

Cambridge Centre for Risk Studies

Cambridge Risk Framework

Sovereign Default Crisis Stress Test Scenario

EUROZONE MELTDOWN STRESS TEST SCENARIO

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This report describes a hypothetical scenario developed as a stress test for risk management purposes. It does not constitute a prediction. The Cambridge Centre for Risk Studies develops hypothetical scenarios for use in improving business resilience to shocks. These are contingency scenarios used for 'what-if' studies and do not constitute forecasts of what is likely to happen.

Sovereign Default Crisis Stress Test Scenario

Eurozone Meltdown

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Sovereign Default Crisis Stress Test Scenario

Eurozone Meltdown

1 Executive Summary

Sovereign default is a failure or refusal by a country's government to make a repayment of national debts. Consequences include devaluation of the principal, as well as loss of yield from the bond.

This report explores the impact of unexpected devaluation of fixed income assets resulting from a cascade of sovereign debt devaluations caused by the sequential exit of countries from a currency union. Such devaluations can have a similar financial effect as defaults which, if occurring in what are conventionally regarded as high quality, low risk investments, from one of our four Financial Catastrophe scenarios.

Scenarios more generally can be used to cover the spectrum of extreme shocks, such as those proposed in the Cambridge Taxonomy of Threats, which encompasses five classes of business risk. A suite of scenarios is a basis for a global enterprise to stress test itself and improve its resilience.

Eurozone Meltdown

In this scenario political pressures force a bloc of European countries into a cascade of exits from the currency union. The speed and rapid incidence of multiple countries exiting is the most significant dimension of the scenario.

The exit from the Euro spreads by contagion of similar political and economic issues across a number of countries and affects other economies that are typically thought of as being core countries of the Eurozone. These problematic political drivers might still endanger the currency union, although the pure financial market risks now seem to be under control as a powerful rescue architecture has been set up since 2011.

While the "standard" scenario variant S1 limits such a contagion on the peripheral countries, it comes, in the more severe scenario variants, S2 and X1, to a Eurozone meltdown with severe global effects.

These scenarios cause a worldwide recession lasting just over a year (approximately five to six fiscal quarters).

The overall expected output loss, expressed as lost global Gross Domestic Product during the scenario compared with the projected rate of growth without the catastrophe occurring ("GDP@Risk"), is between \$11.2, \$16.3 and \$23.2 trillion, depending on the variant narrative. The Great Recession of 2007-2011, comparatively, saw a loss of \$20 trillion in 2015 dollar estimates.

A History of Country Defaults

Scenario selection

Over the past two hundred years there have been over 180 recorded sovereign defaults, with 120 of them occurring in the past century.¹

Causes of defaults include major increases in public debt in foreign currencies, reduction in tax receipts, corruption, decline in employment levels, government regulation or perceived threats of regulation of financial markets, and popular unrest at austerity measures put in place to repay debt fully.

The Eurozone Meltdown Scenario describes scenarios comparable to a default driven by the first of these causes, i.e., high debt in a currency that creates political costs that cannot be managed by the affected sovereign. A premise is that increasing connectedness of global financial markets widens channels for the contagion.

Variants of the scenario

In our "standard" scenario variant S1, some of the weaker European economies – Italy and the other so-called PIGS (Portugal, Ireland, Greece and Spain) – are caught up in a wave of negotiated currency exits.

In variant S2, we explore how this might cascade further to trigger the creation of shadow currencies in Germany and France. In the most extreme variant X1 this further leads to the meltdown of the Eurozone in the sense of a complete dissolution of the Euro.

¹ C. Reinhart, K. Rogoff, "Financial and Sovereign Debt Crises: Some Lessons Learned and Those Forgotten", IMF Working Paper 13/266, December 2013

This is a stress test, not a prediction

This report is one of a series of stress test scenarios that have been developed by the Centre for Risk Studies to explore management processes for dealing with an extreme shock. It does not predict a catastrophe.

Cascade of exits from the Eurozone*Populist government in Italy*

Against the backdrop of Germany's continued hard line on servicing Italy's debt stroked a rebellion among the Populist parties. The third-party movement draws widespread support from the disgruntled Italians protesting anti-austerity, and these populist parties manage to channel public dissatisfaction, together with the economic difficulties caused by a series of long-overdue reforms against the European political and monetary union.

Coming into power, these parties reject the stability measures that constitute the monetary and fiscal framework of the currency union and hence triggering an exit from the Eurozone. Spill over effects from the political and economic agenda from Italy force other peripheral countries to follow suit.

Political reactions in the core countries

The costly exits of the peripheral countries have finally put populist, anti-Euro parties into power even in Germany and France.

These parties support the evolution of shadow currencies in both countries, further weakening the Euro. A weak Euro without political support is an economical risk for the remaining member countries. Hence, it is negotiated to completely dissolve this currency.

Global GDP Impact

To estimate the macroeconomic impact of the Eurozone Meltdown Scenario, we apply shocks to exchange rates and short-term central bank interest rates in defaulting countries within the Oxford Economics' Global Economic Model (GEM). The currency depreciation is calibrated between 25 and 40%, and short-term interest rates are driven up by 0.5 to 15 percentage points. This yields "GDP@Risk" which estimates the loss to the global gross domestic product over 5 years, i.e., the cumulative effect of this scenario on the global economy.

The cascade of Eurozone defaults has a significant impact on the world economy. GDP@Risk is between \$11.2 and \$23.2 trillion across the variants, indicating a more severe effect than the Great Financial Crisis if the Eurozone in its entirety were to fail and disband.

Financial market impact

We estimate the portfolio impacts of this scenario by modelling the outputs from Oxford Economics' GEM into portfolio returns, projecting market changes and cash flows while keep the allocation percentages fixed.

We default all corporate bonds conservatively given the 2008 default rates and government bonds using the most severe government defaults in history.

The economic shocks are applied generally over 5 years and we see the portfolio not recover over the baseline performance. The maximum downturn experienced for the Conservative portfolio in the S1 variant is -9.86% nominal occurs in Yr1Q2. The worst performing equity is the German equity index (DAX) and the best performing stocks is Japan (N225). The worst performing fixed income bonds are the German while the US bonds perform the best. The worst performing portfolio structure is the aggressive with a -13.41% loss for the S1 variant.

For portfolio protection it is recommended that equity allocation is shifted away from Europe towards Japan and away from Euro fixed income towards US fixed income.

Risk management strategies*Scenarios as stress tests*

This scenario is an illustration of the risks posed by social unrest triggered by catastrophic event. The High Inflation World scenario is just one example of a wide range of scenarios that could occur.

This scenario aims to improve organizations' operational risk management plans around contingencies, and strategies for surviving financial and counterparty challenges. It presents a capital stress test for insurers to assess their ability to manage underwriting losses while also suffering market impacts on their investment portfolios. This scenario is an illustration of the risks posed by a plausible but extreme financial market based catastrophe. It represents just one example of such a catastrophe and is not a prediction. It is a "what-if" exercise, designed to provide a stress test for risk management purposes by institutions and investors wishing to assess how their systems would fare under extreme circumstances.

Summary of Effects of Eurozone Meltdown Scenario and Variants						
Scenario Variant	S1		S2		X1	
Variant Description	Standard Scenario		Scenario Variant		Extreme Variant	
Defaulting Countries	Greece, Italy, Spain, Portugal and Ireland		S1 plus France and Germany		S2 plus the Eurozone	
World food price shock	180%		250%		310%	
Currency Exchange Rates Shock	25 – 40%		25 – 40%		25 – 40%	
Gross Government Debt Shock	50%		50%		50%	
Macroeconomic losses						
Global recession severity (Minimum qtrly growth rate global GDP)	0%		-1.8%		-2.6%	
Global recession duration	N/A		5 Qtrs		6 Qtrs	
GDP@Risk \$Tr (5 year loss of global output)	\$11.2 Trillion		\$16.3 Trillion		\$23.2 Trillion	
GDP@Risk % (as % of 5-year baseline GDP)	2.8%		4.1%		5.9%	
Portfolio Impact						
Performance at period of max downturn						
<i>High Fixed Income</i>	-5%		-16%		-18%	
<i>Conservative</i>	-10%		-25%		-28%	
<i>Balanced</i>	-12%		-29%		-31%	
<i>Aggressive</i>	-13%		-32%		-35%	
Asset class performance						
	Yr1Qr4	Yr3Qr4	Yr1Qr4	Yr3Qr4	Yr1Qr4	Yr3Qr4
US Equities (W5000), % Change	-4%	-2%	-10%	-15%	-15%	-39%
UK Equities (FTSE100), % Change	-21%	-2%	-36%	-15%	-43%	-39%
German Treasuries 2yr Notes, % Change	-18%	-36%	-61%	-76%	-64%	-82%
German Treasuries 10yr Notes, % Change	-13%	-18%	-68%	-65%	-70%	-69%

Table 1: Summary impacts of the Eurozone Meltdown scenario

		Trillion US\$ GDP@Risk across scenarios		
		S1	S2	X1
	Millennial Uprising Social Unrest Risk	1.6	4.6	8.1
	Dollar Deposed De-Americanization of the Financial System Risk	1.9	1.6	-1.6
	Sybil Logic Bomb Cyber Catastrophe Risk	4.5	7.4	15
	High Inflation World Food and Oil Price Spiral Risk	4.9	8	10.9
	Sao Paolo Influenza Virus Pandemic Risk	7	10	23
	Eurozone Meltdown Sovereign Default Risk	11.2	16.3	23.2
	Global Property Crash Asset Bubble Collapse Risk	13.2	19.6	
	China-Japan Conflict Geopolitical War Risk	17	27	32
	2007-12 Great Financial Crisis	18		
	Great Financial Crisis at 2014	20		

Table 2: GDP@Risk impact of the Eurozone Meltdown scenario compared with previous Centre for Risk Studies stress test scenarios

2 Financial Catastrophe Stress Test Scenarios

This scenario is an illustration of the risks posed by a plausible but extreme financial market based catastrophe. It represents just one example of such a catastrophe and is not a prediction. It is a “what-if” exercise, designed to provide a stress test for risk management purposes by institutions and investors wishing to assess how their systems would fare under extreme circumstances.

This scenario is one of a series of stress test scenarios developed by the Centre for Risk Studies to explore the management processes for dealing with an extreme shock event. It is one of four financial market catastrophe scenarios being modelled under this work package and includes the following:

- Global Property Crash: Asset Bubble Collapse;
- Dollar Deposed: De-Americanisation of the Global Financial System;
- High Inflation World: Food and Oil Price Spiral.

The scenarios present a framework for understanding how global economic and financial collapse will impact regions, sectors and businesses throughout the networked structure of the economy. These financial stress tests aim to improve organisations’ operational risk management plans to form contingencies and strategies for surviving and minimising the impacts from market-based financial catastrophe. In particular, the stress tests allow institutions to manage and build resilience to different forms of risk during periods of financial stress.

These risks include:

- financial and investment risk stemming from a collapse in asset prices across different sectors and regions;
- supply chain risk and the ability of an institution to effectively manage its input requirements through its supply chain, to meet internal production and operational requirements;
- customer demand risk and knowledge for how demand might shift for goods and services during periods of low investment and consumer spending;
- market or segmentation risk and an understanding of how other firms within the same sector will react and perform during periods of financial stress and how this may impact on the business;
- reputational risk and the protection of brand image for reacting appropriately and confidently under crisis conditions.

Each individual scenario may reveal some aspects of potential vulnerability for an organisation, but they are intended to be explored as a suite in order to identify ways of improving overall resilience to unexpected shocks that are complex and have multi-faceted impacts.

Market catastrophe risk and financial contagion

The Great Financial Crisis of 2007-8 not only revealed the extent to which the global financial system is interconnected but how interrelationships between commercial banks, investment banks, central banks, corporations, governments, and households can ultimately lead to systemic instability. As global financial systems become increasingly interconnected, a shock to one part of the system has the potential to send a cascade of defaults throughout the entire network.

In 2008, it was only through government intervention in the form of extensive bailout packages that a widespread collapse of the global financial system was avoided. New models of the global financial system are an essential tool for identifying and assessing potential risks and vulnerabilities that may lead to a systemic financial crisis.

The literature identifies three types of systemic risk: (i) build-up of wide-spread imbalances, (ii) exogenous aggregate shocks and (iii) contagion (Sarlin, 2013). Similarly we work with three analytical methods that help deal with decision support: (i) early-warning systems, (ii) macro stress-testing, and (iii) contagion models. All three methods are actively under research in the Centre for Risk Studies and utilised in the development of these stress test scenarios.

Understanding financial catastrophe threats

This scenario explores the consequences of a financial market catastrophe by examining the notional 1-in-100 possibility for a High Inflation World Scenario and examining how the shock would work through the system.

For a process that truly assesses resilience to market catastrophe, we need to consider how different market-based catastrophes occur and then propagate these shocks through global financial and economic systems. This exercise would ideally include a thorough analysis for each different type of market catastrophe in addition to the four financial catastrophes included in this suite of stress tests.

