Moody's
ANALYTICS

Modeling Sovereign Credit Risk in a Portfolio Setting

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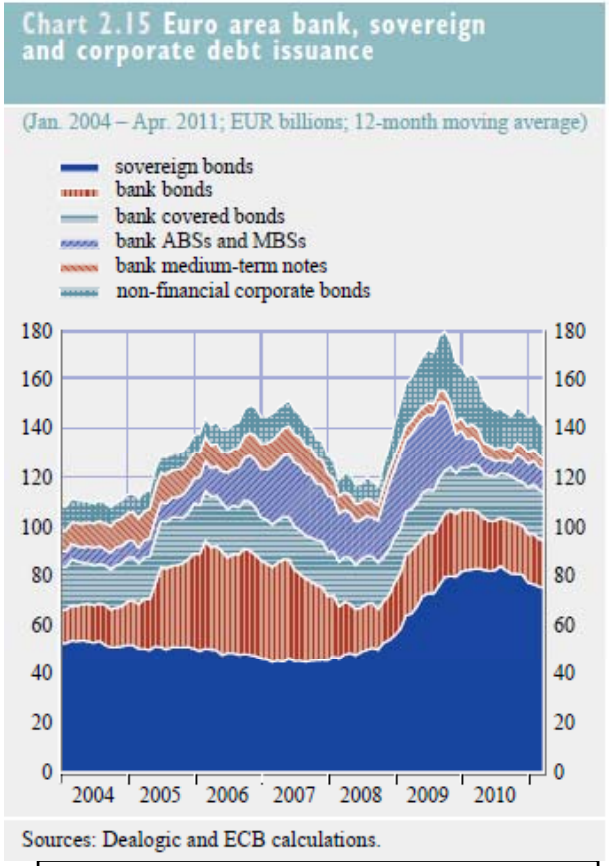
Agenda

1. Sovereign Risk: New Methods for a New Era
2. Data for Sovereign Risk Modeling
3. Modeling Sovereign Probabilities of Default
4. Empirical Patterns of Sovereign Correlations
5. Thinking About Portfolio Credit Risk
6. Modeling Sovereign Risk in a Portfolio
7. Implications

1 Sovereign Risk: New Methods for a New Era

Sovereign debt issuance is growing across the globe…

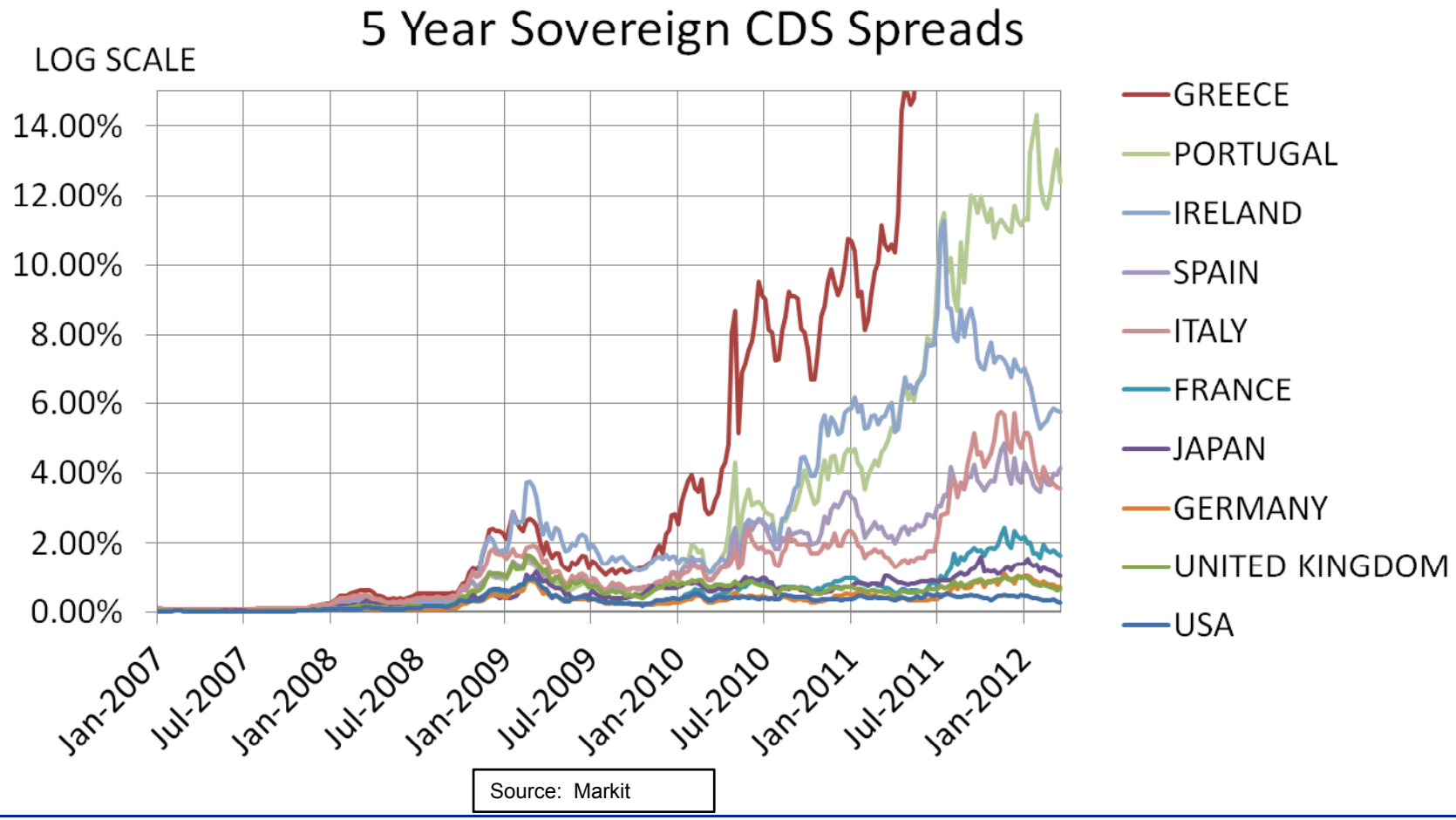
» In the Euro zone sovereign debt accounts for more than 50% of all debt issuance in 2011.



Source: European Central Bank (www.ecb.int), *"Financial Stability Review, June 2011"*

At the same time, sovereign risk is growing….

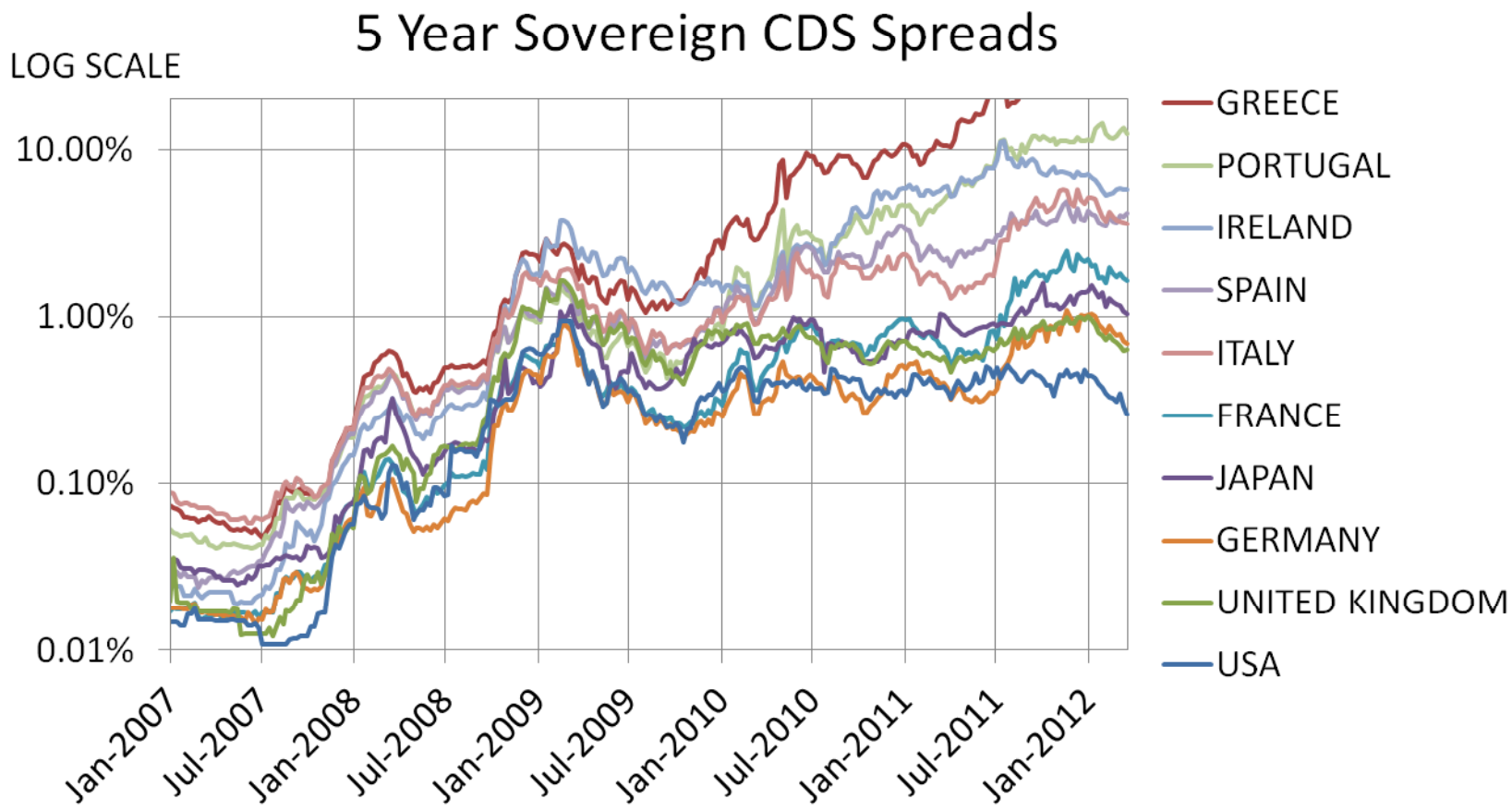
» Sovereigns spreads have increased across the globe.



Source: Markit

Sovereign credit risks are correlated...

» Dynamics of sovereign CDS spreads is affected by common components → correlation.



