Cambridge Centre for Risk Studies

Cambridge Risk Framework

Food and Oil Price Spiral Stress Test Scenario

HIGH INFLATION WORLD STRESS TEST SCENARIO

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The views contained in this report are entirely those of the research team of the Cambridge Centre for Risk Studies, and do not imply any endorsement of these views by the organisations supporting the research.

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.

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1   Executive Summary

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In the following report, we present a narrative of how global inflationary pressure over several years impacts the world economy and financial markets. This provides a basis for a global enterprise to test its operational and strategic model, as a step toward improving its resilience. 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.[1]

High Inflation World Scenario

This scenario envisions cost shocks in response to shrinking global oil supplies and, simultaneously, disruptions to crop production that lead to global food shortages. These inflationary drivers persist over many months, causing international economic and humanitarian pressures.

The economic impact, expressed as lost global Gross Domestic Product over five years, compared with the project rate of growth ("GDP@Risk"), is between $4.9, $8 and $10.9 trillion, depending on the severity of the commodity price shock. The Great Recession of 2007-2011, comparatively, saw a loss of $20 trillion in 2015 dollar estimates. In this perspective, although the High Inflation World Scenario inflicts severe economic loss, the catastrophe does not prevent the recovery of the global economy over time.

High Inflation as a Financial Crisis

Scenario selection

Inflation is tied to the relationship between aggregate supply and demand. Cost-push describes a supply shortage, e.g., due to a disruption in production of a commodity. Demand-pull describes increasing demand, perhaps resulting from a loosening of credit. In both cases, inflation of commodity prices occurs.

The High Inflation World Scenario is a cost-push situation driven by relative scarcity of both oil and agricultural commodities. The final impact of these price hikes depends heavily on the level of exposure a country has to each commodity.

Nonetheless, the direct impact of a global high inflation is the corresponding increase in unemployment rates, albeit varying severity, across major economies.

Variants of the scenario

We calibrate three variants of the scenario using different levels of inflation for food and energy prices. In our standard scenario S1, commodity prices jump between 180 and 210% of the pre-existing price levels, with prices peaking around 15 months after the initial shock. Scenario variant S2 and extreme variant X1 are similar to the standard scenario, but the commodity price increases are raised up to 280 and 440%, respectively.

The scale of loss inflicted by the High Inflation World Scenario has been calibrated to correspond approximately to an event that happens about once a century on average, a 1-in-100 year event. Two indicators that may give a sense of the likelihood of a catastrophe scenario occurring are its impact on equity returns and growth rates, which are expected to be negative as a result of catastrophe.

In the case of the High Inflation World Scenario, however, our analysis does not show extreme behaviour in either of these categories. US (UK) equities over the last two hundred years[2] have experienced return rates below -24% (-13%) about once in twenty years, with return rates below -36% (-20%) signifying 1-in-100 events. In our scenario variants, those return rates are barely effected other than in the extreme X1 variant in which equity return rates are -8% in the US and -4% in the UK.

Near zero economic growth rates are found in our scenarios but these don't compare to the historical record for US (UK) growth rates being below -7% (-3%), which are 1-in-20 year events, or rates below -13% (-5%) which happens every century.

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[1] Cambridge Centre for Risk Studies, "A Taxonomy of Threats for Complex Risk Management", 2014

[2] Prior to records from FTSE and S&P, we use surrogate stocks such as those from American railroad stock prices and other constructed indexes. We use similar surrogate data for estimating growth rates prior to the availability of standardised data. Our identification of%iles uses a normal curve fitting which is conservative in light of the fat tails associated with equity price distributions.

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.

Seeds of shortage

Farming failure

The Scenario assumes that the middle of the year brings with it bouts of extreme weather across the northern hemisphere: a long heatwave in the Pacific West, floods in the Sub-Indian continent, heavy rains in the Atlantic and drought in northern China. Grain yields are sure to suffer.

Concurrently, a pandemic sweeps through the world's population of bees. Inadequate pollination prevents the worldwide development of nuts, fruit and other agricultural products.

Holding the Strait of Hormuz Hostage

A militant group establishes hold on the Strait of Hormuz in the Persian Gulf, effectively seizing control of 20% of the world's crude exports. The group restricts the international shipment of crude oil through the Straits, hiking the price of oil to over $170 per barrel.

The impact affects the international meat and dairy industries significantly. The combination of high production costs and efficiency losses affect aggregate demand as a cost-push spiral emerges worldwide.

Global stagflation

As the international energy crisis continues the consumer price index spikes in many nations, driving demands for national wage increases. Stagflation emerges across the globe as countries that implement wage hikes experience an unemployment spiral.

In an effort to curtail worldwide stagflation at the height of the crisis, national central banks gradually adjust interest rates in order to suppress consumer spending and relieve economic pressure. After eighteen months, prices begin to stabilise and the rate of inflation drops.

Global GDP impact

To understand how the High Inflation World scenario impacts the global economy we use the Global Economic Model (GEM), Oxford Economics' quarterly-linked international econometric model. Price shocks are applied directly to world food and energy prices over a 15 month period, and the model adjusts endogenously to allocate inflation rate increases across the world.

We use the GEM to estimate the loss in global gross domestic product, cumulated over a 5 year period, which is attributed to this stress test scenario. We term this loss 'GDP@Risk'.

GPD@Risk, expressed in real terms in US dollars, ranges from a loss of $US4.9 trillion for S1 to $US10.9 trillion in the X1 variant.

However, this scenario does not necessarily lead to a global recession, but instead slows down the economic growth considerably. These impacts are significant but not of the same scale as the Great Financial Crisis, from 2008-2012, whose GDP@Risk is around $20 trillion in 2015 dollars.

Financial market impact

We estimate the portfolio impacts of this scenario by modelling the outputs from OEM into portfolio returns, projecting market changes and cash flows while keep the allocation percentages fixed. We also default all corporate bonds given the 2008 default rates.

Given that the consumer price index (CPI) was directly shocked in the macroeconomic modelling, we see that the total portfolio returns in real% are more significantly impacted than in nominal dollars.

The maximum downturn experienced for the Conservative portfolio in the S1 variant is -3.89% in nominal or -9.69% in real terms and occurs in Yr2Q4. Best and worst performances (within equities) are the UK (FTSE100), and Japan (N225); within fixed income, US and Japanese bonds, with the worst performing portfolio structure being high fixed income, at 7.93% for the S1 variant.

For portfolio protection it is recommended that equity allocation is shifted away from Japan towards UK and away from Japan 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.

Summary of Effects of High Inflation World Scenario and Variants			
Scenario Variant	**S1**	**S2**	**X1**
Variant Description	Standard Scenario	Scenario Variant	Extreme Variant
World energy price shock	210%	280%	440%
World food price shock	180%	250%	310%
Price spiral duration	5 Qtrs	5 Qtrs	5 Qtrs
Macroeconomic losses			
Global recession severity (Minimum qtrly growth rate global GDP)	1.9%	1.4%	0.6%
Global recession duration		No recession	
GDP@Risk $Tr (5 year loss of global output)	$4.9 Trillion	$8.0 Trillion	$10.9 Trillion
GDP@Risk % (as % of 5-year baseline GDP)	1.7%	2.2%	2.6%
Portfolio Impact			
Performance at period of max downturn			
High Fixed Income	-8%	-10%	-16%
Conservative	-4%	-7%	-14%
Balanced	-3%	-6%	-13%
Aggressive	-1%	-4%	-12%

Asset class performance						
	Yr1Qr4	Yr3Qr4	Yr1Qr4	Yr3Qr4	Yr1Qr4	Yr3Qr4
US Equities (W5000), % Change	-20%	4%	-39%	-36%	-1%	-1%
UK Equities (FTSE100), % Change	-72%	-43%	-73%	-49%	-3%	18%
US Treasuries 2yr Notes, % Change	0%	3%	0%	5%	-7%	-16%
US Treasuries 10yr Notes, % Change	2%	15%	2%	17%	-13%	-22%

Table 1: Summary impacts of the High Inflation World 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 High Inflation World 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;
- Eurozone Meltdown: Sovereign Default Crisis.

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" – that is, a cause of disruption.

In this scenario, we explore the consequences of a "High Inflation World" resulting from a food and energy price spiral. It is also possible that that this global phenomenon could have been triggered by other commodity price spirals, not limited to just food and energy.

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 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.
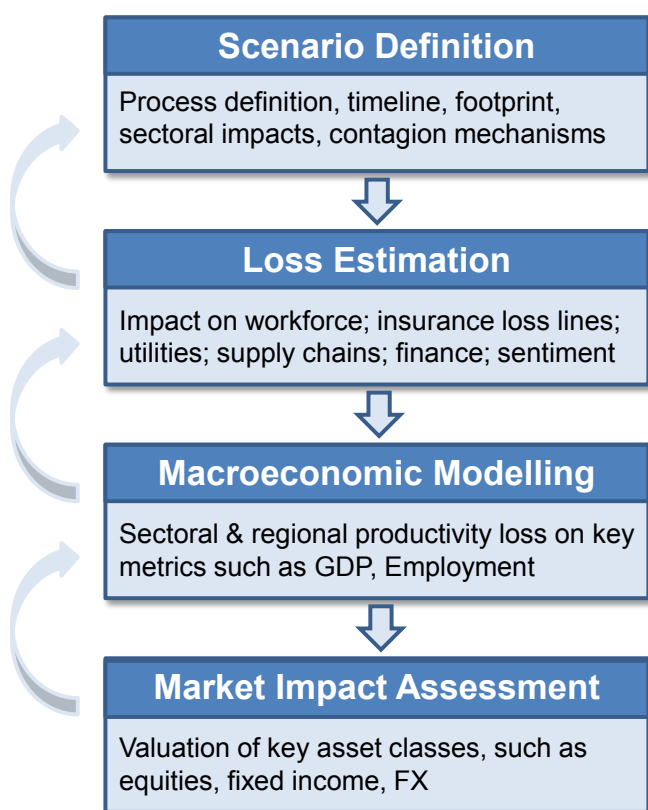
Scenario Definition

Process definition, timeline, footprint, sectoral impacts, contagion mechanisms

Loss Estimation

Impact on workforce; insurance loss lines; utilities; supply chains; finance; sentiment

Macroeconomic Modelling

Sectoral & regional productivity loss on key metrics such as GDP, Employment

Market Impact Assessment

Valuation of key asset classes, such as equities, fixed income, FX

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   High Inflation as a Financial Catastrophe

Inflation refers to the rise in general price levels for goods and services over a given period of time. A low rate of inflation is seen as a positive indicator of a strong economy, growing and acquiring greater value over time. National economies typically aim for a small amount of inflation each year – around 2%.

