Cambridge Judge Business School

Cambridge Centre for Risk Studies 2017 Risk Summit

CAN NATURAL CATASTROPHES IMPACT FINANCIAL MARKETS?

Who Quaked the Markets?

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Centre for Risk Studies

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Research Questions & Scenarios

Research Questions:

1. What are the macroeconomic impacts of natural disasters such as earthquakes, hurricanes and volcanic eruptions?
2. To what extent do these natural catastrophes affect financial and capital markets?
3. What are the financial impacts of such disaster events on standardized portfolios and investments?

Six Nat-Cat Scenarios:

- Earthquake
  - Los Angeles, USA (EQ-LA)
  - Tokyo, JPN (EQ-TKY)
- Hurricane
  - Florida, USA (HU-FL)
  - New Jersey, USA (HU-NJ)
- Volcano
  - Mt. Marapi, IDN (VO-MA)*
  - Mt. Rainier, USA (VO-RA)*

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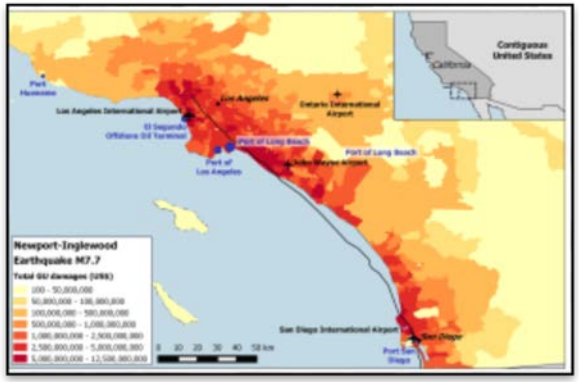
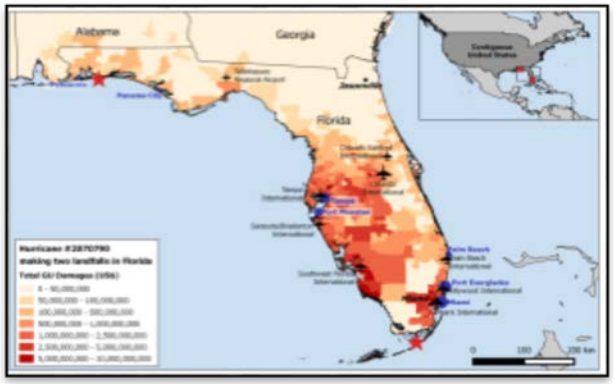
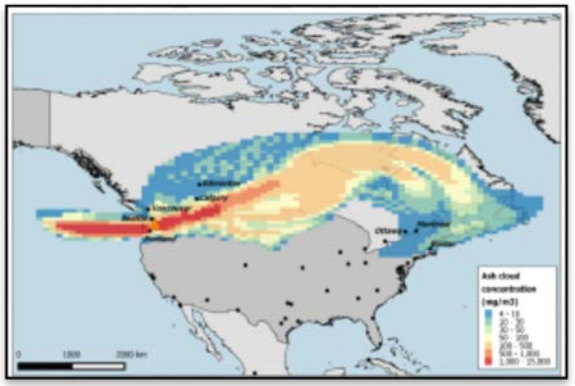
Six ‘Trillion Dollar NatCat’ Events



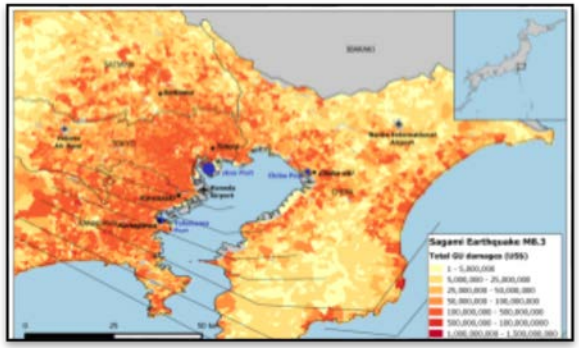
Earthquake M7.7 Los Angeles
GU Loss: $863 Bn
Global GDP Loss: $3.6 Trillion
RP: 1,100 yrs



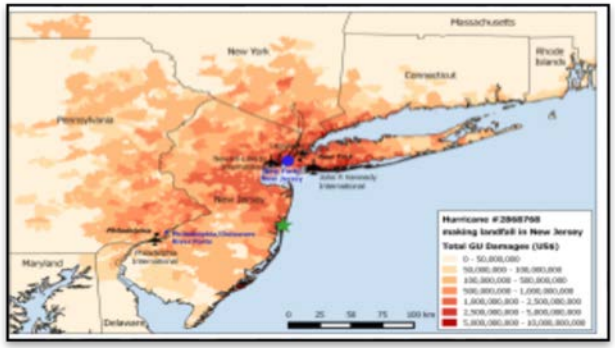
Hurricane CAT 4 Florida
GU Loss: $1,350 Bn
Global GDP Loss: $2.4 Trillion
RP: 1,200 yrs



