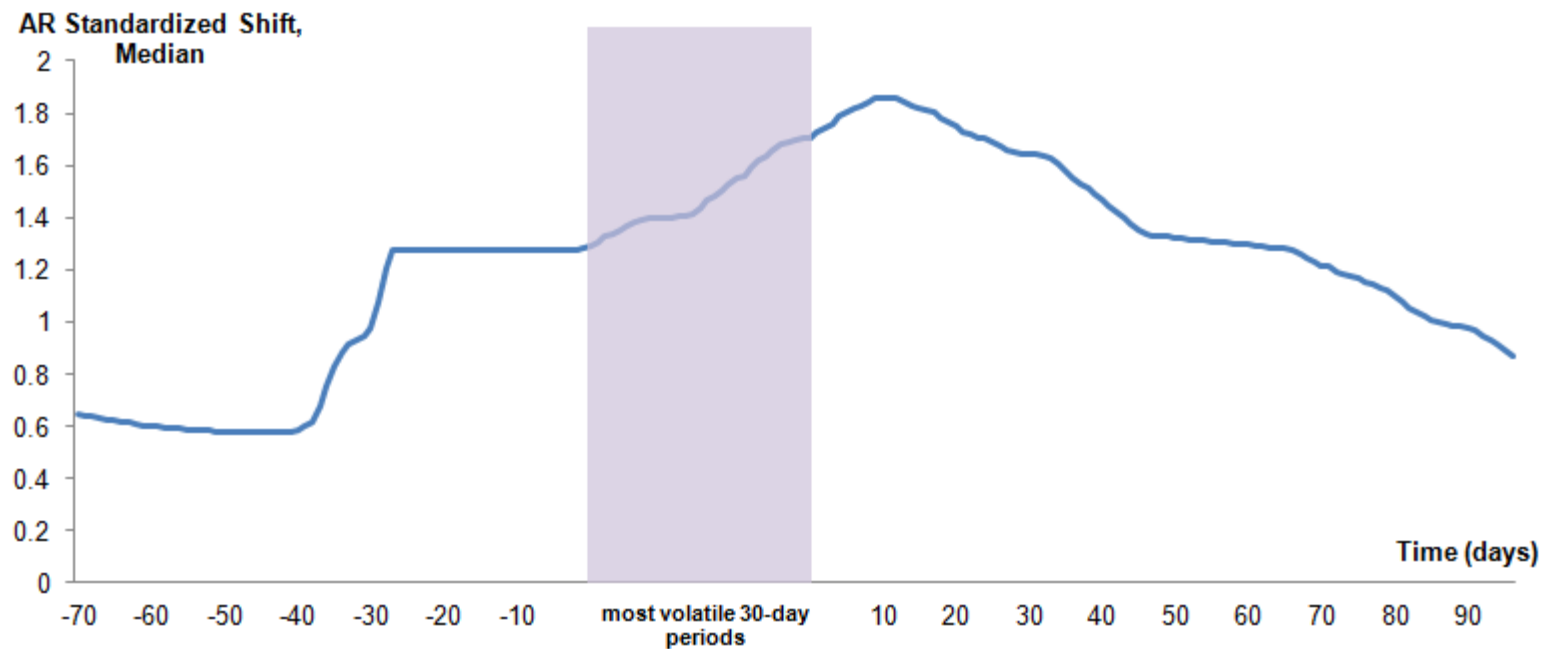


Conditional U.S. equity volatility: next month

Annualized out-of-sample U.S. equity volatility with 1-day lag



The absorption ratio and volatility



We identify the 10% most volatile 30-day periods of the MSCI All Country World Equity Index. We synchronize the volatile periods and measure the median standardized shift of the global absorption ratio leading up to, during, and following these periods of volatility.

The absorption ratio and financial turbulence

$$\mathbf{d}_t = (\mathbf{y}_t - \boldsymbol{\mu})\boldsymbol{\Sigma}^{-1}(\mathbf{y}_t - \boldsymbol{\mu})'$$