High inflation leads to a depreciation in the value of money over time and decreases the value of national debt. Negative inflation, or "deflation", indicates a fall in overall prices and a growth in the value of debt and is usually, but not necessarily, associated with periods of poor economic output.

Based on historical precedents from the 1900s onwards, some economists believe that there is a strong correlation between the level of inflation and the level of unemployment, known as the "Phillips curve". This view proposes that the lower the rate of unemployment in a country, the higher its rate of inflation as the broader spread of money amongst consumers stimulates growth in the economy. The validity of the Phillips curve has been challenged by stagflation (a joint rise in prices and the unemployment rate) exemplified in the oil crisis of the 1970s. Monetarists argue that stagflation may result from an increase in the money supply which leads to inflation without increasing productivity or lowering unemployment.

Causes

The exact causes of inflation remain subject to debate but, it is generally agreed, are closely tied to macroeconomic conditions that relate aggregate supply to demand, potentially including the quality or and quantity of the money supply. Two inflationary causes can be described as demand-pull (or excess demand) and cost-push inflation (supply side).

Demand-pull inflation occurs in growing economies when the aggregate demand outstrips supply, driving up the price of available commodities. The UK Lawson Boom of the 1980s was is typical an example of this type of inflation, when cuts to taxes and interest rates created a wealth effect that pushed up goods and property prices. The 4% growth rate of the economy was unsustainable over the long-term and a sharp recession followed within three years.

Cost-push inflation is caused when the depreciation of a currency drives up the costs of production then reflected in higher market prices; aggregate supply decreases while demand remains steady. Usually, this situation applies to supply-side shocks such as

disruption in an oil supply, labour disagreements or natural disaster along the supply chain. The 2012 Fukushima earthquake led to a cost-push inflationary period in Japan's energy market after damage to nuclear power plants limited output.

Stagflation

The term "stagflation" is a portmanteau term derived from the synthesis portmanteau of "inflation" and "stagnation". It describes a situation where the level of inflation is high but economic growth and employment rates remain low and is regarded as a symptom of bad poorly designed economic policy.

Stagflation was a feature of US and European economic performance during the 1970s. Economic theory at the time, based on the Philips Curve, suggested that the relationship between inflation and unemployment was an inverse one and that inflation was analogous to growth in the wider national economy.

However, conditions in the late 1960s and early 1970s led to a wage-price spiral which, combined with a quadrupling in the price of oil in 1973-4, conflated economic factors into a cost-push inflationary cycle with inflation rates above 10% and historically high unemployment rates of 5%-6%. Further oil price hikes at the end of the 1970s were associated with inflation rates above 13% and continuing high rates of unemployment.

In response the Fed raised interest rates, at the risk of greater unemployment, restricting the monetary flow and driving the country into a recession in the early 1980s. The rate of inflation dropped and the economy stabilized in the middle of the decade.

Hyperinflation

Hyperinflation describes any situation where national inflation is unusually high and either fast-growing or uncontrolled. This usually occurs as a result of a severe supply shock or disruption in money supply. No statistical definition has yet been agreed upon, but a typical rate of inflation approaching 1000% has characterised hyperinflations in recent history. Notable instances of high inflation of this kind occurred in the Weimar Republic in the 1920s, in Peru in the 1990s, and Zimbabwe in the early 2000s.

In this last example, inflation ultimately peaked at 79.6 billion% in 2008 and led to the abandonment of the Zimbabwe dollar.

Hyperinflation may be characterised by so-called "menu prices," when the cost of commodities increases so rapidly that vendors must re-price their stock throughout the day in order to maintain the margin of profit.

Hyperinflation is solved only through powerful policy action and generally involves a complete substitution of a national currency in order to bring exchange rates under control.

Theory & consequences

Consistent high inflation in a national economy drives up the Consumer Price Index (CPI) on goods and services and erodes middle class spending power, increasing wealth disparity. Consumer purchasing behaviour and business confidence are badly affected by rising prices, creating unstable conditions. The burden of high interest costs resulting from high inflation shrinks profit margins in capital-intensive sectors as the price of borrowing within stock markets and the financial system increases.

In developed economies, governmental policy typically accommodates and adjusts for inflation in national markets, aiming to maintain a steady annual rate of economic growth and balance the risk of recession against that of uncontrolled inflation. Supply-side policies stimulate economic productivity through, for instance, the maintenance of incentives-based skilled labour systems. Privatisation and deregulation policy increases competition between firms and reduces the risk of cost-push inflation by stabilising commodity costs. Taxes and spend policies can influence aggregate demand and either create or suppress wealth effects and promote consumer spending.

The key method of controlling inflation relies on central banks to adjust short and long-term interest rates to limit or increase the available liquidity in the financial system. Since the financial crisis of 2007, short-term interest rates in the United States have been kept close to zero by the Fed to encourage recessionary recovery and try to bring the rate of domestic inflation up to 2%.

Provoking global high inflation

Economic monitoring and management by national central banks, as described above, makes it unlikely for a situation of hyperinflation to develop in countries with relatively secure, robust economies. A series of drastic world events, however, could reasonably put pressure on energy and food prices and stimulate an increasing price spiral. Depending on the circumstances, this increasing price inflation could become structural and take many years to bring under control.
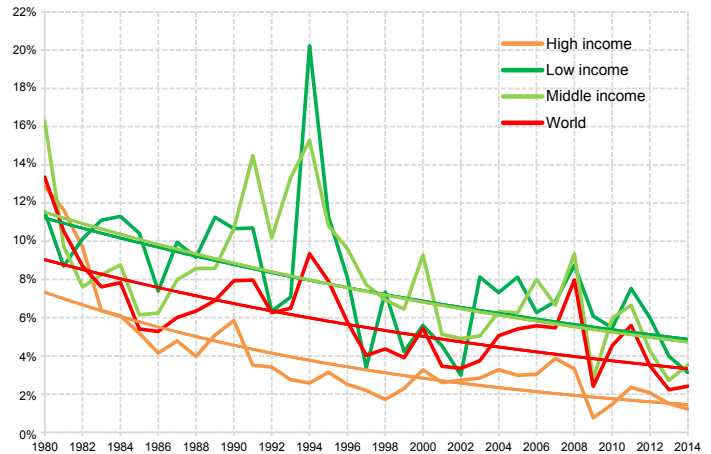

Figure 3: Global inflation time series by country income (Data Source: IMF)[3]

Additionally, Ciccarelli & Mojon (2010) have convincingly argued that inflation should be modelled as a global phenomenon instead of a local or domestic one, in line with the strong international co-movement of inflation amongst the 22 OECD countries undertaken in their study.

The Cambridge Centre for Risk Studies has profiled how global upward price spirals have shaped countries throughout history and modelled the threat they continue to pose.

Historical trend of global inflation rates

Figure 3 illustrates global inflation as a time series over the last three decades, and shows that country income levels are inversely proportional to inflation levels. This could be explained by the stronger commitment to price stability by wealthier countries that are less affected by supply shocks or other perturbations to the economy.

There is also a general downward inflation trend across all the country income groups. Reported in the its annual Global Economic Prospects, the World Bank suggests that global inflation is subdued as a result of easing cost pressures related to commodity prices, and that the demand factors with regard to these commodities in high income countries remain weak.

Driving Forces

Price pressures as driving forces to sustain the high inflation scenarios can emanate from a variety of sources, such as supply disruptions as well as measures addressed at adjusting large macro-economic imbalances.

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[3] 2014 International Finance Statistics and data files; https://www.imf.org/external/data.htm