Source: Markit

Concentrations in financial institutions' credit portfolios are a growing concern…

- Financial institutions are holding sovereign debt for many troubled countries. This is leading to large concentration of sovereign risk in a portfolio setting.
  - Financial institutions are heavily exposed to sovereign debt of their own country.
  - Large cross border concentrations exist as well.

Country Banking Exposure to Sovereign Debt
(millions of Euro)

Greece

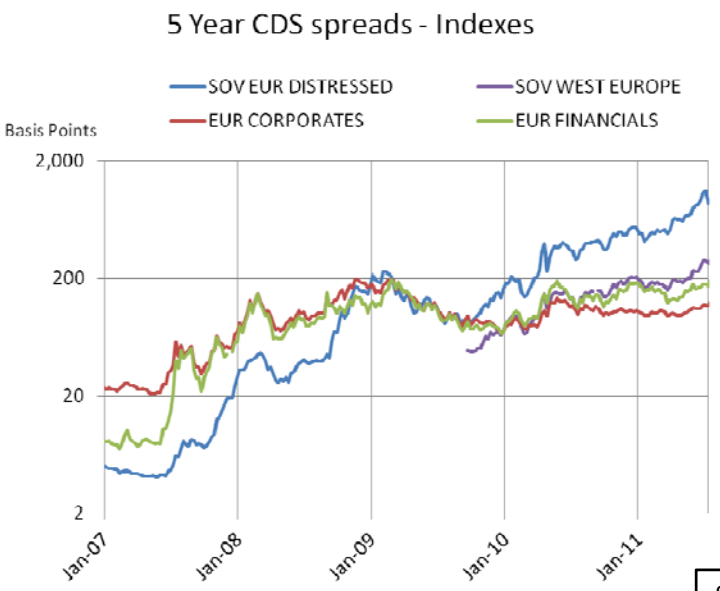
Country	Exposure to Greece	Exposure / Tier 1 Capital
Greek Banks	56,148	226%
German Banks	18,718	12%
French Banks	11,624	6%
Cypriot Banks	4,837	109%
Belgian Banks	4,656	14%

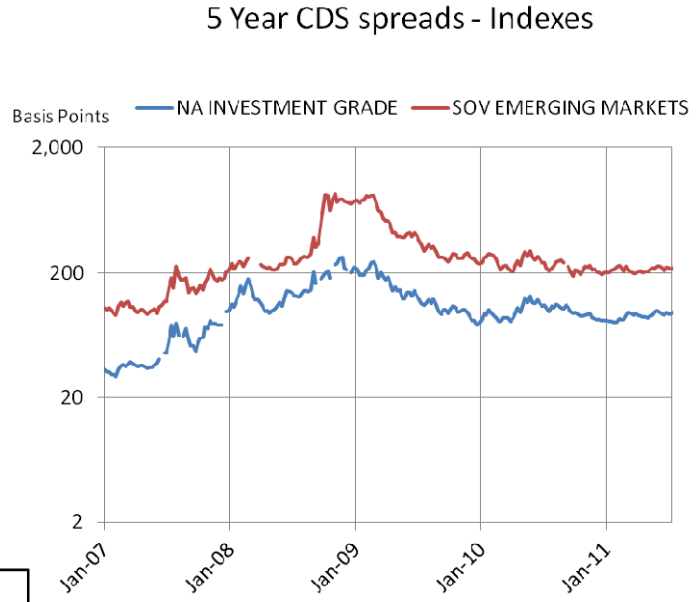
Spain

Country	Exposure to Spain	Exposure / Tier 1 Capital
Spanish Banks	203,310	113%
German Banks	31,854	21%
French Banks	6,592	4%
British Banks	5,916	2%
Belgian Banks	3,530	11%

Source: OECD (www.oecd.org), *"The EU Stress Test and Sovereign Debt Exposures" August 2010*

Sovereign spreads are correlated with other asset classes





Source: Markit

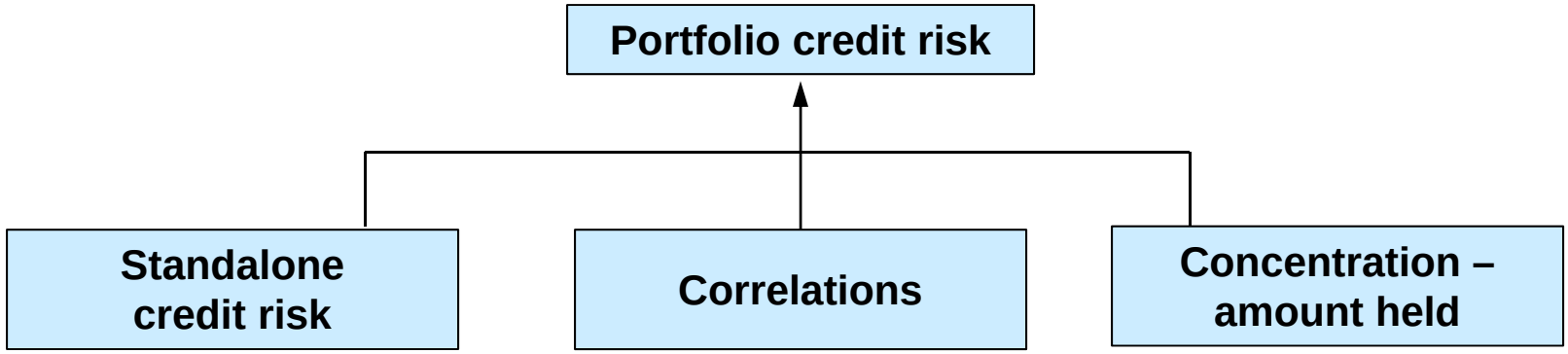
Correlations of weekly CDS spread changes (September 2008 – September 2011)

	Sovereign Europe Distressed	Sovereign West Europe	European Financials	European Corporates
Sovereign Europe Distressed	100%	79%	44%	34%
Sovereign West Europe		100%	78%	65%
European Financials			100%	83%
European Corporates				100%

	North American Investment Grade	Sovereign Emerging Markets
North American Investment Grade	100%	79%
Sovereign Emerging Markets		100%

In order to effectively manage sovereign risk a financial institution must model:

- Stand alone risk of sovereign exposures.
- Correlations among sovereigns as well as between sovereign and other types of exposures that the financial institution has in its portfolio (e.g. corporate exposures).



2 Data for Sovereign Risk Modeling

What data is available for modeling sovereign risk?

- Fundamental approach:
  - Building a model based on economic data about sovereigns – fiscal situation, debt issuance and outstanding debt, currency of the outstanding debt, size and structure of the country's economy, and so forth.
- Sovereign default data:
  - Small number of sovereign defaults to extract information about sovereign correlations.
- Rating data:
  - Credit rating agency views of sovereign credit qualities.
  - By design, ratings represent a long-term, or through-the-cycle, assessment of credit risk.

    → Ratings do not typically change frequently enough to be used in a model of sovereign credit quality co-movements.
- Market data:
  - Sovereign bond data
  - Sovereign CDS data

Sovereign market data

- Market sovereign bond yields and sovereign CDS spreads
  - A dynamic market view of sovereign credit risk
- Sovereign bond data:
  - Challenges – transforming market bond yields into credit quality measures.
  - Removing the risk-free part of the yield, possible embedded optionalities (e.g., early exercise), and other non-credit components.
  - Coverage and liquidity issues.
- Sovereign CDS data:
  - CDS spreads – no need to remove risk-free components or optionalities, as opposed to sovereign bond yields.
  - Broader coverage and higher liquidity than sovereign bonds.
  - Still, liquidity issues need to be addressed.

⇒ Sovereign CDS spreads are used for our sovereign credit risk model.

Using sovereign CDS spreads in practice

» Sovereign credit correlations – how closely do credit qualities of two sovereigns move together?

» Simple approach – correlations of CDS spreads changes.

- Even if credit qualities of two sovereigns are stable, a change in market price of credit risk drives CDS spreads.
- Within the Merton model, changes in CDS spreads are not stationary.

» Alternative – back out distances-to-default for sovereigns from the CDS spreads.

- Changes in distances-to-default are stationary within the Merton model and can be considered proxies to asset returns.
- A model for estimating distances-to-default from CDS spreads

Liquidity issues of CDS spreads

- CDS data used by Moody's Analytics comes from Markit.
  - Markit CDS spreads are dealers' quotes, not transaction data.
  - Advantage: a broader coverage than transaction data
  - Disadvantage: more liquidity issues

- Liquidity problem: changes/stability in distances-to-default may reflect not only changes in a sovereign's creditworthiness, but also illiquidity of the CDS contract (e.g., "stale spreads").

- Steps to address the liquidity problem in our sovereign correlation model:
  - Focusing on the period with higher trading activity and more dynamic spreads → after 2008.
  - Selecting sovereigns with the most liquid CDS contracts. Quotes are provided for 89 sovereigns, however only 64 can be considered suitable for correlation estimation.
  - Further steps – for example, using only the largest spread changes during a given period.

3 Modeling Sovereign Probabilities of Default

Moody's Analytics approach to modeling sovereign probabilities of default

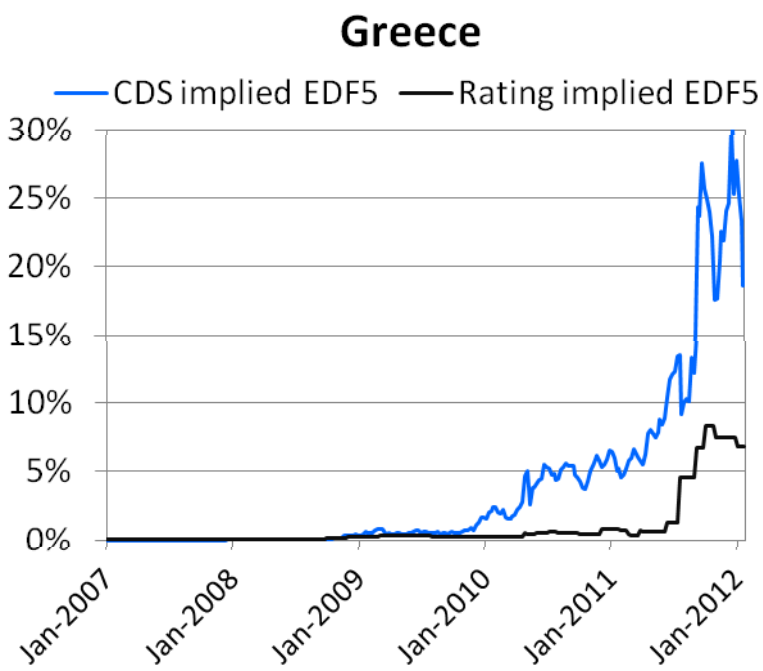
- Sovereign CDS spreads are used to estimate sovereign CDS implied EDFs (Sovereign CDS-I EDFs).
  - The model was developed for corporates and then extended to sovereigns.
- CDS-I EDFs have the same interpretation as the Moody's Analytics EDF measure for listed firms.
- The Sovereign CDS-I EDFs provide a dynamic risk assessment for sovereigns and can complement rating-based approaches.
- The estimated Sovereign CDS-I EDFs are tested against ratings as well as actual sovereign defaults.