Such an analysis would also include a range of different severities and characteristics for these scenarios would occur as a result of these different financial and economic crises.

The Cambridge Risk Framework attempts to categorize all potential causes of future shocks into a “Universal Threat Taxonomy.” We have reviewed more than a thousand years of history in order to identify the different causes of disruptive events, collating other disaster catalogues and categorization structures, and researching scientific conjecture and counterfactual hypotheses, combined with a final review process. The resulting Cambridge taxonomy catalogues those macro-catastrophe threats with the potential to cause damage and disruption to a modern globalised world. The report *Cambridge System Shock Risk Framework: A taxonomy of threats for macro-catastrophe risk management* (CCRS, 2014) provides a full description of the methodology and taxonomy content.

Within this universal threat framework we have developed a specified taxonomy for financial catastrophes. This can be seen in Figure 1 and includes a list of seven unique financial, market and economic catastrophes. A large economic or financial catastrophe seldom affects just one part of the system.

The historical record shows that multiple market catastrophes tend to occur at the same time and impacts cascade from one crisis to the next. The recent Great Financial Crisis (GFC) is one example of this. The financial crisis started in the US as a sub-prime asset bubble but quickly spread to the banking sector where many major banks were left holding assets worth much less than had originally been estimated. The complicated nature of the various financial derivatives that were being sold made it difficult for traders to understand the true underlying value of the asset that was being purchased. This result was a systemic banking collapse that had worldwide implications that still remains to be solved across the globe.

Throughout history there have been many other examples where multiple forms of financial catastrophe have cascaded from one form of crisis to the next, examples include the 1720 South Sea Bubble; 1825 Latin American Banking Crisis; 1873 Long Depression; 1893 Bearing Bank Crisis; 1929 Wall Street Crash and Depression; 1997 Asian Crisis and the 2008 Global Financial Crisis.

Scenario design

Each scenario is selected as a plausible, but not probable, extreme event that is driven by a number of factors and would cause significant disruption to normal lifestyles and business activities.

They are illustrative of the type of disruption that would occur within a particular category of “threat” or “peril” – i.e. a cause of disruption.

In this scenario, we explore the consequences of a “Eurozone Meltdown” resulting from cascade of sovereign debt devaluations caused by the sequential exit of countries from a currency union.

The analysis estimates losses to the real economy using the OEM to calculate losses in expected GDP output. We have also estimated how the event would impact investment asset values, using standardized investment portfolios to show the effect on indicative aggregate returns.

Investment managers could apply these asset value changes to their own portfolio structures to see how the scenario would potentially affect their holdings. The impacts of the different variants of this scenario are applied to four financial portfolios: high-quality fixed income, conservative, balanced, and aggressive.

Developing a coherent scenario



Figure 1: Financial catastrophe “FinCat” taxonomy

It is a challenge to develop a scenario that is useful for a wide range of risk management applications. Fully understanding the consequences of a scenario of this type is problematic because of the complexity of the interactions and systems that it will affect.

The economic, financial, and business systems that we are trying to understand in this process are likely to behave in non-intuitive ways, and exhibit surprising characteristics.

During this process we try to obtain insights into the interlinkages through using an extreme scenario.

To develop a coherent stress test we have devised a methodology for understanding the consequences of a scenario, as summarised in Figure 2.

This involves sequential processing of the scenario through several stages and sub-modelling exercises, with iteration processes to align and improve assumptions.

We believe it is important to create a robust and transparent estimation process, and have tried to achieve this through a detailed recording of the assumptions made, and by making use of sensitivity tests regarding the relative importance of one input into another.

In the macroeconomic stages of the modelling, we are conscious that we are attempting to push macroeconomic models, calibrated from normal economic behaviour, outside their comfort zone, and to use them in modelling extreme events. We have worked closely with economists to understand the useful limits of these models and to identify the boundaries of the models functionality.

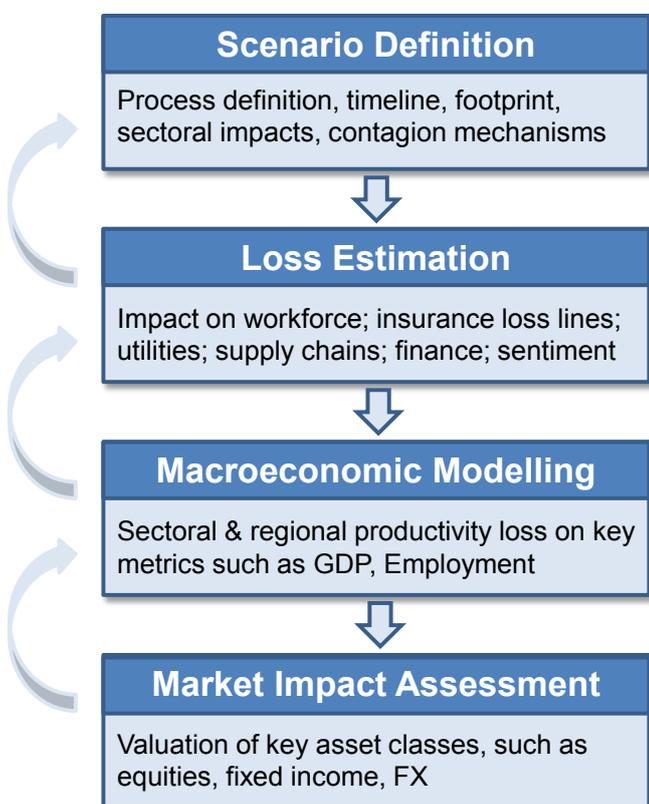


Figure 2: Structural modelling methodology to develop a coherent stress test scenario

Uncertainty and precision

Overall the scenario consequence estimation process retains elements of uncertainty. The process entails making a number of assumptions to assess losses and direct impacts. These are then used as inputs within a macroeconomic model, with additional assumptions and the introduction of uncertainty and variation.

The outputs then feed the assessment of portfolio performance, with further assumptions generating additional uncertainty. Linking all the components into a coherent scenario is problematic to achieve and the process described in this report is one particular approach that has attempted to do this.

It is suboptimal in that the process is imprecise and one of compounded uncertainty at each successive stage and the methodology of various aspects of any particular scenario needs to be understood in this context.

The point, however, of producing the scenario is to understand the consequences in terms of their holistic effects, their relative severities and the patterns of outcome that occur. In fact, the scenario is deterministic and is not designed to provide exceedance probability data points. An approximation selection process has been adopted on the basis of expert elicitation, to be in the range of the 1-in-100 annual probability of occurrence worldwide, but not rigorously determined.

The scenario production process, limited as it is, does provide interesting insights, and many of the applications of the scenario are achieved through this imperfect approach. The scenario is offered as a stress test, to challenge assumptions of continuing status quo and to enable practitioners to benchmark their risk management procedures.

Use of the scenario by investment managers

The scenario provides a timeline and an estimation of the change of fundamental value in assets in an investment portfolio. These are segmented into broad asset classes and geographical markets to provide indicative directional movements.

These provide insights for investment managers into likely market movements that would occur if an event of this type started to manifest. In real events, market movements can sometimes appear random.

This analysis suggests how the underlying fundamentals are likely to change over time, due to the macroeconomic influences. The spread of asset class and geographical distributions enable investors to consider how different portfolio structures would perform under these conditions and how to develop strategies for portfolio management that will minimize the losses that might occur.

Where there are obvious winners and losers by economic sector, these have been highlighted to provide inputs into optimal hedging strategies and portfolio diversification structures.

This report provides performance projections for a standardized high-quality, fixed income portfolio, under passive management.

This is to enable comparisons over time and between scenarios. We also estimate returns for individual asset classes to help investment managers consider how this scenario might impact their particular portfolio and to consider the intervention strategies over time that would mitigate the impact of this financial catastrophe.

Use of the scenario by policy makers

International agencies like The World Bank, The International Monetary Fund (IMF), The Organisation for Economic Co-operation and Development (OECD) and G7-G8 Group Meetings recognise the serious global implications of market-based catastrophe. Scenario stress testing is a sensible and appropriate tool to improve the awareness and decision-making ability of policy advisors.

This scenario is proposed as an addition to the existing frameworks and procedures that are already being used to understand risk and contagion in the global financial and economic systems.

National governments, central banks and other regulatory authorities including the Prudential Regulation Authority (PRA) in the UK use stress tests to determine whether banks have sufficient capital to withstand the impact of adverse economic developments. Many banks also carry out stress tests as part of their own internal risk management processes. Such tests are designed as an early detection system to identify vulnerabilities in the banking sector so that corrective action can be taken by regulators. These stress tests focus on a few key risks such as credit risk, market risk and liquidity risk. In many cases, banks are subject to performance reviews against classified versions of these scenarios and they are a mandatory requirement for many national regulatory authorities.

This scenario is a contribution to the design of future versions of these policy-maker scenarios. It offers a view of the economic environment and broader financial disruption that will be caused. It provides inputs into the decision making and resource planning of these authorities, and is offered as context for policy-makers concerned with stemming the impacts of market catastrophe.

Complex risks and macroeconomic impacts

Financial and economic systems are inextricably linked. Thus, financial market catastrophes are of interest because they represent complex risks – they impact the networks of activities that underpin the global economy, disrupting the interrelationships that drive business, and cause losses in unexpected ways and places.

They have multiple consequences, causing severe direct losses, as well as operational challenges to business continuity, cascading effects on the macroeconomy through trading relationships, and on the capital markets and investment portfolios that underpin the financial system.

The stress test is aimed at providing an illustration of the effects of an extreme event, to help a non-specialist audience understand the potential for events of this type to cause disruption and economic loss. It is aimed at informing risk management decisions for a number of different communities of practice.

3 Sovereign Default as a Financial Catastrophe

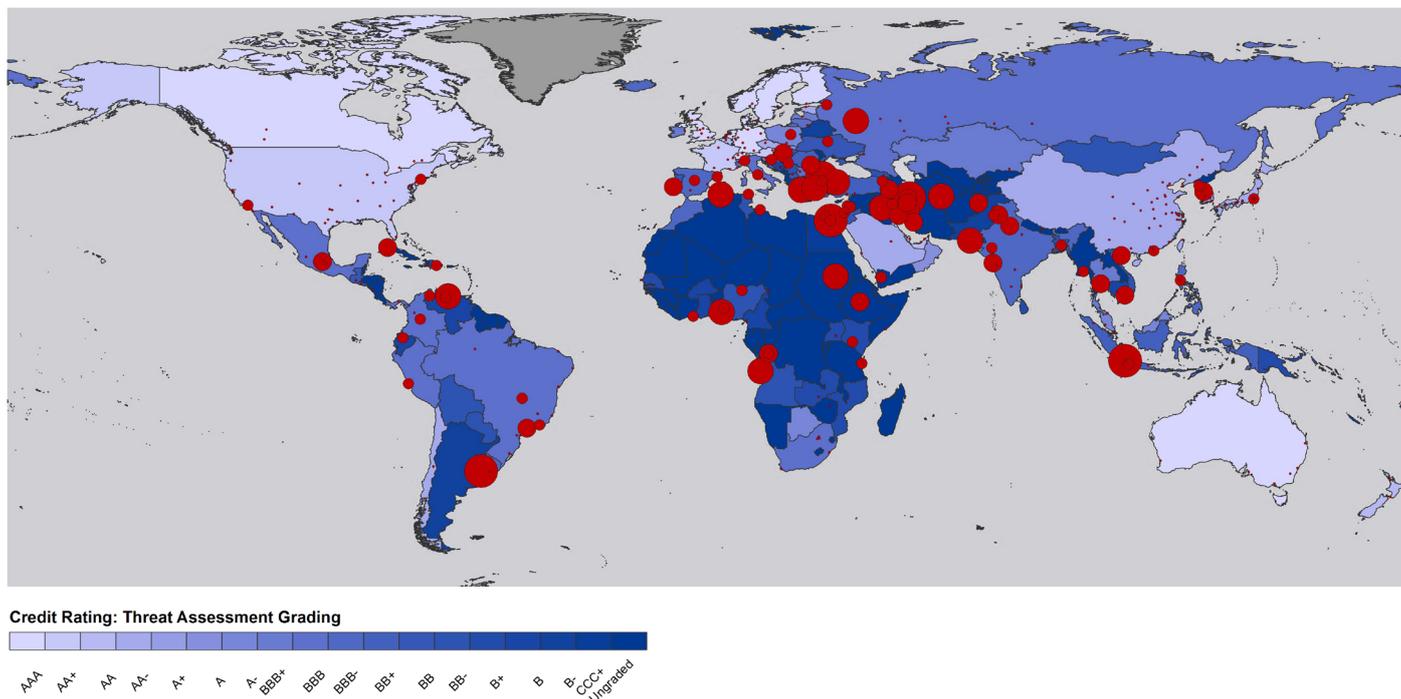


Figure 3: Risk Atlas illustrating global debt ratings across all nations, along with those cities most at risk of sovereign default crisis (Cambridge Centre for Risk Studies)

Sovereign default is a failure or refusal by a country's government to make a repayment of debts. It means that investors who hold the bonds issued by that country's national treasury fail to receive the promised payments and suffer reduced yields and potentially loss in value of the bond.