Inflation, period average
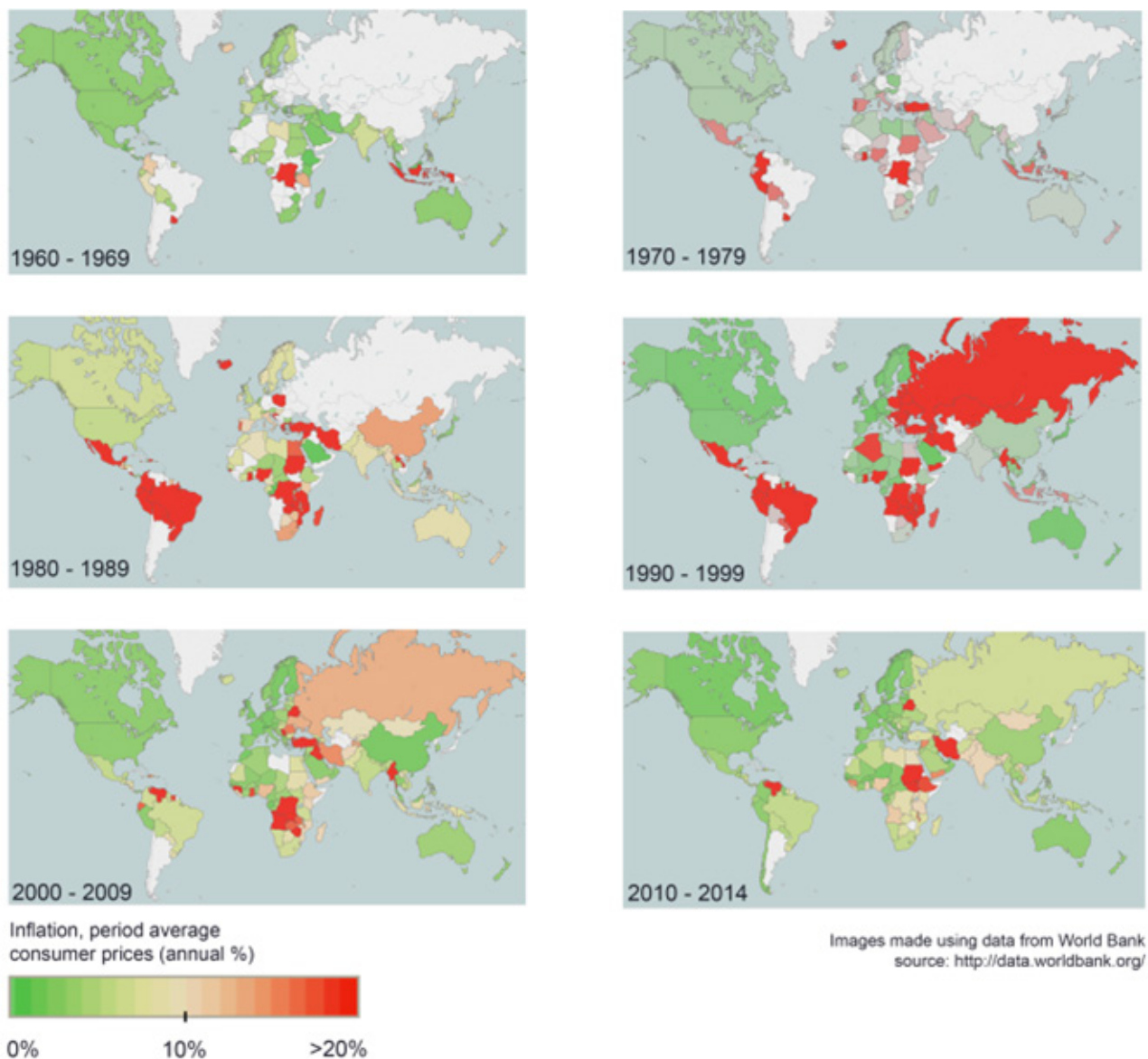consumer prices (annual %)

0%   10%   >20%

Figure 4: Inflationary health worldwide since 1960 (Data Source: World Bank)

Supply and Capacity Constraints

The year-over-year inflation remains high in some large economies, especially Russia, reflecting limited spare capacity. Additionally, unnecessary high costs are associated with importing food and fuel (Jordan and Tunisia) due to the region's high dependence on internationally traded food commodities. There can also be supply shortages caused by international sanctions as well as political and armed conflicts (Venezuela, Iran and Syria).

Currency Devaluation

Currency devaluation and administered price increases exacerbated the upward local price pressures in Venezuela, raising the year-on-year inflation to 35.2% in 2013 – 12.6% points higher than the previous year.

Loose Monetary Policies

A loose monetary policy describes an economic environment in which money is supplied excessively and made too easily available to the people to encourage economic growth.

In the nineteenth century, the Confederate States of America expanded the money supply through the issuance of treasury notes in 1861 and 1862, leading to a runaway inflation with price rises in the Confederacy of more than 9,000%. This instance of high inflationary pressure was generated by drawing down the official foreign exchange reserves and would be recognised today as an incipient disaster to be accompanied by disorderly fiscal and economic adjustment.

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.

Mechanism

Figure 5 illustrates an overview of the key transmission mechanism of cost-push inflation in the High Inflation World scenario.
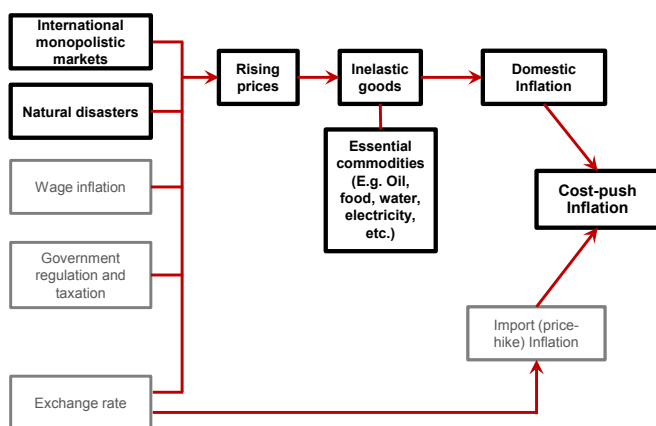

Figure 5: Key transmission mechanism of high (cost-push) inflation world (Data Source: About News[4]**)**

The primary reason for cost-push inflation is the increasing prices on inelastic goods, which are usually essential commodities without alternative substitutes that demand remains high no matter the price.

[4] K. Amadeo, *About News*, "Federal Funds Rate History; Highs, Lows and Chart with Major Events."

Increasing prices on these inelastic goods can be attributed to the several factors shown in Figure 5.

In this particular stress-test scenario, we concentrate in detail on how monopolistic markets and natural disasters could have an international impact on global inflation rates.

The monopoly power over oil, for example, can create cost-push inflation, as it has the same effect as reducing supply. The Organisation of Petroleum Exporting Countries (OPEC) was founded on the basis of exercising this monopolistic power over oil, one of the most highly sought after non-renewable natural resources. By cooperating with one another over production and price agreements via an effective cartel, the OPEC members fundamentally control 80% of the world's proven oil reserves, determine prices and have the ability to create cost-push inflation. For example, when the OPEC restricted oil in 1973, it resulted in the oil embargo, where oil prices quadrupled and global inflation significantly increased.

Natural disasters can also act as catalysts for cost-push inflation. It can be an indirect effect of natural disasters, such as the large eruption of Tambora in Indonesia in 1815, leading to a global volcanic winter that disrupted monsoon seasons in Asia, and failed summer harvests across the Northern Hemisphere. It was the worst famine of the 19th century, where food prices rose sharply across the United States, Europe and the United Kingdom.

The scope of coverage by both monopolistic markets controlling oil prices and natural disasters restricting food harvests can be significant on a global stage, thus laying the foundation to our selection mechanism of the High Inflation World scenario.

Severity

Inflation has the potential to impact investments through central banks' monetary policies, as well as eroding the nominal value of assets held within investment portfolios.

When inflation rates are rising fast, central banks typically raise short-term interest rates as an immediate response to reduce demand for credit and prevent their economies from overheating. As short-term rates rise, long-term bond yields tend to move in parallel bond yields and prices are inversely proportional; rising yields tend to lower the principal value of the fixed-income investments.

Another effect of high inflation is more hidden such that it silently erodes the positive nominal returns of any investments rendering them negative after adjusting for inflation. Further, in times of high inflation, investments may look much attractive because their growths are inflated, which can distort investors' judgement.

Fixed-income investments will be the hardest hit by high inflation for the reasons cited above. Further, portfolios that mirror features observed in the investment strategies of insurance companies, such as the high quality fixed income portfolios, will underperform in times of sustained high inflation relative to other representative portfolios, such as the balanced or conservative ones.

Food security and the price spiral

The price of food has a direct impact on global food security as a whole. The availability of food drops as inflation rises due to the growing costs of fuel and labour as well as export restrictions and stockpiling practices; increased demand then drives prices further up. According to the FAO's Food Price Index, the average cost of food worldwide has risen roughly 110% in the past decade.

In this scenario, we assessed the historical and current states of global upward price pressures for essential commodities in achieving a sustained high inflation threat. We chose a two-pronged approach from several candidate scenarios for simulating a cost-push global inflation spiral by threatening two major features of the food production and supply chains: honeybees and the supply of oil.

Global food prices increase. Our scenario assumes that there is a sudden collapse in the population of commercial honeybee colonies. Colony collapse disorder (CCD) has made headlines since 2006 when a sudden rise in the seasonal death-rate of western honeybees in North America caused international alarm.[5,6] Since 2010, the population loss in commercial bee hives has fallen between 30 and 50% year-on-year.[7] The causes of CCD remain an issue of debate with various experts linking the phenomenon to an increase in the use of plant pesticides or the aggravated effects of climate change.

The loss of commercial pollinators in Australia has already led to a crisis amongst fruit farmers in Japan who rely on shipments of honeybees to fertilise their crops. This phenomena is exacerbated by the rapidly growing global population from the 1950s onwards and hence the increasing demand for meat from developing countries, which expands demand and restricts the available supply of food crops, eventually pushing up the global food prices.

Global energy prices increase. Due to the political instability in oil producing countries in the Middle East, crude oil prices have been volatile and fluctuated between $50 and $130 USD for the past five years.[8] More recently, the oil market has been adversely affected by the crisis in Syria where Islamic State has assumed control over 60% of the local oil fields.[9] IS makes profits up to $1 million daily from selling oil at heavily discounted prices to middlemen.[10]

From this perspective point, we postulate a hypothetical conflict at a key chokepoint in the crude shipping network at the Strait of Hormuz. Roughly 20% of the world's oil passes through the 21km ocean passage daily and the seizure of these waters would greatly restrict global supply. The ongoing conflict in the area and increasingly stringent sanctions on purchasing oil can potentially cause a sustained high and increasing global energy prices.

Scenario Variants

We introduce a set of variants to the sustained high inflation scenario to provide sensitivity analysis so as to gain an improved understanding of the wider effects of such a global commodity price shock.

Standard scenario S1 consists of commodity price increases between 180 and 210% of the pre-existing price levels for the 5-year modelling period, with prices peaking after one year of applying the shock. This variant creates an inflation rate that peaks at approximately 6% globally in Y2Q1 before falling back to pre-shock levels towards the end of the modelling period.

Scenario variant S2 and extreme variant X1 are similar to the standard scenario, but the commodity price increases are raised up to 280 and 440% respectively.

