Stress Testing Tail Risk:
From Expectations to Realizations.

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WHAT'S KEEPING INSTITUTIONAL INVESTORS UP AT NIGHT?

71% believe it is likely or highly likely a SIGNIFICANT TAIL RISK EVENT will occur in the next 12 months

WHAT WILL BE THE CAUSE?

Macro worries dominate investors' sleepless nights

36% The global economy falls into recession

35% Europe slips back into recession

29% Greece exits the Euro

21% US slips back into recession

33% The Eurozone breaks up

Source: Economist Intelligence Unit survey of US and European institutional investors

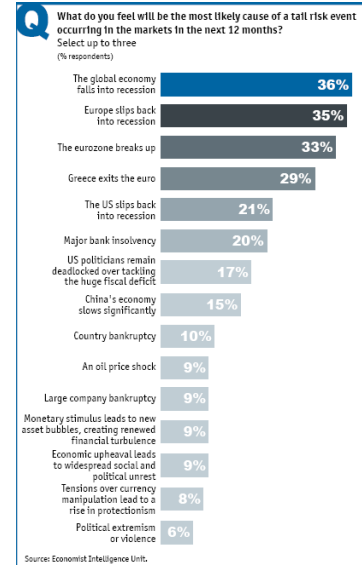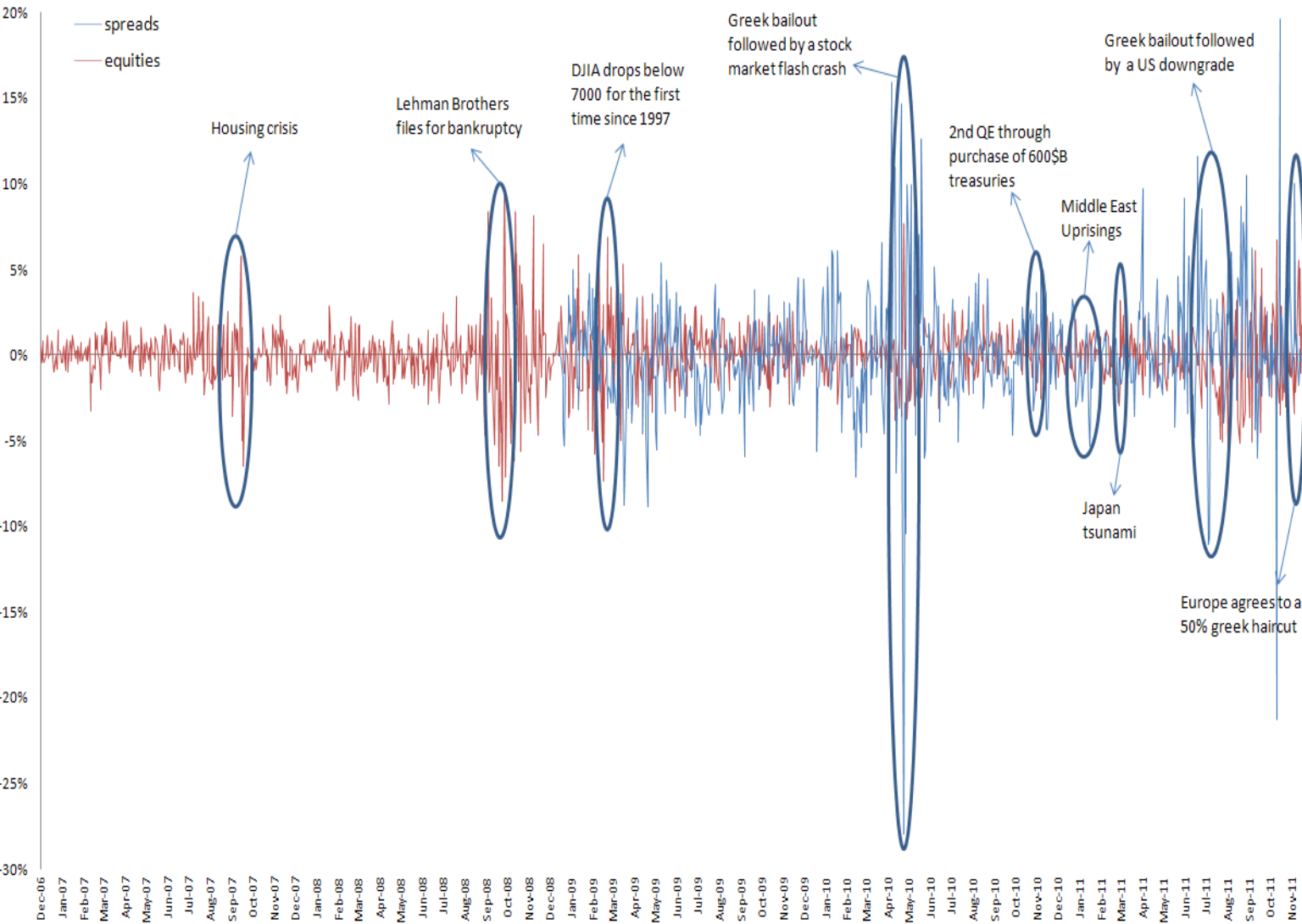## IF ANY OF THESE EVENTS HAPPENS...

WHAT WOULD BE MY LOSS?

Introduction

- **The accumulation of (external) debt in Europe in combination with lack of bank funding has resulted in a continuously unfolding crisis that has spread worldwide**

- **There has already been a Greek restructuring and fear exists of one or more defaults from other Euro-zone countries**

- **We develop models to provide a qualitative and quantitative treatment of such potential defaults**
  - **assuming no exit from the EU or a EUR breakup**

- **Our results target <u>extreme events</u> and follow a combination of historical, intuitive and modeled scenarios**

- **The question we are trying to answer is:**

  "What would be the impact of one or more EU Periphery defaults to the global markets

A brief history

WHAT's NEXT?