d_t = vector distance from multivariate average

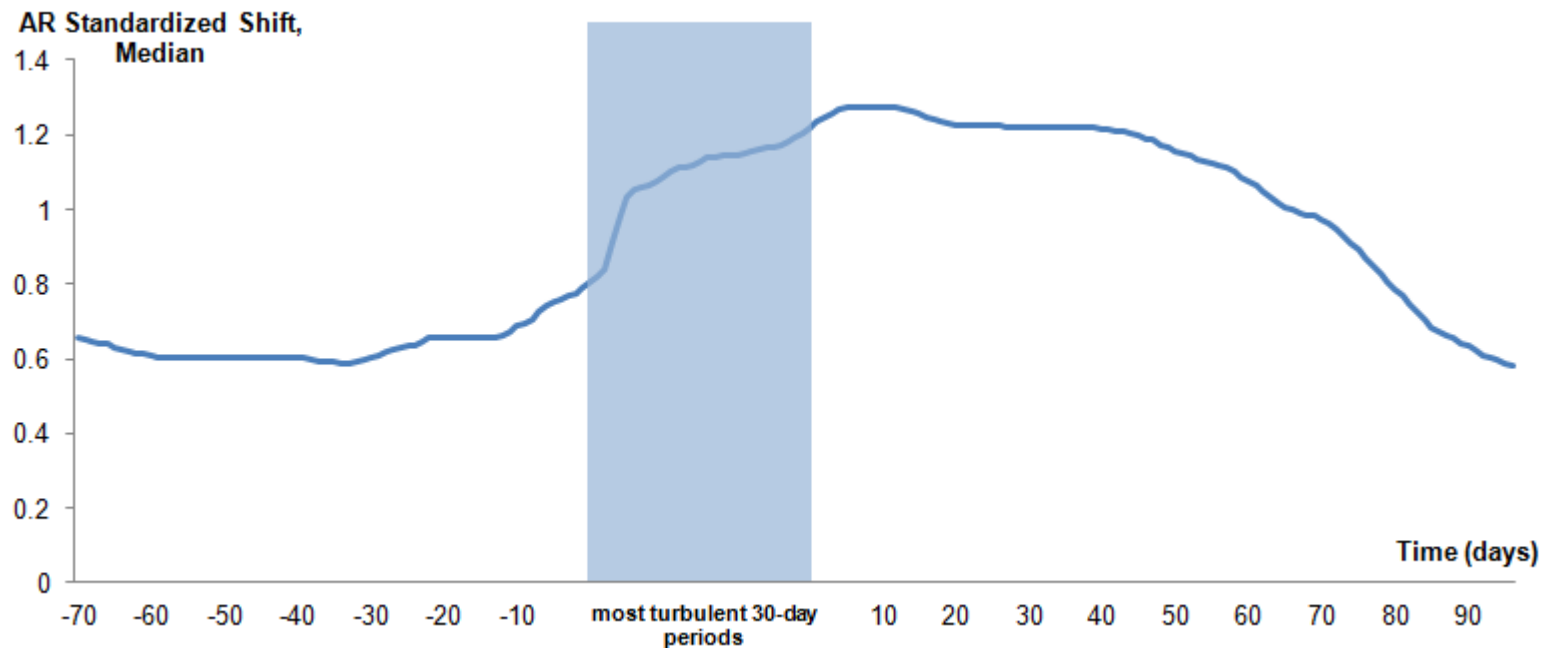
y_t = return series

μ = mean vector of return series y_t

Σ = covariance matrix of return series y_t

- We measure financial turbulence as a condition in which asset prices behave in an uncharacteristic fashion, given their historical pattern of behavior. This includes extreme price moves, decoupling of correlated assets, and convergence of uncorrelated assets.
- Differences from historical averages capture the extent to which one or more return was unusually high or low.
- Multiplying by the inverse of the covariance matrix makes the measure scale independent and captures interaction of assets.
- Post multiplying by the transpose of differences converts the vector to a single number.

The absorption ratio and financial turbulence



We identify the 10% most turbulent 30-day periods in global equities, as measured from industries of the MSCI All Country World Equity Index. We synchronize the turbulent periods and measure the median standardized shift of the global absorption ratio leading up to, during, and following these periods of high turbulence.

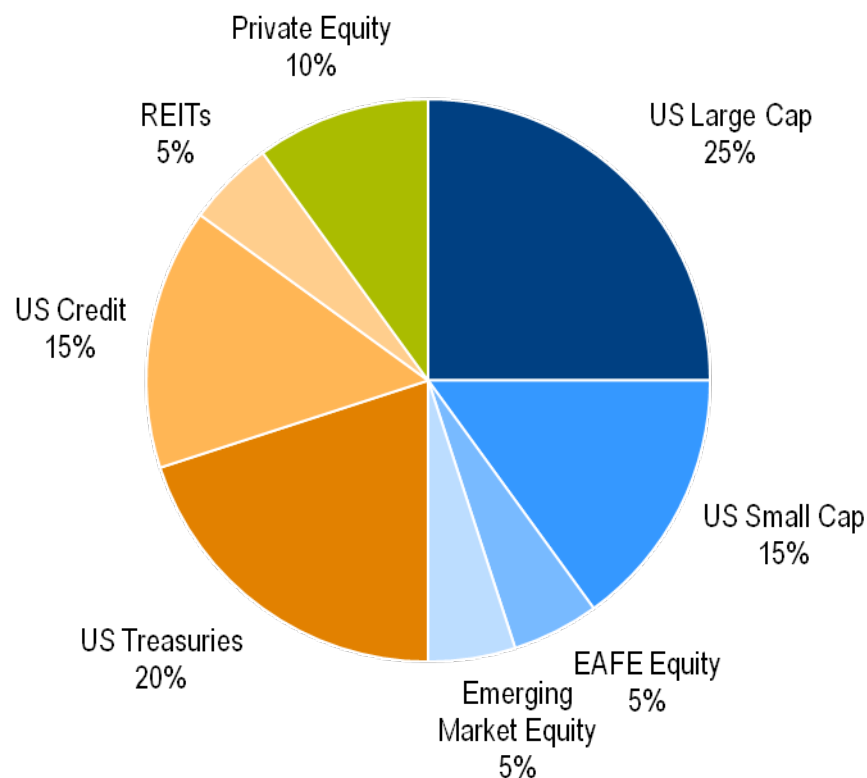
Other markets

- We have applied the same model with the same calibration to other markets:
 - The global stock market
 - The European Monetary Union stock market
 - The Australian stock market
 - The Canadian stock market
 - The German stock market
 - The Japanese stock market
 - The UK stock market
 - 16 Emerging market stock markets
 - US risk factors (market neutral)
 - US stock market sectors (market neutral)
 - EMU stock market sectors (market neutral)
- In all cases the results were qualitatively similar.