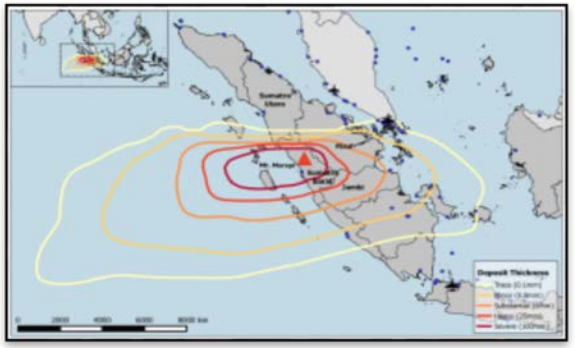
Volcano VEI VII Mt Rainer, Seattle
GU Loss: $1,100 Bn
Global GDP Loss: $6.3 Trillion
RP: 3,000 yrs



Earthquake M8.3 Tokyo, Japan
GU Loss: $1,368 Bn
Global GDP Loss: $1.6 Trillion
RP: 1,400 yrs



Hurricane CAT 4 New Jersey
GU Loss: $1,150 Bn
Global GDP Loss: $3.6 Trillion
RP: 1,150 yrs



Volcano VEI VII Mt Marapi, Indonesia
GU Loss: $493 Bn
GDP Loss: $2.5 Trillion
RP: 750 yrs

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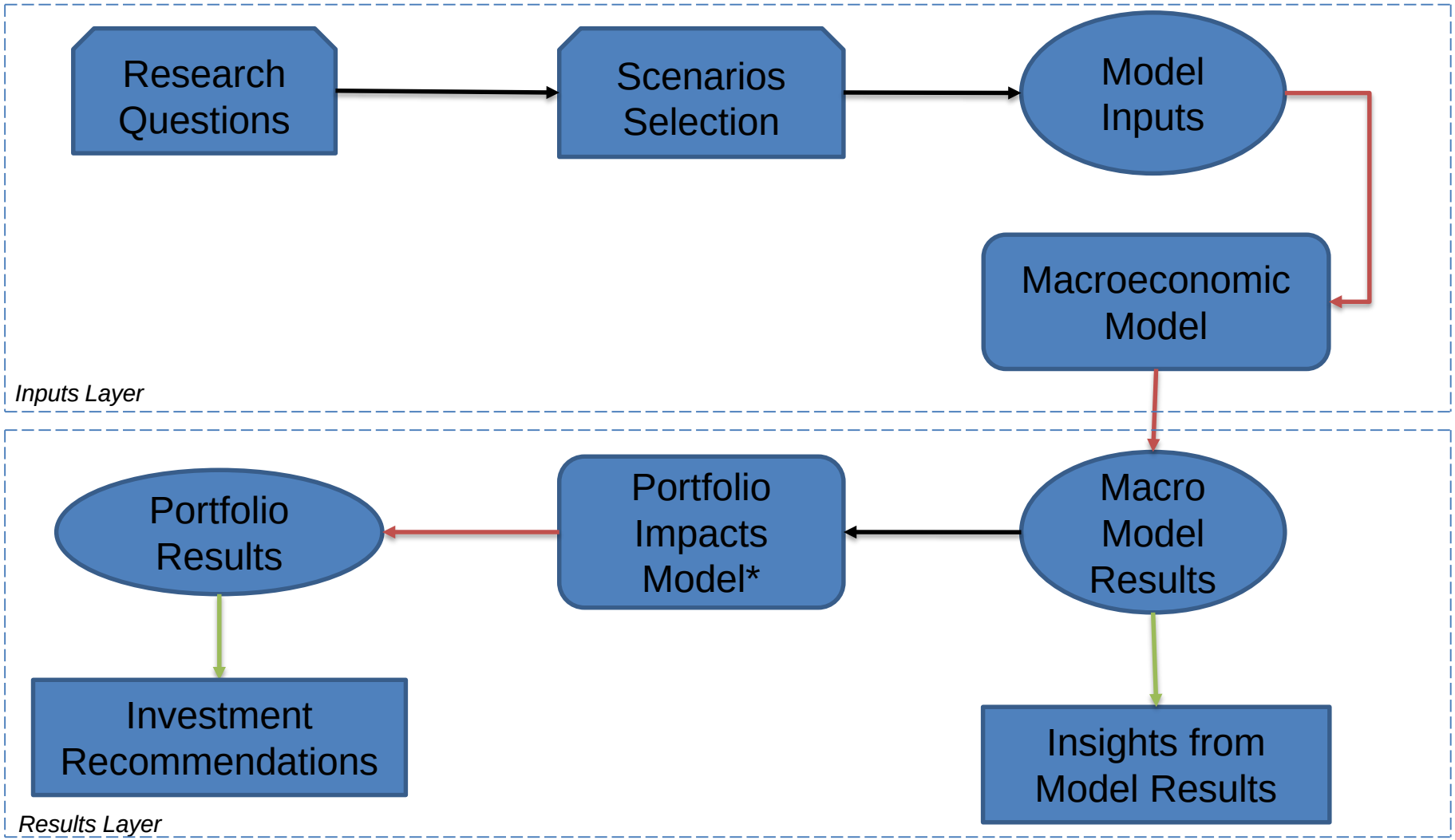
Modelling Framework