Sovereign defaults can cause significant problems to private investors, particularly institutional investors and asset managers who tend to structure investment portfolios that contain a high proportion of fixed income investment assets, including government treasury bonds from a basket of different countries. A sovereign default can mean a devaluation of the principal, as well as loss of yield from the bond. This report explores the impact of unexpected devaluation of fixed income assets in a portfolio resulting from a cascade of sovereign defaults in what are conventionally regarded as high quality (i.e. low risk) investment instruments.

Risk levels of sovereign bonds are reflected by the ratings published by ratings agencies, such as Standard and Poor's; Moody's; Fitch.

Governments commonly lend to each other, and the failure of a country to repay its debts to another can cause financial problems to the lender and, in the worst case, trigger a default in that country in turn.

Defaults from one country to another have even historically triggered wars between countries (see box) before the 1945 United Nations charter prohibited the use of force to enforce creditor nation rights. However, the risk of sovereign default remains closely linked with geopolitical events as well as financial and economic circumstances.

Inter-government debt can be a cause of systemic risk that triggers cascades of defaults and financial distress across multiple countries. In times of economic hardship, sovereign defaults become more likely and several countries who are reliant on each other's loan repayments can be pushed into cascades of defaults. Neighbouring countries facing similar economic problems may all default in a short period of time. These regional cascades of defaults can be seen in the historical catalogues: in 1982 Argentina, Mexico, Brazil and Ecuador all defaulted within 12 months of each other. Within two years Venezuela, Uruguay, Peru and Chile had followed suit. High interest rates and the collapse of global commodity prices were contributing common factors behind a number of sovereign defaults.

National governments try hard not to default on their debts, as this makes it much more expensive and difficult to borrow funds after a default event.

Countries default for a number of reasons, mostly economic factors that cause imbalance between national income and demands on their treasury. Most governments borrow and maintain a balance of debt to fund longer term or strategic projects, which may include political change and restructuring of the economy, so national debt management has a high degree of political control. Political reasons may force governments to tolerate high levels of debt, and crises can occur that force unplanned financial shortfalls. Political pressure from the electorate can restrict a government's ability to manage their debt.

The period since the Great Financial Crisis of 2008 has seen many countries attempting to reduce their deficits by imposing highly unpopular austerity measures on public spending. These shifts in policy have triggered protest movements and social unrest which have influenced politicians to moderate their attempts at fiscal prudence. In some democracies, governments attempting to reduce national debts have been voted out of office and replaced by anti-austerity parties that promise to maintain public spending.

The various causes for countries to default include:

- major increases in public debt;
- reduction in tax receipts;
- decline in employment levels;
- government regulation or perceived threats of regulation of financial markets;
- popular unrest at austerity measures to repay debt fully.

Negative scenarios for the market value of bonds – be it just for rising yields or even for an actual default – also weaken the currency these bonds are denominated in. One direct reason for this is that foreign currency reserves are usually not stored in the form of bank deposits - which would expose them to the counterparty risk of a private bank - but in the form of sovereign bonds. Selling these bonds leads to a downside pressure on the corresponding currencies.

Indirect reasons are the weaker growth prospects in the affected countries and a falling stock market.

A specific variant of exchange rate risk is redenomination risk. In the case of the Euro area, the southern countries may see a redenomination of their debt and labour cost from Euro into their new own currency as a way to devalue this debt and cost and to push nominal growth rates.

Of course, this comes at the cost of inflation and

damages not only external creditors but also their domestic savers, but might be easier to sell to their voters than adhering to a common currency that is perceived as being controlled by external institutions.

In northern countries which traditionally adhered to a more conservative monetary policy than that the ECB currently runs many citizens call for a return to their own currencies. In Germany, in particular, the “Alternative für Deutschland” (AfD) calls for a return to the Deutschmark, disregarding the advantages of the common currency for the export revenues of the country. The motives behind this strategy might be their voter base, which are mainly pensioners with little international experience. After introduction of a new Deutschmark, the new currency would likely rise in value relative to the Euro and USD, heavily damaging the export-oriented German industry making the country more like present Switzerland, though with fewer wealth reserves than its southern neighbour.

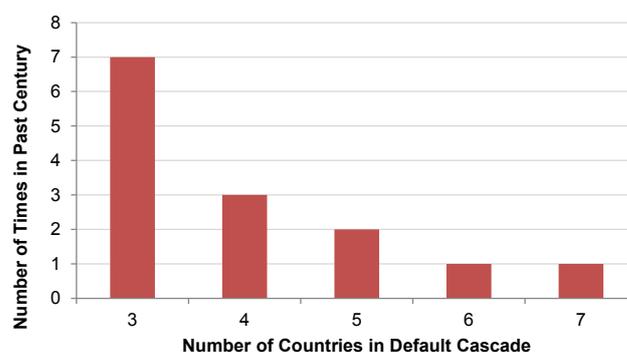


Figure 4: Cascades of sovereign defaults by size (number of countries), over the past century.

A History of Sovereign Defaults

In the catalogue of financial crises compiled by Reinhart and Rogoff², over the past two hundred years there have been over 180 recorded sovereign defaults, with 120 of them occurring in the past century. Somewhere in the world about once a year a country defaults on its debts.

Our scenario replicates a severe wave of sovereign defaults or currency exits, with the countries affected all being major economies and issuers of investment grade sovereign bonds. The scenario includes several variants of increasingly severe and improbable assumptions, ranging from five countries that contribute 6% of the world's GDP, through to all the countries in the Eurozone which accounts for 17% of the global economy.

² Reinhart and Rogoff (2009)

4 Defining the Scenario

The practice of using stress tests to check the health of banks and economic institutions in the wake of the Great Financial Crisis is currently a point of some contention in financial circles. While stress tests have restored confidence in some instances, they have also failed to accurately capture the risk limits of the institutions whose financial health they seek to diagnose. Recently, the rapid rate of change in the economic climate means that results of such stress tests have little longevity and are quickly rendered obsolete. In this period of general economic recovery there are concerns that current stress tests are too predictable, too poorly applied, or even perhaps ‘set the bar too low’ and require closer re-examination.

In light of this issue, the University of Cambridge Centre for Risk Studies has designed a new suite of coherent stress tests to reflect potential, though improbable, global financial crises with a view to test longevity. This particular scenario, of the four designed, explores the consequences of commodity price spirals leading to a period of sustained high cost-push inflation worldwide.

Likelihood and probability

Assessing the probability of severity for a sovereign default is complex. Historically individual countries have defaulted at a rate of around one a year, and once a century we have seen a cascade of six or seven countries defaulting in a single year. These cascades have typically been in emerging markets or the weaker economies of the world. One benchmark of a modern severe stress that might fit the criteria of a ‘one-in-a-hundred’ annual probability event would be a cascade of seven countries undergoing a sovereign default in a single year.

However it is clear that the financial system has undergone a significant transformation in the past generation.

Long term historical observations may be a poor benchmark for modern risk assessment. In the companion volumes to this report being produced as part of our research into financial crises, we observe that financial crises have increased in frequency since globalization and financial deregulation in the last third of the twentieth century.

The likelihood of cascades of sovereign defaults – the ‘tail risk’ of extreme scenarios – is probably higher today than would be assessed by looking at the extremes from the past one or two centuries.

The interconnectedness of the modern financial system has made markets more aligned and less independent. When one market fails, others fail with it in ways that did not occur before globalization. Understanding this process is key to the risk assessment of modern financial crises.

Markets are increasingly correlated – their day-to-day movements up and down are closer aligned than they have ever been. National economies and banking systems have migrated from being individual markets with idiosyncratic behaviour to being part of one global financial ecosystem.

The potential for systemic ‘contagion’ of a financial crisis from one nation to another is driven by their interbank lending patterns. This includes the flow of capital between countries, common investment strategies across an international range of financial assets and cross shareholding patterns in the ownership of increasingly globalized financial institutions. The shared philosophy and actions of central banks and technological advances in communication and transaction management also play a role.

The risk that is the major concern of investment managers and financial risk analysts is the threat of sovereign defaults in some of the major economies of the world.

These are the bonds that are rated as investment grade by the ratings agencies and that provide the safe havens of investment for fixed income returns. Their default seems almost unthinkable, and it is a general assumption that these investment instruments are completely safe. Our stress test scenario is intended to challenge this assumption and to pose the question about risk levels inherent in investment grade sovereign bonds,

In selecting the scenario for stress testing, a number of candidate scenarios were reviewed in addition to the Eurozone cascading default. These were all compared with reasons why they were unlikely to occur, to identify what kind of control mechanisms would have to fail in order for the event to come about.

The most impactful scenario would be one in which the United States defaults – US treasury bonds are one of the most popular investment instruments in high quality portfolios.

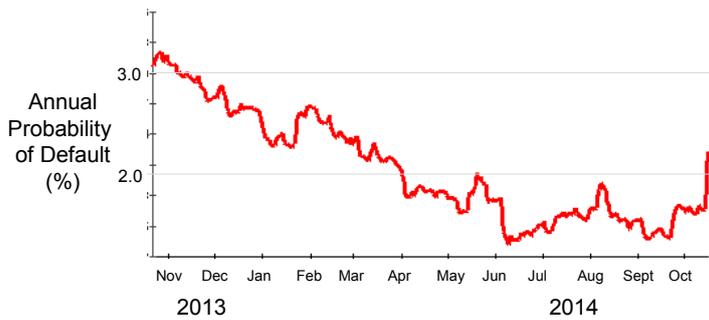


Figure 5: Annual probability of Italian default from 5 year CDS spreads

Selected scenario

As of November 2015, the situation in the Euro area shows public political pressure from populist parties towards the governments, although the combination of the rescue architecture and political reforms technically had worked well to decrease the credit spreads from their 2012 highs. In the southern countries, Brussels is still blamed as cause for painful reforms the local governments were reluctant to implement.

To the North, the willingness for any further unlimited financial support to their southern counterparty decreases significantly. In July 2015, an uncontrolled Greek exit was barely avoided after several months of intense negotiations that concluded in a third-bailout package.

The scenarios selected reflect this political pressure. A market-driven meltdown of a Euro area willing to stay together seems unlikely, as the combined quantitative easing (QE) firepower of the European Central Bank (ECB) and the cheap funding from the European Stability Mechanism (ESM) proved to overcome negative market forces. Instead, the scenarios focus on the rise of populist parties that challenge the consensus of the combination of rescue architecture and reforms. The order and sequencing of the exits from the Euro are especially important, as the functioning of the Euro system depends on the commitment of the central countries France and Germany.

Instead, it is the political decisions in several countries to return to their own currencies to regain full spending control over their deficits that is the most significant dimension of the scenario.

The scenario spreads by political contagion across a number of countries. We test the severity of the scenario through a number of variants. In variant S1, some of the weaker European economies – Italy and the so-called PIGS (Italy, Portugal, Ireland, Greece and Spain) are caught up in a wave of defaults.

In variant S2, we explore how populist parties also in France and Germany could trigger the end of the coordinated rescue politics and the introduction of parallel currencies.

In variant X1 we expand the scenario to a dissolution of the Eurozone. Many remaining countries with similar cultures would probably follow Germany to build a new currency zone with strict monetary policy.

There are plausible extensions of the scenario that could go even further, to pull United States and potentially Japan into financial distress from these events, and that could potentially result in defaults of the mainstay investment instruments of US Treasury bonds and Japan government bonds. However, this may seem too extreme as a stress test and its likelihood is extremely remote. We encourage investment risk managers to add assumptions about additional default likelihoods of US treasuries and Japan government bonds to their stress test for worst-case scenarios.

Scenario Variants

We introduce a set of variants to the Eurozone Meltdown scenario to provide sensitivity analysis so as to gain a better understanding of the greater effects of a negotiated exit from the Euro area.

S1 consists of the peripheral countries, Italy, Greece, Spain, Portugal, and Ireland, exiting the Euro area, and evolving into their original currencies and further weakening the Euro. Scenario variant S2 and extreme variant X1 are similar to the standard scenario, but the populist, anti-Euro parties spread into power even in Germany and France, and ultimately the entire Eurozone. The weak Euros without political support become a significant economic risk; hence it is negotiated to be completely dissolved.

	S1	S2	X1
Italy	Italy	Italy	Italy
Greece	Greece	Greece	Greece
Spain	Spain	Spain	Spain
Portugal	Portugal	Portugal	Portugal
Ireland	Ireland	Ireland	Ireland
		Germany	Germany
		France	France
			Rest of Eurozone
Total GDP (2013)			
US\$4.2 Tn	\$10.8 Tn	\$12.9 Tn	\$12.9 Tn
5.6%	14.3%	17.0%	17.0%

Table 3: Summary of dissolving countries from the Euro area across the scenario variants

5 The Scenario

Background

Anti-austerity rioting in Italy leads to the resignation of Prime Minister Renzi and triggers a snap general election.