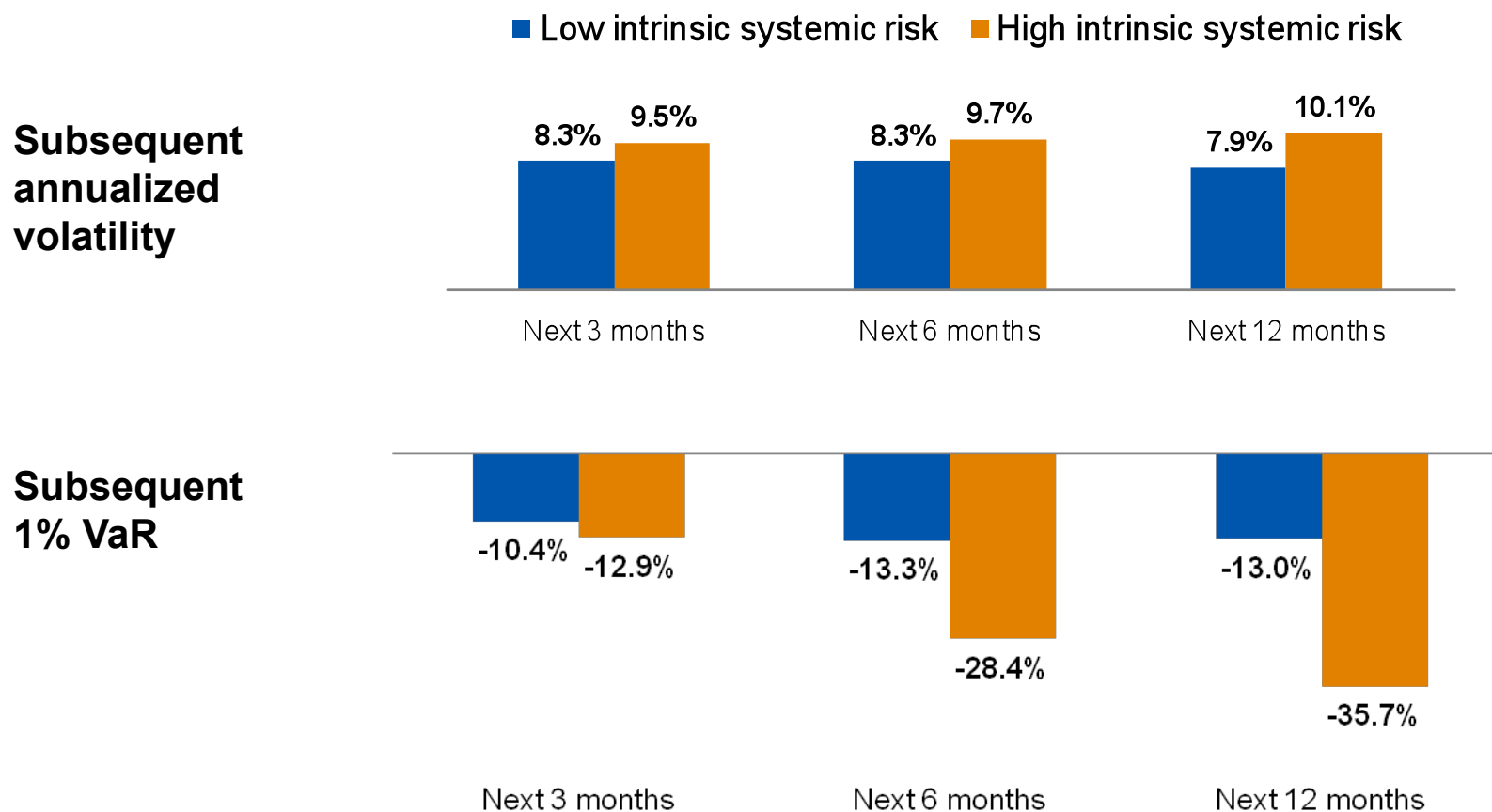
**The absorption ratio as a measure of
intrinsic systemic risk**

The absorption ratio as a measure of intrinsic systemic risk

- We construct an absorption ratio based on the returns of eight asset classes
- Then, we measure the risk of a typical institutional portfolio following both high and low systemic risk
- The allocation for this portfolio is shown at right



The absorption ratio as a measure of intrinsic systemic risk



* Results from 2/21/1996 through 3/30/2011.

Source: State Street Global Markets

Slide 24 of 44

The absorption ratio as a measure of intrinsic systemic risk

	Average volatility increase across asset classes*	Volatility increase of portfolio
1998-present	1.2x	1.3x
2007-2009	1.4x	1.7x

* Portfolio-weighted average

* Results from 2/21/1996 through 3/30/2011.

Source: State Street Global Markets

Slide 25 of 44

Centrality as a measure of systemic importance

Why is systemic importance important?

- Investors care about systemic importance in order to assess their portfolios' vulnerability to shocks and to pursue defensive tactics if needed.
- Policymakers need this information to ensure that policies and regulations target the appropriate entities and to engage in preventive or corrective measures more effectively.