[5] "Dramatic honey bee die-off worries beekeepers and crop producers", Penn State College of Agricultural Sciences, 29 January 2007

[6] E. Mack, "The Cause of Colony Collapse Disorder, Disappearing Bees Becoming More Clear", *Forbes*, 5 December, 2014

[7] "Colony Collapse Disorder Progress Report", CCD Steering Committee, US Department of Agriculture, June 2010

[8] Data source: InvestmentMine, "5 Year Crude Oil Prices and Price Charts"

[9] NBC News, 'ISIS Generations Millions From Seized Oil Fields: Iraqi Officials', July 23, 2014

[10] Sridharan, V, "Iraq Crisis: US Warns Buyers and Middlemen Involved in Isis Oil Trade", *International Business Times*, 24 October, 2014

5   The Scenario

Background

As the world's population increases, so too does the demand for food. With the growth in numbers comes the growth in income – more people are buying meat and dairy in the developing world than ever before. In order to meet demands at the current rate of distribution, agricultural production must increase by 60% by the year 2050.

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Rising urban populations threatens worldwide food security

Global warming and increasing populations means that food shortages are only going to get worse

Saturday, November 13

NEW YORK, NY (1322 EST) -
A new paper from the FAO examines the new risks to food supply as population growth spikes in developing cities

Drought, crop blight, water shortages and sky-high bread prices all contributed to the social unrest seen in the Middle East and North Africa last year, but experts suggest the situation is unlikely to improve anytime soon. As

Agricultural output must increase by 60% in order to meet expected global demand in 2050

Greater food demand taxes almost all of the earth's available yet depleting resources. The removal of forests to create farmland, over-farming practices and growing use of pesticides cause soil fatigue and erosion, making the land more susceptible to flood, drought, and other extreme weather patterns.

Globalisation has implemented a large commercial network of food supply chains linking rice farmers in Thailand to buyers in the United States, ranchers in New Zealand to diners in Europe, Argentinian vintners to wine-drinkers in China. The growing supply chains fuels the growing demand for transport and distribution – a strain on energy sources to support the international food economy.

Phase one

The middle of the year brings with it bouts of extreme weather across the northern hemisphere: a long heatwave in the Pacific West, heavy rains in the Atlantic and drought in northern China. Following a sudden cold snap in the late part of the winter, commercial honey-beekeepers across Australia report unusually high rates of colony loss as they inspect their hives at the start of the season. The media attention is significant, but the story falls from the front pages

as news of torrential rains and floods in the Indian Subcontinent makes international headlines.

Within six months, spring in the northern hemisphere confirms earlier fears of a breaking an impending ecological crisis. Beekeepers across China, Europe and the US witness a 70% loss in colonies. The price of commercial hives in the agricultural sector triples and the market for certain soft commodity goods suffers tremendously from is adversely affected by the twin spectres of drought and pollinator collapse. The price of certain particular fruits and vegetables – almonds, avocados, plums – is almost doubled, although most crops, initially, keep maintain a steady supply.

A more pressing issue is the sudden shortage in maize and cattle feed grains, a result of harsh droughts across continents.

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Bee decline is "cataclysmic" event

After a period of extreme weather worldwide, apiculturists say the loss in hive populations is "irrecoverable"

Wednesday, February 5

SACRAMENTO, CA (1214PST) -
Time has run out on seeking remedies to global bee decline as commercial keepers in the US report a 70% loss in honeybee populations

The first trumpet sounded in August when Australia's honeybee industry suffered a significant loss of product following a harsh winter storm. Japanese agricultural output dropped partially in reaction to the loss of natural pollinators. Now, however, the writing is on the wall as California

Between 80-90% of fruit, nut, seed and vegetable crops rely heavily on wild and commercial bees

The demand for wind-pollinated

Phase two

A militant Sharia separatist group out of Iran establishes hold on the Strait of Hormuz in the Persian Gulf, effectively seizing control of more than 17 million bbl/d out of OPEC – 20% of the world's crude exports. A coalition of western forces begins immediate military strike action against the group's bases in Musandam and southern Iran. In response to the military offensive, the separatists issue an ultimatum and restrict the international shipment of crude oil through the Straits, raising the price of oil to over $170 per barrel.

The impact hits the international meat industry significantly. Feed grain supplies are already reduced by drought and the gasoline used in abattoir and transport equipment reaches an all-time high

of $7.23/gallon. Within a few months, the dairy industry is also adversely affected. Ranchers sell at a higher price to compensate for the cost of grain and loss of production and millions of people are forced to go without food

The high cost of fuel also interferes with both the planting and reaping seasons in the agricultural marketplace and billions of dollars are lost through production inefficiencies generated by compromised farming methods. Farmers raise prices to remain in business, but increasing production costs begin to affect aggregate demand as a cost-push spiral emerges worldwide.

Phase three

Within a year, the global food basket shrinks rapidly and world inflation rates approach double digits. Continued conflict in the Middle East keeps fuel prices high, removes the opportunity for farmers to recover harvests and increase supply and continues the breakdown of supply chain lines across the globe. Governments initially invest in biofuel sources as an alternative to gasoline, but ethanol prices remain high due to the shortage of corn.

The crop famines and weather- spoilt harvests have claimed millions of lives in the developing world as such food as exists is limited in its distribution due to the increasing transport costs and widening income gap. In developing countries, shop owners struggle to renew supplies of the essentials and re-price products by the week.

Consumer Price Inflation (CPI) spikes and the demand for a rise in national wage levels stimulates an unemployment spiral which exacerbates the growth of inflation.

In an effort to curtail worldwide stagflation at the height of the crisis, national central banks gradually adjust interest rates in order to suppress consumer spending and relieve economic pressure. After eighteen months, prices begin to stabilise and the rate of inflation drops.

6 Macroeconomic Analysis

Economic impacts of high inflation

Severe price inflation occurs when costs rise above a stable and predictable rate. This can potentially be harmful to a country's economic performance and to the welfare of its citizens. When price inflation is expected, it can be considered healthy for the economy as relevant stakeholders can plan for it and act accordingly – businesses raise prices, workers demand higher wages, and lenders raise interest rates. However, when inflation is higher and its duration longer than expected, it tends to impact workers, recipients of fixed incomes, and savers. Over the long-term, unexpected high inflation can significantly cause distortion of the price mechanism, reduce confidence and investment sentiment, and cause overall public consumption to fall due to the erosion of the value of money and assets.

Further, the evidence base suggests (Boyd, Levine, & Smith, 2001) that sustained high inflation can have adverse and nonlinear impacts on financial sector activities, and those of banks and stock markets, once annual inflation rates increase beyond a 15% threshold.

Macroeconomic effects of inflation

Price stability is commonly regarded as one of the most important macro-economic policy objectives and is usually measured by inflationary rates. The management of inflation, therefore, is usually done through increasing interest rates.

The governments and central banks of major world economies, including the US, Europe, China, will adjust short-term and long-term interest rates in an attempt to curb and manage inflation. However, higher interest rates would ultimately feed through to the rate of consumption and commercial investments, which in turn has an adverse effect on trade. Eventually, these effects slow economic growth, resulting in significant shocks to global GDP.

Additionally, price levels across the other commodities such as raw materials and minerals are affected indirectly as global food and energy prices increase and interest rates adjust accordingly. The compounded effects affecting the relationship between commodities and fuel prices could have further prolonged impacts on a sustained high inflation.

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 the various "Sustained High Inflation" scenarios.

The model contains a detailed database with observations over 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. These models are suitable for analysing the impacts of future policy changes, to the respective major economies from an exogenous source.

Assumptions and uncertainty

The economic estimates presented in this analysis are subject to the assumptions made in the development of the narrative and in 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 and follows 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. Therefore, the final estimates represent a best attempt to model the economic outcomes of a low probability event with highly uncertain outcomes.

Macroeconomic modelling of the scenario

To model the effects of a sustained high inflation scenario, a number of key indicators were selected to simulate the effects. Commodity price shocks were chosen based on historical precedents relevant to the scenario such as the sustained high inflation case studies as seen in Venezuela and Argentina. While most historical high inflations rarely last longer than a few months, the shocks applied in the model persist and the impact lasts for a period of five years before returning to baseline.

The model assumes the shock begins in the first quarter of 2015 as (Y1Q1). The exact timing of the high inflation is not intended to be specific but deliberately flexible as to when a global price shock could manifest in the future.

S/N	Macroeconomics input variables	Scenario Variants			Justification for shock	Scenario-specific key assumptions
		S1	S2	X1		
1	**Global Energy Prices**					
	Magnitude	210%	280%	440%	**1973 Oil Embargo**	***Global oil production:***
	Duration		4 Qtrs		• Expansionary monetary policies (many economies adopted Keynesian principles after WW2)[11] • Oil production was cut by up to 25% by members of the OPEC and Arab States[12] • Price of oil increased $3 to $12 per barrel, after the oil embargo[13]	• OPEC accounts for 40% global production[14] • Growing risk of military dictatorship and oil production control[15]
2	**Global Food Prices**					
	Magnitude	180%	250%	310%	**2007-8 World Food Crisis**	***Global population trend***[17]**:**
	Duration		4 Qtrs		• World population increased from 6.6 to 6.7 billion during this period[16] • Developing countries food imports rose by 25% in 2007 • On average the world price for rice increased by 217%, whilst wheat increased by 136%, maze by 125% and soybeans by 107% during this period	• Population density explosion • Higher affluence • Rising demand for feed crops and meat consumption ***Changing weather patterns:*** • Crops and livestock adversely impacted through diseases, extreme natural disasters ***Rising Oil Prices***[18]**:** • Domino effect on costs of fertilisers and food transportation ***Bee colony disorders***[19]**:** • Globally 71% of crop species are bee-pollinated • Up to 75% of bee colonies in the US collapse during the 2006-07 period

Table 3: Catalogue of macroeconomic scenario assumptions made in the modelling process

[11] Jahan, S., Saber Mahmud, A. S., Papageorgiou, C. (2014) What Is Keynesian Economics? Finance & Development,51(3).