What Impact those macro views could have on my portfolio ?

Macroeconomic variables

Economic Growth

- USA and China GDP expanded in last two quarters and growth forecast is positive..

- ..while core EU countries, Brazil and India are in recovery mode..

- ..eastern and periphery Europe leads economic slowdown

- Expansion – CLI is increasing and above 100 for last quarter
- Downturn – CLI is decreasing but above 100 for last quarter
- Slowdown – CLI is decreasing and below 100 for last quarter
- Recovery – CLI is increasing but below 100 for last quarter
- China Q1 2012 had a 1.8% QOQ growth while UK and Spain would join the countries under recession with two consecutive negative quarters
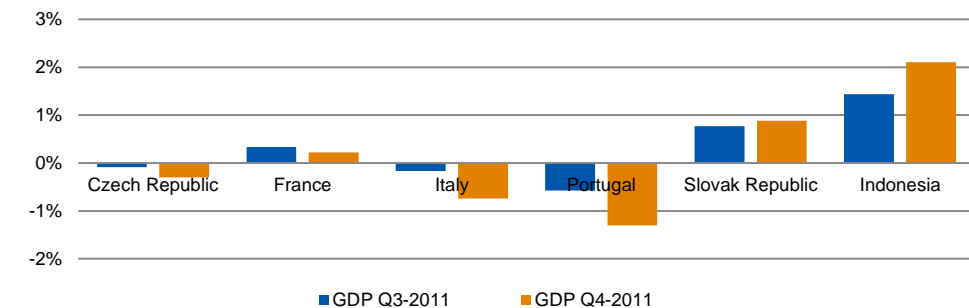
Expansion
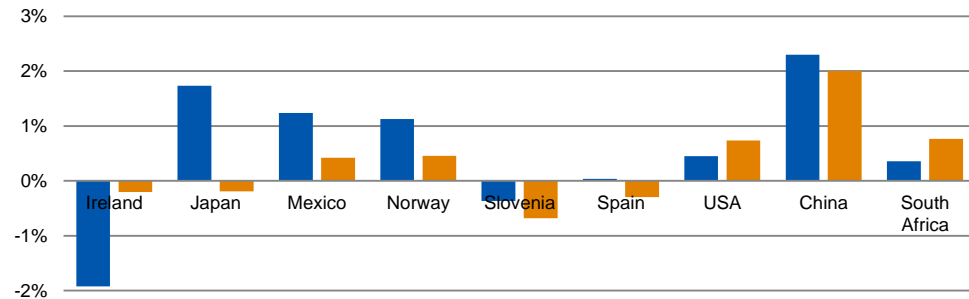
Recovery
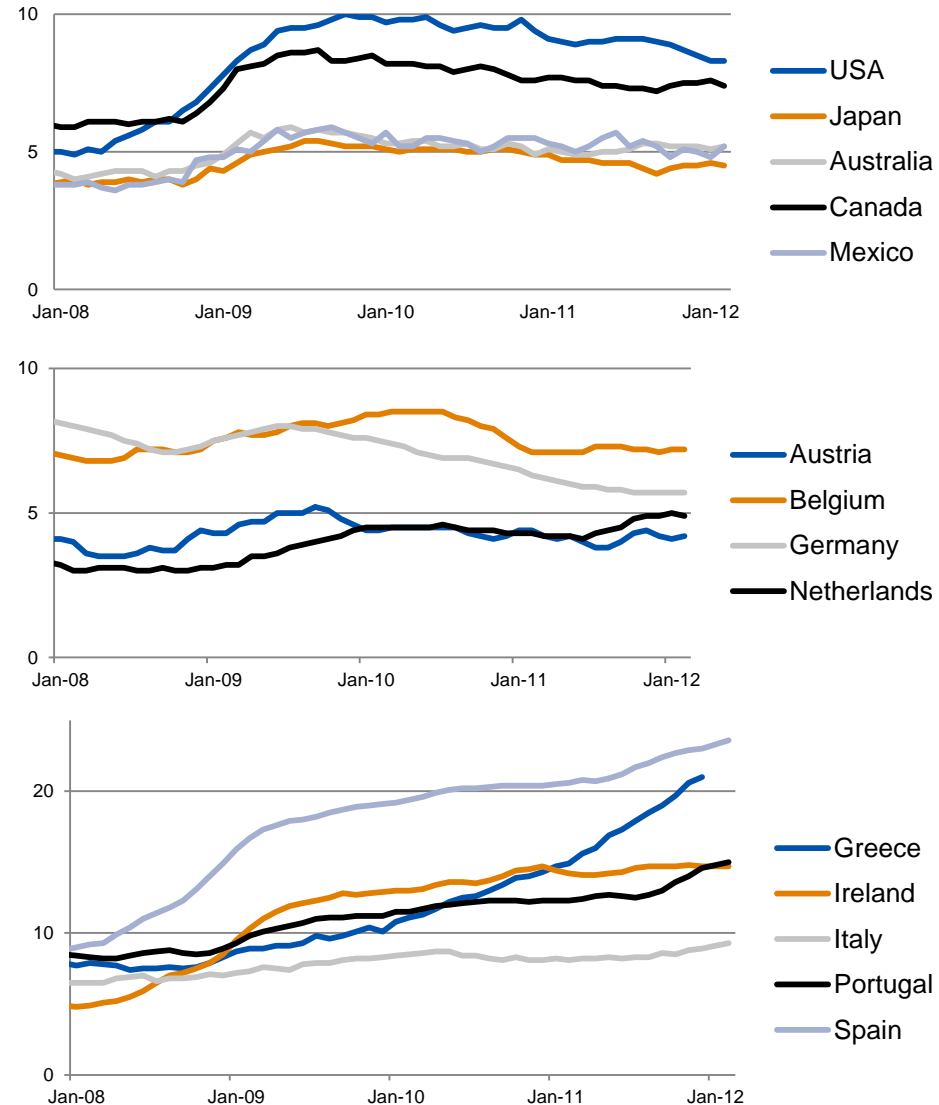

