

Cambridge Judge Business School

Centre for Risk Studies 7th Risk Summit Research Showcase

Financial Catastrophe Research & Stress Test Scenarios

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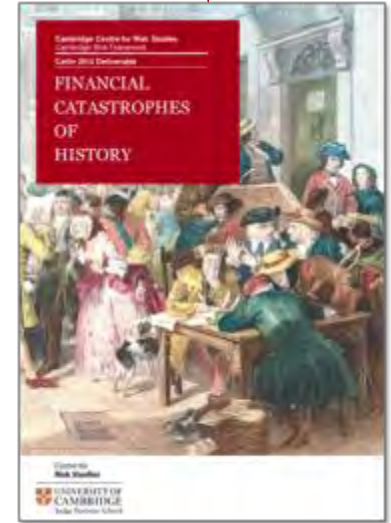
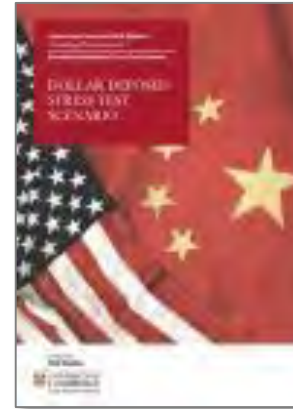
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Financial Catastrophe Research

1. Catalogue of historical financial events
2. Development of stress test scenarios



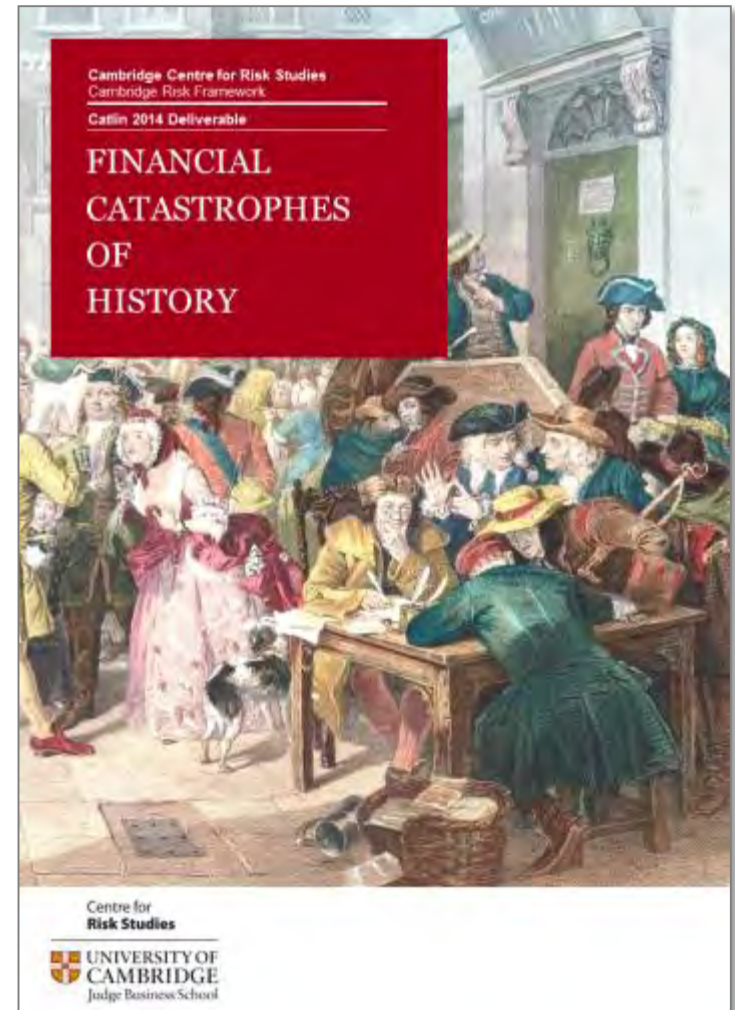
3. Understanding contagion processes in financial networks (eg, interbank loans)

- Network models & visualisations
- Role of central banks in financial crises
- Practitioner model – scoping exercise



Learning from History

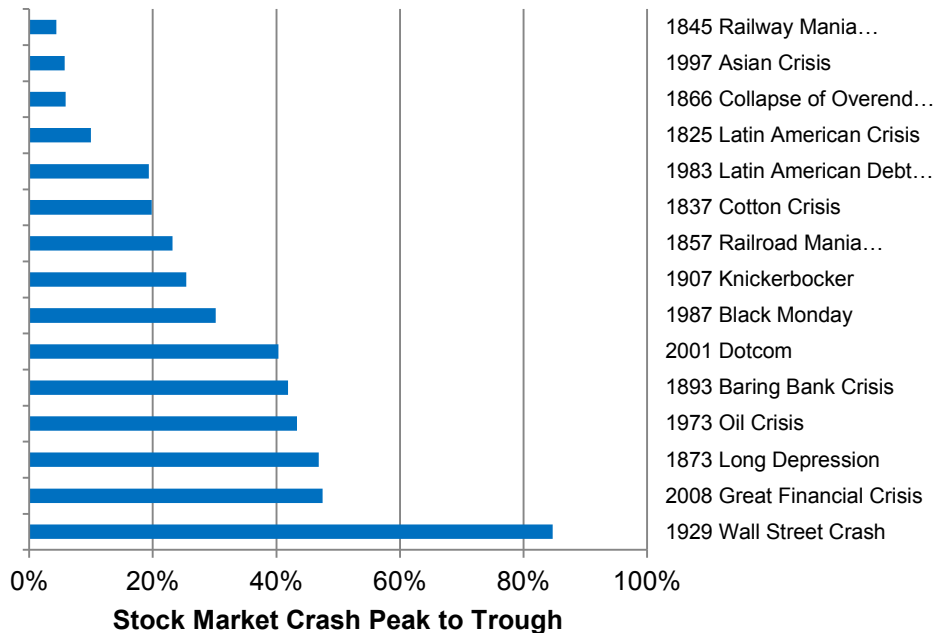
- Financial systems and transaction technologies have changed
- But principles of credit cycles, human trust and financial interrelationships that trigger crises remain relevant
- 12 Historical Financial Crisis
- Crises occur periodically
 - Different causes and severities
 - **Every 8 years** on average
 - **\$0.5 Tn** of lost annual economic output
 - **1%** of global economic output
- Without FinCat global growth could be **4% a year** instead of 3%
- **Financial catastrophes are the single greatest economic risk for society**
 - We need to understand them better