[12] Paust, J., & Blaustein, A. P. (1974) The Arab Oil Weapon—A Threat to International Peace 68(410)

[13] Background: What caused the 1970s oil price shock? The Guardian. 3 March 2011.

[14] U.S. Energy Information Administration. International Energy Statistics 2014.

[15] The Economist. (2014). Iraq and global oil markets: The ISIS effect.

[16] 2008 World Population. Population Reference Bureau Data Sheet.

[17] McMichael, P. (2009). The world food crisis in historical perspective. Monthly Review, 61(3),32.

[18] Global food crisis (2008). Global Financial Crisis portal.

[19] Kluser, Stéphane, et al. (2010). UNEP Emerging Issues: Global honey bee colony disorders and other threats to insect pollinators.

S/N	Input Variable	Scenario Variants			Max Shock duration applied
		S1	S2	X1	
1	World energy prices	210%	280%	440%	5 Qtrs
2	World food prices	180%	250%	310%	5 Qtrs

Table 4: Overview of key input variables to the respective scenario variants

Variable Descriptions

The scenario analysis includes three independent narrative variants, modelled using the Oxford Economic GEM, to provide sensitivity analysis around the assumptions made. The following lists the key variables in the model in which the shocks were applied. Table 4 summarises the overview of the input variables applied to the scenario variants.

We shocked the global economic model through high global energy (represented by oil, gas, and coal) and food prices. When a country is subjected to high political and economic instability, rising commodity prices are likely to directly reduce the purchasing power of the public. Furthermore, indirect impacts are felt through the higher interest rates adjusted by governments to manage the high inflation, which would feed through to lower public and private consumption as well as foreign investment.

Input variables

The following trend lines (Figure 6) illustrate the generic profile of the applied shocks on these two input variables, with the separate scenario variants visible in different colours, shown in comparison with the baseline. The figure also presents the historical precedents of commodity price indices, where prices have been stable since the 1980s before gradually increasing from year 2000.
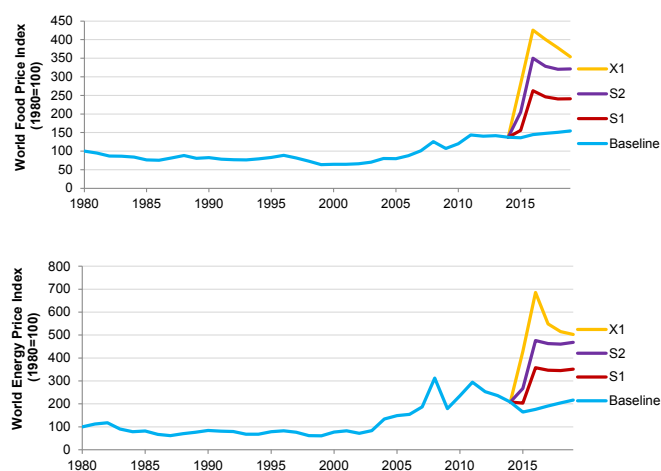

Figure 6: Trend lines of world energy and food price indices since the 1980s

The 400% increase in the world energy prices in the X1 variant was made in reference to the Oil Shock of 1973-74, when the world price of oil quadrupled in less than four months from US$2.90 a barrel to $11.65 due to a series of oil production cuts by OPEC.[20] As a direct impact of the food and energy price spiral, global inflation rates rapidly increase and reach their peak in the second year, before steadily falling back to pre-shock levels towards the end of the modelling period.
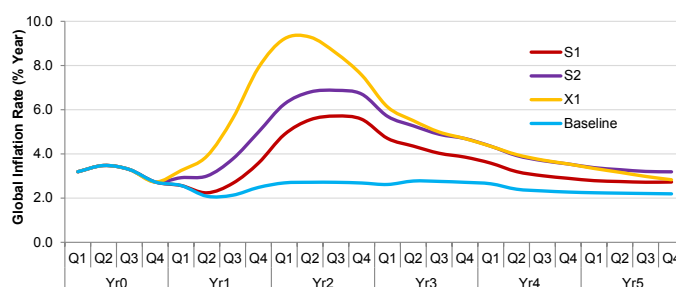

Figure 7: Global inflation rates across scenario period per variant scenario

Since the year 2000, the world Food Price Index has seen a steady increase of approximately 50% in real terms (Figure 7). Despite the index's recent downward trend, falling for the sixth consecutive month, short-term issues and long-term fundamental problems underlying the global food crisis remain.
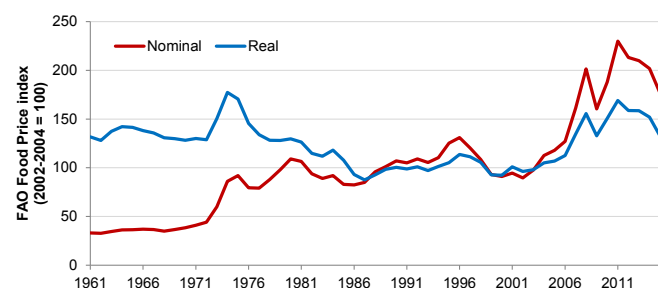

Figure 8: Food price index in nominal and real terms (Source: FAO); Real price index is the nominal price index deflated by the World Bank Manufactures Unit Value Index

Results

As global commodity prices rise, the final impact of these price changes on any particular country is a function of the level of exposure a country has with respect to each particular commodity. Some countries may have higher demand for oil and use it very inefficiently, making them more exposed and vulnerable to an oil price increase. Thus, different countries and variables are affected differently by the global commodity price shocks.

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[20] M. Corbett, "Oil Shock of 1973-4", Federal Reserve History; http://www.federalreservehistory.org/Events/DetailView/36

Impact on regional inflation rates

Inflation is a direct economic impact caused by the rise in global commodity price. Price shocks are applied directly to global commodities and the model adjusts and calculates endogenously to allocate inflation rate increases amongst the countries.

Figure 9 presents a general increase in inflation rates for all observed countries, with the United Kingdom showing more than 10% of maximum inflation rate in the extreme variant X1. Although Japan shows just above 5% of maximum inflation, relatively lower than other countries analysed, it has suffered decades of prices falling at a variable rate. Therefore, such a slight increase in its annual rate of inflation can be considered relatively substantial to its flat domestic economy.
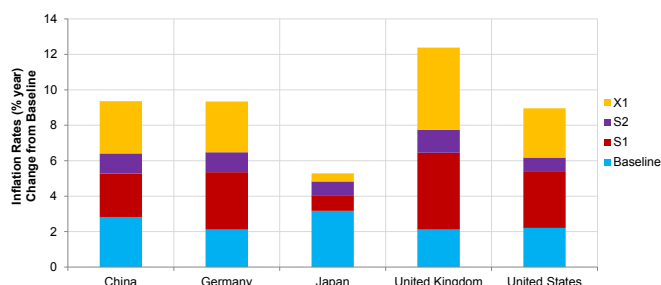
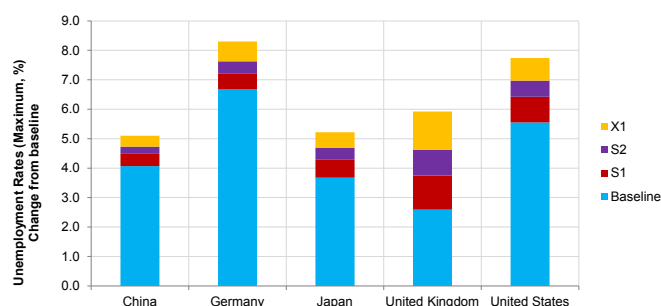**Figure 9: Impact on regional inflation rates (% year) across scenario variants**

Figure 10: Impact on regional unemployment rates (maximum, %) across scenario variants

Impact on employment

The direct impact of a period of global high inflation is the corresponding increase in unemployment rates as depicted across the countries shown in Figure 10. The cost-push inflation caused by the energy and food price spiral erodes the margins made by employers in real terms and, therefore, firms react by hiring less workers and this leads to a rise in unemployment. In this scenario, the UK sees the highest incremental increase in unemployment states, which corresponds to the largest inflation rate increase.
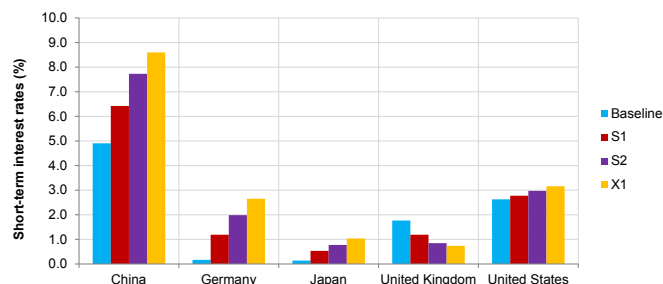

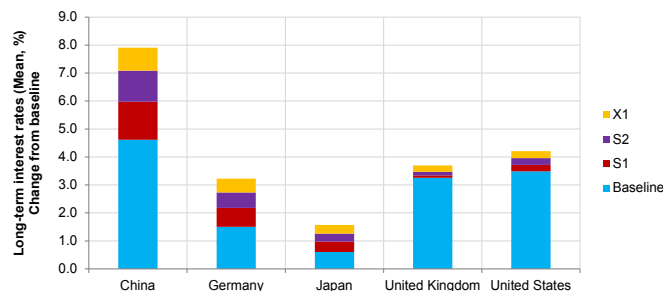**Figure 11: Impact on short-term interest rates (%) across scenario variants**

Figure 12: Impact on long-term interest rates (%) across scenario variants

Impact on interest rates

The combined effect of changes to commodity prices causes inflation, and feeds through to adjust the central banks interest rate for each country. Changes in interest rates then have an impact on exchange rates and overall competitiveness within the global economy. Thus a country that relies heavily on exports will be impacted negatively by an appreciating currency by making it more expensive for other countries to purchase what this country produces. However, there is a trade-off that tighter monetary policy may lead to a rise in unemployment. As shown in Figure 11, it is generally observed that most countries react to rising inflation by increasing short-term interest rates.