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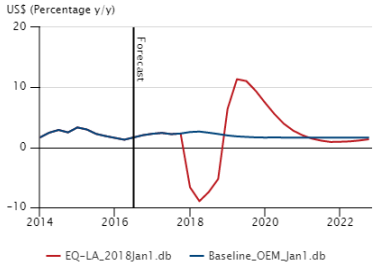
* CCRS in-house model

Macroeconomic Model Inputs

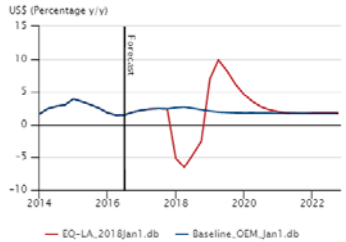
	Variable	EQ-LA	EQ-TKY	HU-FL	HU-NJ	VO-MA	VO-RA
Consumption	**C**						
United States		-11%		-17%	-14%		-16%
Japan			-21%				
Indonesia						-8%	
Potential Output	**YHAT**						
United States		-11%		-17%	-14%		-16%
Japan			-21%				
Indonesia						-8%	
Exports/ Imports	**X & M**						
United States		-8%		-5%	-10%		-13%
Japan			-39%				
Indonesia						-13%	
Malaysia						-14%	
Singapore						-33%	
Canada							-3%
Confidence	**CONF_SHOCK**						
World		-3	-4	-3	-4	-3	-3
Asia			-5			-5	
Commodity Price							
World food	**WPFOOD**					+40%	+40%
World oil	**WPO**					+40%	+40%

Model Outputs: Domestic impacts (EQ-LA)

GDP

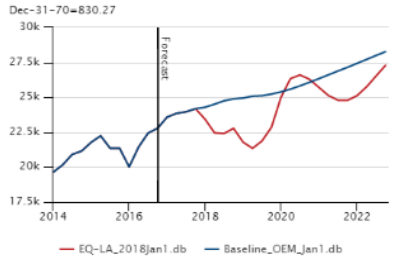


Domestic demand

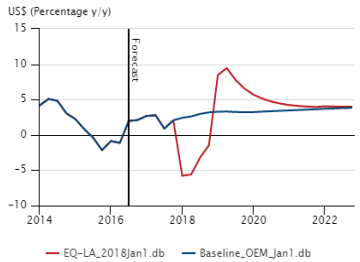


Bond yields

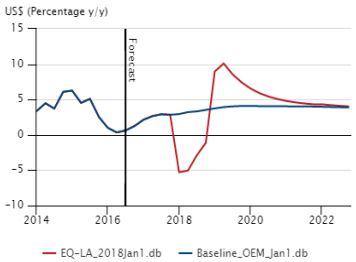
Equity prices



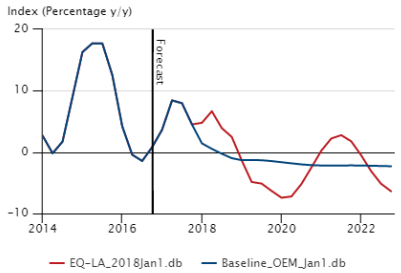
Exports



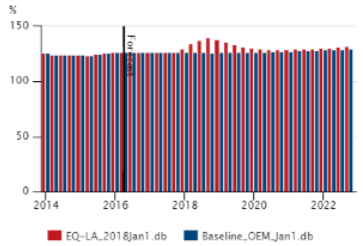
Imports



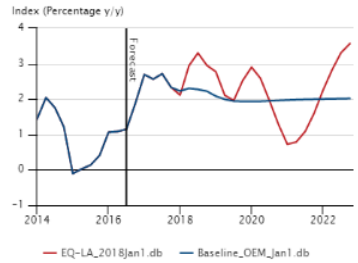
Effective exchange rate



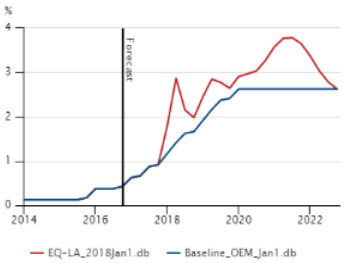
Government debt (% of GDP)