Slowdown

■ GDP Q3-2011   ■ GDP Q4-2011
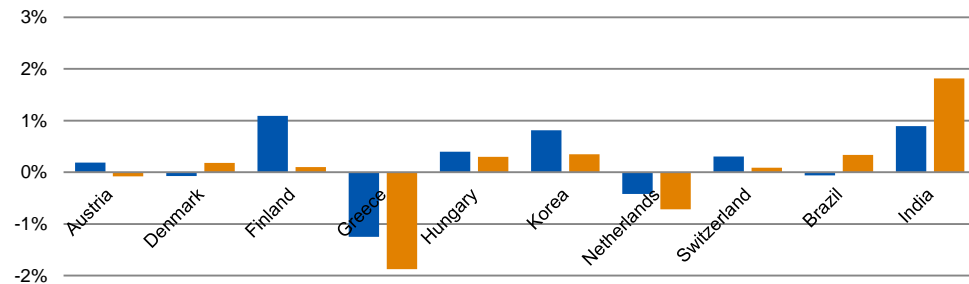
Source: OECD, REUTERS, SSIA calculations

Unemployment

- has stabilized for USA, central European and other countries..

- ..while it becomes even more elevated in the European periphery

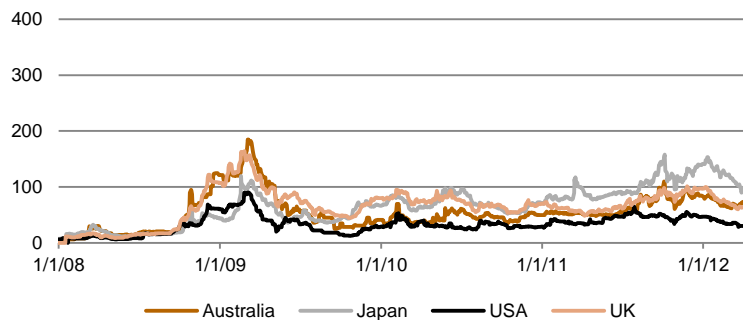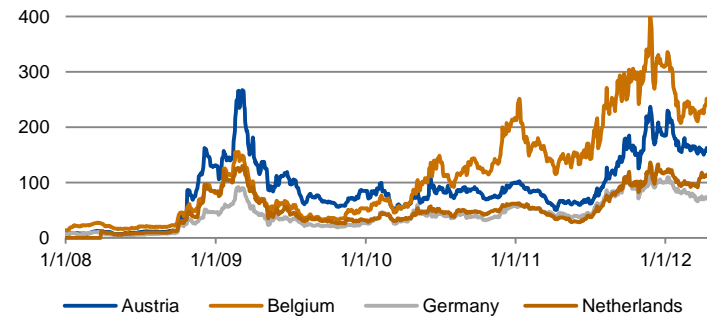**Monthly harmonized unemployment rate (in %, as of Feb-29)**

Source: OECD

Sovereign Default
(5YR CDS Spreads)

- Developed countries perceived to be out of risk
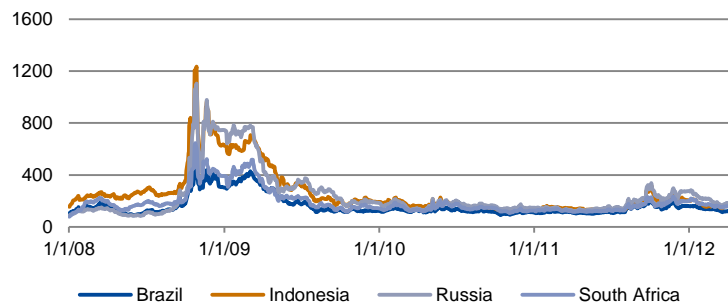- While emerging markets have stabilized

- Central Europe seems to be out of trouble
- But default risk in the periphery remains high

Developed

EU Central

Emerging markets

EU Periphery

Source: Fitch

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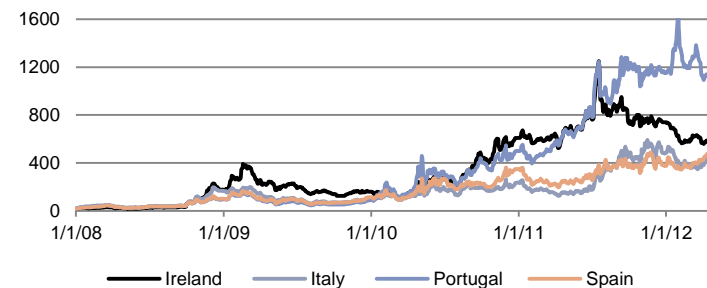
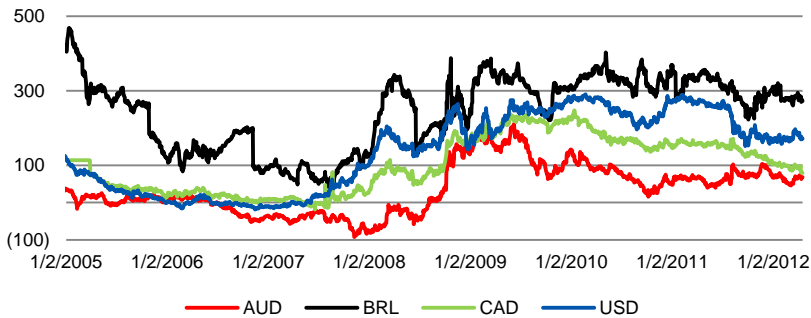# Interest rates