The lower UK short-term interest rates assume the Central Bank attempts to control the sharp increase in unemployment rates over inflation rates. The more relaxed monetary policy in the UK suggests that the rate decrease aims to reduce the cost of borrowing so as to increase credit availability, which is an attempt to spur economic growth and hence control the unemployment rate in the UK economy despite high inflation.

Figure 12 shows an increase in long-term interest rates across all variants and major economies. This reflects weak confidence in the long-term outlook of both consumers and investors and signals a decreasing risk appetite. Further, long-term interest rates increase as a consequence to the global high inflation and increasing uncertainty.

Location	Minimum GDP Growth Rate (% Qtr)				Worst recession duration (Qtr)	Recession scenario variant(s)
	Baseline	S1	S2	X1		
China	5.3	2.7	1.4	-0.6	3	X1
Germany	1.0	0.5	0.1	-0.8	3	X1
Japan	-1.2	-2.0	-2.5	-3.2	7	S1, S2, X1
UK	2.2	1.2	0.6	-0.7	3	X1
US	2.7	0.6	-0.2	-1.6	3	S2, X1
World	2.7	1.9	1.4	0.6	N/A	N/A

Table 5: Impact on GDP growth rates in the course of the High Inflation World scenario variants

Location	Baseline	S1		S2		X1	
	5-yr GDP (US$ Trillion)	GDP@Risk (US$ Trillion)	GDP@Risk (%)	GDP@Risk (US$ Trillion)	GDP@Risk (%)	GDP@Risk (US$ Trillion)	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%	0.3	1.7%
Japan	29.3	0.3	1.3%	0.4	1.8%	0.7	2.1%
UK	14.0	0.2	1.5%	0.3	2.2%	0.4	2.7%
US	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%

Table 6: Global inflation and GDP@Risk values for the three scenario variants

Impact on GDP growth rates

The energy and food spiral adversely impacts the GDP growth rates; it increases the costs of production and lowers investment in general. As a result, most countries experience a period of recession, defined as negative GDP growth rates over at least two successive quarters. Global GDP shrinks from an expected baseline quarterly growth rate of 2.7% over the five-year modelling period to 0.6% in the most extreme variant, although no global recession is expected to occur (Table 6).

GDP@Risk

The macroeconomic consequences of this scenario are modelled as described, using the Oxford Economics GEM. The output from the model is a five-year forecast for the world economy, repeated for each variant, and the impacts of the scenario are then compared with the macroeconomic baseline projection of the global economy that is forecasted without any crisis occurring, to assess the world gross domestic product (GDP) at risk from this scenario.

The primary figure produced is the GDP@Risk, which is the total difference in GDP between the baseline projections and the scenario-specified projections.
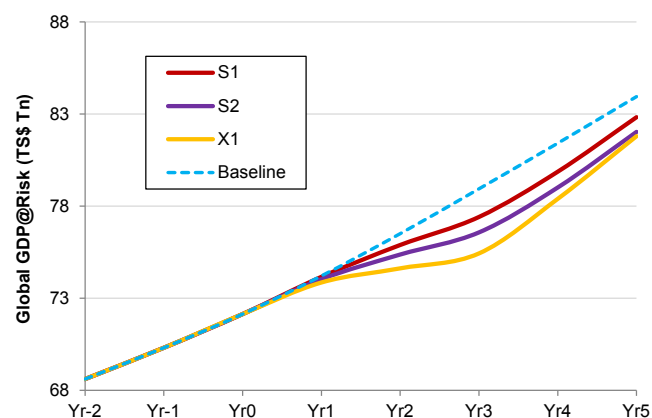

Figure 13: Estimated loss in global output as a result of "sustained high inflation" scenario

When a crisis occurs, such as a global commodity price shock scenario considered here, there is a significant deviation from the expected trend in GDP growth. The total GDP loss over five years, beginning in the first quarter of Year 1 during which the shock of global commodity price levels is applied and sustained through to the last quarter of Year 5 (Yr5Q4), defined the GDP@Risk for this scenario. Figure 13 illustrates the reduction in global GDP that is modelled to occur as a result of the scenario, in all its variants.

These are compared with the expected growth (Baseline) without the scenario occurring.

Table 5 provides the GDP loss of each of the variants of the scenario, both as the total lost economic output over five years, and as a percentage of the respective baseline GDP values.

Economic conclusions

A high inflation trend of this extent clearly has significant implications for the global economy. In this macroeconomic analysis, we have demonstrated how a food and energy price spiral may cascade through the global economy. We have also shown how these price shocks result in more harm to countries relatively more exposed to international commodity prices, which leads to higher production costs, increasing interest rates and decreasing international competitiveness.

In addition to the high inflation rates that erode the real value of money across the global economy, there is a general tightening of monetary policy (rates increase) that seek to control the effects of cost-push inflation on the economy. Higher interest rates then have the effect of increasing unemployment rates, reducing investment and lowering aggregate expenditure in the economy. These all have negative effects on output and growth.

The extreme variants of this scenario result in a recession across major economies, although there is no global recession recorded. The total cost of the scenario to the global economy is estimated to be between US$5 and US$11 trillion, and predicted to recover from Yr3Q1 onwards. The maximum GDP losses in the US and China are substantial, approximately US$6 trillion, which contribute more than half of the global GDP losses.

7   Impact on Investment Portfolio

The macroeconomic effects of the High Inflation World 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, alternative investments and equities in different markets are estimated from the macroeconomic outputs of the modelling exercise, 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, changes in 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 is a stylised assumption, 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 High Inflation World scenario.

We have built a fictional representative portfolio that mirrors features observed in the investment strategies of insurance companies, titled High Fixed Income Portfolio and three others that mirror 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 7, Figure 14, Figure 15 and Figure 16.

Details of the Conservative Portfolio are shown on the following page in Table 8, Figure 16, Figure 17 and Figure 18.

Details of the Balanced Portfolio are shown on the following page in Table 9, Figure 20, Figure 21 and Figure 22.

Details of the Aggressive Income Portfolio are shown on the following page in Table 10, Figure 23, Figure 24 and Figure 25.

High Fixed Income portfolio structure

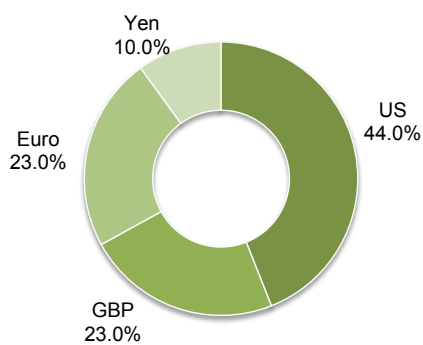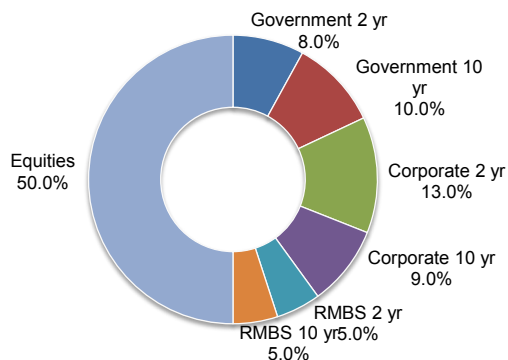|	USD	GBP	Euro	Yen	Total
Government 2 yr	8%	6%	5%	3%	**22%**
Government 10 yr	8%	7%	6%	2%	**23%**
Corp. Bonds 2yr	4%	4%	4%	2%	**14%**
Corp. Bonds 10yr	6%	7%	3%	2%	**18%**
RMBS 2 yr	2%	1%	1%	1%	**5%**
RMBS 10 yr	1%	1%	1%	1%	**4%**
Equities	2%	3%	3%	2%	**10%**
Cash	4%	0%	0%	0%	**4%**
Total	**35%**	**29%**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

Table 7: Composition of the High Fixed Income Portfolio Structure
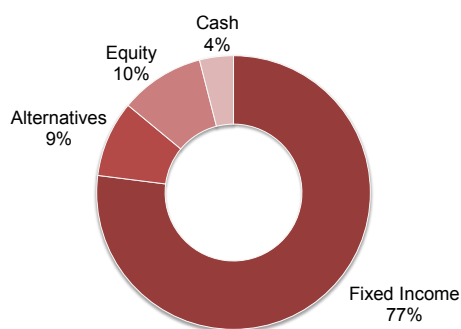
Figure 14: Asset classes in High Fixed Income Portfolio Structure
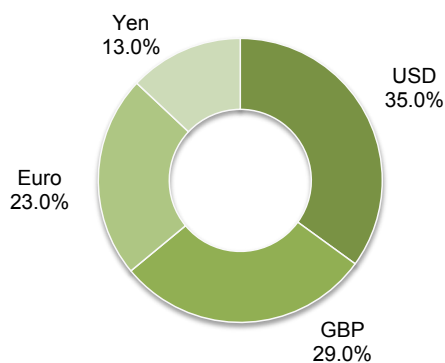
Figure 15: Geographic market spread of High Fixed Income Portfolio Structure
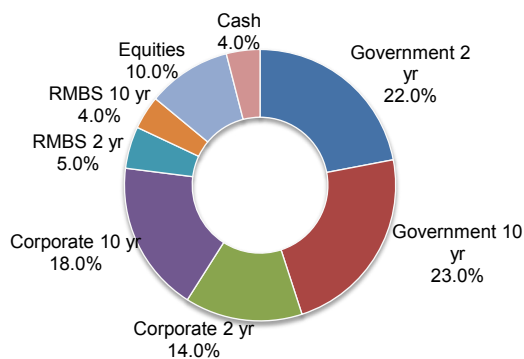
Figure 16: Detailed asset class breakdown of High Fixed Income Portfolio Structure