Voters perceive Italy as unfairly burdened with the brunt of Europe's current refugee crisis and the fear that the influx of illegal immigrants will draw down native employment rates, so parties run on a platform of economic reform and take a hard line against continuing austerity measures and kowtowing to German control of national finance policies.

Phase 1: Five Star Italian Government

The soft Eurosceptic party, M5S, which had been gaining ground in the Italian senate, wins the election by a slight majority and forms a coalition with Lega Nord, Italy's most anti-European party. Beppe Grillo, leader of M5S, becomes Italy's new prime minister.

Despite the election, European Union authorities inform Italy that further servicing of Italy's debt will be contingent on the resumption of austerity measures as part of a coordinated effort to bolster economic resilience, Europe-wide.

Prime Minister Grillo gains widespread popular support after submitting a robust rebuttal of the Chancellor's demands. The new government announces that it will no longer fulfil the Maastricht criteria but instead starting an extensive public welfare program.

Phase 2: Nuova Lira

The countries agree on an Italian exit with an extensive support package for Italy - namely a substantial haircut, a guaranteed extensive financial aid program to prevent MSE to default in the transition phase, and 1000t of gold together with 10bn EUR and USD cash reserves - to support the new Italian currency. The market value of Italian debt falls by 50% as a consequence of these measures.

Markets react strongly to the 50% devaluation of Italian debt and foreign investment in Italy grinds to a halt. Foreign markets begin to dump Eurobonds. A sell off of Italian assets begins among the country's major trading partners.

The announcement of the agreement also puts Spain, Portugal, and Greece under pressure: their long-term bond yields explode and cut them off from the financial markets.

Silmultaneously, there are anti-European mass demonstrations in these fiscally insolvent countries. Polls show that their governments will lose the coming elections.

Phase 3: Cascade of Defaults in the Weaker Trading Partners

The shake-up immediately impacts the other vulnerable PIIGS nations.

Fearing a return to financial crisis and extreme austerity, Spain's government is left with little option but to default on its debt. It leaves the Euro with a comparable support package from the remaining member states. Spain's announcement sends international markets into an even greater frenzy at the suggestion that the Eurozone may be about to fall apart. Business and consumer confidence levels drop sharply in reaction to heightened uncertainty and there is a sharp decline in equity prices.

As the contagion spreads, Portugal swiftly follows Spain's example, with Ireland doing the same within a week. Dealt a blow by the rapid secession of European states, Greece remains in the Eurozone for several weeks before it, too, declares that it is exiting and devaluing its currency.

There is a surge in inflation in the exiting countries and central banks respond by raising interest rates between 8-10%. National exchange rates drop by up to 40% against the Euro, while the Euro itself initially depreciates 15% against the dollar. The remaining eleven members of the Eurozone are dragged into a recession over the next ten fiscal quarters and stock markets fall significantly in other major economies.

6 Macroeconomic Analysis

Economic impacts of sovereign default

Sovereign default occurs when the government of a sovereign state fails or refuses to pay back its debt in full. A recent and prominent example of sovereign default occurred during the course of this study in Argentina which has defaulted twice on its debt in 13 years. Argentina first defaulted in 2001 when the IMF refused to release a US\$1.3 billion loan that resulted in the country not being paid interest on a loan payment.

Despite being one of the largest sovereign defaults seen in the history of Latin America, the default (\$82bn) did not lead to any significant spread of contagion. Reasonably, Argentina's economy is probably too small (less than one% of global GDP) to render a significant financial collapse in Latin America, or the global economy.

Macroeconomic effects of Sovereign Default

The previous Argentine default of 2001 had increased the unemployment rate from an average of 15%, in the late 1990s, to 22.5% in the year after the default. It also resulted in a new government, the rise of an alternative currency and the end of the peso's fixed exchange rate to the US dollar. The economy shrank by more than half between 2002 and 2004 but, within two years, GDP growth returned to pre-crisis state and its economy began to grow at an average annual rate of 9%.

Oxford Economics Global Economic Model

We use the Oxford Economics Global Economic Model (GEM), a quarterly-linked international econometric model, to examine how the global economy reacts to shocks on the global economy. It is the most widely used international macroeconomic model with clients including the IMF and World Bank. The model contains a detailed database with historical values of many economic variables and equations that describe the systemic interactions among the most important 47 economies of the world. Forecasts are updated monthly for the 5-year, 10-year and 25-year projections.

The Oxford GEM is best described as an eclectic model, adopting Keynesian principles in the short run and a monetarist viewpoint in the long run. In the short run output is determined by the demand side of the economy, and in the long term, output and employment are determined by supply side factors.

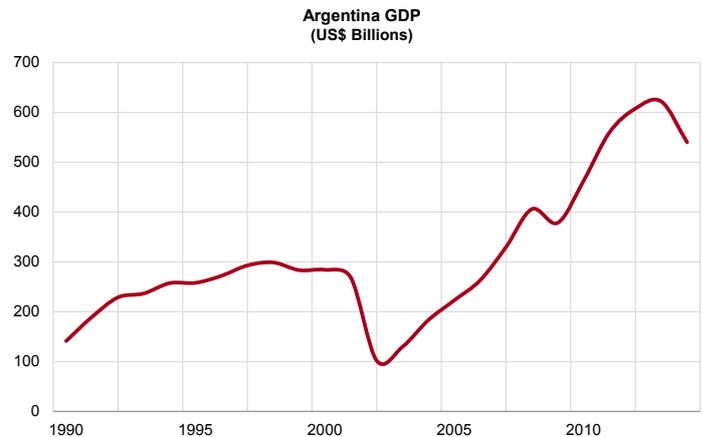


Figure 6: Historical GDP data of Argentina from 1990 to present (Source: World Bank)

The Cobb-Douglas production function links the economy's capacity (potential output) to the labour supply, capital stock and total factor productivity. Monetary policy is endogenised through the Taylor rule, where central banks change nominal interest rates in response to changes in inflation. Relative productivity and net foreign assets determine exchange rates, and trade is the weighted average of the growth in total imports of goods (excluding oil) of all remaining countries. Country competitiveness is determined from unit labour cost.

Assumptions and uncertainty

The economic estimates presented in this analysis are subject to the assumptions made in the development of the narrative and how the scenario may unfold over time.

The modelling and analysis completed are also subject to several sources of uncertainty. A best attempt has been made to ensure the macroeconomic interpretation of the narrative is justified on historical grounds as well as following sound economic theory and principles. However, the unusual and unprecedented nature of this particular catastrophe introduces several layers of uncertainty in final model outputs that cannot completely be ruled out. Thus final estimates represent a best attempt to model the economic outcomes of a low probability event with highly uncertain outcomes.

Macroeconomic narrative of the scenario

The key indicators selected to simulate the effects of Sovereign Default are government debts, short-term interest rates and currency exchange rates.

S/N	Macroeconomics input variables	Scenario Variants			Justification for shock	Scenario-specific key assumptions
		S1	S2	X1		
1	Gross Government Debt (% of GDP)					
	Portugal	-50%	-50%	-50%	2001 Argentinian debt default³: <ul style="list-style-type: none"> Defaulted debt of \$155bn (largest in history)⁴ External debt-to-GDP ratio increased from 28.4% in 1991 to 51% in 1999⁵ Government forced to abandon fixed exchange rate. 	The Greek national debts⁶: <ul style="list-style-type: none"> 180% of GDP (2014) Government revenue fell by 15% between 2007 and 2014 Misaligned budget imbalances and economic cycles with other Eurozone members Debt cannot be serviced
	Ireland					
	Italy					
	Greece					
	Spain					
	France	+25%				
	Germany	+50%				
	Rest of Eurozone	+30%	+400%			
	Rest of the World			+10%		
2	Exchange Rates (Against the Euro)					
	Portugal, <i>Escudo</i>	-25%	-25%	-35%	2001 Argentinian debt default: <ul style="list-style-type: none"> The Peso devalued by 70% against the dollar⁷ Debt value partially lost 	Weak euro⁸: <ul style="list-style-type: none"> Numerous Quantitative Easing programmes led to a fall in the currency. High uncertainty over euro currency. Currency outflows-investors looking for better places to invest.
	Ireland, <i>Punt</i>					
	Italy, <i>Lira</i>					
	Greece, <i>Drachma</i>					
	Spain, <i>Peseta</i>					
	France, <i>Franc</i>					
	Germany, <i>Deutsche mark</i>					
	Rest of Eurozone					
3	Long-term government bonds yields					
	Portugal	+50%	+50%	+50%	2001 Argentinian debt default: <ul style="list-style-type: none"> Long-term interest rates on borrowing increased sharply⁹ 	2001 Argentinian debt default: <ul style="list-style-type: none"> Higher credit risks in the Eurozone Increase in interest rates on borrowing 4.3% of Greece's GDP was devoted to interest payments in 2014¹⁰
	Ireland					
	Italy					
	Greece					
	Spain					
	France					
	Germany					
	Rest of Eurozone					
4	Market Confidence (% points)					
	Portugal	-50	-50	-50	General market confidence affected by decreases in¹¹: <ul style="list-style-type: none"> Credit ratingⁱ GDP by 10% Investment by 30% Consumption by 15% 	Specific examples: <u>Portugal, 2008</u> <ul style="list-style-type: none"> 200% external debt-to-GDP ratio¹² Government bonds rated 'junk' <u>Italy, 2013</u> <ul style="list-style-type: none"> Downgraded from BBB+ to BBB¹³ Debt-to-GDP ratio of 133% Low growth -1.7%¹⁴

Table 4: Catalogue of macroeconomic scenario assumptions made in the modelling process

	Ireland				<u>Spain, 2012/3</u> <ul style="list-style-type: none"> • Debt-to-GDP ratio 94.2%¹⁵ • Credit rating BBB-¹⁶ <u>Ireland, 2014</u> <ul style="list-style-type: none"> • Sharp increase of debt-to-GDP ratio 114.8% • High banking liabilities <u>Greece</u> <ul style="list-style-type: none"> • Downgraded to 'junk'¹⁷ • High capital withdrawals¹⁸
	Italy				
	Greece				
	Spain				
	France	-10			
	Germany	-10			
	Rest of Eurozone	-10	-10		
	Rest of the World	-5	-7	-10	

¹ Credit Rating provides investors some insight into how risky investment into a particular country is. It takes into account the performance of an economy as a whole, its balance of payment, foreign debt, foreign investment, public and private investment, foreign currency reserves, development of financial markets, and capital market transparency. Thus a good credit rating is important for a country to access funds in international capital markets. A weak credit rating may lead to outflow of domestic funds.

Table 4 (continued): Catalogue of macroeconomic scenario assumptions made in the modelling process

³ J. Hornbeck, Jeff, *Argentina's Defaulted Sovereign Debt: Dealing with the 'Holdouts'*, United States Congressional Research Service, July; 2010.

⁴ Also known as "A decline without parallel". Source: *The Economist*, 28 February 2002

⁵ M. Braun, "The political economy of debt in Argentina, Or why history repeats itself", *CIPEC*, 2 October, 2006

⁶ D. Altman, "The Greek Euro Crisis is on the back burner - but next in line are Portugal, Italy And Spain". *Financial Review*, 2 August 2015

⁷ BBC News, Q&A: Argentina's economic crisis. 12 February 2003

⁸ R. Ruparel, "Will The Euro Get Weaker?". *Forbes*, 29 April 2015

⁹ W. Baer, D. Margot, G. Montes-Rojas, *Argentina's default and the lack of dire consequences*, School of Social Sciences, City University London, 2015

¹⁰ A. Watt, *Is Greek Debt Really Unsustainable?* Social Europe Occasional Paper, January 2015

¹¹ L. Tedesco, J. Barton, *The State Of Democracy In Latin America*. London, 2004

¹² International Monetary Fund, Portugal: 2008 Article IV Consultation—Staff Report; Staff Statement, *Public Information Notice on the Executive Board Discussion; and Statement by the Executive Director for Portugal*, October 2008

¹³ J. Kearns, A. Frye. "Italy's credit rating cut to BBB by S&P; outlook stays negative". *Bloomberg*, 10 July 2013

¹⁴ Focus Economics, 'Italy Economic Output'.

¹⁵ A. Gonzalez, "Spain's Public Debt to approach 100% of GDP end-2014", *Reuters*, 30 September 2013

¹⁶ BBC News, "Spain Credit Rating cut by S&P to BBB-", 10 October 2012

¹⁷ J. Kell, "S&P downgrades Greece to junk status", *The Wall Street Journal*, 27 April 2010

¹⁸ J. Siegel, "Devaluation – last option to save the euro", *The Financial Times* 22 May 2012

Table 5: Key input variables and their maximum shocks applies to the respective scenario variants

S/N	Input Variable	Scenario Variants			Max. Shock duration applied
		S1	S2	X1	
1	Gross government debt	-50%	-50%	-50%	1 Qtr
2	Market confidence	-150%	-150%	-150%	5 Yrs
3	Exchange rate per Euro	-60%	-60%	-60%	5 Yrs
4	Long-term interest rates	+6%	+4%	+4%	5 Yrs
5	Defaulting Countries				
	<i>Portugal</i>	√	√	√	
	<i>Ireland</i>	√	√	√	
	<i>Italy</i>	√	√	√	
	<i>Greece</i>	√	√	√	
	<i>Spain</i>	√	√	√	
	<i>France</i>		√	√	
	<i>Germany</i>		√	√	
	<i>Rest of Eurozone</i>			√	

These shocks are chosen based on historical precedents, such as the Argentine defaults in 2001 and 2014. Although most of the past sovereign defaults lasted between one and two years, the shocks persist and last throughout the modelling period to represent the ongoing macroeconomic effects created by the defaults to reflect the permanent Eurozone break-up.