Term Spread (10YR – 2YR)

- Term structure remains steep overall
- Largest decrease for Canada and UK
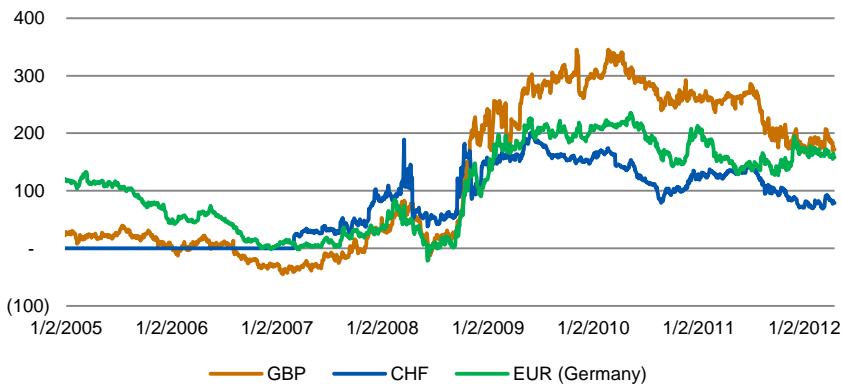
Libor-OIS spread (3month)

- Developed countries see no bank refinancing issues
- Europe's bank are doing much better due to LTRO

Rest of the world

Rest of the world

Europe

Europe

Source: Reuters, Bloomberg

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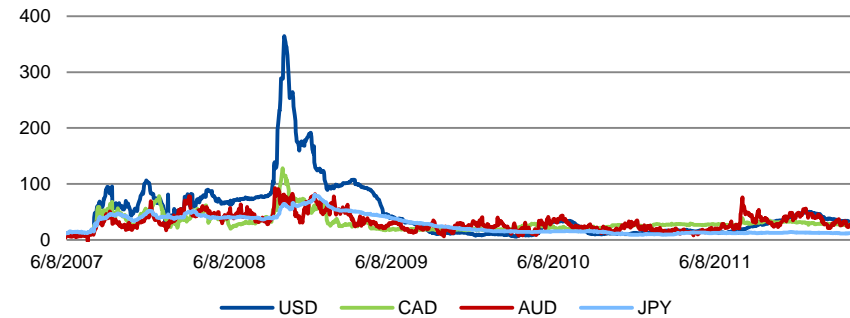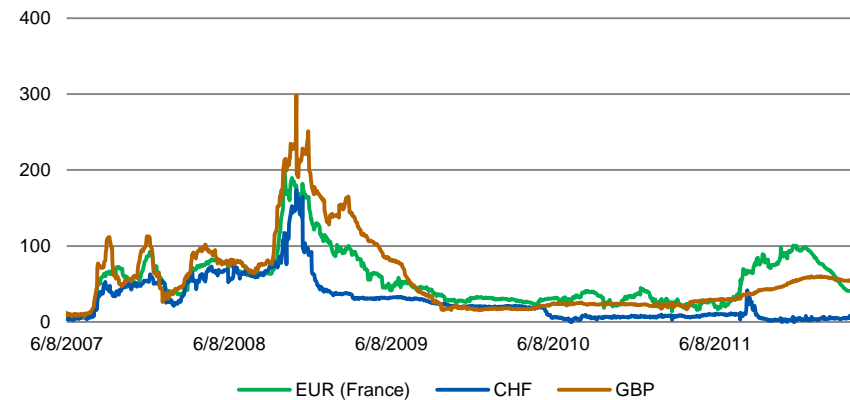
Commodities, fx, vols

Commodities

- Gold has stabilized the last four months reflecting 'risk on' by investors

- Energy is moving higher relative to other commodities reflecting supply concerns and increased business activity

- Equity volatility drops, USD and EUR FI volatilities remain steady while EUR/USD fx volatility has dropped