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 8: Composition of the Conservative Portfolio Structure
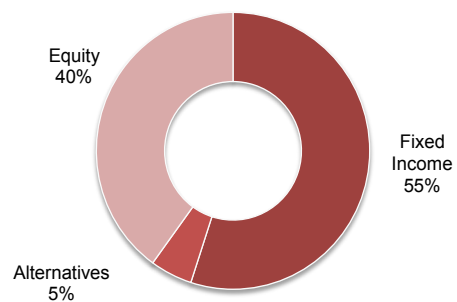
Figure 17: Asset classes in Conservative Portfolio Structure
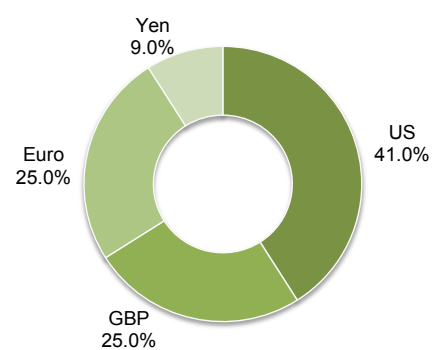
Figure 18: Geographic market spread of Conservative Portfolio Structure
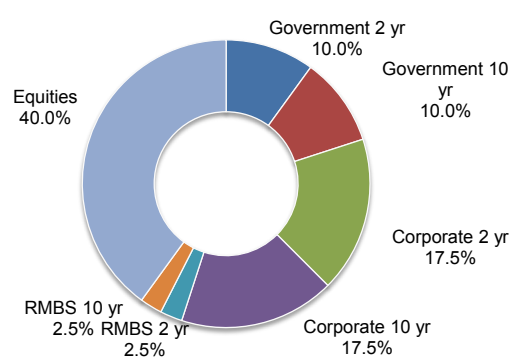
Figure 19: Detailed asset class breakdown of the Conservative Portfolio Structure

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 9: Composition of the Balanced Portfolio Structure
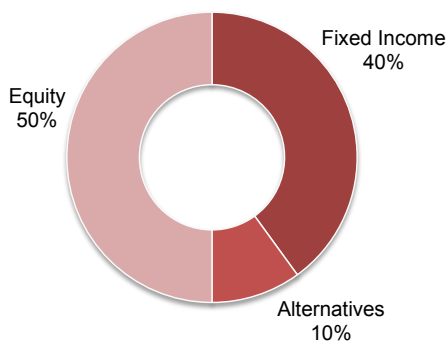
Figure 20: Asset classes in Balanced Portfolio Structure

Figure 21: Geographic market spread of Balanced Portfolio Structure

Figure 22: 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 10: Composition of the Aggressive Portfolio Structure
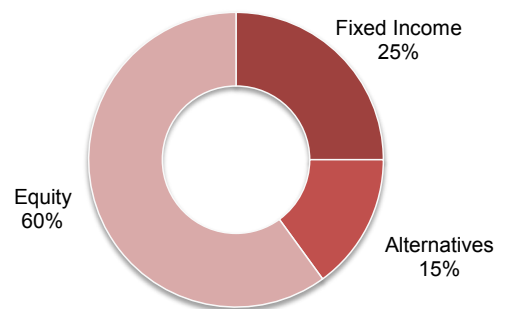
Figure 23: Asset classes in Aggressive Portfolio Structure
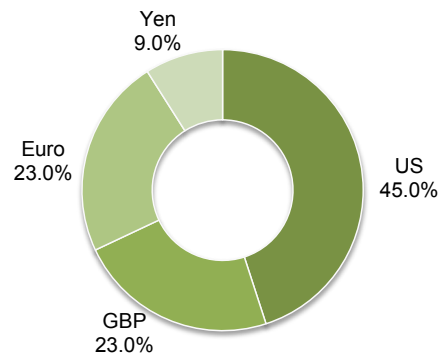
Figure 24: Geographic market spread of Aggressive Portfolio Structure
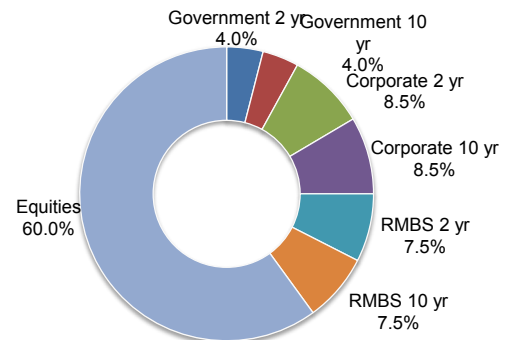
Figure 25: Detailed asset class breakdown of Aggressive Portfolio Structure

Computation of returns

The estimation of portfolio returns is carried out using the following method.

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 t h e following values: D_b =7 for ten years bonds and D_b =1.8 for two years bonds. SD_b represents t h e 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.

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 11. The actual corporate bond default rates used were calculated as the weighted average of default rates by credit rating and geographic regions.

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 effects are taken into to account to ensure that all reported portfolio returns are with respect to US dollars. Inflation rates are used to discount the nominal portfolio returns into real portfolio returns. This is an important exercise specifically for the High Inflation World scenario as inflation rates are directly shocked in the economic modelling.

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%

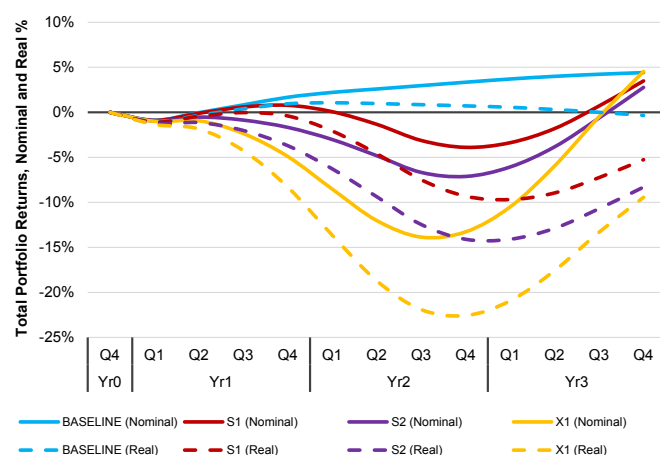Table 11: Annual default probabilities for corporate bonds

Figure 26: High Inflation World Scenario Impact by Variant, Conservative Portfolio (Nominal vs. Real %)

Portfolio returns

Results of our analysis are presented in Figure 26, Figure 27, Figure 28 and Figure 29.

Figure 26 shows the scenario impacts by variant for the Conservative portfolio structure. In all variants we observe a significant departure from the baseline (blue lines) projections. The solid lines represent the impact in nominal% and the dashed lines represent the impact in real% relative to Yr0Q4. For the High Inflation World the economic shocks were applied over a five year period starting in Yr1Q1. After three years, we see the portfolios begin to recover. The maximum downturn experienced for the Conservative portfolio in the S1 variant is -3.89% nominal or -9.69% real and occurs in Yr2Q4. Another interesting point to note is that the returns in real% are much more impactful than in nominal dollars. This means that the value of the portfolio in today's dollars is greatly reduced by the High Inflation Scenario, this affect is as large as -6% for the S1 variant.

Figure 27 shows the scenario variant impacts by portfolio structure. For the High Inflation World scenario, we see the high fixed income portfolio structure underperform compared with the other structures.

Figure 28 shows market impacts on equity performance by geography for the least extreme variant, S1. The Japanese (N225) stock index ais most negatively impacted by this scenario, while the US (W5000), UK (FTSE100) Euro (Dax) are generating positive returns over the three year period.

Figure 29 shows the market impact on fixed income performance by geography for the most least variant, S1. Although all geographies are impacted negatively in this scenario, Japan fairs the worst, while US is least impacted. The largest negative impact to a single fixed income asset is greater than 15%, while it is only 5% for equities. This confirms the finding that
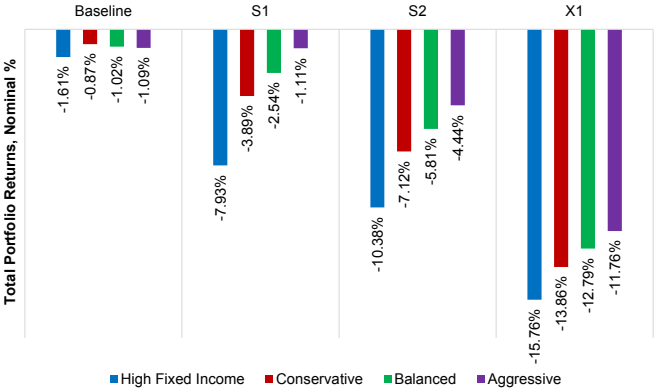
Figure 27: High Inflation World scenario max downturn by portfolio structure in nominal %
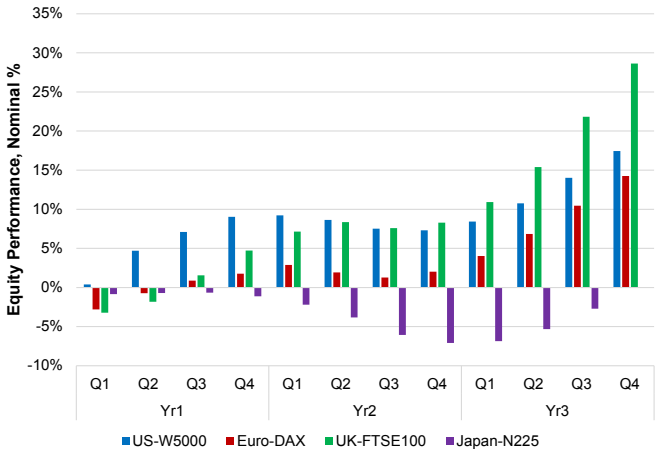

Figure 28: High Inflation World equity performance by geography in nominal % for S1
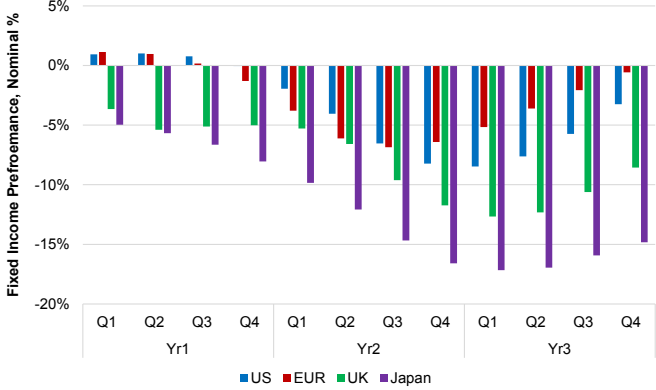

Figure 29: High Inflation World Fixed Income portfolio performance by geography in nominal % in S1

a high equity portfolio performs better than a high fixed income portfolio.