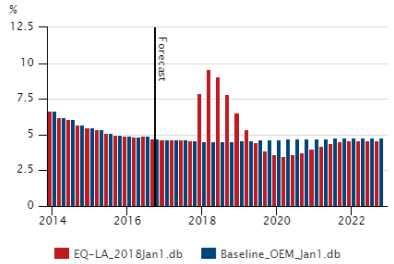
CPI



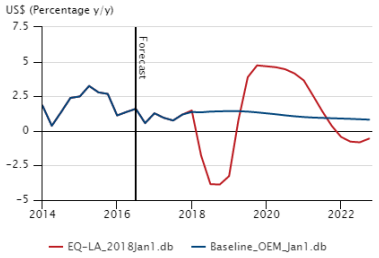
Central Bank policy rate



Unemployment rate



Real earnings vs CPI



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OEM VARIABLES		DOMESTIC IMPACTS	INTERNATIONAL SPILL OVERS				
		General trends	General trends	Variants			
				Extreme deflation	*Non-US originating shock*	*For Germany & Eurozone*	*Volcano scenario*
GDP related	GDP	-1	-1	-1	-1	-1	-1
	Consumer Spending	-1	-1	-1	-1	-1	-1
	Fixed Investment	0	-1	-1	-1	-1	-1
	Government Consumption	0	0	0	0	0	0
	Domestic Demand	-1	-1	-1	-1	-1	-1
	Exports	-1	-1	-1	-1	-1	-1
	Imports	-1	-1	-1	-1	-1	-1
Labour related	Average Earnings	-1	-1	-1	-1	-1	-1
	Real Earnings	-1	-1	1	-1	-1	-1
	Productivity	-1	-1	-1	-1	-1	-1
	Unit Labour Costs	1	1	1	1	1	1
	Total employment	-1	-1	-1	-1	-1	-1
	Labour Supply	-1	0	0	0	0	0
	Unemployment Rate	1	1	1	1	1	1
Trade related	Exports of Goods	-1	-1	-1	-1	-1	-1
	Imports of Goods	-1	-1	-1	-1	-1	-1
	Exports of Services	-1	-1	-1	-1	-1	-1
	Imports of Services	-1	-1	-1	-1	-1	-1
	Visible Trade Balance (% of GDP)	1	1	1	1	1	-1
	Current Account Balance (% of GDP)	1	1	1	1	1	-1
	Government Balance (% of GDP)	-1	-1	-1	-1	-1	-1
	Government Debt (% of GDP)	1	1	1	1	1	1
Finance related	CPI Inflation	1	-1	-1	-1	-1	1
	CB Policy Rate	1	1	1	1	0	1
	Bond Yields	1	1	1	-1	1	1
	Equity Prices	-1	-1	-1	-1	-1	-1
	Effective Exchange Rate (EER)	1	1	1	1	1	1
World related	World Oil Price	-1	-1	-1	-1	-1	1
	Non-Oil Commodity Prices	-1	-1	-1	-1	-1	-1
	World Trade	-1	-1	-1	-1	-1	-1

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	Government Consumption	0	0	0	0	0	0
	Domestic Demand	-1	-1	-1	-1	-1	-1
	Exports	-1	-1	-1	-1	-1	-1
	Imports	-1	-1	-1	-1	-1	-1
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World related	World Oil Price	-1	-1	-1	-1	-1	1
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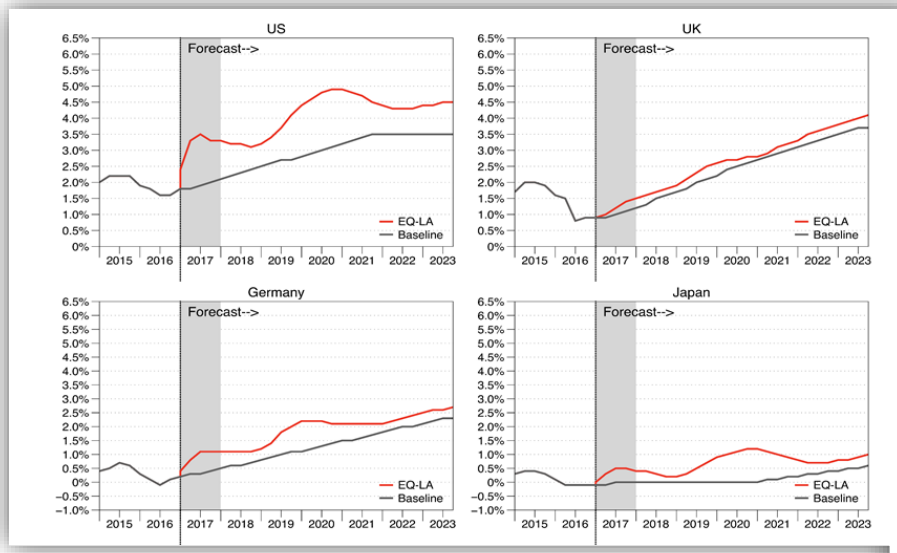
Finance related	CPI Inflation	1	-1	-1	-1	-1	1
	CB Policy Rate	1	1	1	1	0	1
	Bond Yields	1	1	1	-1	1	1
	Equity Prices	-1	-1	-1	-1	-1	-1
	Effective Exchange Rate (EER)	1	1	1	1	1	1
World related	World Oil Price	-1	-1	-1	-1	-1	1
	Non-Oil Commodity Prices	-1	-1	-1	-1	-1	-1
	World Trade	-1	-1	-1	-1	-1	-1