- USD/JPY carry unwinds while EUR/USD has gained some momentum

FX rates

Volatilities

Source: Reuters, Icap, Bloomberg
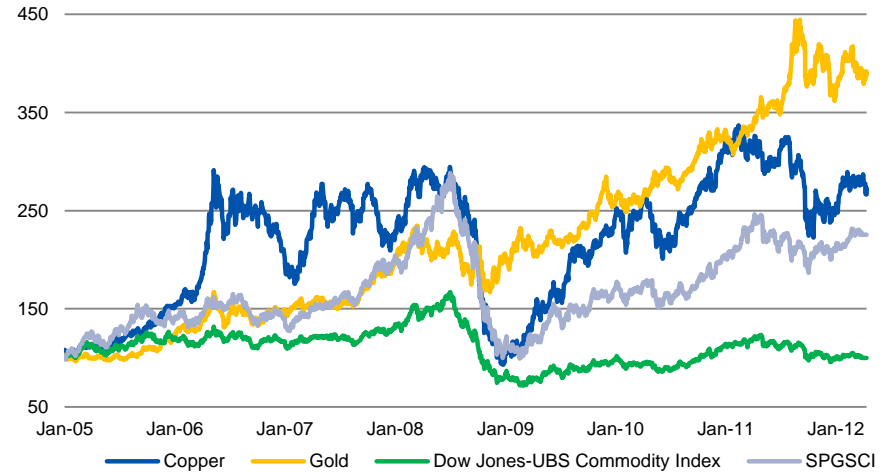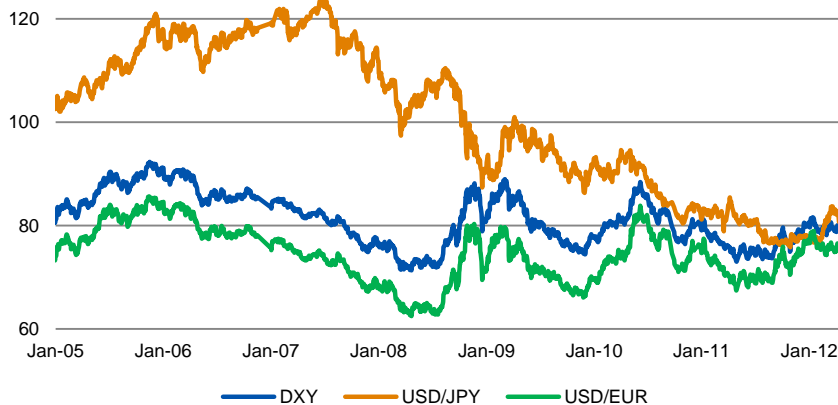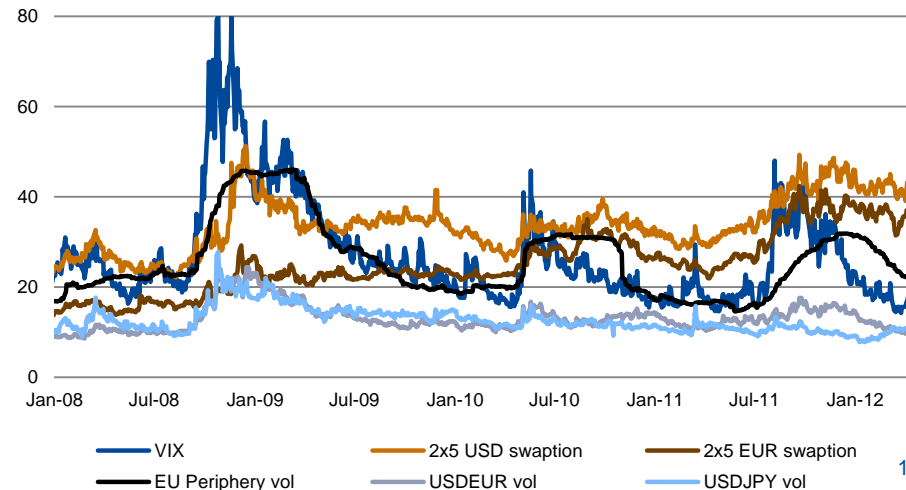
Stock markets

- USA and emerging markets have reached pre-crisis levels

- We observe a large decoupling between South and central European markets since the European crisis began

- The average correlation between EU Periphery and developed markets remains high

USA and Europe

Legend: EU Periphery — EU Central — Russell 2000 value — Russell 2000 growth — S&P 500

**Average Correlation
EU Periphery - World
(monthly over 2 years)**

Rest of the world

Legend: MSCI EM — MSCI EM Latin America — FTSE XINHUA CHINA A 50 — Russian RTS
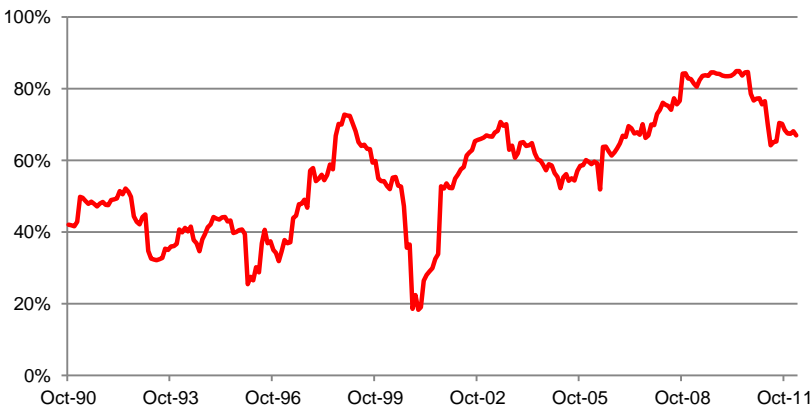
Source: Reuters, Bloomberg, SSIA calculations
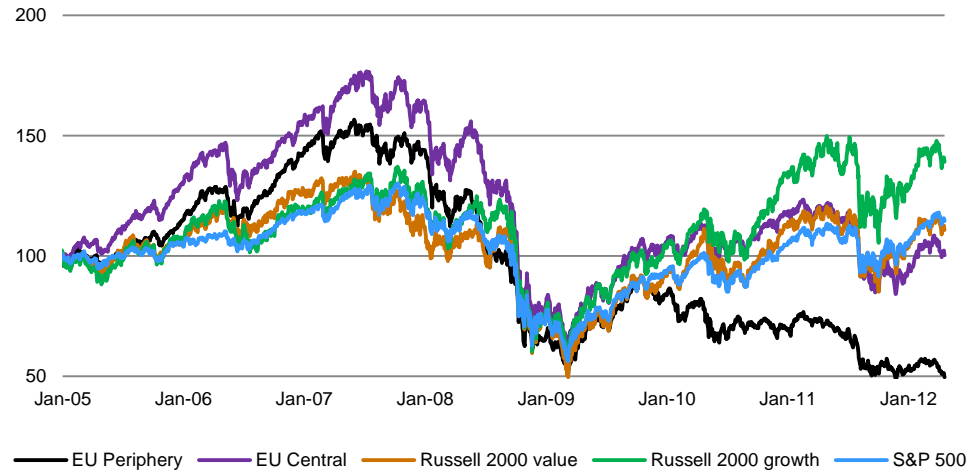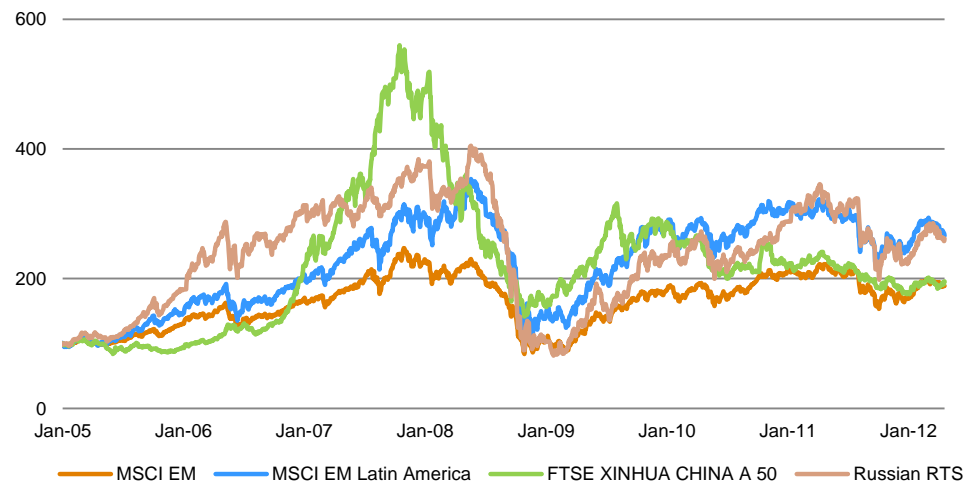
Model Setup