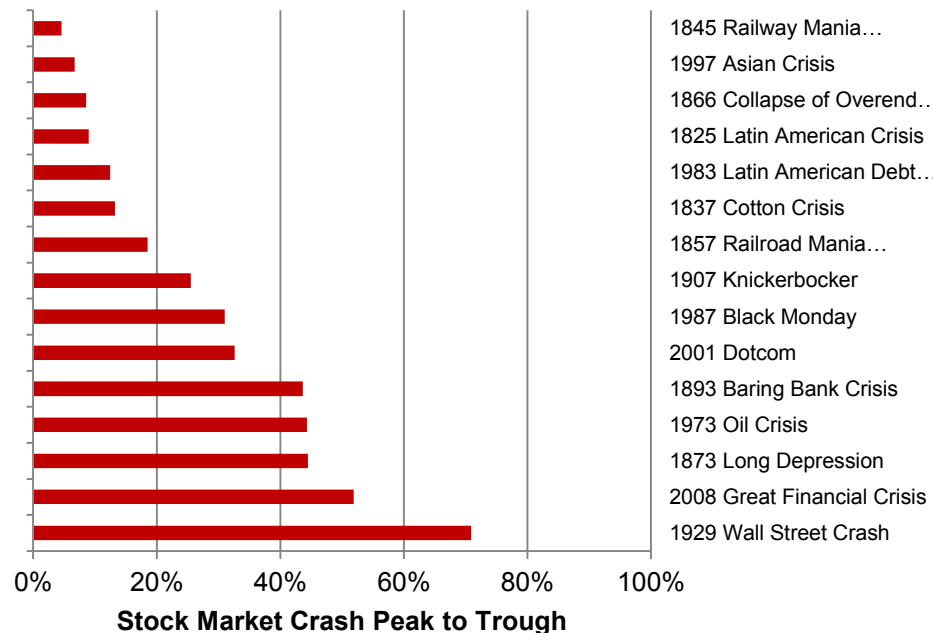
Historical Severities of Crashes – Past 200 Years



US Stock Market Crashes



UK Stock Market Crashes



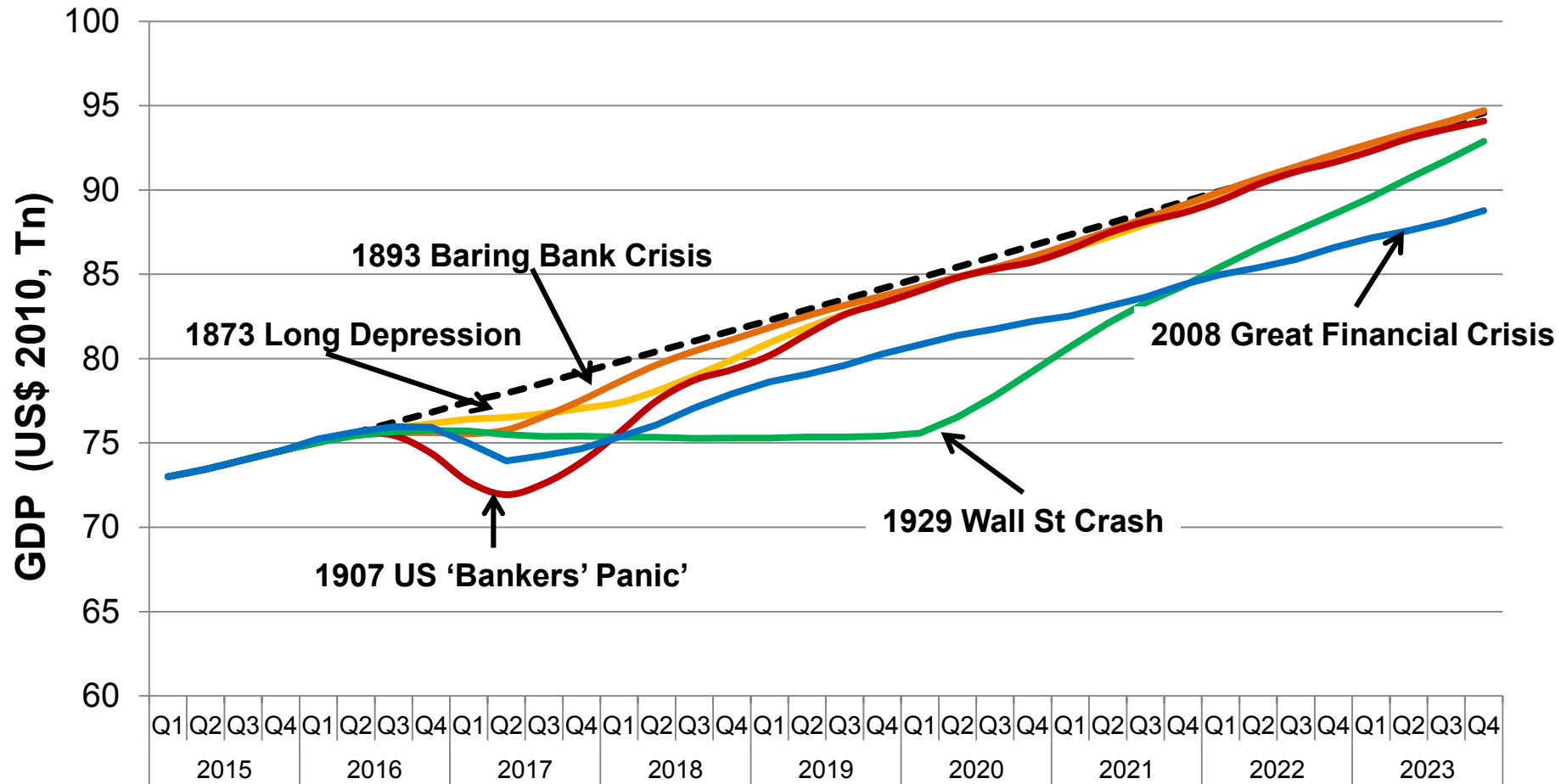
Observed, last 200 years

Crashes Greater Than	Number of Crises	Average Interval (Yrs)
10%	12	16
20%	9	21
40%	6	32
50%	1	190