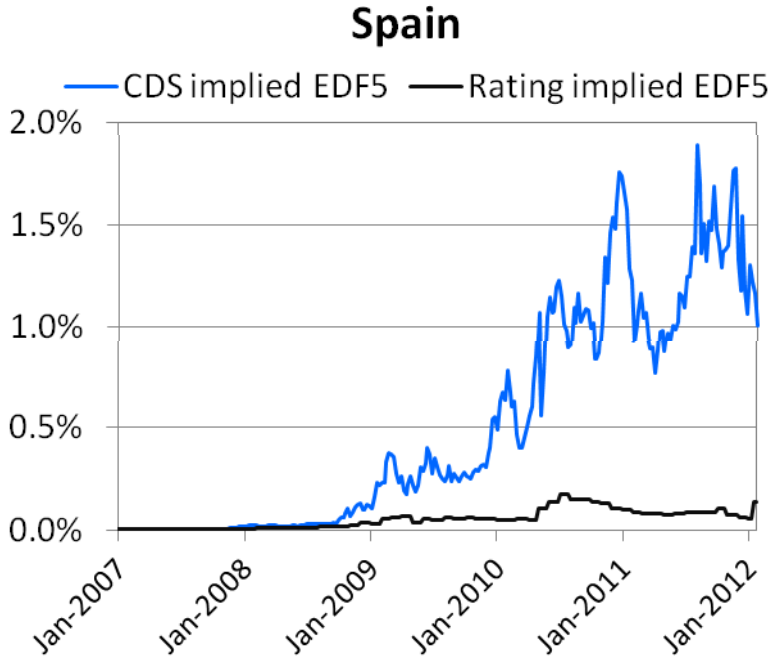
The data: agency ratings and CDS spreads both signal sovereign credit quality

- Agency Ratings
  - Opinions based on all information that the team of analysts chooses to use.
  - Intended to be stable over time.
- CDS spreads
  - Reflect collective judgment of market participants.
  - Can move quickly as market sentiment changes or new information is released.

The goal: for risk management, physical PDs are the preferred risk measure

» Comparison of sovereign CDS-I EDFs and rating-implied EDFs.

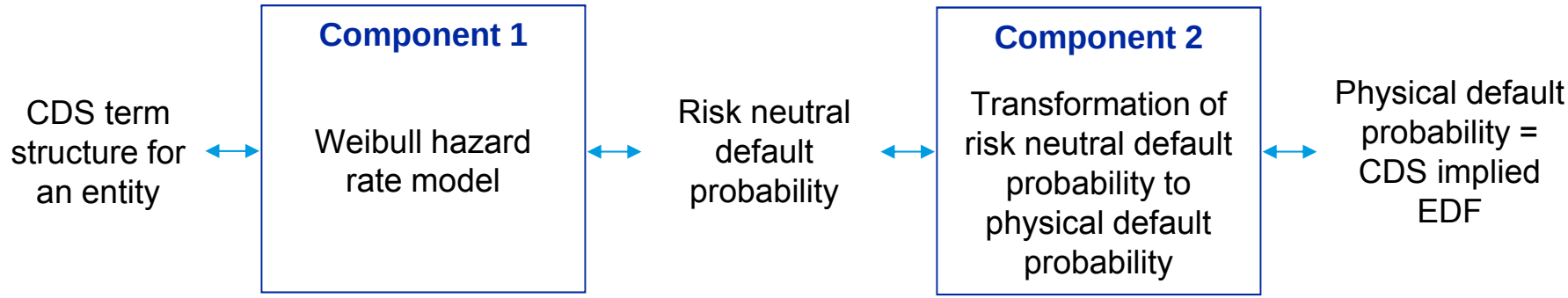




Note: For the purposes of this chart, CDS implied EDF was updated weekly, whereas rating implied EDF monthly.

Using CDS spreads to calculate probabilities and correlations

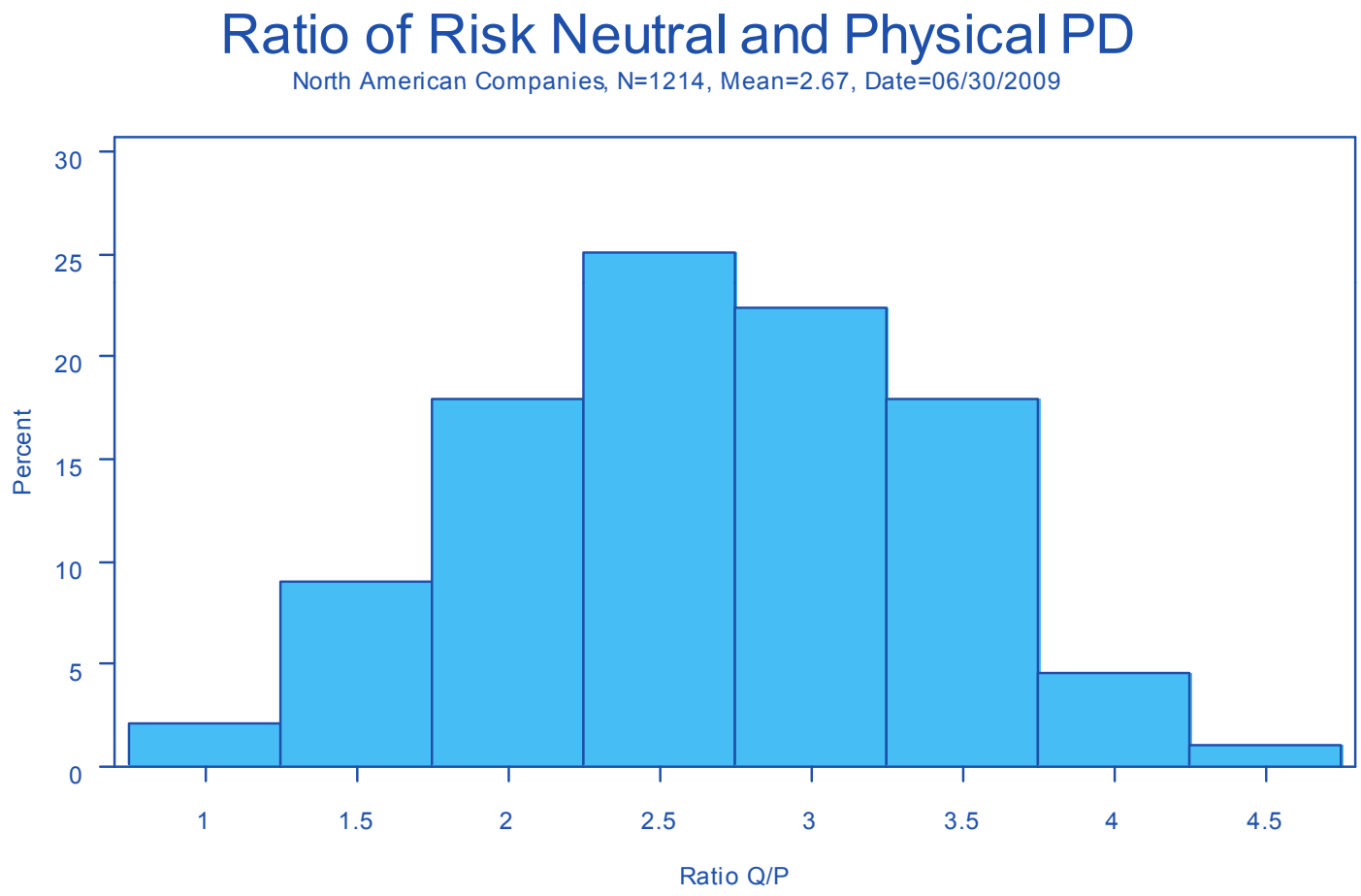
» Structure of the Moody's Analytics methodology for corporate and sovereign CDS implied EDFs.



» Spread implied correlations are calculated by first transforming the physical probability to distance-to-default (DD) measures. We calculate the correlation between DD changes for each pair of sovereigns:

$$corr(\Delta DD_i^{CDS}, \Delta DD_j^{CDS}) = corr(r_i, r_j)$$

The difference between a risk neutral and a physical probability of default (PD) can be big…



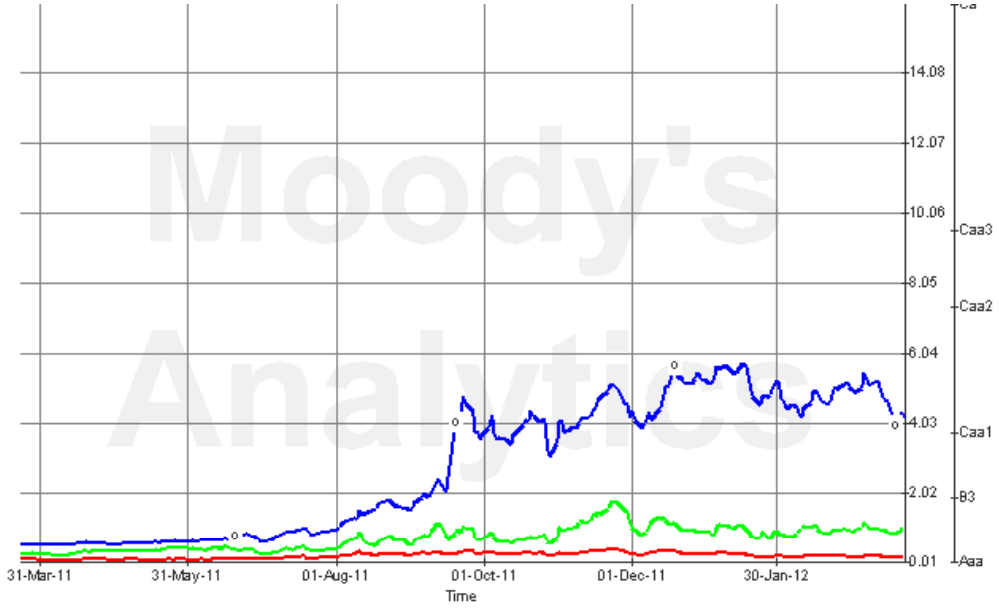
The output of our Sovereign CDS-I EDF model passes our “sanity checks”

- Sovereign CDS-I EDFs are
  - Elevated prior to default
  - Significantly correlated with rating-implied EDFs
  - Comparable to that of safest companies from the corresponding countries

Sovereign CDS-I EDFs are market-driven and ready to use

- Reliability:
  - The key driver of sovereign CDS-I EDFs is the CDS market.
  - Extension of a model that has been validated corporates.
- Usability:
  - Already in the form of physical PDs.
  - Calibrated to be comparable to PDs from our public firm EDF model.