Economic scenarios

Simulation

Scenarios

Global satellite models
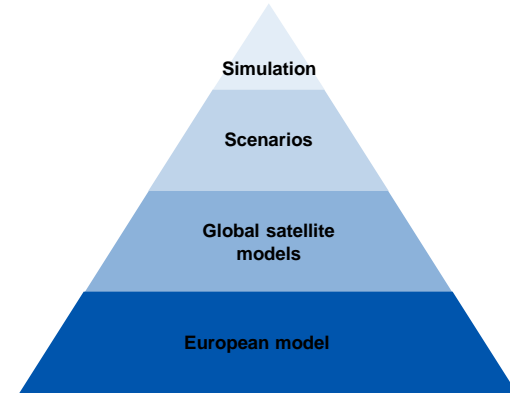
European model

European model
We develop a forecasting model that allows for feedback effects between the EU periphery and central EU

Global satellite models
We develop satellite regression models that link the above factors with major market indices and global key rates

Scenarios
We shock the model and other factors using intuitive scenarios
We calculate scenarios for key global variables using the above factors and satellite models
We propagate the shocks to all other rates through univariate regressions

Simulation
We simulate the portfolio to calculate P&L

European model key factors

- Unless otherwise stated, the below factors are calculated based on averages between EU Periphery countries and central EU
  - EU Periphery: Ireland, Portugal, Spain, Italy, Greece
  - Central EU: Belgium, Netherlands, Germany, Austria

- Economic Sentiment Indicator (ESI)
  - Composite indicator made up of five sectoral confidence indicators with different weights: Industrial, Services, Consumer, Construction, Retail trade
  - Source: Eurostat

- Harmonized Unemployment
  - Compiled from sample household surveys on a monthly basis following standard methodology across countries
  - Source: OECD

- Industrial Production Index (IPI)
  - Proxies for GDP growth
  - Source: OECD and national statistical agencies

- Stock Index
  - Based on major local country indices
  - Source: OECD

- Interest Rate Spread
  - Spread between average 10 year treasury note of EU Periphery and central EU
  - Proxies for sovereign credit risk
  - Source: Reuters and SSIA calculations

- TED Spread
  - Spread between 3 month Euribor and 3 month French bill. Proxies for bank financing.
  - Source: Bloomberg and SSIA calculations

Back-testing key factors

Setup

- 16 years rolling estimation window

- 1 month out of sample returns

- 3 years monthly out of sample period

Results

- VAR has a better hit ratio (sign of change) than satellite regression in 6 out of 8 variables

- Mean square error improvement in VAR occurs in as many variables as it does in satellite regression but it's more consistent

* Hit Ratio is defined as the percent of cases where the predicted sign of change matches the actual one

Hit Ratio

Legend: VAR base forecast, VAR shocked forecast, Satellite shocked forecast

Categories: Stock Central, Unemployment Periphery, Unemployment Central, ESI Periphery, ESI Central, IPI Periphery, IPI Central, TED Spread
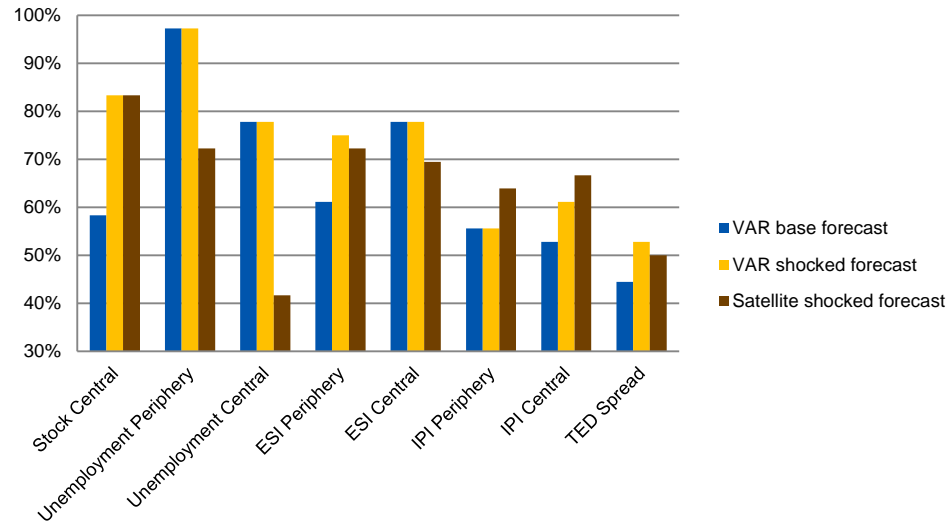
Mean Square Error Change vs Base Forecasts