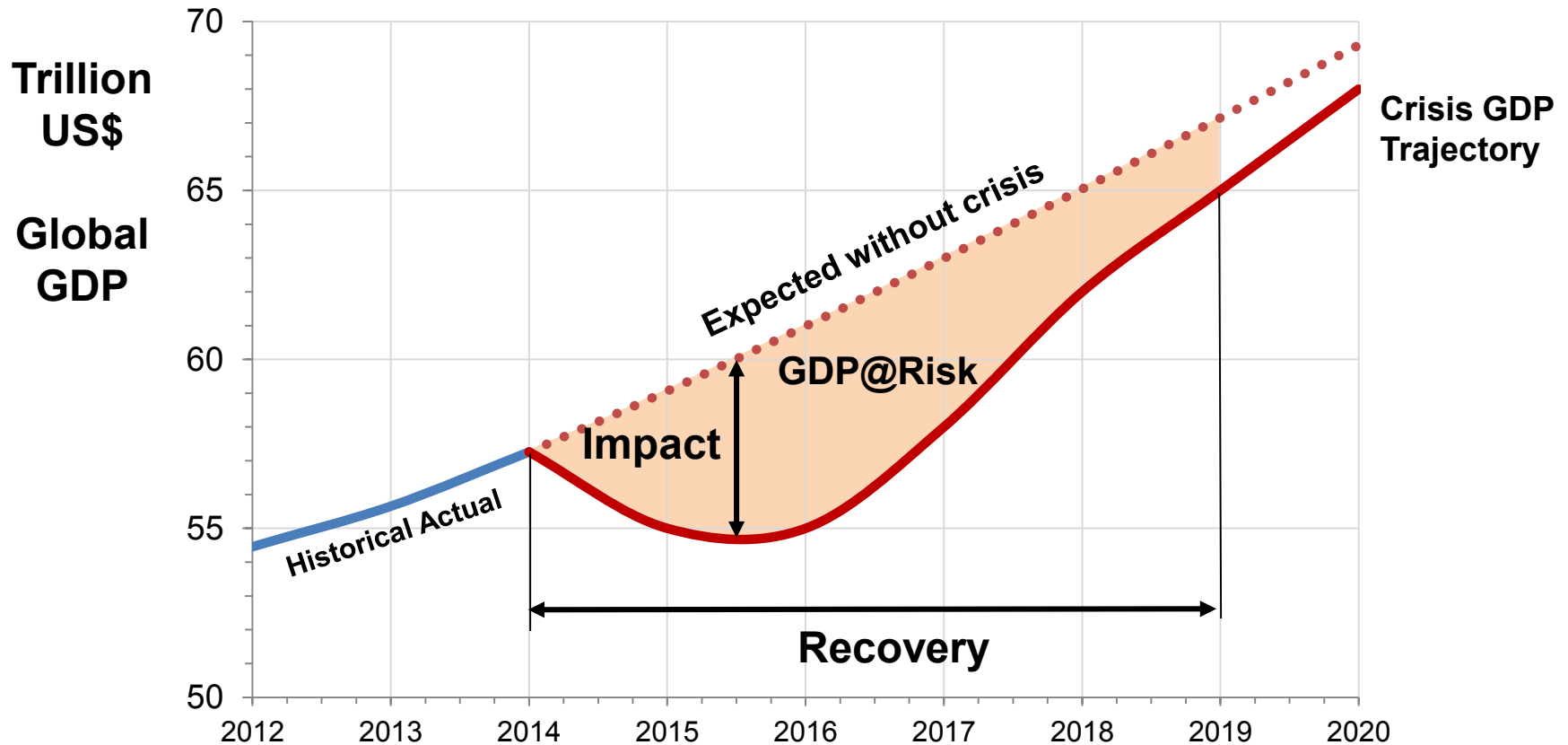
Observed, last 200 years

Crashes Greater Than	Number of Crises	Average Interval (Yrs)
10%	11	17
20%	8	24
40%	5	38
50%	2	95

Modelling Historical Financial Crises



Estimating GDP@Risk



GDP@Risk: Cumulative first five year loss of global GDP, relative to expected, resulting from a catastrophe or crisis

GDP@Risk from Historical Events

GDP@Risk US\$ Trillion, 2010 prices	GDP@Risk
1893 Baring Bank Crisis	5
1873 Long Depression	7
1907 US 'Bankers' Panic'	14
2008 Great Financial Crisis	20
1929 Wall Street Crash	30