Differences in CDS-I EDFs and EDFs may reflect degree of implied support



Plot: Values
Period: Last 1 Year
From: March 23, 2011
Currency: EURO[EUR]
To: March 23, 2012

Description	Value	As Of
CREDIT AGRICOLE SA [ACA] EDF	4.15	23-Mar-12
CREDIT AGRICOLE SA [ACA] CDS-I EDF	1.01	22-Mar-12
FRANCE, GOVERNMENT OF [] CDS-I EDF	0.16	22-Mar-12

EDF of ACA is 4.15%

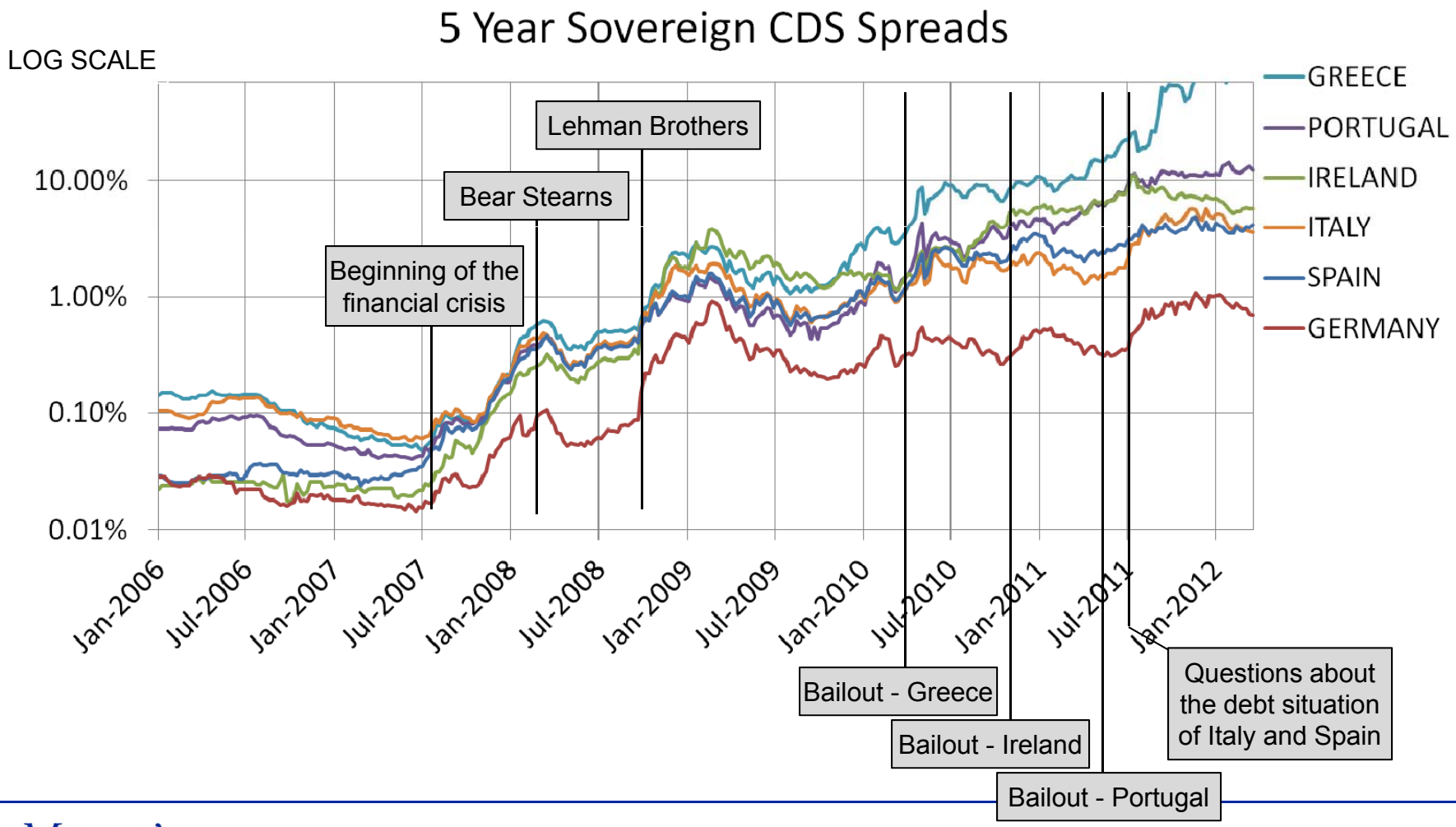
CDS-I EDF of ACA is 1.01%

CDS-I EDF of France is 0.16%

» For Credit Agricole, the CDS-I EDF is less than the EDF but greater than the CDS-I-EDF of government of France. The CDS market is pricing possibility of a governmental support.

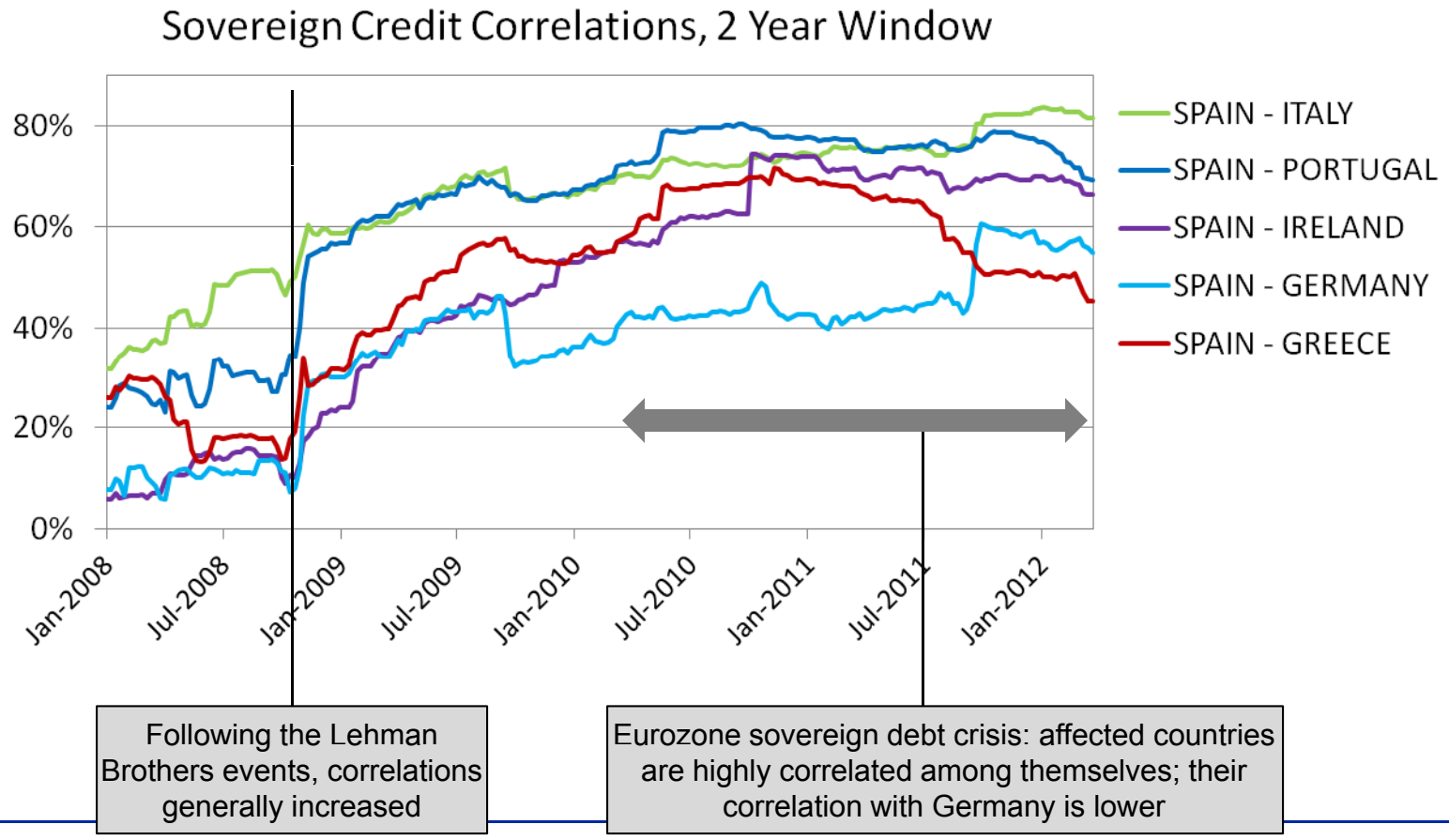
4 Empirical Patterns of Sovereign Correlations