Portfolio Impacts Model (PIM)

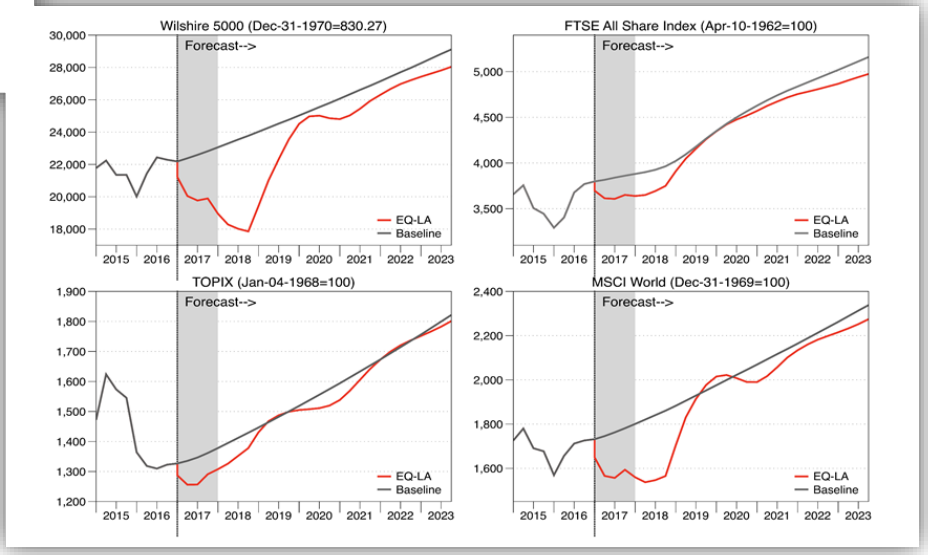
- Model developed by CCRS with the aim of understanding the financial markets impacts of each Nat-Cat scenario to enable informed investment decision making
- Provides insights into how fundamentals of asset values are likely to change due to changes in market conditions
- **Three asset classes**:
  1. Fixed income instruments
     - Long-term bonds (10 year) and short-term bonds (2 year)
     - Sovereigns and high-grade corporate bonds
  2. Equities
     - Indices such as W5000 (US), FTSE 100 (UK), Nikkei 225 (Japan) and DAX (Germany)
  3. Alternative investments such as RMBS
     - Residential Mortgage Backed Securities (RMBS) yields calculated using available data
- **Currency exposures**: GBP, USD, EUR and JPY
- Performance of such assets are estimated from OEM outputs for each scenario, and comparison to the baseline (no shock case) is made
- Wherever applicable, output values are adjusted for CPI inflation and normalized to USD using spot exchange rates
- **Assumption**: passively managed portfolio, where such a portfolio could serve as a benchmark to actively managed portfolios in real world