Taxonomy of Financial Crisis

Complex / Technological

- ↳ Flash crash
- ↳ Black box trading
- ↳ Complex derivatives
- ↳ Cyber crash



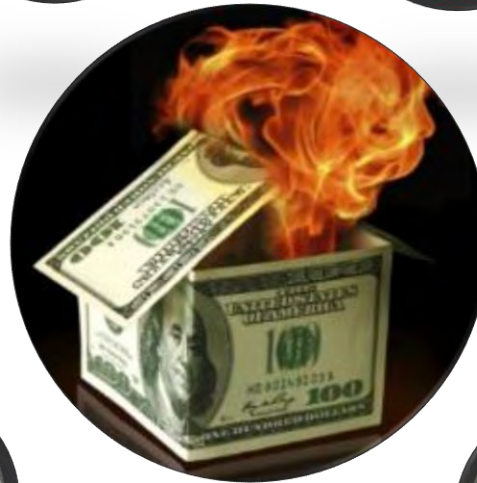
Inflation

- ↳ Cost-push inflation
- ↳ Demand-pull inflation
- ↳ Deflation



Currency Crisis

- ↳ Reserve currency
- ↳ FX shock



Banking Crisis

- ↳ Systemic failure
- ↳ Bank run
- ↳ Credit crunch



Asset Bubble

- ↳ Stock market crash
- ↳ Commodity price bubble
- ↳ Property price bubble



Illegal Activity

- ↳ Fraud
- ↳ Financial irregularity

Debt

- ↳ Sovereign Debt
- ↳ Private Debt

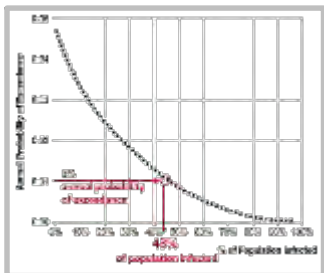
What is a Stress Test Scenario?

- Use **narratives** that pose ‘what if’ questions and explore views about alternative futures.
- Help deal with **complexity** and **uncertainty**
- Release us from conditioning and existing habits that may inhibit new actions and insight
- Bring together creativity and analytics
- **Not predictions, or forecasts**
- A **coherent, ‘severe yet plausible’** expectation about the future
 - Sufficiently impactful to reveal vulnerabilities in a portfolio/system
 - Realistic enough to justify managerial attention or remediation
- Used to improve business resilience to shocks

Cambridge Stress Test Scenarios

Context

A justification and context for a 1% annual probability of occurrence worldwide based on historical precedents and expert opinion



Timeline & Footprint

Sequencing of events in time and space in hypothetical scenario



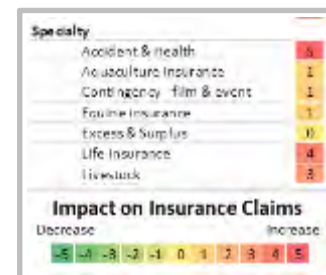
Narrative

Detailed description of events
3-4 variants of key assumptions for sensitivity testing



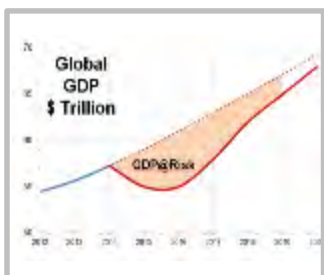
Loss Assessment

Metrics of underwriting loss across many different lines of insurance business



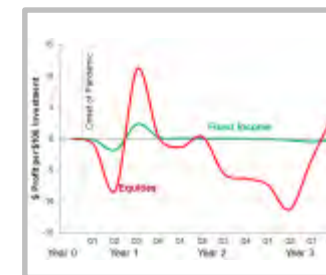
Macroeconomic Consequences

Quantification of effects on many variables in the global economy



Investment Portfolio Impact

Returns and performance over time of a range of investment assets



Cambridge Financial Stress Test Scenarios



Global Property Crash

Sudden collapse of property prices in the inflated property markets and this triggers a cascading crisis throughout the global financial system



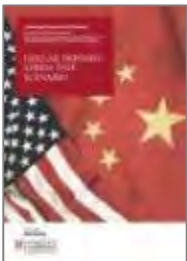
Eurozone Meltdown

The default of Italy is followed by a number of other European countries, leading to multiple cession from the European Union and causing an extensive financial crisis for investors



High-Inflation World

A series of world events puts pressure on energy prices and food prices in a price increasing spiral, which becomes structural and takes many years to unwind



Dollar Deposed

US dollar loses its dominance as the default trading currency as it becomes supplanted by the Chinese Renminbi, with rapid unwinding of US Treasury positions and economic chaos

Global Property Crash: Narrative

1. Shake-up

- Emerging market property prices & rental returns begin to slip
- Triggers sell-off by shrewd investors that gains momentum
- Chinese & Indian property markets begin to plummet
- International property market destabilised – most inflated markets hit first

2. Bubble Bursts

- Contagion flows through global financial system
- Bubble bursts in Australia, followed by NZ & Canada (all with highly inflated property markets)
- Labelled a “global collapse” & worldwide property prices plummet
- Mortgage equity markets shrink, several large European banks allowed to fail

3. Rock Bottom

- IMF declares a global recession
- Global cycle of negative growth – austerity measures have little effect for several years
- Low consumer confidence dampens low interest rate stimulus measures
- Triggers deflationary spirals in major economies for next 3 years, with 2 more years till recovery

(quarter-on-quarter) across the affected regions.

through to the last quarter of Year 5, and the GDP@Risk for this scenario.

Global Property Crash: Macroeconomic losses

Table 10: Global GDP@Risk for the Global Property Crash Scenario variants

Location	Baseline	S1		S2	
	5-yr GDP (US\$ Tn)	GDP@Risk (US\$ Tn)	GDP@Risk (%)	GDP@Risk (US\$ Tn)	GDP@Risk (%)
Tier 1: China	48.4	0.8	1.6%	1.1	2.2%
Tier 2: Canada	9.5	0.4	4.3%	0.6	5.9%
Tier 3: Sweden	2.8	0.1	3.0%	0.1	4.4%
Tier 4: UK	14.0	1.1	8.0%	1.3	9.6%
Tier 5 & 6: Eurozone	67.1	2.9	4.4%	3.7	5.6%
Tier 7: US	88.9	3.0	3.3%	6.1	6.9%
Tier 8: Germany	19.1	0.5	2.8%	0.8	4.1%
Tier 9: Japan	29.3	0.7	2.3%	1.2	4.2%
World	395.0	13.2	3.3%	19.6	5.0%