Asset centrality

We construct a measure of asset centrality, which captures:

- an asset's vulnerability to failure
- how broadly and deeply an asset is connected to other assets in the system
- the riskiness of the other assets to which it is connected.

Asset centrality

$$Asset\ Centrality_i = \frac{\sum_{j=1}^n \left(AR^j \cdot \frac{|EV_i^j|}{\sum_{k=1}^N |EV_k^j|} \right)}{\sum_{j=1}^n AR^j}$$

→ Normalized component
“weights” in each eigenvector

$Asset\ Centrality_i$ = the centrality score for asset i

AR^j = the absorption ratio of the j -th eigenvector (percentage of variation explained)

EV_i^j = the absolute value of the exposure of the i -th asset within the j -th eigenvector

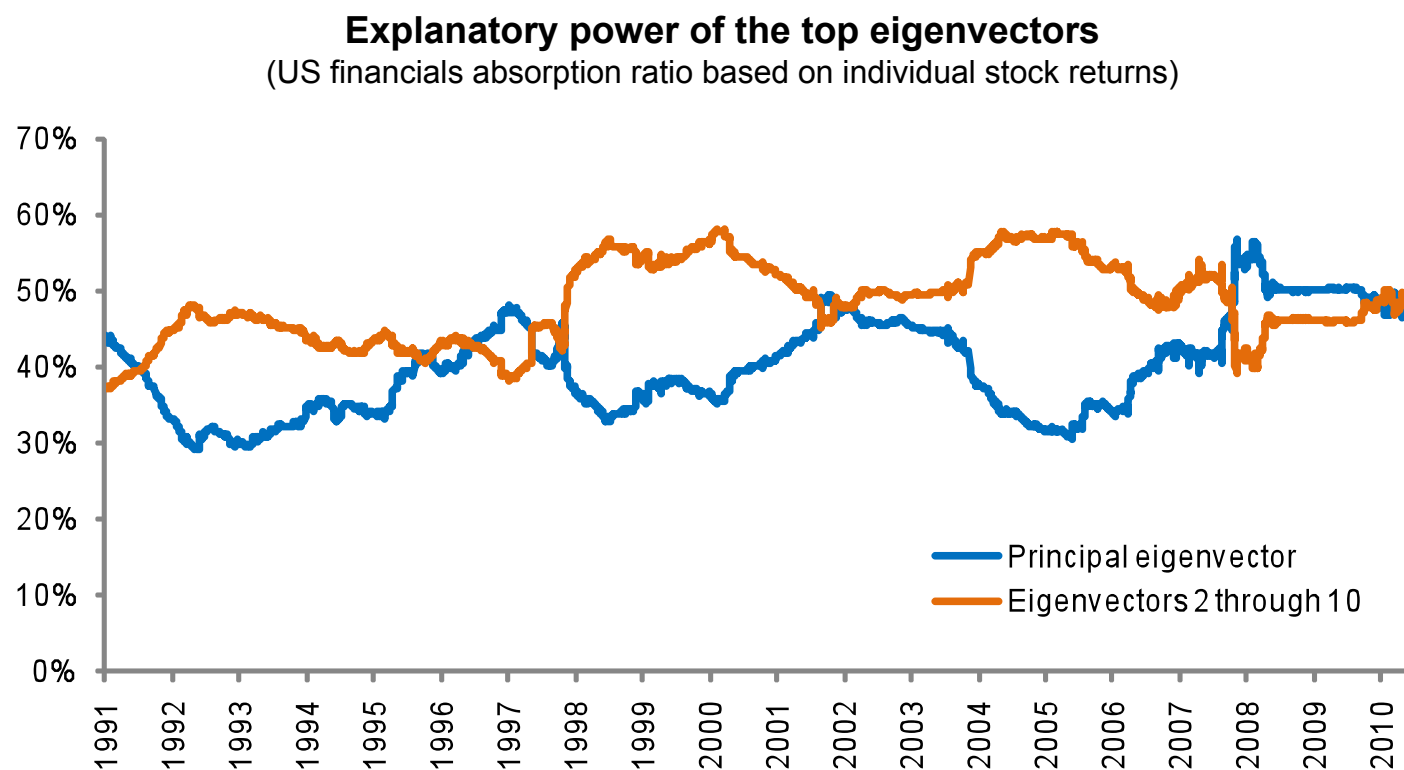
n = the number of top eigenvectors to include in the calculation