An example is the effect on exchange rates: historical data after the 2001 Argentina default shows a period of sustained currency depreciation for at least six years.

The model assumes the shock begins in the first quarter of 2015 (YOQ1). The exact timing of the shock is not an important component of the model, but of more interest is the generic result showing the potential impact on the wider economy.

Variable Descriptions

This scenario has included several independent variants, modelled using the Oxford Economic GEM, to provide sensitivity analysis around the assumptions being made. Table 5 summarises the maximum shocks applied to the key input variables and spatial extent of Eurozone meltdown.

In the S1 variant, the sovereign default shock is mainly contained within the few defaulting nations, while in variants S2 and X1 the contagion spreads across to France and Germany, before engulfing the rest of the Eurozone respectively.

Results

There are often many international negotiations that end up in partial or full debt cancellation, or debt restructuring prior to a nation defaults.

During the Argentine default of 2001, creditors had to accept renunciation of up to 75% of outstanding debts as Argentina disposed of its financial obligations, an immediate reduction on gross government debts and interest payments. Debts are retired by “restructuring” or default, where partial or the full value is lost, thereby severely damaging the reputation and credit ratings of the defaulting nations. Some may even subsequently be restricted of credit loans from the capital markets.

Furthermore, as market confidence levels take the plummet and foreign investors avoid the defaulting nation, a currency crisis usually occurs and depreciates the currency value drastically.

Impact on inflation rates

The psychological aspect of credit crunch and currency devaluation cannot be overstated. The market sentiment shifts into pessimism, resulting in creditors, debtors, consumers, and investors to change their primary behavioural orientation into conservative (i.e. less spending, lending, and borrowing and more savings), reducing the “velocity” of money. Defaults and/or the fear of default exacerbate the psychology, putting a downside pressure on prices and begin a downward deflationary spiral.

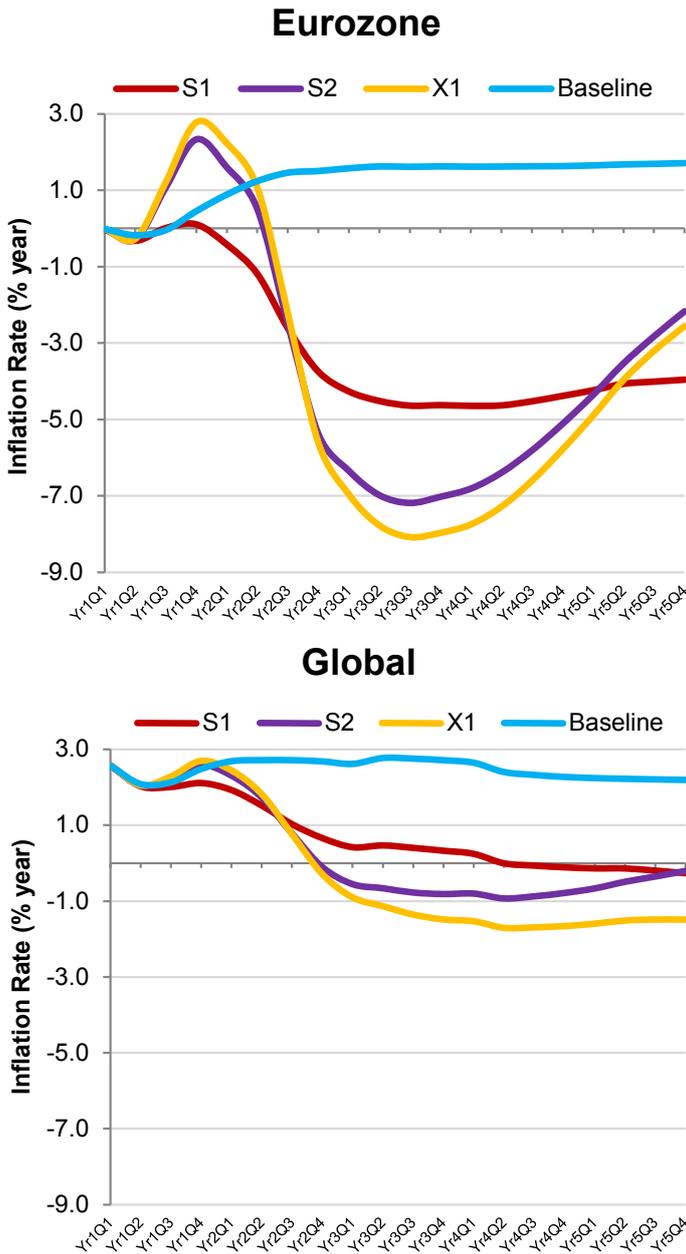


Figure 7: Eurozone and global inflation rates (% year) comparison

Figure 7 compares both the Eurozone and the global inflation rates, across different sovereign default severities. In the standard scenario, S1, the Eurozone first experiences a sharp hike in inflation rates up to 3% within the first year before it begins the downward deflationary spiral up to -5% throughout the modelling period. On the other hand, the S1 variant results in a global disinflation and then sustains it at 0% throughout the modelling period.

Effect on interest rates

As Eurozone enters a deflationary spiral following the several sovereign defaults, the short-term interest rates (Figure 8) plummet to near zero in an attempt to expand

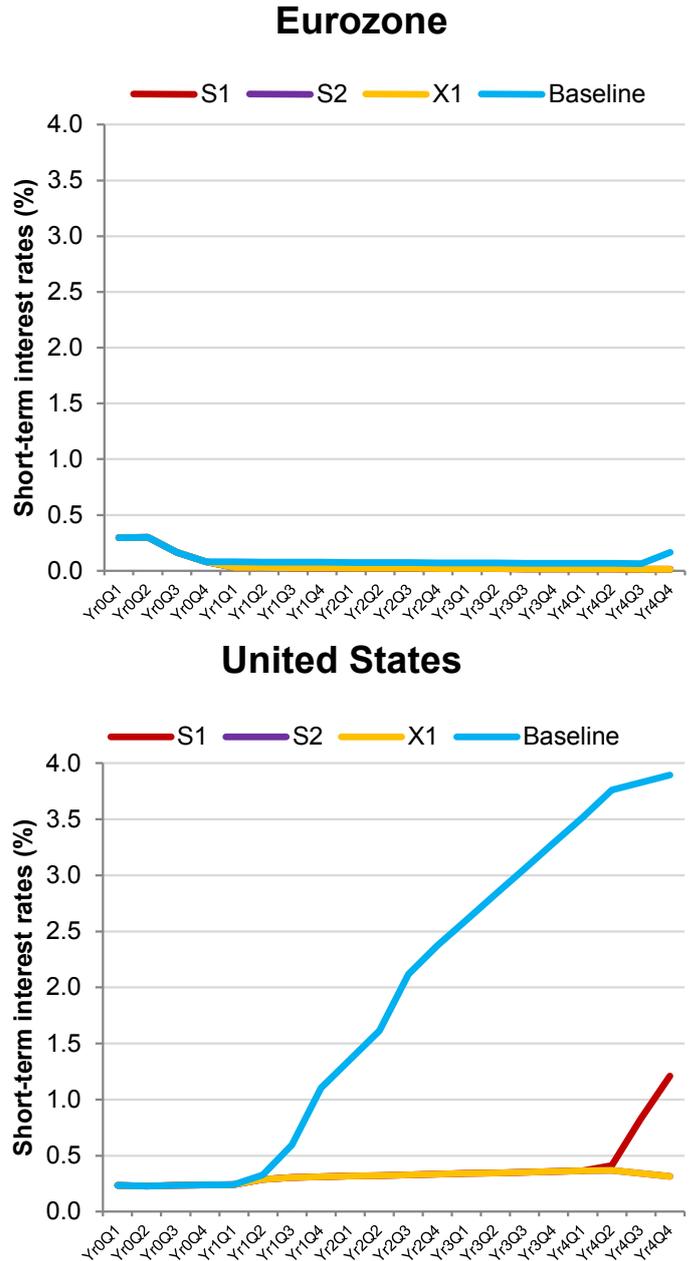


Figure 8: Eurozone and US short-term interest rates (%) comparison

the money supply and encourage economic growth.

Results also indicate that the projected QE tapering in the US will probably not occur as the government further maintains low interest rates to encourage lending to boost the economy from the global disinflation and deflation scenarios.

Long-term interest rates increase drastically in the Eurozone compared to the baseline projection, but the trend is reversed in the US (Figure 9). The sharp rise in the long-term interest rate is primarily due to the long-term uncertainty outlook in the economy and to compensate for additional risks associated with the Eurozone default. Conversely, the US measures consistently low and decreasing long-term interest

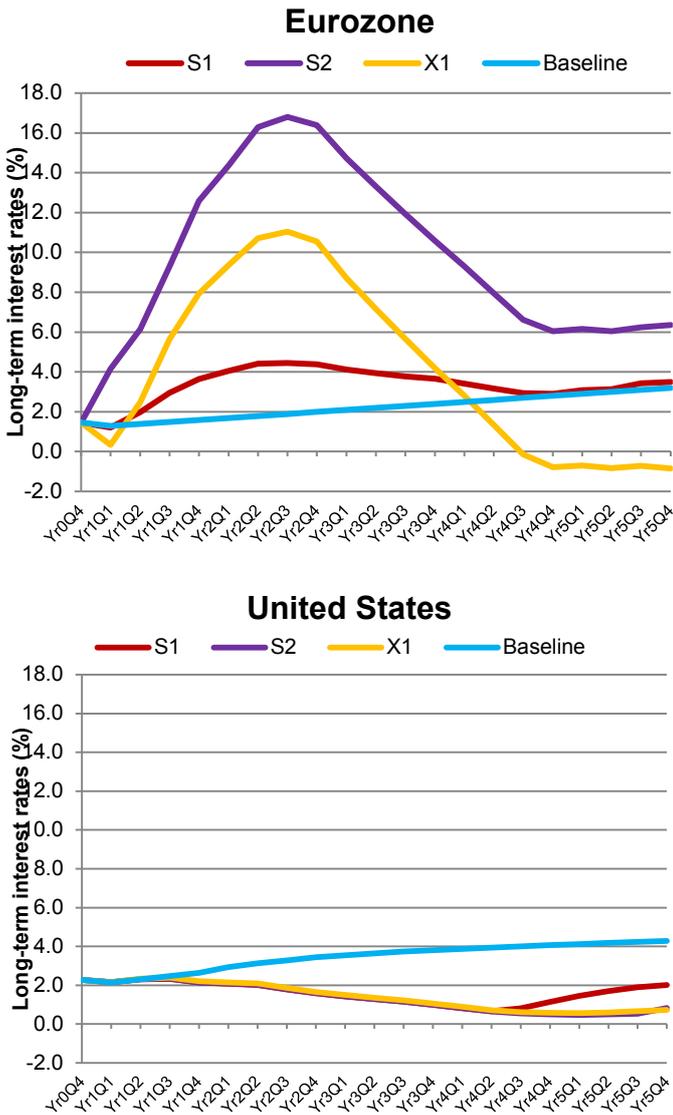


Figure 9: Eurozone and the US long-term interest rates (%) comparison

rates that reflect a marginally safer investment market compared to the Eurozone in the near future.

Effect on credit ratings

It is clear that credit ratings of the defaulting countries suffer the largest downgrades. However, credit ratings of non-defaulting countries are similarly affected. This is due to the transfer of the full or partial defaulted debts to other governments or additional debts incurred by these governments to bail out the defaulted ones.