PIM Inputs from EQ-LA outputs



10-year Sovereign Yields

Stock Market Indices



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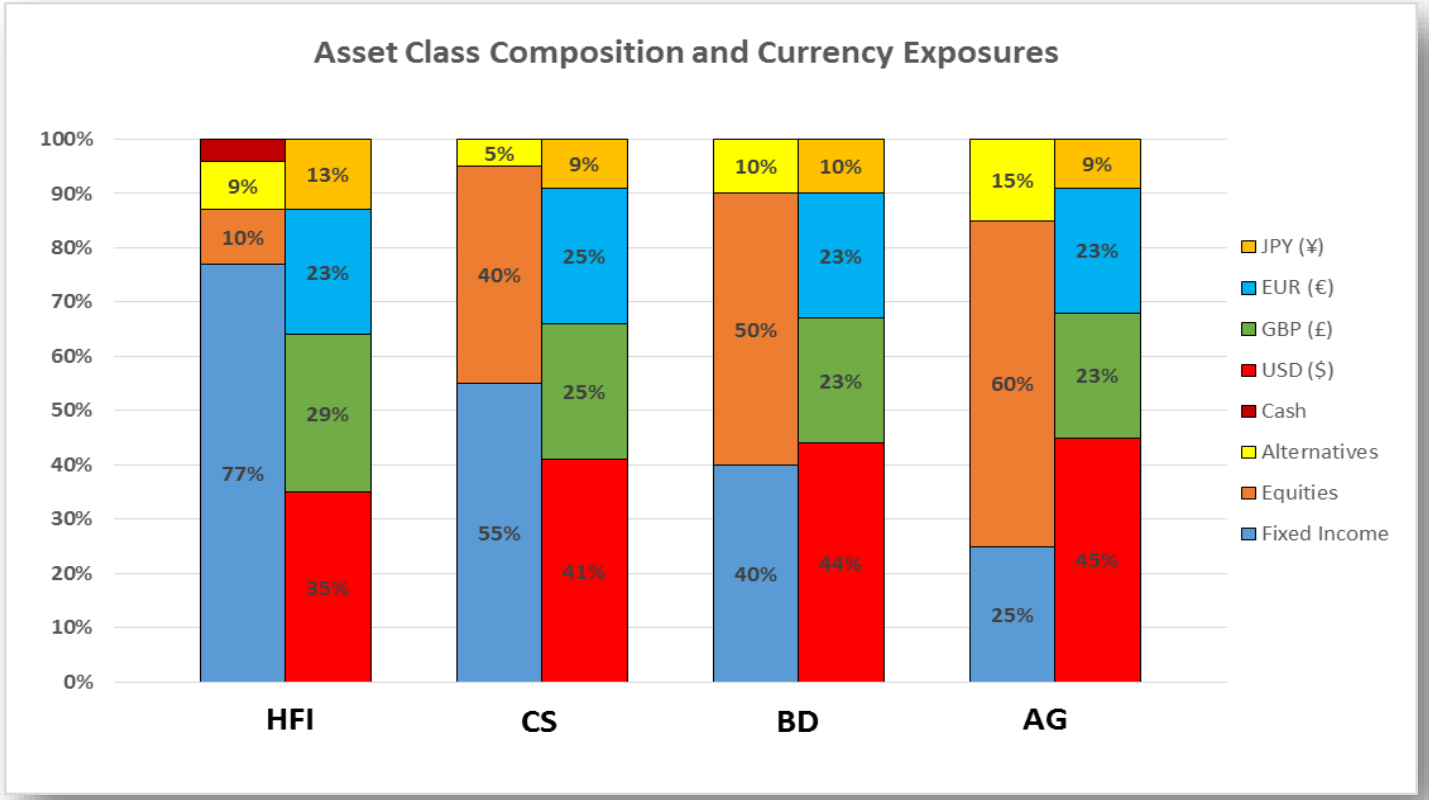
Portfolios Structure

Four standardized portfolios:

- High Quality Fixed Income (HFI)
- Conservative (CS)
- Balanced (BD)
- Aggressive (AG)



PIM Results

GDP@Risk

LOCATION	Baseline 5-yr GDP (US$ Tn)	GDP@Risk (US$ trillion)					
		EQ-LA	EQ-TKY	HU-FL	HU-NJ	VO-MA	VO-RA
Germany	19.76	0.09 (0.46%)	0.04 (0.20%)	0.12 (0.61%)	0.12 (0.61%)	0.05 (0.25%)	0.12 (0.61%)
Japan	31.02	0.06 (0.19%)	0.90 (2.90%)	0.11 (0.35%)	0.10 (0.32%)	0.09 (0.29%)	0.21 (0.68%)
UK	14.64	0.12 (0.82%)	0.08 (0.55%)	0.05 (0.34%)	0.17 (1.16%)	0.07 (0.48%)	0.20 (1.37%)
US	91.45	1.89 (2.07%)	0.28 (0.31%)	0.28 (0.31%)	2.38 (2.60%)	0.39 (0.43%)	3.39 (3.71%)
WORLD	**428.51**	**3.81 (0.89%)**	**1.89 (0.44%)**	**2.35 (0.55%)**	**3.59 (0.84%)**	**2.51 (0.59%)**	**7.63 (1.78%)**