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 30 and Figure 31.
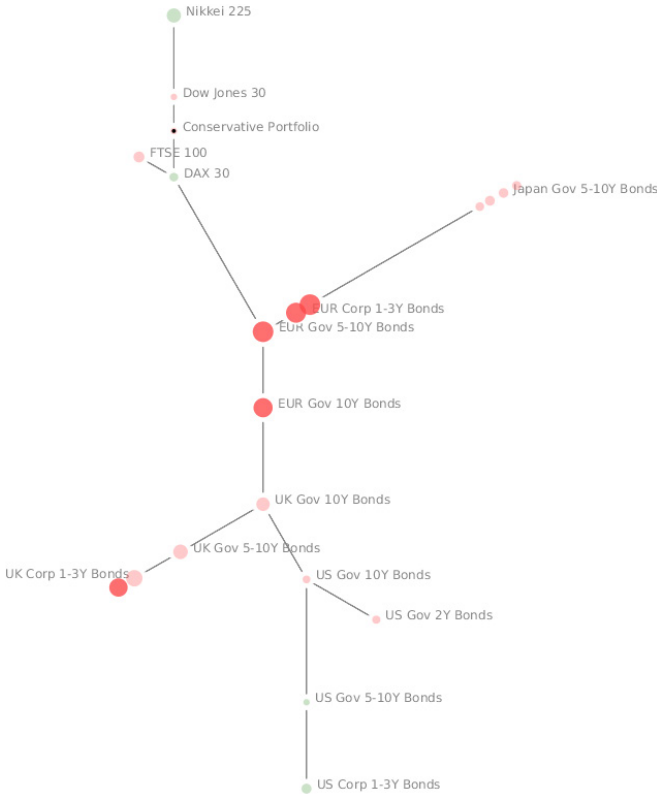

Figure 30: Conservative Portfolio before stress test
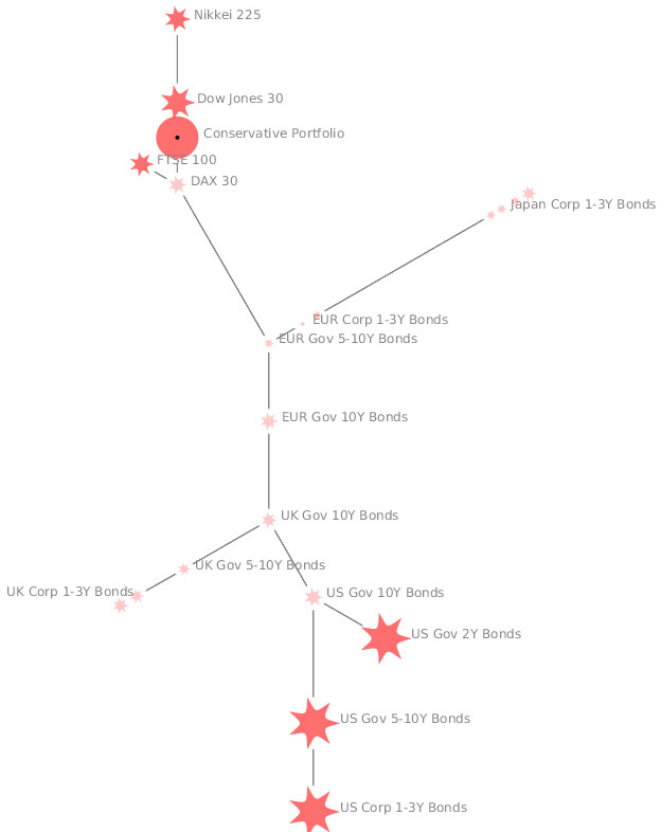

Figure 31: Conservative Portfolio after X1 stress test at Yr2Q2

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 High Inflation World scenario and compared it with the business as usual performance or baseline. The High Fixed Income portfolio structure performs the worst in this scenario, with a loss of -8% 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 12 summarises the maximum downturn by portfolio structure and scenario variant.

An important issue that we have yet to address 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%	-8%	-10%	-16%
Conservative	-1%	-4%	-7%	-14%
Balanced	-1%	-3%	-6%	-13%
Aggressive	-1%	-1%	-4%	-12%

Table 12: Summary of portfolio performance (max downturn) by structure and scenario variant, nominal %.

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%	-2%	-4%	-7%	-6%	-11%	-13%	-16%
Gov Bonds Long	10 yr	-1%	-3%	-7%	-13%	-9%	-17%	-21%	-22%
Corp Bonds Short	2 yr	0%	-1%	-3%	-6%	-2%	-8%	-11%	-13%
Corp Bonds Long	10 yr	1%	-1%	-6%	-11%	-4%	-14%	-17%	-19%
RMBS Short	2 yr	0%	-1%	-3%	-6%	-2%	-7%	-10%	-12%
RMBS Long	10 yr	0%	-1%	-6%	-12%	-6%	-14%	-18%	-19%
Equities	W5000	8%	7%	4%	-1%	15%	6%	2%	-1%
UK									
Gov Bonds Short	2 yr	-5%	-5%	-6%	-6%	-9%	-15%	-17%	-17%
Gov Bonds Long	10 yr	-6%	-7%	-11%	-15%	-13%	-18%	-20%	-19%
Corp Bonds Short	2 yr	-4%	-4%	-5%	-6%	-8%	-14%	-16%	-17%
Corp Bonds Long	10 yr	-5%	-6%	-10%	-15%	-11%	-16%	-18%	-18%
RMBS Short	2 yr	-5%	-4%	-5%	-5%	-8%	-13%	-15%	-16%
RMBS Long	10 yr	-6%	-6%	-10%	-15%	-12%	-16%	-18%	-18%
Equities	FTSE100	5%	4%	1%	-3%	24%	19%	16%	18%
EU (Germany)									
Gov Bonds Short	2 yr	0%	-5%	-4%	-1%	-2%	-16%	-18%	-21%
Gov Bonds Long	10 yr	0%	-10%	-16%	-26%	-7%	-24%	-28%	-30%
Corp Bonds Short	2 yr	2%	-4%	-3%	0%	2%	-14%	-16%	-19%
Corp Bonds Long	10 yr	3%	-9%	-15%	-25%	-1%	-20%	-24%	-26%
RMBS Short	2 yr	-5%	-4%	-3%	0%	-8%	-13%	-15%	-18%
RMBS Long	10 yr	-5%	-9%	-15%	-25%	-12%	-20%	-24%	-26%
Equities	DAX	3%	1%	-3%	-9%	12%	5%	2%	0%
Japan									
Gov Bonds Short	2 yr	-9%	-10%	-11%	-13%	-18%	-18%	-19%	-20%
Gov Bonds Long	10 yr	-8%	-9%	-12%	-15%	-20%	-23%	-26%	-27%
Corp Bonds Short	2 yr	-9%	-10%	-11%	-13%	-18%	-19%	-20%	-20%
Corp Bonds Long	10 yr	-8%	-9%	-12%	-15%	-20%	-23%	-26%	-28%
RMBS Short	2 yr	-9%	-10%	-11%	-13%	-16%	-18%	-20%	-20%
RMBS Long	10 yr	-8%	-9%	-12%	-15%	-17%	-23%	-26%	-27%
Equities	N225	-2%	-3%	-5%	-9%	-5%	-7%	-8%	-6%

Table 13: High Inflation World summary of asset class performance by variant and geography, in real %.

8   Mitigation and Conclusions

China, Germany, Japan, UK and US are all adversely affected by the High Inflation World Scenario with rising stagflation causing GDP to grow more slowly if not, in the most extreme X1 variant of this scenario, putting those nations into recession. The same issues are expected for other economies with high energy consumption per capita, whether this reflects consumer or industrial demand.

This global economic cloud has a "silver lining" for nations and sectors which produce oil and other commodities and hence find themselves in a boom that more than compensates the increasing cost of doing business.

In financial markets the High Fixed Income Portfolio performs particularly badly, registering significant losses in returns on government bonds, while portfolios that are more heavily weighted in equity indexes perform much better. Japanese stocks take a large loss however. The best performing equities are UK (FTSE 100) with good performance in equities also from the US and to a lesser extent Europe.

The High Inflation World Scenario points to the danger of relying solely on the traditional safe havens of government bonds in developed markets of North America, Europe and Japan.

Nevertheless even the better performing portfolio strategies, which have higher proportions of investments in equities, experience large losses in the more extreme variants of the High Inflation World Scenario.

Commodity shocks have many causes. Instances of oil price rises include withholding of production by collusive cartels such as OPEC in the 1970s; an expanding world economy that is fuelled in part by energy consumption, which arguably describes the period 2002-2007; or a decrease in the rate of supply that may be driven by production problems or interruptions to the supply chains, e.g., Hurricane Katrina in 2005 damaged oil and gas production in the Gulf of Mexico oil and led to an oil price rise.

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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