N = the total number of assets

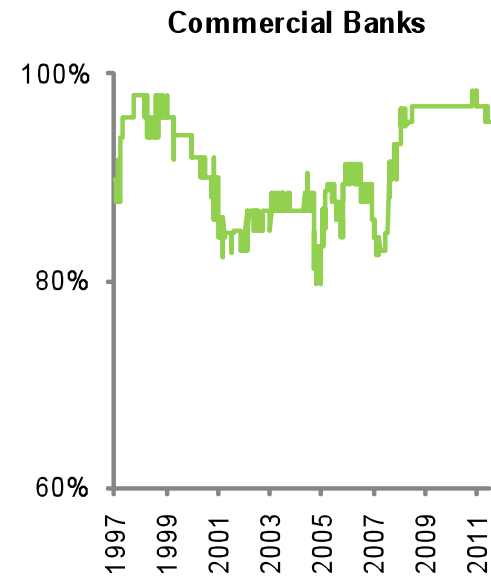
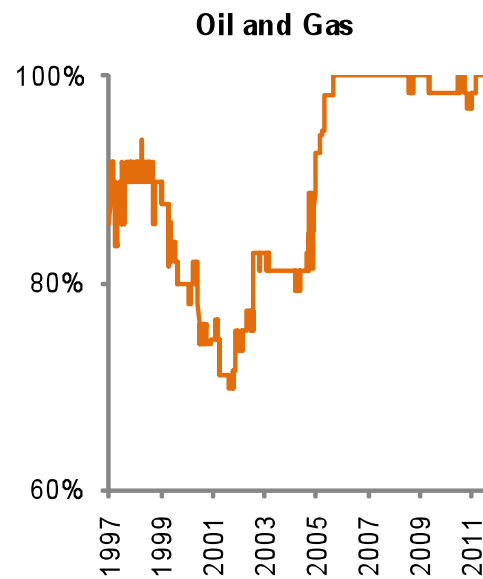
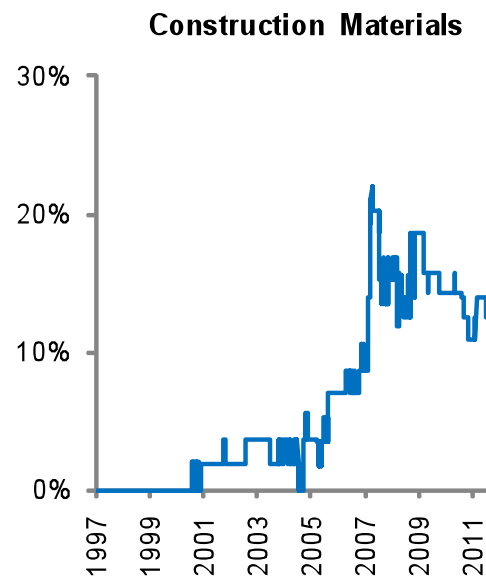
Asset centrality: an intuitive interpretation

- If we were to use only the first eigenvector to compute asset centrality, this would be the same technique used in Google's PageRank algorithm.
- We instead chose to use several eigenvectors in the numerator of the absorption ratio because in many instances – perhaps most – several factors contribute importantly to market variance.

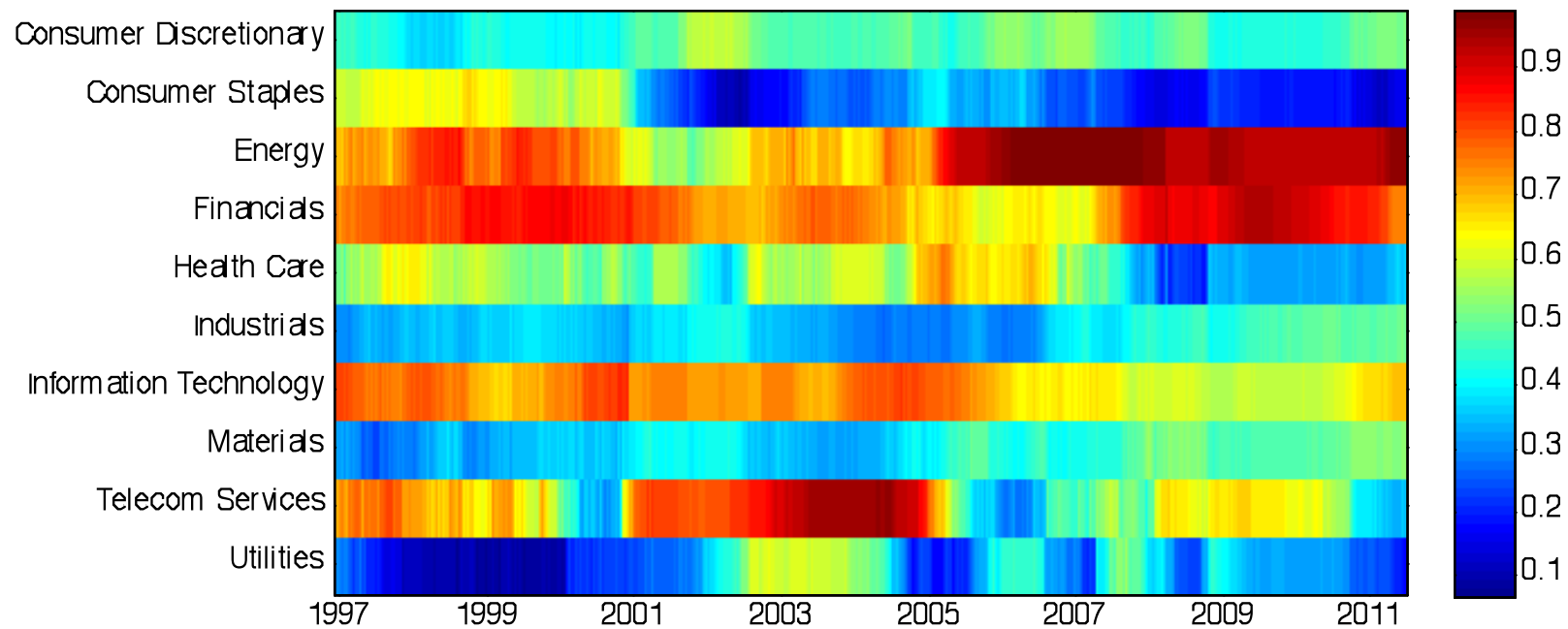
Multiple eigenvectors contribute importantly to variance



Centrality percentile ranks for selected US industries



US sector centrality percentile ranks



Systemic importance

Systemic importance equals the asset centrality percentile rank *conditioned on high systemic risk*.