Case I – Eurozone sovereign debt crisis

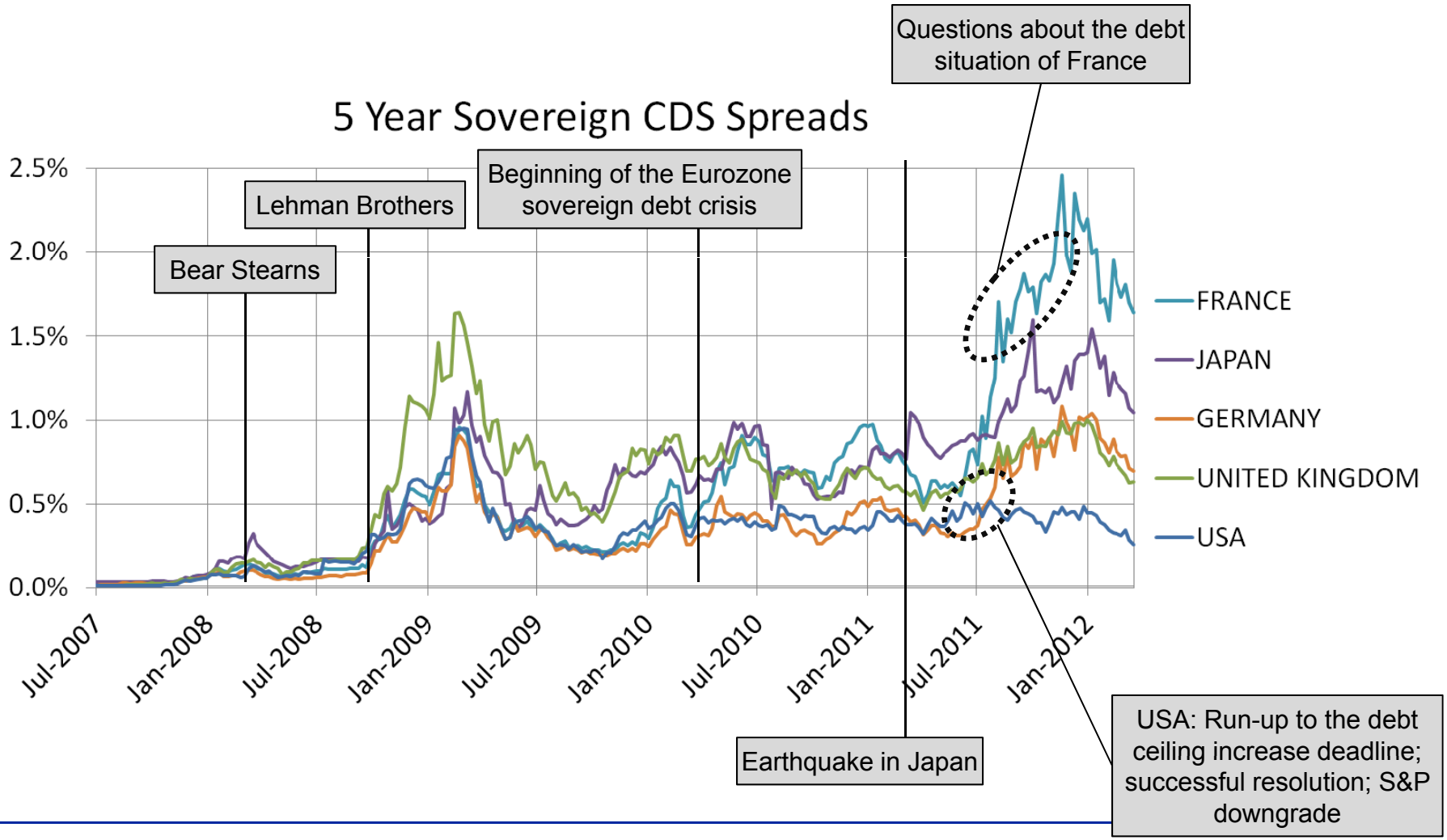


Effects on correlations

- Spain and Ireland had low correlation levels before the crisis: less than 20%.
- Both Ireland and Spain affected by the contagion of the Eurozone debt crisis: correlation around 70% in the first half of 2012.

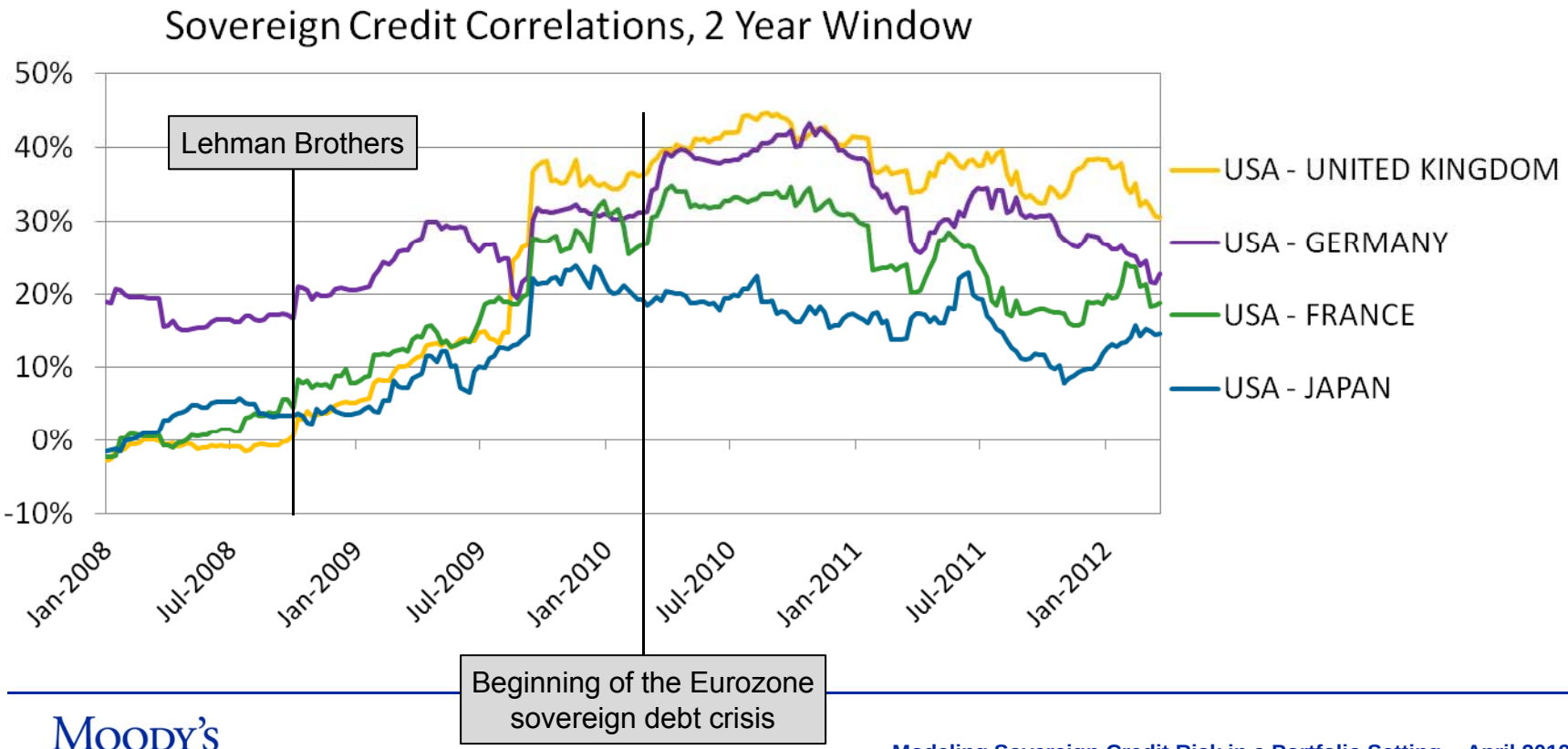


Case II – The largest developed countries, U.S. debt ceiling negotiations



Effects on correlations

- Correlations among large developed countries have also increased during the crisis.
- The correlation levels are however lower than for emerging countries or countries affected by the Eurozone sovereign debt crisis.

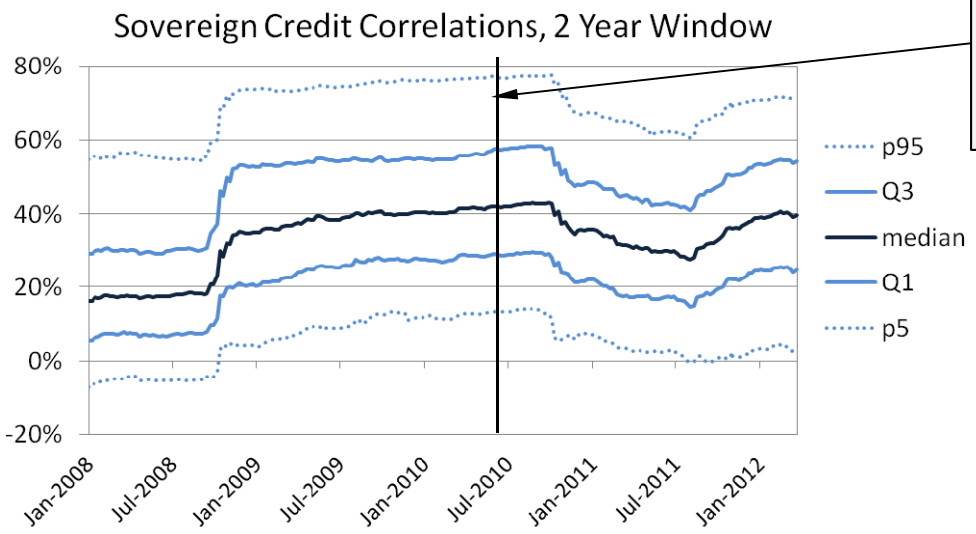


Sovereign credit correlations increased during the financial crisis

- 64 sovereigns with the most liquid sovereign CDS contracts.
- Distribution of sovereign credit correlations implied by market CDS spreads:
  - across 64*63/2 (= 2,016) pairs

Overall level of sovereign correlations in 2012:

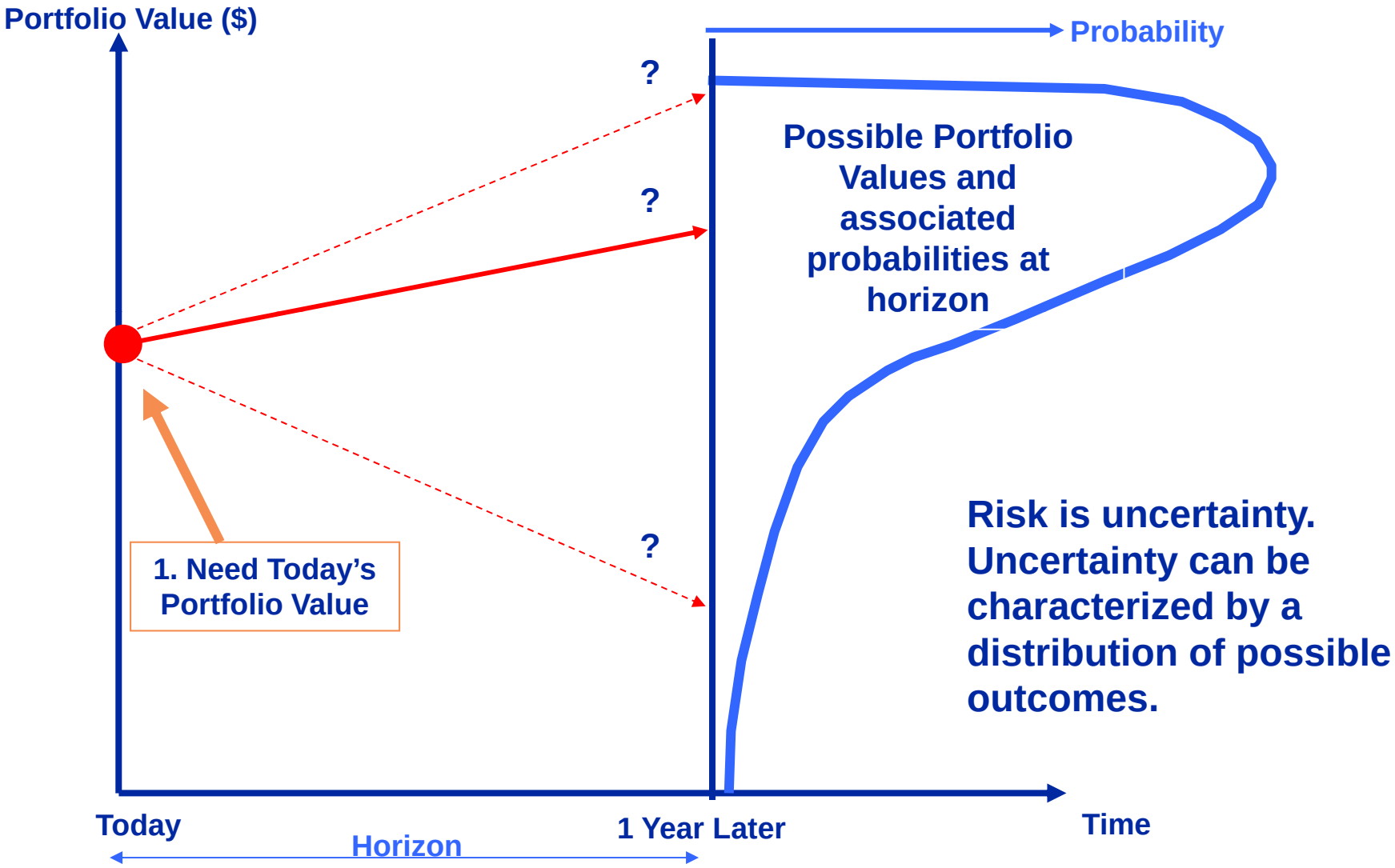
- Slightly lower than the high point during the financial crisis
- Still higher than the pre-crisis level



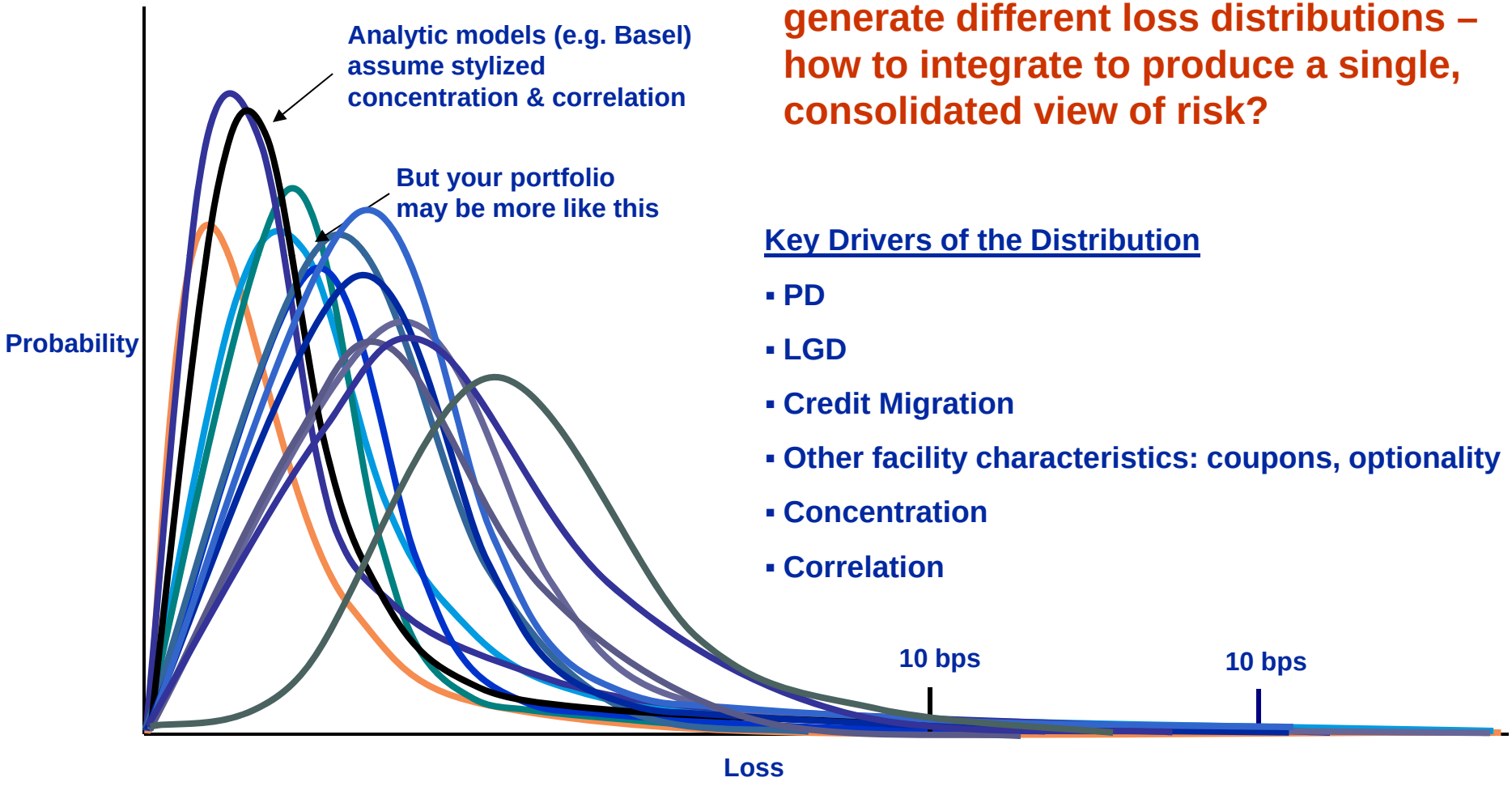
The Moody's Analytics model is based on empirical correlations over Jul 2008 – Jun 2010

5 Thinking About Portfolio Credit Risk

The portfolio value distribution



Shape of the distribution is driven by various inputs

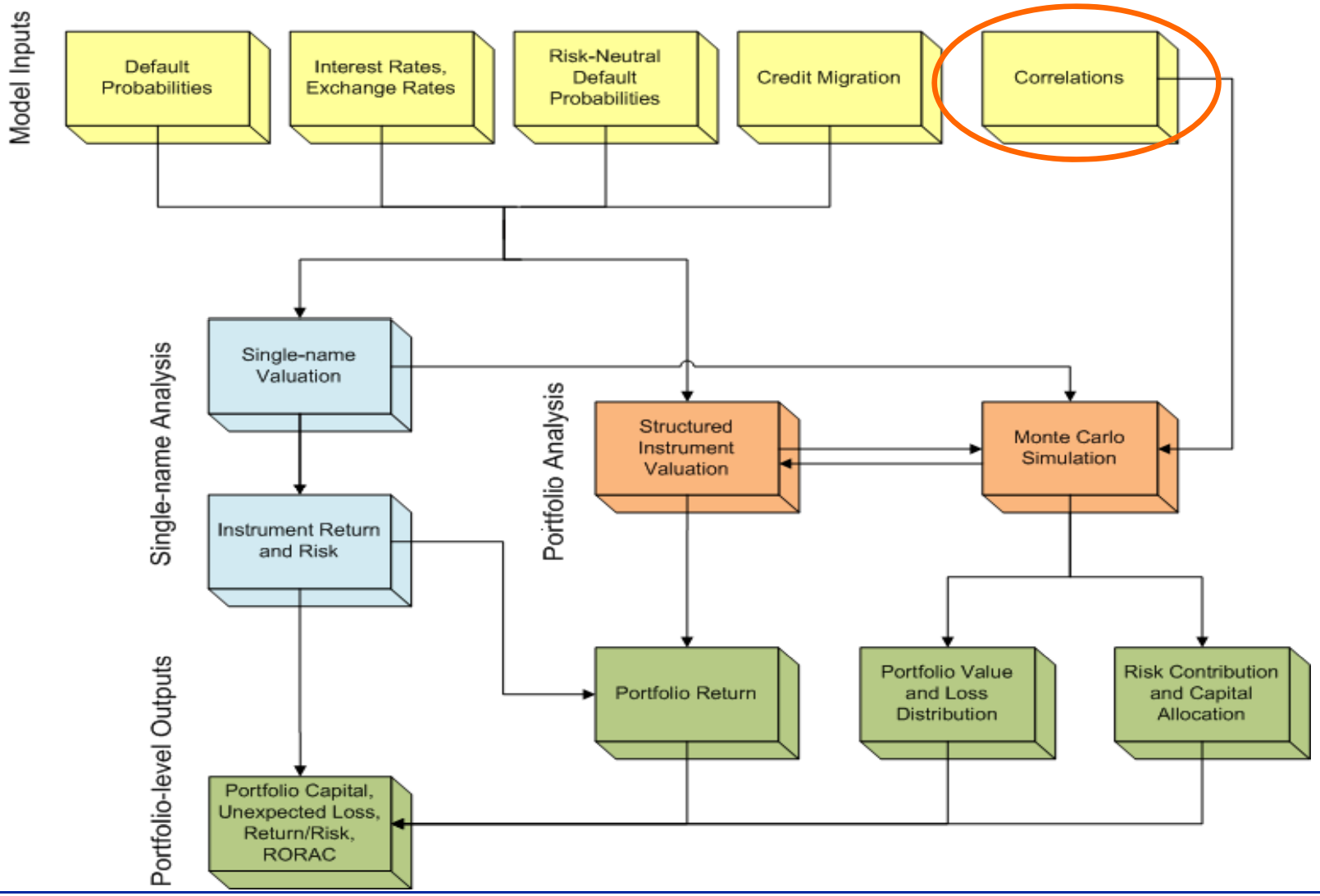


Different portfolio segments will generate different loss distributions – how to integrate to produce a single, consolidated view of risk?