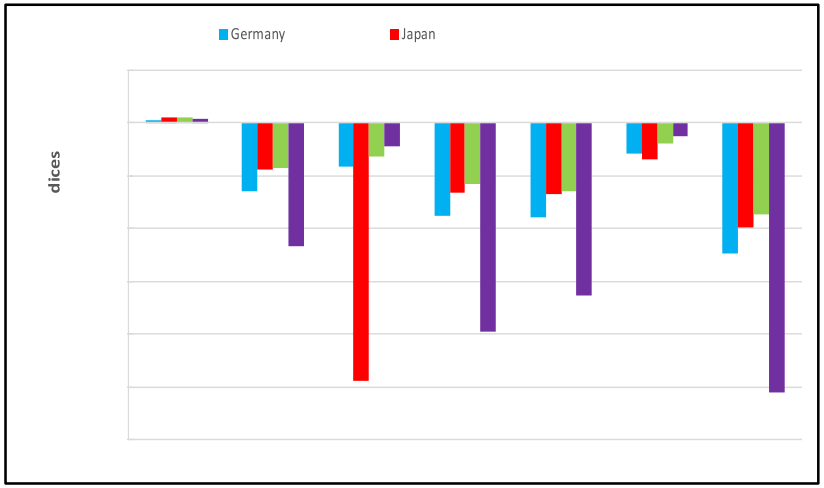
Maximum Growth Rates (Quarterly)

	Baseline	EQ-LA	EQ-TKY	HU-FL	HU-NJ	VO-MA	VO-RA
Germany	0.6%	0.2%	0.4%	-0.1%	-0.1%	0.5%	-0.6%
Japan	-0.9%	-0.4%	-10.7%	-0.3%	-0.4%	-0.4%	-0.9%
UK	1.2%	0.1%	0.7%	-0.4%	-0.4%	0.6%	-1.0%
US	1.5%	-9.0%	1.0%	-14.9%	-12.0%	1.3%	-18.6%
WORLD	2.4%	-0.7%	1.6%	-2.3%	-1.6%	1.8%	-3.4%

Bond Markets

	Baseline	EQ-LA	EQ-TKY	HU-FL	HU-NJ	VO-MA	VO-RA
Germany	AAA	AAA	AAA	AAA	AAA	AAA	AAA
Japan	A	A	BBB	A	A	A	BBB
UK	AA	AA	AA	AA	AA	AA	AA
US	AAA	A	AA	A	A	AA	BBB

Equity Markets



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Portfolio Impacts: Returns

5-YEAR CUMULATIVE RETURNS	EQ-LA	EQ-TKY	HU-FL	HU-NJ	VO-MA	VO-RA
High Fixed Income	2.6%	-1.1%	3.3%	3.2%	-0.6%	-6.0%
Conservative	1.2%	-0.9%	0.5%	1.3%	0.3%	2.1%
Balanced	1.1%	-0.7%	0.2%	1.1%	0.4%	2.2%
Aggressive	1.1%	-0.6%	0.2%	1.1%	0.6%	2.5%

- US origin shocks that are non-volcano related:
  - HFI offers highest returns while AG portfolio offers worst returns
- Non-US origin shocks that are not volcano related:
  - HFI offers the lowest returns
- Volcano-related scenarios:
  - HFI offers the lowest returns while AG offers the highest returns
- CS offers the middle-ground in terms of returns for all scenarios, along with the BD specifically for volcano related scenarios
- Scenarios with non-US origin shocks seem to have the least impact in terms of returns across all the portfolios

Portfolio Impacts: Overall

5-YEAR CUMULATIVE RETURNS	EQ-LA	EQ-TKY	HU-FL	HU-NJ	VO-MA	VO-RA
High Fixed Income	2.6%	-1.1%	3.3%	3.2%	-0.6%	-6.0%
Conservative	1.2%	-0.9%	0.5%	1.3%	0.3%	2.1%
Balanced	1.1%	-0.7%	0.2%	1.1%	0.4%	2.2%
Aggressive	1.1%	-0.6%	0.2%	1.1%	0.6%	2.5%
5-YEAR VOLATILITY	**EQ-LA**	**EQ-TKY**	**HU-FL**	**HU-NJ**	**VO-MA**	**VO-RA**
High Fixed Income	4.3%	2.5%	6.0%	5.2%	1.8%	7.4%
Conservative	5.9%	2.5%	8.7%	7.4%	2.1%	10.1%
Balanced	6.6%	2.5%	9.8%	8.2%	2.2%	11.4%
Aggressive	7.2%	2.5%	10.8%	9.1%	2.3%	12.6%
RISK-ADJUSTED RETURNS	**EQ-LA**	**EQ-TKY**	**HU-FL**	**HU-NJ**	**VO-MA**	**VO-RA**
High Fixed Income	0.60	-0.43	0.55	0.62	-0.32	-0.81
Conservative	0.20	-0.36	0.06	0.18	0.14	0.21
Balanced	0.17	-0.28	0.02	0.13	0.18	0.19
Aggressive	0.15	-0.24	0.02	0.12	0.26	0.20