US Sector systemic importance

Top sectors when standardized shift > 1	Average percentile rank
Energy	85
Financials	75
Telecommunication Services	64
Information Technology	62
Health Care	46
Consumer Staples	43
Consumer Discretionary	39
Materials	35
Industrials	34
Utilities	30

Top 10 systemically important US industries

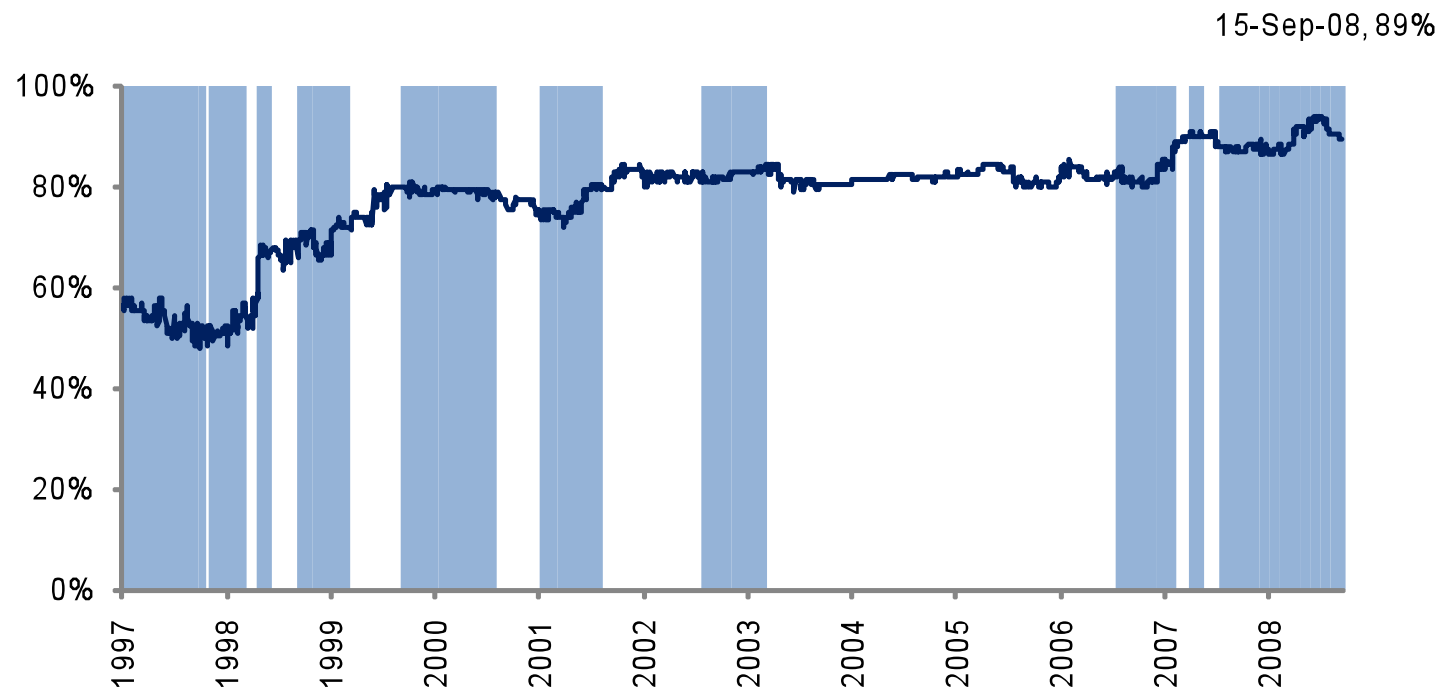
Top industries when standardized shift > 1	Average percentile rank
Diversified Financial Services	95
Capital Markets	94
Software	92
Commercial Banks	91
Communications Equipment	90
Oil, Gas & Consumable Fuels	90
Computers & Peripherals	90
Real Estate Investment Trusts (REITs)	87
Pharmaceuticals	85
Industrial Conglomerates	85