Key Drivers of the Distribution

- PD
- LGD
- Credit Migration
- Other facility characteristics: coupons, optionality
- Concentration
- Correlation

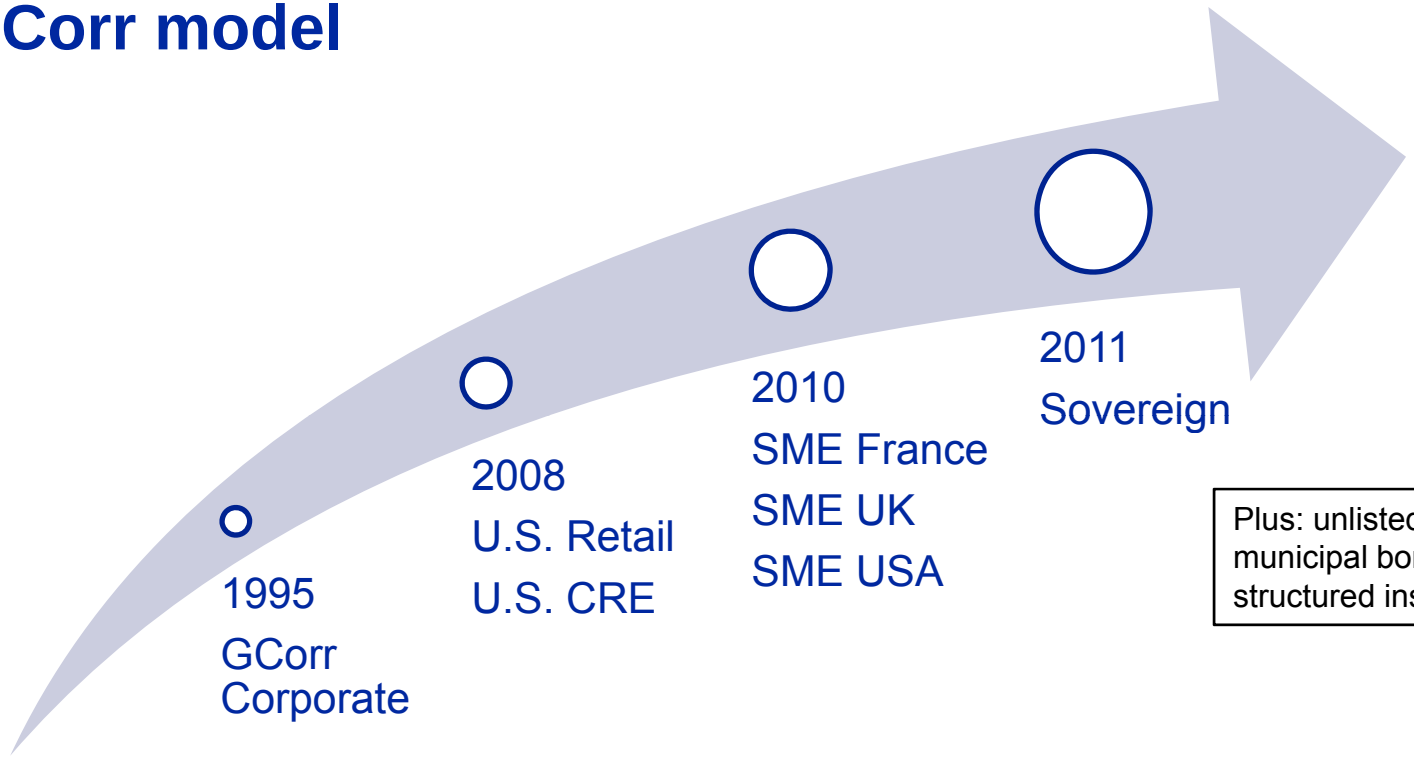
Credit Portfolio Modeling: The Big Picture



What is GCorr?
GCorr – Global Correlation Model

- Moody's Analytics has developed a factor model for estimating correlations among borrowers' asset returns:
  - GCorr estimates these asset correlations for several asset classes: corporate (listed firms), Retail, CRE, unlisted firms including SMEs.
  - Asset correlations for sovereigns, municipal bonds, and structured instruments can be also estimated by utilizing GCorr.
- In the Moody's Analytics portfolio modeling framework, asset returns are interpreted as a proxy for changes in the borrower's credit quality.
- GCorr can be used to estimate a portfolio value distribution at a future horizon:
  - Using the GCorr factor structure, correlated asset returns are simulated.
  - The asset returns determine firms' new credit qualities at the horizon, including whether they have defaulted.
  - The credit qualities imply values of the instruments in portfolio at the horizon.
  - Instrument values are aggregated to get the portfolio value distribution.

Moody's Analytics is continuing to expand the GCorr model



» GCorr – a multi-factor model of correlations among borrowers' asset returns.

» GCorr Corporate – a forward-looking multi-factor model of asset correlations among about 42,000 listed firms from over 70 countries and a wide range of industries.

Business benefits to clients

Benefits of a correlation model which accounts for the portfolio type and asset class:

- More appropriate modeling interactions of different asset classes to achieve *improved portfolio VaR* measurements
- Necessary for understanding portfolio *diversification benefits* with the potential to offer capital relief
- Improvement of *capital allocation* amongst facility types to improve:
  - Facility Pricing
  - Addresses *Pillar II requirements*
- Recent market turmoil underscores the importance of evaluating the *interactions* between sub-portfolios and varying asset classes

From a factor model of asset returns to asset correlations

» In GCorr, the asset return of a borrower *k*, r_k, is broken down into two components:

$$r_k = \sqrt{RSQ_k}\,\phi_k + \sqrt{1-RSQ_k}\,\varepsilon_k$$

Systematic component

Idiosyncratic component

In this setup, ϕ_k and ε_k are independent random variables with a standard normal distribution.

» ϕ_k – custom index for borrower *k*. In GCorr, each borrower has its own custom index which is composed of multiple systematic factors.

» RSQ_k – R-squared of borrower *k* – proportion of the asset return r_k explained by the systematic factors

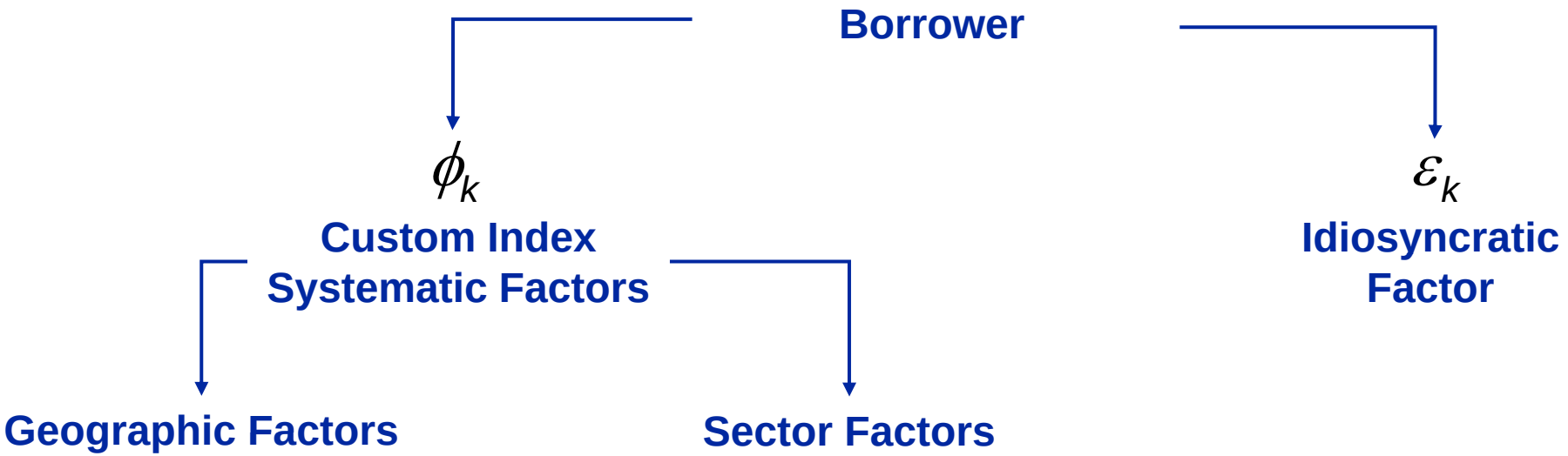
» Given the assumptions, the asset correlation between firms *i* and *k* is:

$$corr(r_i, r_k) = \sqrt{RSQ_i}\sqrt{RSQ_k}\,corr(\phi_i, \phi_k)$$

⇨ In this factor model, asset correlations are given by two sets of inputs: R-squareds and custom index correlations.