In Table 6, no credit rating is provided for Greece, Germany and the Eurozone in their respective defaulting scenario variants, as credit ratings in the Oxford Economics Model are measured primarily through the proportion of gross government debts. By definition, the defaulting countries have their sovereign debts “restructured” and interest payments reduced, hence the new measured credit ratings of the defaulting

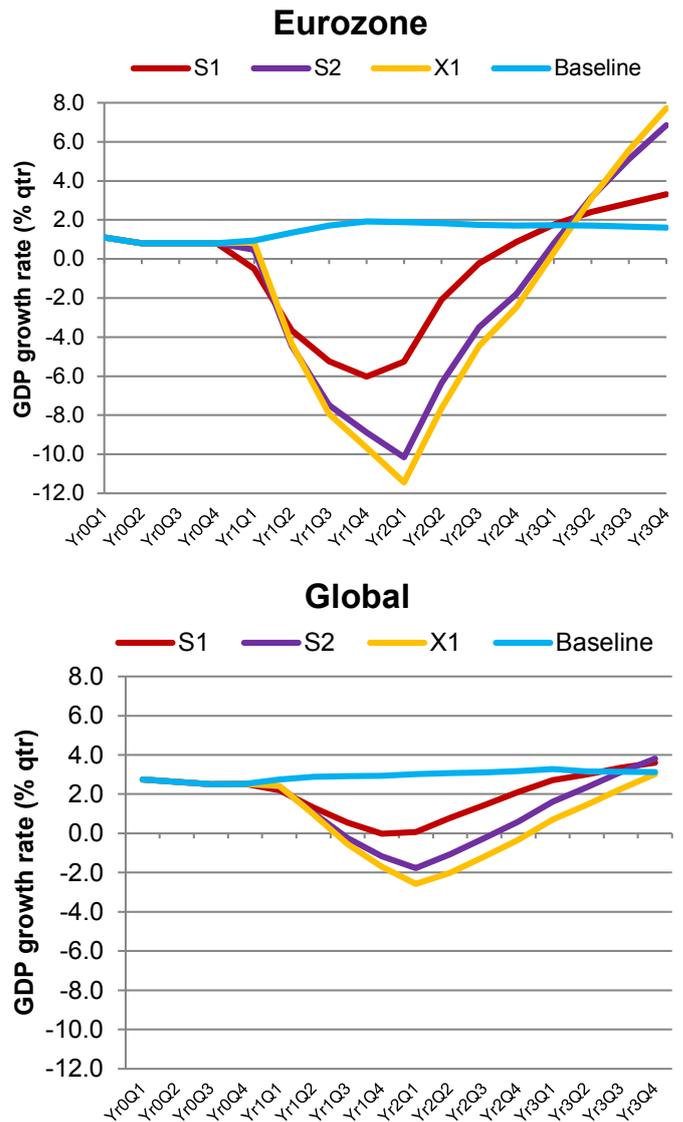


Figure 10: GDP growth rates (% qtr) comparison across the Eurozone and the global economy

countries will not be meaningful in the analysis.

Location	Minimum Credit Rating			
	Baseline	S1	S2	X1
Greece	C	N/A	N/A	N/A
Germany	AAA	BB	N/A	N/A
Eurozone	AA	BB	N/A	N/A
China	AA	AA	BBB	BBB
Japan	AA	BBB	BBB	BBB
United Kingdom	AAA	AA	BB	B
United States	AAA	AAA	AA	BB

Table 6: Credit ratings comparison across affected countries and regions

With the restructured debts passed on to other governments, we observe a collective credit rating downgrade across the remaining non-defaulting countries, such as the UK and the US.

Effect on economic growth rates

The technical indicator of a recession is two consecutive quarters of negative economic growth commonly measured by a country's GDP. In standard scenario S1, the five defaulting countries resulted in a Eurozone recession (see Figure 10) that last slightly over a year after the default cascade.

The same scenario sees a reduction in global economic growth to almost zero for less than two quarters but is not quantifiable as a "global" recession. However, in the extreme variant X1, the Eurozone default plunges the world economy into a global recession that lasts up to six quarters.

GDP@Risk

The macroeconomic consequences of this scenario are modelled using the Oxford GEM. The output from the model is a five-year forecast for the world economy.

The impacts on each variant of this scenario are

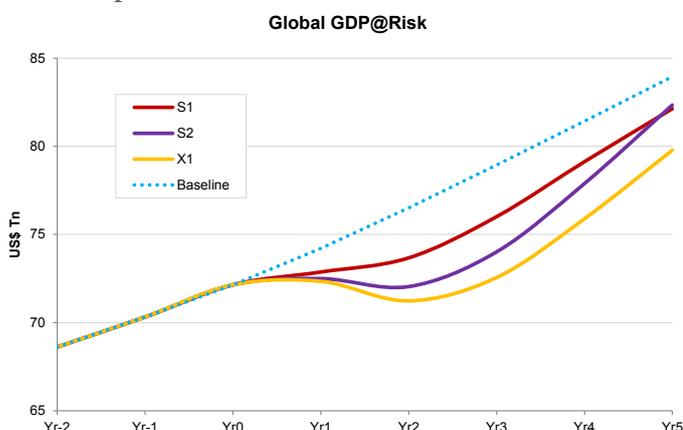


Figure 11: Estimated loss in global output as a result of sovereign default scenario variants

compared with the macroeconomic baseline projection of the global economy under the condition of no crises occurring. The primary figure representing the impact of this catastrophe is the GDP@Risk, which is the total difference in GDP between the baseline projections and the scenario-specified projections.

The total GDP loss over five years, beginning in the first quarter of Year 0 (YoQ1) during which the high inflation shock is applied and sustained through to the last quarter of Year 4 (Y4Q4), defines the GDP@Risk for this scenario. This is expressed as a percentage of the total GDP projection for the five years without the crisis occurring.

Figure 11 illustrates the dip in global GDP that is modelled to occur as a result of the scenario, across variants. Table 7 provides the GDP loss of each of the variants of the scenario, both as the total lost economic output over five years, and as the GDP@Risk.

Economic conclusions

A Eurozone Meltdown scenario clearly has very significant implications for the defaulting countries as well as the global economy. In this analysis, we have shown how sovereign defaults that take place within a small geographical region can spread around the world and affect almost every other major economy. While changes in exchange rates, inflation and interest rates are important factors influencing economic output, other factors such as capital flight, weak market confidence and pessimism, unemployment and existing government debt levels, all have important effects on output and growth.

The impact severity and extent of this scenario result in recessions across different economies and model variants. The GDP@Risk over the five-year period is expected to cost up to 6% of the expected global GDP output, in the projected baseline scenario. The global economy is also analysed to experience a deep recession (i.e. negative GDP growth of up to 3% for six quarters) should the entire Eurozone defaults.

The total cost of the scenario to the global economy is estimated to be between US\$11 and US\$23 trillion. The GDP losses in the US and Eurozone are substantial, approximately US\$13 trillion, which contribute more than half of the global GDP loss over this period. However, the trajectories of global GDP show the closing of the gaps in GDP caused by the Eurozone meltdown towards the end of the 5-year shock period, more significantly in the S1 and S2 variants.

Location	Baseline	S1		S2		X1	
	5-yr 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%

Table 7: Effect of global property crash on minimum GDP growth rates comparison

7 Impact on Investment Portfolio

Introduction

The macroeconomic effects of the Eurozone Meltdown scenario will have an inevitable effect on the capital markets. This section considers the market impact of the scenario and the consequence for investors in the capital markets.

The performance of bonds, alternatives and equities in different markets are estimated from the macroeconomic outputs, and compared with a baseline projection of their expected performance that would result from the economic projection without the scenario occurring.

Valuation fundamentals

Note that this is an estimate of how the fundamentals of asset values are likely to change as a result of these market conditions, as directional indication of valuation. This analysis is not a prediction of daily market behaviour and does not take into account the wide variations and volatility that can occur to asset values due to trading fluctuations, sentiment and the mechanisms of the market.

Passive investor assumption

A fundamental assumption we make in our analysis is that of considering a passive investment strategy. This assumption is unrealistic, as we expect an asset manager to react to changing market conditions in order to reduce losses and large fluctuations in returns. It is however a useful exercise to consider what would happen to a fixed portfolio, in particular because this represents a benchmark against which to compare the performance of dynamic strategies. Understanding what drives the behaviour of the fixed portfolio at different times gives useful insight towards the design of an optimal investment strategy.

A standardized investment portfolio

We assess the performance of four typical high quality investment portfolios under the Eurozone Meltdown scenario. We built a fictional representative portfolio that mimics features observed in the investment strategies of insurance companies, titled High Fixed Income Portfolio and three others that mimic the investment strategies of pension funds titled Conservative, Balanced and Aggressive. For example the Conservative Portfolio structure has 55% of investments in sovereign and corporate bonds, of which 95% are rated A or higher (investment grade). Residential Mortgage Backed Securities (RMBS) make up 5 % of the Conservative Portfolio structure.

Investments are spread across the US, UK, Germany and Japan. Equities compose 40% of the Conservative Portfolio. We will assume for simplicity that equity investments correspond to investments in stock indexes. The Wilshire 5000 Index (W5000), FTSE 100 (FTSE), DAX (DAX) and Nikkei 225 (N225) stocks are used to represent equity investments in the US, UK, Eurozone and Japan, respectively. We assume a maturity of 10 years for long-term bonds, while short-term bonds have a maturity of 2 years in each country.

Details of the High Fixed Income Portfolio are shown on the following page in Table 8, Figure 12, Figure 13 and Figure 14.

Details of the Conservative Portfolio are shown on the following page in Table 9, Figure 15, Figure 16 and Figure 17.

Details of the Balanced Portfolio are shown on the following page in Table 10, Figure 18, Figure 19 and Figure 20.

Details of the Aggressive Income Portfolio are shown on the following page in Table 11, Figure 21, Figure 22 and Figure 23.

High Fixed Income portfolio structure

	USD	GBP	Euro	Yen	Total
Government 2 yr	8%	6%	5%	3%	22%
Government 10 yr	8%	7%	6%	2%	23%
Corp. Bonds 2yr	4%	4%	4%	2%	14%
Corp. Bonds 10yr	6%	7%	3%	2%	18%
RMBS 2 yr	2%	1%	1%	1%	5%
RMBS 10 yr	1%	1%	1%	1%	4%
Equities	2%	3%	3%	2%	10%
Cash	4%	0%	0%	0%	4%
Total	35%	29%	23%	13%	100%

Table 8: Composition of the High Fixed Income Portfolio Structure

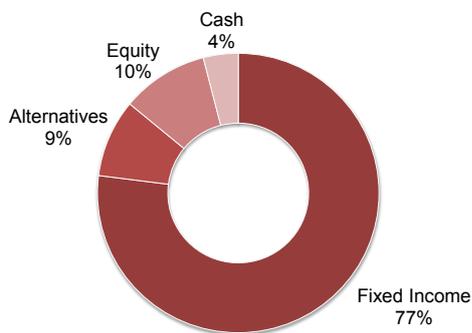


Figure 12: Asset classes in High Fixed Income Portfolio Structure

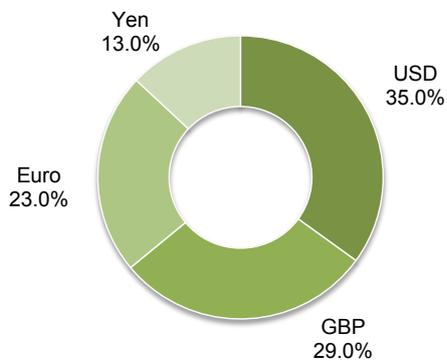


Figure 13: Geographic market spread of High Fixed Income Portfolio Structure

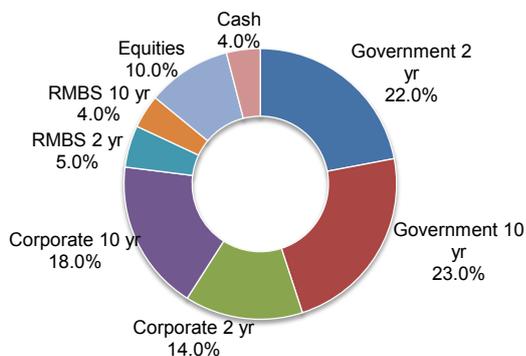


Figure 14: Detailed asset class breakdown of High Fixed Income Portfolio Structure

Conservative portfolio structure

	USD	GBP	Euro	Yen	Total
Government 2 yr	4%	3%	3%	0%	10%
Government 10 yr	3%	3%	3%	1%	10%
Corp. Bonds 2yr	6%	5%	5%	1.5%	17.5%
Corp. Bonds 10yr	6%	5%	5%	1.5%	17.5%
RMBS 2 yr	1.5%	0.5%	0.5%	0%	2.5%
RMBS 10 yr	1.5%	0.5%	0.5%	0%	2.5%
Equities	19%	8%	8%	5%	40%
Cash	0%	0%	0%	0%	0%
Total	41%	25%	25%	9%	100%

Table 9: Composition of the Conservative Portfolio Structure

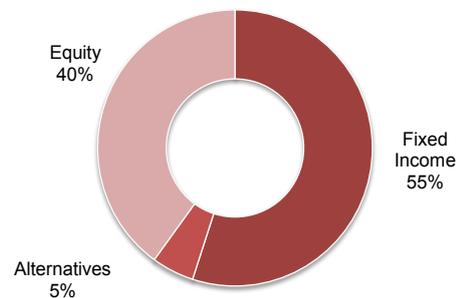


Figure 15: Asset classes in Conservative Portfolio Structure

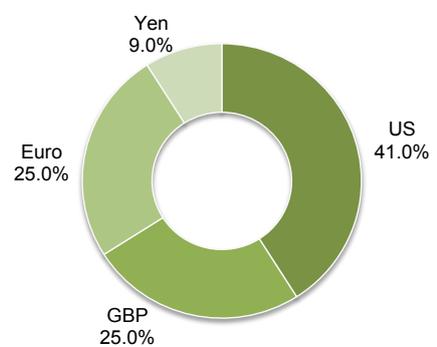


Figure 16: Geographic market spread of Conservative Portfolio Structure

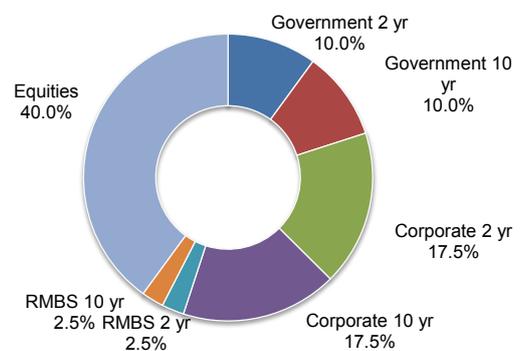


Figure 17: Detailed asset class breakdown of the Conservative Portfolio Structure