Top 10 systemically important US financial stocks

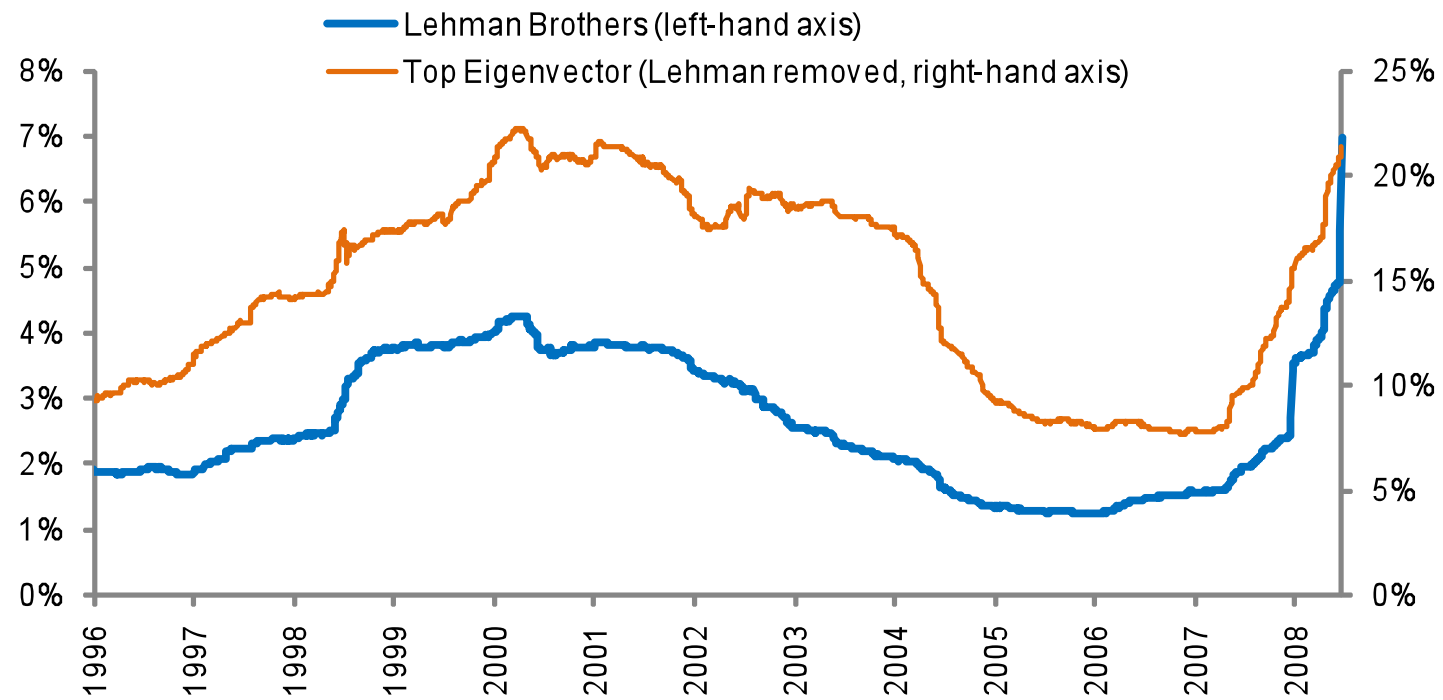
Top stocks when standardized shift > 1	Average percentile rank
Citigroup	98
Bank of America	97
JP Morgan Chase	96
American International Group	96
Fannie Mae	93
Morgan Stanley	92
American Express	92
Merrill Lynch	91
Bank One (Acquired)	91
Goldman Sachs	89

Company names provided above are for illustrative purposes only and do not represent an analysis of the merits of investing in such companies.

Lehman Brothers centrality score through time



Daily volatility over the past 500 days



Comparison to the Financial Stability Board methodology

	Our methodology	Financial Stability Board
Data and calculation	Systemic importance scores are derived from securities price movement, using principal component analysis. This technique captures: • how broadly and deeply an institution is connected to other institutions in the system, • the institution's vulnerability to failure, and • the riskiness of the other institutions to which it is connected.	Systemic importance scores are calculated by weighting a range of fundamental factors or indicators, often from company balance sheets. The indicators used (and their weightings) are:¹ • Cross-jurisdictional claims (10%) • Cross-jurisdictional liabilities (10%) • Total exposures as defined by Basel III leverage (20%) • Intra-financial system assets (6.67%) • Intra-financial system liabilities (6.67%) • Wholesale funding ratio (6.67%) • Assets under custody (6.67%) • Payments cleared and settled via systems (6.67%) • Values of underwritten debt & equity trans. (6.67%) • OTC derivatives notional value (6.67%) • Level 3 assets (6.67%) • Trading book value and avail. for sale value (6.67%)
Timeliness	One week delay	Two year delay ²

¹ Basel Committee on Banking Supervision, "Global systemically important banks, Assessment methodology and the additional loss absorbency requirement," *Bank for International Settlements*, July 2011.

² As noted in: Financial Stability Board, "Policy Measures to Address Systemically Important Financial Institutions," 4 November, 2011, November 2011 values were based on data as of the end of 2009.

Top 25 systemically important financial institutions (as of Dec 2009)

Financial institutions	Rank
Bank of America	1
JP Morgan Chase	2
Wells Fargo	3
Citigroup	4
Barclays	5
Royal Bank of Scotland	6
HSBC	7
Lloyds Banking Group	8
BNP Paribas	9
Goldman Sachs	10
Morgan Stanley	11
Santander	12
US Bancorp	13

Financial institutions (cont'd)	Rank
UBS	14
ING	15
AXA	16
Unicredit	17
Mitsubishi UFJ FG	18
Credit Suisse	19
Met Life	20
Prudential Financial	21
Societe Generale	22
AIG	23
Deutsche Bank	24
Credit Agricole	25