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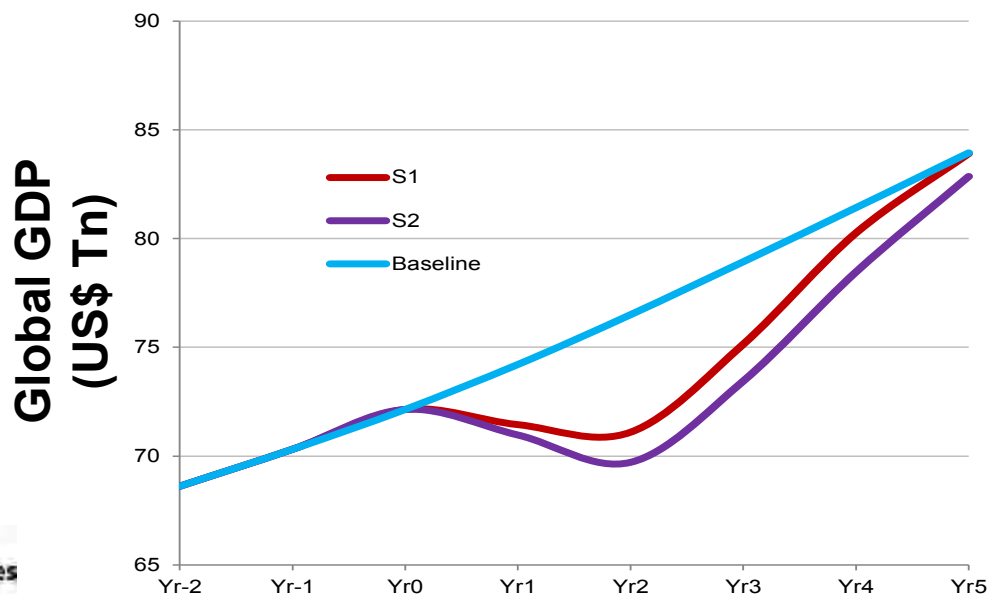


Figure 13: Estimated loss in global output as a result

The result is a global output loss ranging between 1.1% and 9.6% total cost of 25% is estimated between more than half is in the US and European economies.

Despite the large losses in vulnerable domestic and emerging economies, the macroeconomic impact is less severe than representatives. The impact differs from the global impact presented in the previous section amongst the worst affected regions is among the least

Eurozone Meltdown: Narrative

1. Anti-Euro Italy

- Anti-austerity & Eurosceptic party wins snap Italian election & forms coalition with anti-European party
- EU declares that servicing of Italy's debt contingent on austerity measures
- New government offers robust rebuttal & announces extensive public welfare program

2. Italian Exit

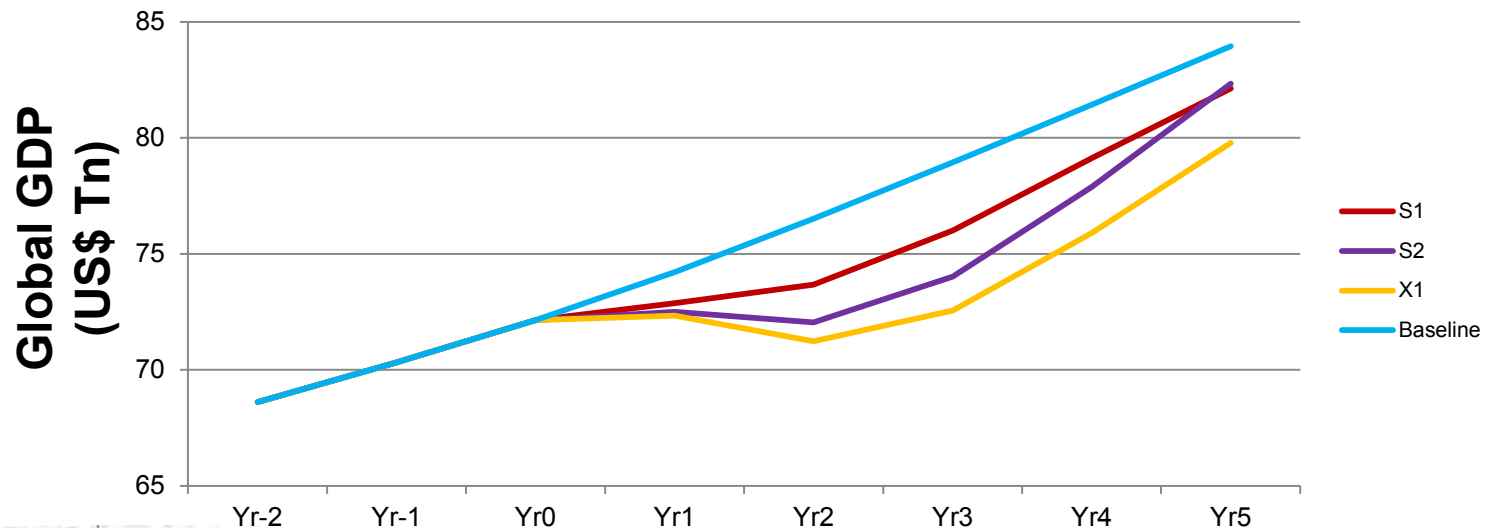
- Italian exit agreed with an extensive support package
- Market value of Italian debt falls by 50%
- FI grinds to halt, foreign markets dump Eurobonds, sell-off of Italian assets
- Spanish, Portuguese & Greek long-term bond yields explode – leading to fiscal insolvency

3. Default Cascade

- Spain defaults and exits with comparable support package
- Markets fear Eurozone about to fall apart – confidence drops & decline in equity prices
- Portugal follows Spain, then Ireland within the week, then Greece
- Remaining members dragged into recession & stock markets fall

Eurozone Meltdown: Macroeconomic losses

Location	Baseline	S1		S2		X1	
	5-Year GDP (US\$ Tn)	GDP @Risk (US\$ Tn)	GDP @Risk (%)	GDP @Risk (US\$ Tn)	GDP @Risk (%)	GDP @Risk (US\$ Tn)	GDP @Risk (%)
Greece	1.3	0.16	11.6%	0.22	16.3%	0.24	17.9%
Germany	19.1	0.95	5.0%	0.78	4.1%	0.95	5.0%
Eurozone	67.1	4.17	6.2%	4.72	7.0%	4.91	7.3%
China	48.4	-0.08	-0.2%	0.03	0.1%	0.61	1.3%
Japan	29.3	0.33	1.1%	0.47	1.6%	0.65	2.2%
United Kingdom	14.0	1.39	9.9%	1.88	13.5%	2.34	16.8%
United States	88.9	2.72	3.1%	4.62	5.2%	8.62	9.7%
World	395.0	11.24	2.8%	16.26	4.1%	23.24	5.9%