Legend: VAR shocked forecast, Satellite shocked forecast

Categories: Stock Central, Unemployment Periphery, Unemployment Central, ESI Periphery, ESI Central, IPI Periphery, IPI Central, TED Spread

Source: SSIA calculations

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Back-testing all indices

Setup

1. Use monthly data for recent high correlation period
   - Jan 2008 to Sep 2011

2. Run stepwise regression between a variety of market indices and rates and the full set of contemporaneous and lagged key factors

3. Perform rolling regressions using a 3 year estimation window for the high correlation period

Results

- We shock only variables where hit ratio exceeds 60%

- Overall we get a significant number of variables with high hit ratios
  - We only accept stepwise if it improves the hit ratio, otherwise we use all variables to calculate the shocks

- For these variables we observe that the mean square error largely improves using stepwise regression

- Performance using the high correlation period is better than using the last 10 years as expected

Hit Ratio
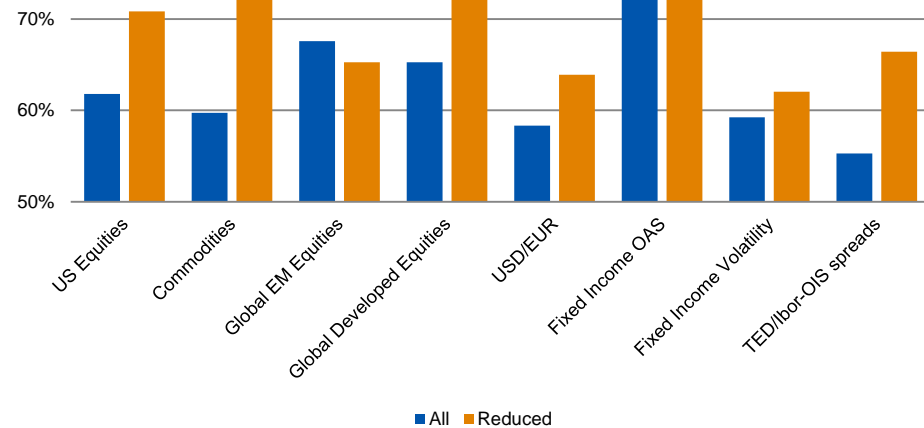
Mean Square Error Change
Vs using all variables

Source: SSIA calculations

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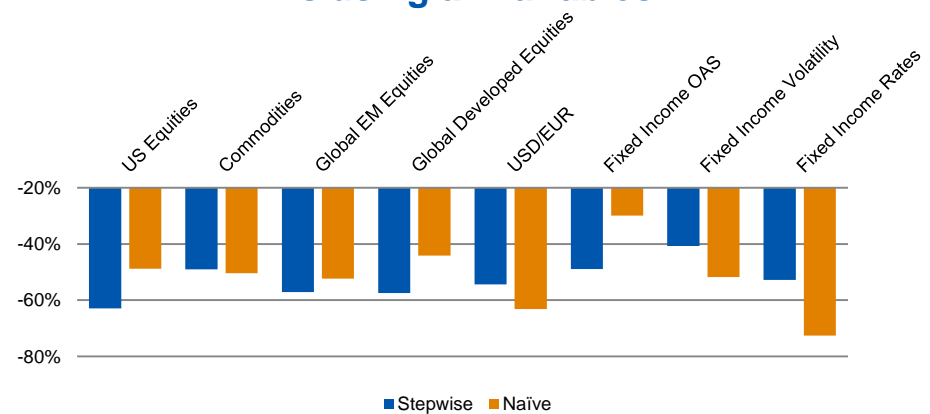
Results

The case of EU Periphery default

- EU Periphery finds it hard or impossible to borrow
  - Peripheral yield spreads widen

- Banks suffer mark to market losses and face severe financing constraints
  - TED and Libor-OIS spreads widen
  - Bank stocks fall more than the market

- Corporate credit risk increases

- Investors place their money in safe assets
  - US and German 10YR Treasury bonds, gold gain value
  - Global equities drop

- Markets become nervous
  - Volatilities increase
  - Economic sentiment drops

- Companies cut down on production and fire staff
  - Growth turns negative
  - Unemployment increases
  - Most commodity prices fall due to reduced demand

Input Scenarios & Assumptions

Index	Spain default	All default
Ibex 35	-20%	
All EU Periphery stock indices except Spain	-10%	
EU Periphery stock indices		-30%
DJ Euro Stoxx Bank	-20%	-50%
Global equity volatilities	100%	300%
Spain 5 year CDS spread	10,000bp*	
EU Periphery 5 year CDS spread		10,000bp*
Global sovereign CDS spreads	100%	200%
EU TED spread	100bp	200bp
EUR/USD	-10%	-15%

% shocks are multiplicative, bp additive, * indicates the value after the stress test

Scenario Results

- Modeled scenarios are consistent with expectations

- EU Periphery suffers more than central

- The case for all defaults consistently shows larger scenarios

- Emerging markets are projected to fall more than developed

- US growth stocks underperformed value stocks, consistent with the recent Lehman crisis

* During one default the EU Periphery spread jumps by 55bp, found by regressing against the EU Periphery CDS spread. During all defaults they jump by 267bp.