 Also appears on the FSB's list of 29 systemically important institutions

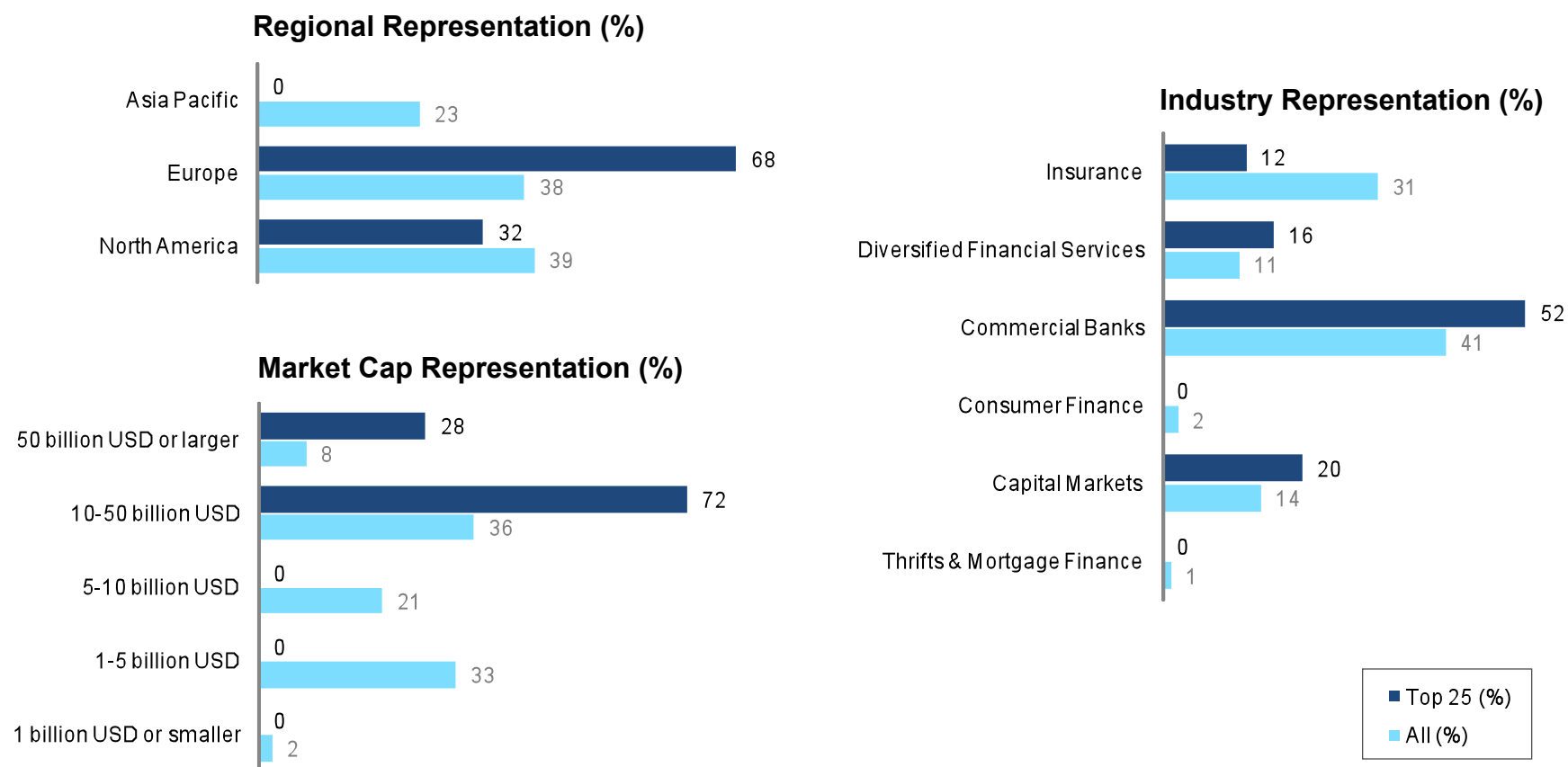
Company names provided above are for illustrative purposes only and do not represent an analysis of the merits of investing in such companies.

The universe is based on the MSCI Developed World Financials Sector index constituents as of November 2011. We removed companies from the Real Estate industry group as well as 22 companies that did not have a long enough stock price data history to include in our study.

Slide 41 of 44

Source: State Street Global Markets, Financial Stability Board

Stratification of the top 25 institutions compared to the full universe as of November 25, 2011



The universe is based on the MSCI Developed World Financials Sector index constituents as of November 2011. We removed companies from the Real Estate industry group as well as 21 companies that did not have a long enough stock price data history to include in our study.

Source: State Street Global Markets

Slide 42 of 44

11th – 25th most systemically important global financial institutions *as of November 25, 2011*

Global financial institution	Rank
Societe Generale	11
Unicredit	12
Morgan Stanley	13
Goldman Sachs	14
ING	15
AXA	16
Intesa Sanpaolo	17
BBV Argentaria	18
UBS	19
Credit Suisse	20
Credit Agricole	21
Deutsche Bank	22
Allianz	23
MetLife	24
US Bancorp	25

Company names provided above are for illustrative purposes only and do not represent an analysis of the merits of investing in such companies.

Slide 43 of 44

Source: State Street Global Markets

Top 10 systemically important global financial institutions

as of November 25, 2011

Global financial institution	Rank
Bank of America	1
Citigroup	2
JP Morgan Chase	3
Wells Fargo	4
BNP Paribas	5
Santander	6
Lloyds Banking Group	7
Barclays	8
HSBC	9
Royal Bank of Scotland	10

Company names provided above are for illustrative purposes only and do not represent an analysis of the merits of investing in such companies.