- US origin shocks that are non-volcano related:
  - HFI has the highest returns and lowest volatility
- Non-US origin shocks that are not volcano related (EQ-TKY):
  - AG is the best pick since it offers the highest return while all the portfolios display very similar volatility
- Volcano-related scenarios:
  - HFI has the lowest returns and lowest volatility
  - AG has the highest returns but the highest volatility
  - Clear trade-off for investors depending on their preferences

Investor Profiles

Investment Objectives:

- High Yield investors:
  - care mostly about returns despite risks
  - hedge funds, investment banks, etc..
- Risk Minimizing investors:
  - concerned with low volatility
  - pensioners, very risk averse agents, etc..
- High RAR (Risk Adjusted Return) investors:
  - performance oriented mutual funds investors
  - typically seek high Sharpe-ratio investments

Hedging Objectives:

- Threat specific:
  - Earthquakes
  - Hurricanes
  - Volcano
  - Non-volcanic events
- Geography specific:
  - US-origin shocks
  - International shocks
- Universal Nat-Cat events

Investment Recommendations

5-YEAR CUMULATIVE RETURNS	RISK SPECIFIC				GEOGRAPHY SPECIFIC		UNIVERSAL
	EQ	HU	VO	Non-VO	US shocks	International	
High Fixed Income	0.8%	3.3%	-3.3%	2.0%	0.8%	-0.9%	0.2%
Conservative	0.2%	0.9%	1.2%	0.5%	1.3%	-0.3%	0.8%
Balanced	0.2%	0.7%	1.3%	0.4%	1.2%	-0.2%	0.7%
Aggressive	0.3%	0.7%	1.6%	0.5%	1.2%	0.0%	0.8%

5-YEAR VOLATILITY	RISK SPECIFIC				GEOGRAPHY SPECIFIC		UNIVERSAL
	EQ	HU	VO	Non-VO	US shocks	International	
High Fixed Income	3.5%	5.6%	5.4%	4.7%	5.8%	2.2%	4.9%
Conservative	4.5%	8.1%	7.3%	6.5%	8.2%	2.3%	6.8%
Balanced	5.0%	9.0%	8.2%	7.3%	9.2%	2.4%	7.6%
Aggressive	5.4%	10.0%	9.1%	8.0%	10.1%	2.4%	8.4%

RISK-ADJUSTED RETURNS	RISK SPECIFIC				GEOGRAPHY SPECIFIC		UNIVERSAL
	EQ	HU	VO	Non-VO	US shocks	International	
High Fixed Income	0.21	0.58	-0.61	0.42	0.13	-0.38	0.05
Conservative	0.03	0.11	0.16	0.08	0.16	-0.13	0.11
Balanced	0.04	0.07	0.16	0.06	0.13	-0.06	0.09
Aggressive	0.05	0.06	0.17	0.06	0.12	0.00	0.10

Investment Recommendations

PORTFOLIO CHOICE	RISK SPECIFIC				GEOGRAPHY SPECIFIC		UNIVERSAL
	EQ	HU	VO	Non-VO	US shocks	International	
High Yield	HFI	HFI	AG	HFI	CS	AG/None	AG
Risk Minimizing	HFI	HFI	CS	HFI	HFI	None	HFI
High RAR	HFI	HFI	AG	HFI	CS	AG/None	CS

- Investors wishing to hedge EQ, HU or more generally the non-VO scenarios would prefer to hold HFI portfolio
- Investors wishing to hedge against VO events are more likely to benefit from holding AG portfolio
- Investors hedging against US-based natural disasters would benefit from holding CS portfolio
- No suitable portfolio available within the given set to effectively hedge against shocks originating outside of the US
- Investors wishing to hedge against all disasters originating globally hold different portfolios depending on investment objectives

Summary

- Extreme natural disaster events have potential to effect market fluctuations and macroeconomic variables in the domestic as a well as international markets with some key differences and therefore have portfolio choice implications for investments
- Among all six Nat-Cat scenarios, VO-MA and EQ-TKY had the least impact on model portfolio characteristics, primarily due to their smaller if not zero exposure to domestic currency assets
- Equities have played a role as the main contributor to risk within the model portfolios. Despite higher returns, performance of portfolios large share of equity exposures are quite volatile and therefore there is a clear trade-off
- The choice of portfolio to hold boils down to investment objectives and hedging requirements and recommendations are sensitive to the underlying portfolio structure
- HFI seems to be the best portfolio to hold during non-inflationary scenarios while investors wishing to hedge shocks of non-US origin might weakly prefer AG over the others

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