High Inflation World: Narrative

1. Weather troubles

- Extreme weather across northern hemisphere
- Ecological crisis – US, Europe & China see 70% decline in bee colonies
- Droughts lead to shortages in maize & cattle feed grains
- Prices increase for certain food groups

2. Oil troubles

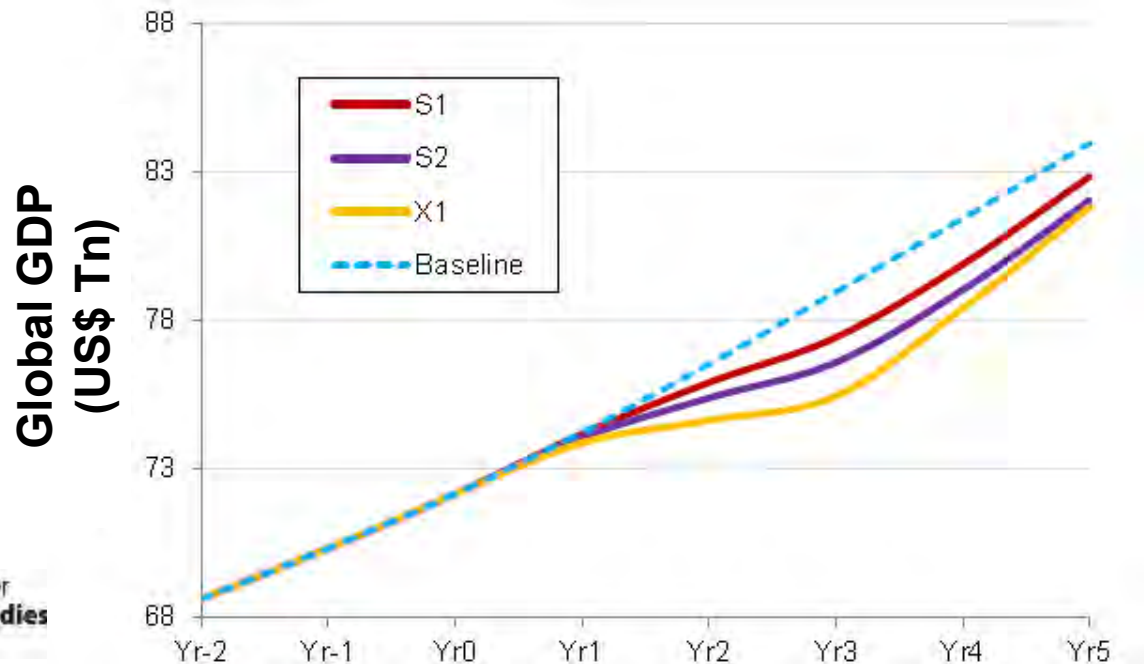
- Militant separatist group seize control of Strait of Hormuz & 20% of world's crude exports
- Shipments of crude through the Strait restricted leading to surge in the price of oil
- Food prices escalate – millions go without food
- Cost-push spiral emerges worldwide

3. Worldwide Inflation

- Global food basket shrinks & world inflation rates approach double figures
- Consumer Price Inflation (CPI) spikes
- Demand for higher wages stimulates an unemployment spiral, exacerbating growth of inflation
- Central banks gradually adjust rates & prices begin to stabilise

High Inflation World: Macroeconomic Losses

Scenarios	Baseline	S1		S2		X1	
Locations	5-year GDP	GDP@Risk (US\$, Tn)	GDP@Risk (%)	GDP@Risk (US\$, Tn)	GDP@Risk (%)	GDP@Risk (US\$, Tn)	GDP@Risk (%)
China	48.4	1.1	2.9%	2.0	3.9%	2.7	4.6%
Germany	19.1	0.1	1.1%	0.2	1.5%	0.5	1.7%
Japan	29.3	0.3	1.3%	0.4	1.8%	0.7	2.1%
United Kingdom	14.0	0.2	1.5%	0.3	2.2%	0.4	2.7%
United States	88.9	1.6	2.4%	2.5	3.1%	3.4	3.6%
World	395.0	4.9	1.7%	8.0	2.2%	10.9	2.6%



Dollar Deposited: Narrative

1. Trouble Brewing

- Reduced global liquidity of the USD
- China's growth continues – increased int. trade, FDI & confidence in RMB trade
- China begins massive industrial development plan, funded by domestic bond market
- Business development predicted to follow