GCorr factor structure

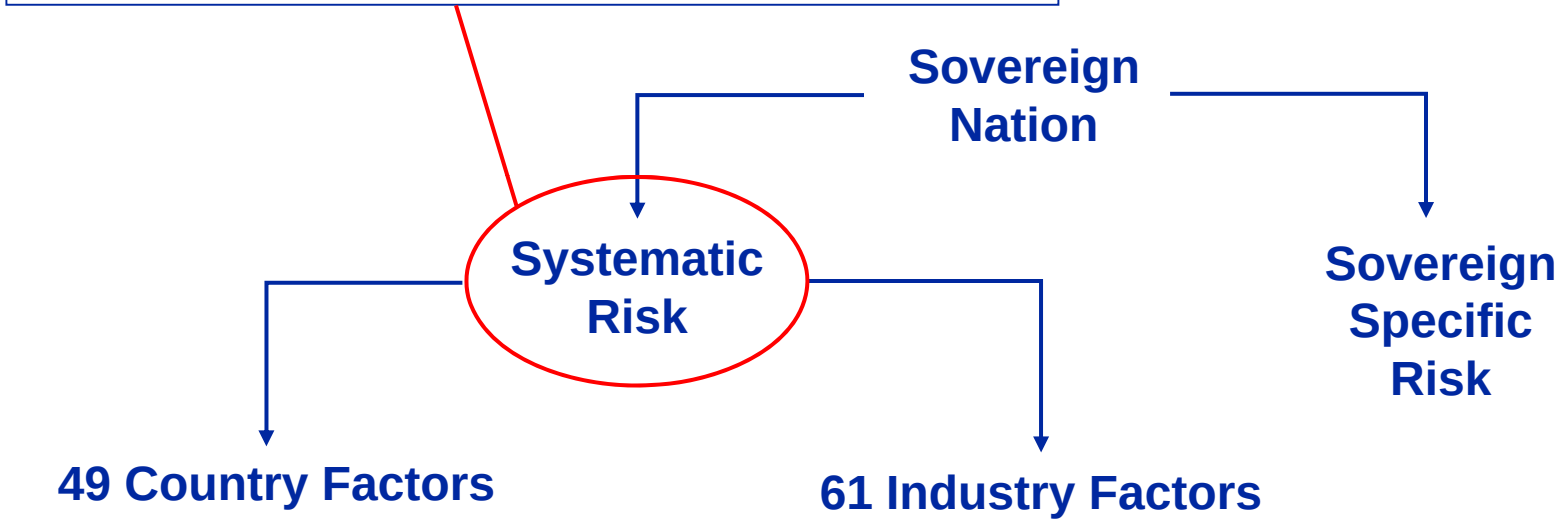
$$r_k = \sqrt{RSQ_k}\,\phi_k + \sqrt{1-RSQ_k}\,\varepsilon_k$$



- Two borrowers are correlated only through their exposures to the systematic factors.
- The GCorr factor structure
  - captures the intra- as well as the inter- asset classes correlations, and
  - can be used for all major asset classes: Corporates (public and private), CRE, Consumer Credit, Sovereigns, and Structured Instruments.

Decomposing a sovereign borrower's credit risk

$$\phi_j = \sum_{i=1}^{61} w_i^{Sov_j} r_i^{Industry} + \sum_{k=1}^{49} w_k^{Sov_j} r_k^{Country}$$



» The weights $w_i^{Sov_j}$ {i =1 to 61} are the sovereign *j*'s industry weights and they are determined based on the GDP composition of the region to which the sovereign belongs.

» The weights $w_k^{Sov_j}$ {k =1 to 49} are sovereign *j*'s country weights. These weights are determined by GDP weighting countries from the sovereign's region, with an extra weight put on the sovereign's own country factor.

6 Modeling Sovereign Risk in a Portfolio

Moody's Analytics approach to modeling sovereign correlations

- Utilize sovereign CDS spreads to estimate distance-to-default changes for sovereigns.
  - Estimate correlations among sovereigns using distance-to-default changes over the period June 2008 - July 2010.
- The GCorr model for sovereigns is parameterized to match the levels of correlations implied by the sovereign CDS spreads.
- The estimated sovereign correlations are validated with goodness of fit tests as well as out of sample tests which includes using data from the corporate CDS market.

Strategy for modeling sovereign correlations

Factor Model Approach:

» Enables us to calculate the correlations among sovereigns, and between sovereigns and other asset classes.

Model Building Blocks:

» We integrate sovereigns into the GCorr framework by using the corporate country/industry factors.

» Sovereign R-squareds are calculated so that the modeled correlation on average matches the empirical correlations implied by the sovereign CDS spreads.

» Sovereign R-squareds capture how a sovereign's credit co-moves with the sovereign's country and region fundamentals.

» We define "fundamentals" as the asset returns of corporate firms.

Parameterizing the GCorr model to incorporate sovereign correlations

» GCorr correlation between asset returns of borrowers *j* and *k*:

$$corr(r_j, r_k) = \sqrt{RSQ_j}\sqrt{RSQ_k}\,corr(\phi_j, \phi_k)$$

RSQ_j – R-squared of borrower *j*

ϕ_j – custom index of borrower *j*

» We can solve for the R-squareds using OLS regression:

$$\log\left(\frac{corr(r_j, r_k)}{corr(\phi_j, \phi_k)}\right) = \log(\sqrt{RSQ_j}) + \log(\sqrt{RSQ_k}) + \varepsilon_i = \beta_j 1_j + \beta_k 1_k + \varepsilon_i$$

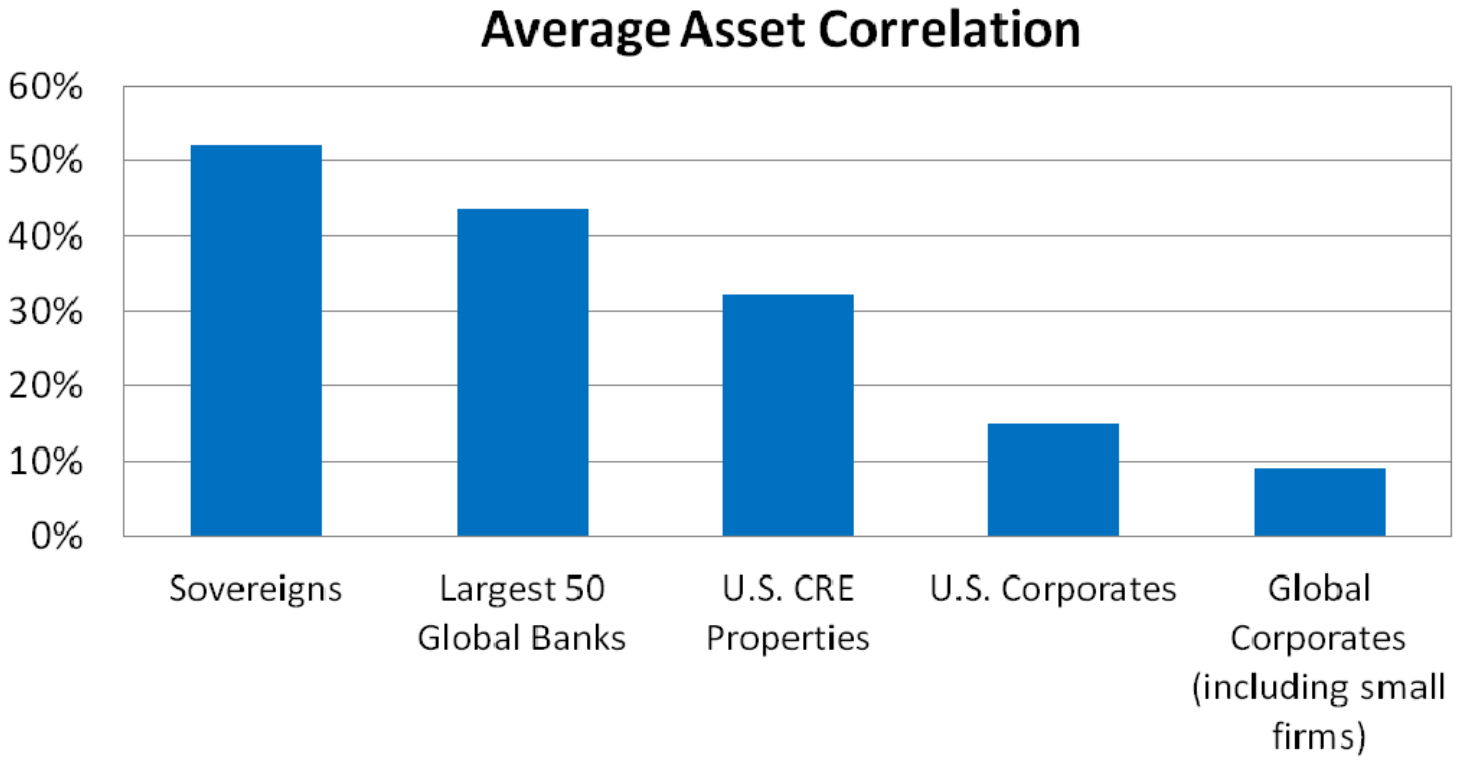
» A sovereign custom index is a weighted combination of GCorr country/industry factors that best describes a sovereign's own country and region.

Empirical and modeled correlations closely match across regions

Regions	1	2	3	4	5
Region 1 (Australia and New Zealand)	72.9% 74.1%				
Region 2 (North America – USA and Canada)	37.4% 41.1%	34.9% 49.1%			
Region 3 (Europe)	47.1% 51.8%	34.0% 42.9%	55.2% 60.2%		
Region 4 (LA EA ME Af)	43.8% 44.3%	31.3% 35.3%	48.3% 45.1%	62.5% ← Empirical Corr. 65.2% ← Modeled Corr.	
Region 5 (Japan)	52.1% 47.9%	28.3% 34.5%	49.6% 46.3%	55.0% 42.9%	100.0% 100.0%

- Empirical Correlation: Average of $corr(r_j^{SOV}, r_k^{SOV})$ across pairs of sovereigns from the region.
- Modeled Correlation: Average of $\sqrt{RSQ_j}\sqrt{RSQ_k}corr(\phi_j^{SOV}, \phi_k^{SOV})$ across pairs of sovereigns from the region.

Sovereign's exhibit high levels of systematic risk



» The average level of sovereign correlations is higher than the average correlation of other asset classes.

Corporate CDS data was used to validate the sovereign R-squared estimates

- Including corporate CDS data directly into estimation of sovereign R-squareds:
  - The estimates of sovereign R-squareds do not substantially differ from the original ones.
- Out-of-sample comparison with corporate CDS:
  - The sovereigns that are highly correlated with other sovereigns tend to also be highly correlated with corporates.
- Purpose of the tests: “Are the sovereign correlation estimates robust for a portfolio consisting of both sovereign and corporate exposures?”

7 Implications

Methodology: key features

- By extracting the physical PD from CDS spreads we are able to compare the credit risk of sovereigns on a level playing field with corporates and financial institutions.
- Sovereign CDS-I EDFs provide a dynamic risk assessment for sovereigns which can complement rating-based approaches.
- The correlation methodology integrates the sovereign CDS data and the GCorr factor model.
- It allows portfolio managers to more accurately assess concentration and correlation among sovereign exposures as well as across their portfolio.
- Our approach of modeling sovereign risk allows for portfolio wide stress testing.

Implications

- Sovereigns exhibit high levels of systematic risk and can be highly correlated with other asset classes – important considerations for portfolio credit risk management.
- There is considerable variation in correlation levels across countries.
- Using one fixed correlation level for all sovereigns is not prudent.