Balanced portfolio structure

	USD	GBP	Euro	Yen	Total
Government 2 yr	3%	2%	2%	1%	8%
Government 10 yr	3%	3%	3%	1%	10%
Corp. Bonds 2yr	4%	3.5%	3.5%	2%	13%
Corp. Bonds 10yr	4%	2.5%	2.5%	0%	9%
RMBS 2 yr	2.5%	1%	1%	0.5%	5%
RMBS 10 yr	2.5%	1%	1%	0.5%	5%
Equities	25%	10%	10%	5%	50%
Cash	0%	0%	0%	0%	0%
Total	44%	23%	23%	10%	100%

Table 10: Composition of the Balanced Portfolio Structure

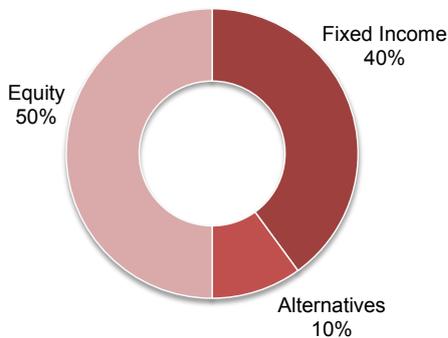


Figure 18: Asset classes in Balanced Portfolio Structure

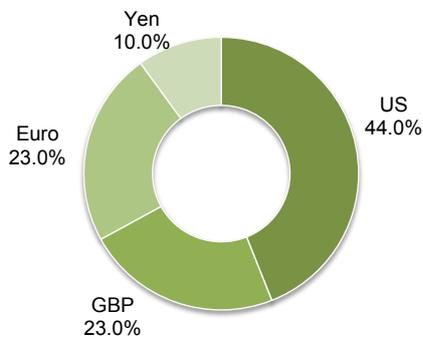


Figure 19: Geographic market spread of Balanced Portfolio Structure

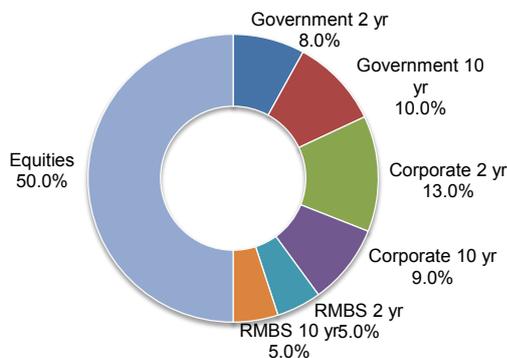


Figure 20: Detailed asset class breakdown of Balanced Portfolio Structure

Aggressive portfolio structure

	USD	GBP	Euro	Yen	Total
Government 2 yr	1.5%	1%	1%	0.5%	4%
Government 10 yr	1.5%	1%	1%	0.5%	4%
Corp. Bonds 2yr	3%	2.5%	2.5%	0.5%	8.5%
Corp. Bonds 10yr	3%	2.5%	2.5%	0.5%	8.5%
RMBS 2 yr	3%	2%	2%	0.5%	7.5%
RMBS 10 yr	3%	2%	2%	0.5%	7.5%
Equities	30%	12%	12%	6%	60%
Cash	0%	0%	0%	0%	0%
Total	45%	23%	23%	9%	100%

Table 11: Composition of the Aggressive Portfolio Structure

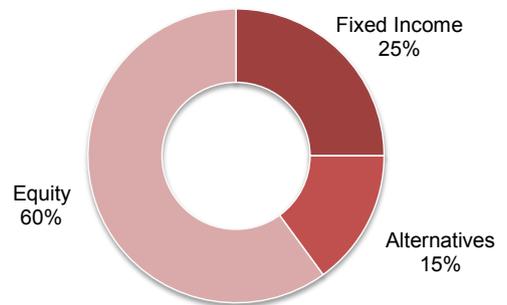


Figure 21: Asset classes in Aggressive Portfolio Structure

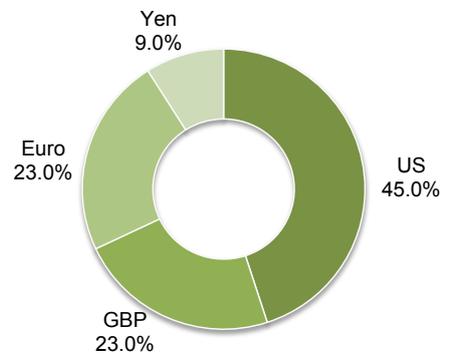


Figure 22: Geographic market spread of Aggressive Portfolio Structure

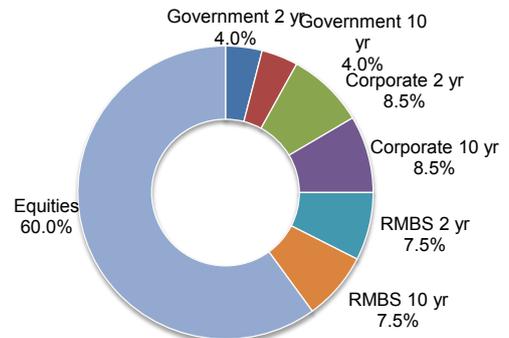


Figure 23: Detailed asset class breakdown of Aggressive Portfolio Structure

Scenario	Default Countries	UK 2 yr	UK 10 yr	Euro 2 yr	Euro 10 yr
S1	Greece, Italy, Spain, Portugal and Ireland	0%	0%	14.86%	7.43%
S2	Plus France and Germany	0%	0%	37.89%	18.94%
X1	All of Eurozone, including UK	9.12%	4.56%	46.10%	23.05%

Table 12: Sovereign Bond Haircut Rates

Computation of returns

Market price changes or Mark to Market (MtM) are calculated for all government bonds using equation (1) and for corporate bonds and RMBS using equation (2).

$$(1) \Delta MtM_{Gov,t} = (D_b)(-\Delta I/100)$$

$$(2) \Delta MtM_{Corp,t} = (D_b)(-\Delta I/100) + (SD_b)(-\Delta CS/100)$$

Where D_b is the bond duration, for which we assumed the following values: $D_b = 7$ for ten years bonds and $D_b = 1.8$ for two years bonds. SD_b represents the spread duration. The change in interest rates, ΔI on government and corporate bonds and the change in credit spreads, ΔCS are taken from the output of the macroeconomic analysis discussed in the previous chapter.

Government bond yields are estimated using a representative quarterly yield. While corporate and RMBS yields are estimated using a representative quarterly yield and the period averaged credit spread.

In our analysis, we take into account default on government bonds. There are three common transformations of debt when a government defaults: maturity extensions, coupon reductions and nominal haircuts; the most common being maturity extensions.

Given the severity of this Eurozone Meltdown scenario, we will assume that the defaulted governments will use haircuts to transform their debt. Haircuts on bond principal were seen in 45% of the sovereign bond restructuring cases since 1997. To calculate the % haircut for 2 year bonds we average the four largest haircuts on government bonds since 2005. To calculate the % haircut for 10 year bonds, we average several less severe cases. Thus, we assume that Euro and UK sovereign bonds receive a haircut of 63% for 2 year bonds and 31% for 10 year bonds. The overall haircuts applied to the Euro and UK government bonds are calculated as a weight average of the % GDP contribution that each default country contributes to the Eurozone as a whole, see Table 12.

Defaults on corporate bonds are accounted for

through the introduction of a discount factor in the calculations. The 2008 volume-weight corporate default rates from Moody's are shown in Table 13. The actual corporate bond default rates used were calculated as the weighted average of default rates by credit rating and geographic regions. A multiplier was used to increase the 2008 default rates severity for the Eurozone Meltdown scenario. It is safe to assume that corporate bonds were heavily impacted in a Eurozone Meltdown scenario.

Equities market prices are calculated using the change in equity value from the macroeconomic modelling. The equity dividends are estimated using a representative quarterly yield.

Exchange rate affects are taken into to account to ensure that all reported portfolio returns are with respect to US dollars.

Portfolio returns

Bond Credit Rating	Corporate
AAA	0.000%
AA	0.816%
A	2.370%
BBB	1.108%
BB	8.097%
B	1.287%
CCC	11.019%

Table 13: Annual default probabilities for corporate bonds

Results of our analysis are presented in Figure 24 Figure 25, Figure 26 and Figure 27.

Figure 24 shows the scenario impacts by variant for the Conservative portfolio structure. In all variants we observe a significant departure from the baseline (blue line) projections.

For the Eurozone Meltdown scenario the economic shocks were applied over a five year period starting in Yr1Q1. After three years, we see the portfolio begin to recover. The maximum downturn experienced for the Conservative portfolio in the S1 variant is -9.86% nominal occurs in Yr1Q2.

Figure 25 shows the scenario variant impacts by portfolio structure. For the Eurozone Meltdown scenario, we see the aggressive portfolio structure underperform compared with the other structures. This implies that investments in heavy equity portfolios will yield the worst returns.

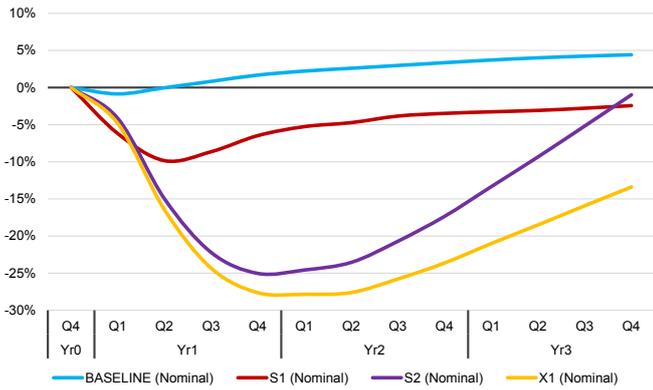


Figure 24: Eurozone Meltdown scenario impact by variant, Conservative Portfolio (nominal %)

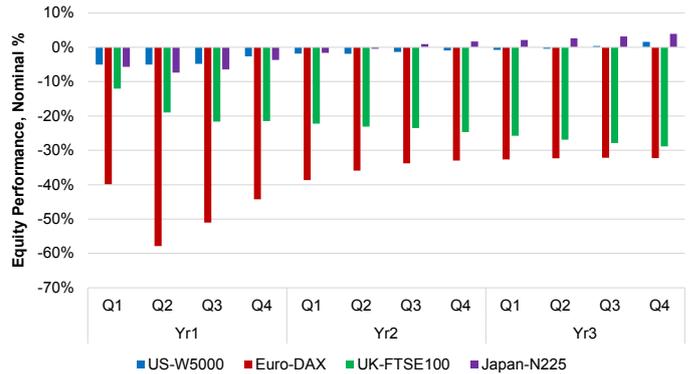


Figure 26: Eurozone Meltdown scenario maximum downturn by portfolio structures in nominal %

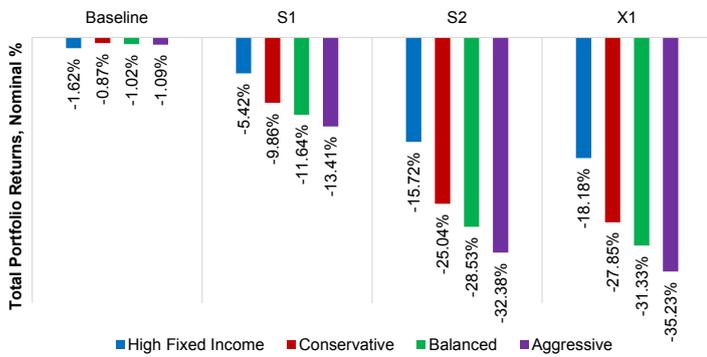


Figure 25: Eurozone Meltdown scenario maximum downturn by portfolio structures in nominal %

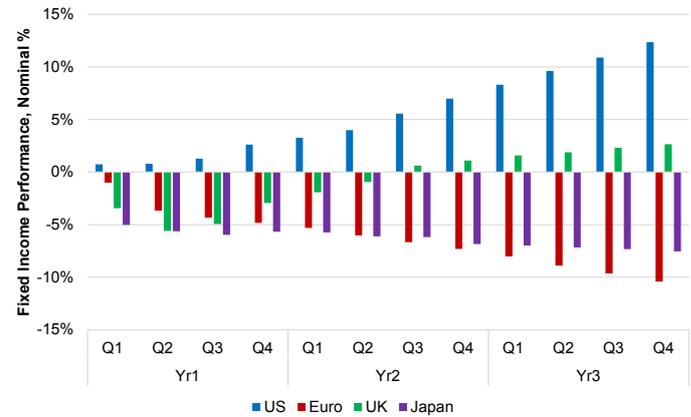


Figure 27: Eurozone Meltdown High Fixed Income portfolio performance by geography in nominal % for S1

Figure 26 shows market impacts on equity performance by geography for the least extreme variant, S1. Although, all the stocks are performing poorly, the Euro (DAX) stock is impacted the most. Interestingly, the Japanese (N225) stock index is starts generating positive returns after three years.