2. Dollar Dumped

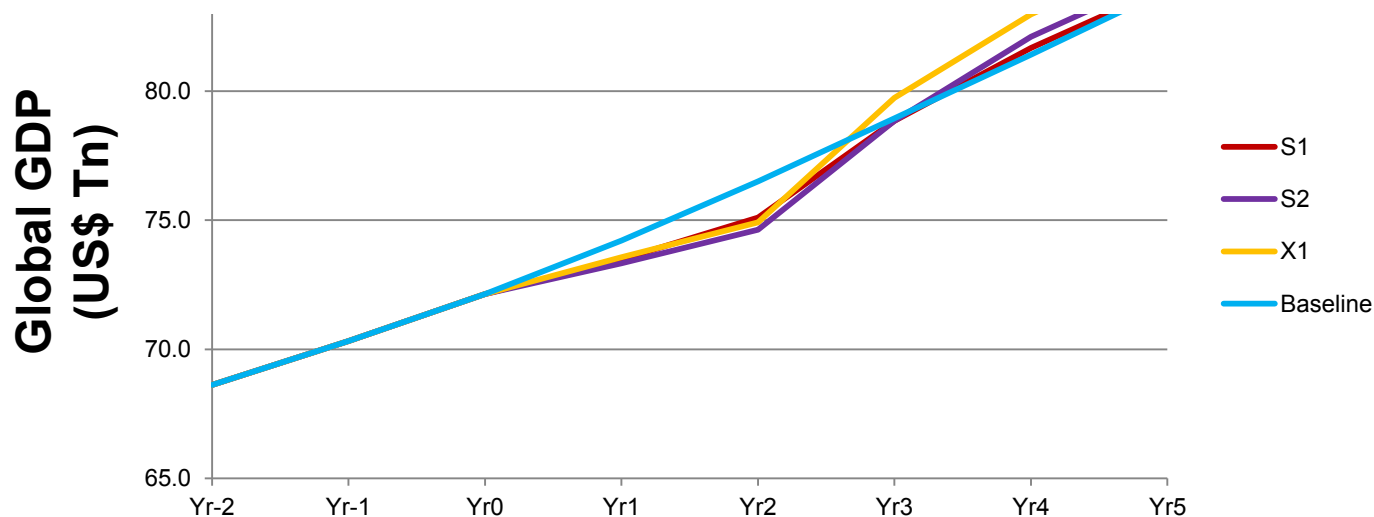
- China's economy continues to accelerate
- Large scale infrastructure & commodity commitments (funded by US treasuries) drives USD down
- Forces flotation of RMB – de facto 'dump' of US bonds
- RMB gains credibility as reserve currency
- US rating downgraded – panic ensues

3. Rise of the RMB




- Smart money favours growth prospects in China
- US interest rate raised but faith in USD lost
- US falls into recession
- Flight to quality seen as investors move out of US into China, boosting FDI
- China's interest rate reduced as RMB gains strength in global markets

Dollar Deposited: Macroeconomic Losses


Location	5-Year GDP (US\$ Tn)	S1		S2		X1	
		GDP@Risk (US\$ Tn)	GDP@Risk (%)	GDP@Risk (US\$ Tn)	GDP@Risk (%)	GDP@Risk (US\$ Tn)	GDP@Risk (%)
China	48.4	-0.4	-0.8%	-0.9	-1.8%	-1.5	-3.1%
Germany	19.1	0.0	0.1%	0.0	-0.2%	-0.2	-1.1%
Japan	29.3	0.2	0.8%	0.2	0.6%	-0.2	-0.8%
UK	14.0	0.0	0.1%	0.0	0.0%	-0.1	-0.8%
US	88.9	1.5	1.7%	2.1	2.4%	2.3	2.6%
World	395.0	1.9	0.5%	1.6	0.4%	-1.6	-0.4%



Historical Events & Scenarios: GDP@Risk

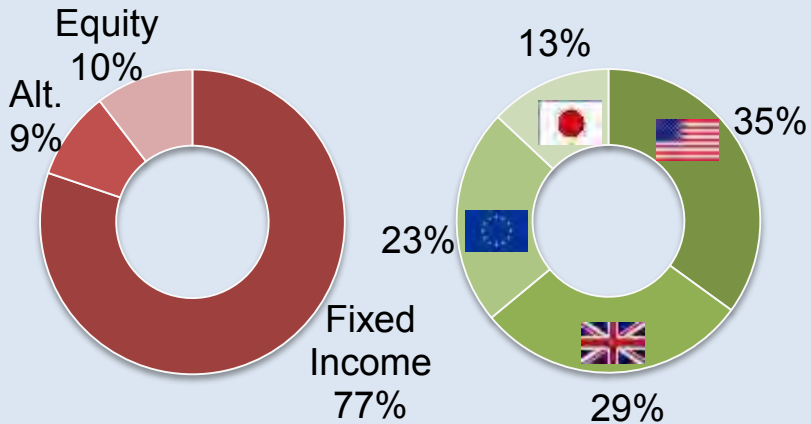
GDP@Risk US\$ Trillion, 2010 prices	GDP@Risk
1893 Baring Bank Crisis	5
1873 Long Depression	7
1907 US 'Bankers' Panic'	14
2007 Great Financial Crisis	20
1929 Wall Street Crash	30
 CRS Dollar Deposed	2
 CRS High Inflation World	5-11
 CRS Eurozone Meltdown	11-23
 CRS Global Property Crash	13-30

Cambridge Scenarios: GDP@Risk

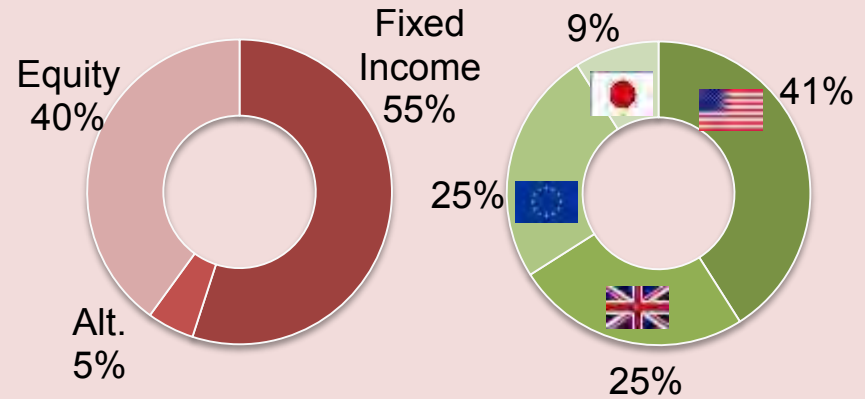
GDP@Risk US\$ Trillion		S1	S2	X1
	Geopolitical Conflict China-Japan Conflict	17	27	32
	Asset Bubble Shock Global Property Crash	13	20	30
	Pandemic Sao Paulo Virus	7	10	23
	Sovereign Default Shock Eurozone Meltdown	11	16	23
	Food and energy price spiral High Inflation World	5	8	11
	Cyber Catastrophe Sybil Logic Bomb	5	7	15
	Social Unrest Millennial Uprising	2	5	8
	De-Americanisation of Financial System Dollar Deposed	2	2	-2