Key factors
(European model)

■ All default ■ Spain default

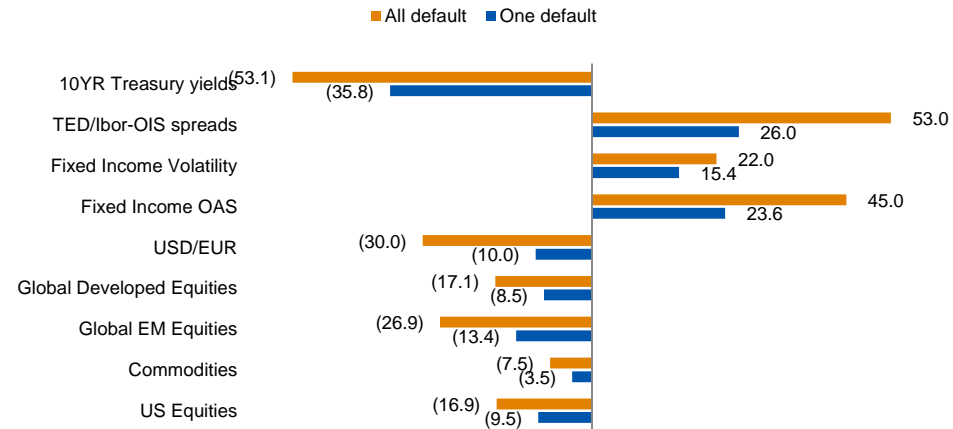| Factor	All default	Spain default
IPI Central	(0.7)	(0.3)
IPI Periphery	(0.7)	(0.4)
ESI Central	(1.8)	(0.9)
ESI Periphery	(2.0)	(0.8)
Unemployment Central	0.7	0.6
Unemployment Periphery	1.4	1.0
Stock Central	(26.0)	(16.3)
Stock Periphery	(30.0)	(19.0)

All indices
(Satellite models)

■ All default ■ One default

Index	All default	One default
10YR Treasury yields	(53.1)	(35.8)
TED/Ibor-OIS spreads	53.0	26.0
Fixed Income Volatility	22.0	15.4
Fixed Income OAS	45.0	23.6
USD/EUR	(30.0)	(10.0)
Global Developed Equities	(17.1)	(8.5)
Global EM Equities	(26.9)	(13.4)
Commodities	(7.5)	(3.5)
US Equities	(16.9)	(9.5)

Shocks to interest rates and spreads are displayed in bp, additive
All others are in %, multiplicative
Source: SSIA calculations

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Appendix

- Bayesian VAR (vector autoregressive) model: $Y_t = c + A_1 Y_{t-1} + \ldots + A_p Y_{t-p} + \varepsilon_t$
  - $Y_t = (Y_{1t}, \ldots, Y_{Kt})'$ is a (K x 1) random vector of economic and financial factors
  - A is a fixed (K x K) coefficient matrix
  - $c = (c_1, \ldots, c_K)$ is a fixed (K x 1) vector of intercept terms allowing for the
  -   possibility of non zero mean E(yt)
  - $\varepsilon_t = (\varepsilon_{1t}, \ldots, \varepsilon_{Kt})'$ is a K-dimensional white noise process
  - p = number of lags, we used p=13
  - The time period covers 20 years monthly history up to April 2012
  - The latest 1-2 months of economic factors are based on economist predictions or other economic time series

- Benefits
  - Preserves long run relationship between variables
  - No need for an economic theory to explain market movements
  - Good for analyzing the joint dynamics of a set of series

- Challenges
  - Economic data only available monthly with lags
    - Limits amount of data that can be used
    - Bayesian prior used to improve forecasts
  - Too many free parameters
    - Goes up with the square of number of variables
  - Short term economic forecasts are highly volatile

Appendix

- ## *Significant* Satellite Models

  - US Equities
    - Russell 1000 and Russell 1000 growth & value
    - Russell 2000 and Russell 2000 growth & value
    - Russell 3000
    - S&P 500

  - Commodities
    - S&P GSCI
    - Dow Jones UBS
    - Gold

  - Global EM Equities
    - MSCI EM small cap value
    - MSCI EM Latin America
    - MSCI EM
    - Brazil Bovespa
    - FTSE Xinhua China
    - Russian RTS

  - Global Developed Equities
    - MSCI EAFE Growth
    - MSCI EAFE
    - MSCI Europe
    - Topix
    - MSCI Canada
    - MSCI Australia
    - S&P TSX
    - S&P ASX 200

  - Fixed Income OAS
    - Barclay's Capital Corporate High Yield OAS

  - Fixed Income Volatility
    - 2x5 ATM AUD,CHF,EUR swaption volatility

  - TED/Libor-OIS spreads
    - 3 month JPY TED
    - 3 month JPY,GBP,AUD,USD Libor-OIS

  - 10 Year Treasury Yields
    - AUD,EUR,USD

Appendix

- ## Non *Significant* Satellite Models

  - Fixed Income OAS

    - o Barclay's Capital Corporate High Yield OAS

  - Fixed Income Volatility
    - o 2x5 ATM USD,JPY swaption volatility
    - o 2x5 ATM CHF swaption volatility

  - TED/Libor-OIS spreads
    - o 3 month AUD,CHF,GBP TED
    - o 3 month CAD,CHF Libor-OIS

  - 10 Year Treasury Yields
    - o BRL,CAD,CHF,GBP,JPY

  - Term Spreads

    - o AUD,CAD,GBP,JPY

  - FX

    - o DXY