Figure 27 shows the market impact on fixed income performance by geography for the most least variant, S1. Over the three year analysis window, German fixed income bonds are impacted the most. Japan is also yielding negative returns, while the US is least impacted. The largest negative impact to a single equity asset is greater than 55%, while it is only over 10% for fixed income. This confirms the finding that a high fixed income portfolio performs better than a high equity structure.

Correlation Structure

A new market analytics tool called Financial Network Analytics (FNA) is used to monitor market dynamics for each scenario. A daily correlation map was created for a pre-scenario and post-scenario view, see Figure 28 and Figure 29 on the following page.

Assets in the Conservative portfolio are shown as nodes and the correlations are shown as links. Shorter links represent strong correlations. The size of the nodes represent asset returns in relation to the portfolio, the larger the node the larger the return. Nodes that are coloured red represent a negative correlation and thus negative asset returns.

Summary of investment portfolio analysis

In this part of the scenario analysis we have taken the output from the macroeconomic model and used it as an input to assess the performance of the four different portfolio structures. We have estimated the performance of the portfolio under the different variants of the Eurozone Meltdown scenario and compared it with the business as usual performance or baseline. The Aggressive portfolio structure performs the worst in this scenario, with a loss of -13.41% in the least extreme variant, S1.

The analysis presented in this section assumes a passive investment strategy. Nonetheless, it represents a useful benchmark to compare more asset management strategies.

In particular, it can be used to discuss strategies that improve portfolio performance on a counterfactual basis under the scenario. Table 14 summarises the max downturn by portfolio structure and scenario variant.

An important issue that we have not addressed in our analysis is that of systematically testing the stability of the results with respect to the parameter settings used in the earlier stages of the scenario development. This is to a certain degree taken into account given that we considered different variants of the scenario, but a more systematic analysis will be needed in this respect.

	Baseline	S1	S2	X1
High Fixed Income	-2%	-5%	-16%	-18%
Conservative	-1%	-10%	-25%	-28%
Balanced	-1%	-12%	-29%	-31%
Aggressive	-1%	-13%	-32%	-35%

Table 14: Summary of portfolio performance (max downturn) by structure and scenario variant, nominal %.

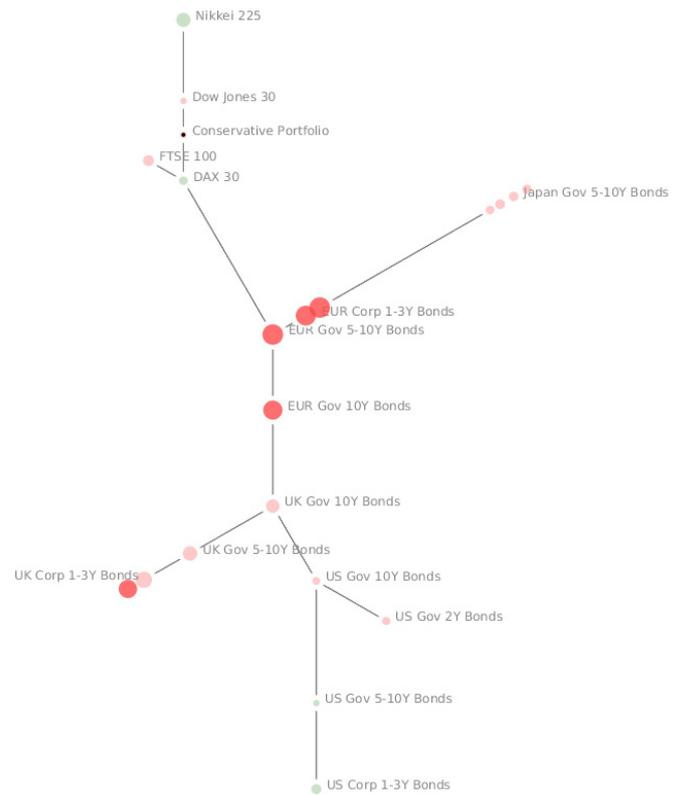


Figure 28: Conservative Portfolio before stress test

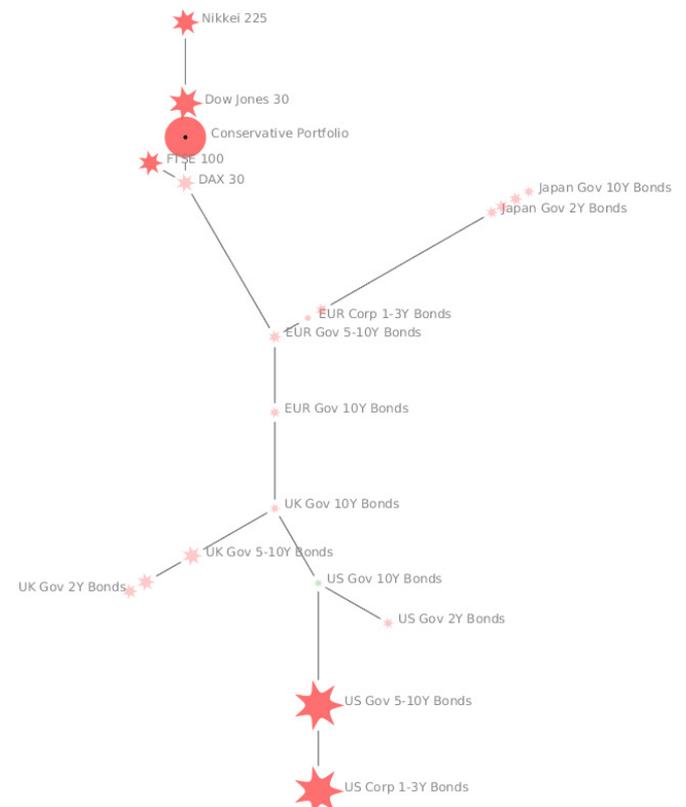


Figure 29: Conservative Portfolio after stress test

REAL USD PERCENTAGE VALUES		Baseline Yr1Q4	Short-Term Impact at Yr1Q4			Baseline Yr3Q4	Long-Term Impact at Yr3Q4		
			S1	S2	X1		S1	S2	X1
US									
Gov Bonds Short	2 yr	-1%	0%	0%	0%	-6%	1%	2%	2%
Gov Bonds Long	10 yr	-1%	2%	2%	2%	-9%	13%	14%	14%
Corp Bonds Short	2 yr	0%	1%	0%	0%	-2%	3%	4%	3%
Corp Bonds Long	10 yr	1%	3%	3%	2%	-4%	16%	16%	14%
RMBS Short	2 yr	0%	1%	1%	1%	-2%	5%	6%	7%
RMBS Long	10 yr	0%	3%	3%	2%	-6%	16%	17%	16%
Equities	W5000	8%	-4%	-10%	-15%	15%	-2%	-15%	-39%
UK									
Gov Bonds Short	2 yr	-5%	-2%	-4%	-13%	-9%	4%	2%	-22%
Gov Bonds Long	10 yr	-6%	-3%	-18%	-22%	-13%	5%	-8%	-19%
Corp Bonds Short	2 yr	-4%	-3%	-5%	-5%	-8%	4%	2%	2%
Corp Bonds Long	10 yr	-5%	-3%	-18%	-19%	-11%	6%	-7%	-7%
RMBS Short	2 yr	-5%	-2%	-3%	-3%	-8%	6%	5%	7%
RMBS Long	10 yr	-6%	-2%	-18%	-18%	-12%	8%	-5%	-4%
Equities	FTSE100	5%	-21%	-36%	-43%	24%	-27%	-41%	-61%
EU (Germany)									
Gov Bonds Short	2 yr	0%	-18%	-61%	-64%	-2%	-36%	-76%	-82%
Gov Bonds Long	10 yr	0%	-13%	-68%	-70%	-7%	-18%	-65%	-69%
Corp Bonds Short	2 yr	2%	-5%	-43%	-44%	2%	1%	-21%	-21%
Corp Bonds Long	10 yr	3%	-6%	-63%	-63%	-1%	5%	-34%	-34%
RMBS Short	2 yr	-5%	-3%	-42%	-42%	-8%	6%	-16%	-15%
RMBS Long	10 yr	-5%	-5%	-63%	-63%	-12%	8%	-31%	-30%
Equities	DAX	3%	-44%	-98%	-98%	12%	-29%	-66%	-68%
Japan									
Gov Bonds Short	2 yr	-9%	-8%	-8%	-8%	-18%	-10%	-10%	-10%
Gov Bonds Long	10 yr	-8%	-6%	-6%	-6%	-20%	-8%	-8%	-7%
Corp Bonds Short	2 yr	-9%	-8%	-8%	-8%	-18%	-11%	-11%	-11%
Corp Bonds Long	10 yr	-8%	-6%	-6%	-7%	-20%	-9%	-8%	-9%
RMBS Short	2 yr	-9%	-8%	-8%	-8%	-16%	-10%	-10%	-10%
RMBS Long	10 yr	-8%	-6%	-6%	-6%	-17%	-8%	-8%	-8%
Equities	N225	-2%	-5%	-7%	-9%	-5%	2%	1%	-1%

Table 15: High Inflation World summary of asset class performance by variant and geography, in real %.

8 Mitigation and Conclusions

Possible prevention or mitigation strategies of the described risk potential is a concern for European policymakers, but also for European and global investors.

European financial policies are usually prepared by the EU institutions, which is the EU commission, the EU parliament, and the Euro group of finance ministers which are direct delegates of their nations' governments. The lead is with the EU commission, which also forms the public picture about the EU.

The national governments often lack to show public loyalty towards their voters concerning the common decisions made on EU level. For example, Italy is economically divided between the north and the south, with the north being similarly competitive than the south of Germany, Switzerland and Austria and a southern part that depends on transfer payments. However, populist parties in the north of Italy tend to present the EU as being the reason for necessary reforms to increase competitiveness, not their own failure in developing the southern part of their own country.

From 2011 to 2015, a combination of reforms and rescue mechanisms were installed that successfully addressed the problems of market-driven default risk and high funding cost for the southern countries at little direct cost for the northern countries. However, the EU institutions that executed these programmes could not successfully communicate this equilibrium, leading to little acceptance at the level of the national European voters.

A better communication strategy which explains the strong links between competitiveness, funding cost, public spending and economic growth is necessary. European parliamentarians should contribute in defending the EU policies in their home countries.

From the viewpoint of a European or global investor, the described scenario involves substantial market risk in fixed income securities, equity markets and the external value of the Euro, even if there is no formal default event. Global diversification is not a simple solution to this problem as other geographic regions have their own specific problems. The hedging properties of sovereign credit derivatives are questionable, as their payout depends on a formal credit event. If the insured bonds lose market value and need to be sold before a formal default to combat investment constraints, the increase in market value of the credit derivative might not fully cover the overall loss.

This is a form of basis risk due to the legal uncertainties of sovereign risks. For example, the “private sector involvement” of private creditors to Greece in early 2012 only involved bonds issued under Greek law, rather than those issued under English law (BIS 2012). Holders of the bonds who also owned credit derivatives pushed for a “collective action clause” (CAC) to be included retroactively although the process would weaken the credit's market value. However, a credit event was only determined by ISDA after the collective action clause was executed by a large majority of bondholders.

The existence of a liquid market of listed futures allows to hedge sovereign bond risks of the largest Euro area issuers Germany, France and Italy via liquid futures. The clearing and collateral systems of the futures exchanges proved to work smoothly even during 2008. In the case of sharp losses in the market value of core European bonds, a shortage of collateral and large imposed haircuts on the accepted bonds are to be expected. For the main European equity indices, also liquid futures contracts are available.

For the currency risk, the choice of the bank counterparty to execute FX transactions might be crucial as the described scenarios might also involve the default of international banks.

Given the unpredictability of high impact events, whether due to “Mother Nature” or a market or macroeconomic episode, early warning indicators of large commodity shocks are not sufficiently reliable to act upon without affecting risk profile. Warning signs are therefore only inputs to risk management tools for damage mitigation rather than pointers to comprehensive risk solutions. Indeed we advocate that recognition of catastrophic events entails recognition of substantial losses, especially in the short term.

Stress tests such as the High Inflation World Scenario balance magnitude and likelihood of impact, and facilitate questions such as, “Is my organisation able to withstand a 1-in-100 year catastrophe?” and “What would I do to improve the resilience of my organisation to such a shock?”

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