Comparing Different Investment Portfolios

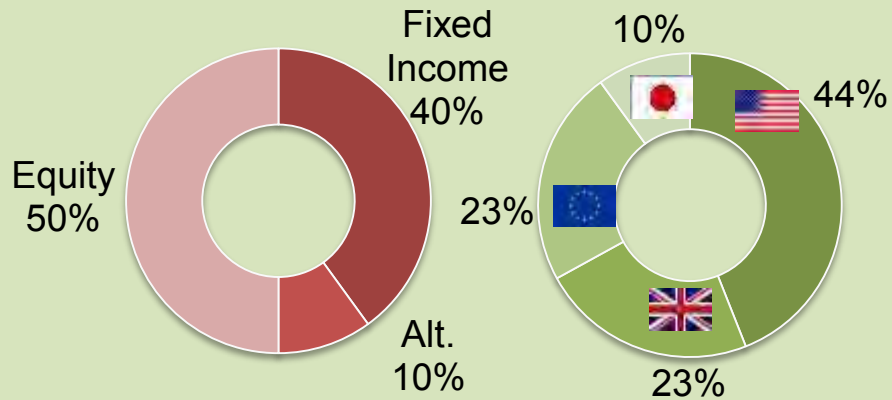
High Quality, Fixed Income



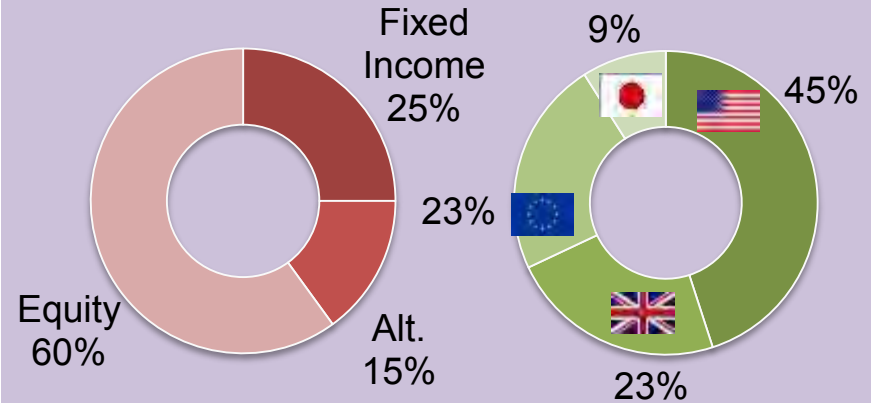
Conservative



Balanced



Aggressive



Maximum Downturn in Portfolios across 4 Financial Catastrophe Scenarios

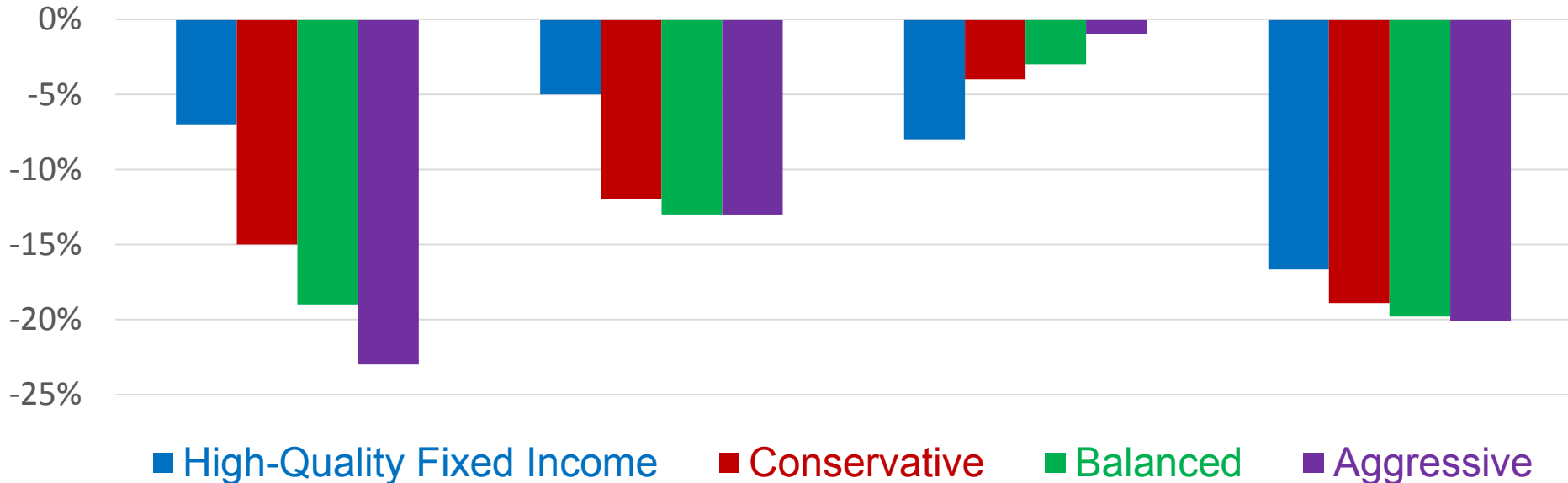


Global Property Crash

Eurozone Meltdown

High Inflation

Dollar Deposed



Future Research: Towards a Probabilistic FinCat Model

- Two problems:
 - Regulators: How to set capital requirements to buffer future events that haven't been seen before, but can be imagined?
 - Financial institutions: How to find an optimal rebalancing plan when faced with a catalogue of what-ifs?
- Probabilistic Graphical Models (PGMs) could be used to help give a quantitative probability dimension to scenario narratives and in a logically coherent manner¹
 - Modular approach
 - Intuitive visual interface transparent to all (not a black box model)
- Systematic generation of shock scenarios²
 - Middle ground between traditional stress testing & reverse stress testing
 - Reduces danger of 'blind spots' in stress testing
- Early warning systems leading to real-time probabilities, dynamic capital measures and portfolio rebalancing plans

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