FULCRUM ASSET MANAGEMENT

Disastrous bond yields

This paper looks at 'disaster risk' and bond markets.

Disasters are abnormally large declines in economic activity. They make equities riskier and the safe haven of government bonds more attractive.

During the past decade the risk of disaster has increased and this can explain the low level of yields in core government bond markets such as the US and Germany.

As long as disaster risk remains high it is likely that yields on core government bonds will remain low.

But the probability of governments defaulting increases with disaster risk and this can make bonds progressively more like equities.

Bonds and equities then become positively correlated as default risk increases. This has happened for each of Italy, Spain and Greece at broadly the same level of default risk.

Introduction and summary

Ten year yields on US government bonds fell to the lowest level since 1946 at the beginning of June. Equivalent German yields reached 1.21%, the lowest level ever recorded. Such historic lows together with a persistent trend of falling yields have led many to argue that they are too low and that there is a 'bubble' in bond markets.

This paper argues that standard frameworks to value bonds might be wrong and it is possible to explain a decline in bond yields to unusually low levels. The core of our approach is the role of economic disasters.

Economists think of 'disasters' as substantial declines in economic activity. Historic examples would include the Great Depression and World War II. More recent examples might include the decline in GDP in Iceland following the collapse of its banking system, or the current position of Greece. Economists started to become interested in such events because they help explain financial market puzzles. Our interest here is to shed light on the valuation of government bond markets.

We show that a model in which the risk of disasters increases can explain abnormally low bond yields. Faced with a higher probability of severe economic events, investors seek safety by switching into core government bond markets. Yields can then remain very low for as long as economic risks are extreme. In other words, there is no valuation puzzle for bonds—crucially, low yields need not imply a bubble.

Low bond yields can mean markets are correctly pricing in greater risk. We calibrate the model to illustrate the impact of disaster risk. Decline in yields relative to 'fair value' of 70-100bp are straightforward to justify, in line with measures of over-valuation in many conventional models.

The framework also explains why bond yields on the safest countries can fall even as default risk rises. This has happened in Germany as yields and credit default swap spreads moved in opposite directions. Even though default risk is increasing, bonds are more attractive relative to equities as disaster risk rises.

Finally, the framework highlights how growing default risk makes bonds more closely correlated with equities. Analysis of peripheral European equity markets suggest there is a link between the probability of default and the bond-equity correlation, as predicted by the model. Correlation shifts have taken place in Greece, Spain, Italy as well as France over the past three years at default probabilities of around 3% per annum. This corresponds to five year credit default swap spreads of around 200 basis points. There appears to be something significant about this level. Germany is below it at present but is edging closer.

The article focuses almost exclusively on bond markets. It should aid understanding of what has been driving bond yields down, what might keep them low in the future, and what to look for to spot them becoming riskier. The impact of disaster risk on equities via the equity risk premium is noted (increased disaster risk raises the premium), as are the implications of the analysis for correlations between bonds and equities. Other than these small points though, we do not touch on equities.

Historic disasters and asset returns

Economists' interest in disasters is fairly recent. It began in the past decade as they wrestled with the equity risk premium puzzle (ERP). This puzzle is the relatively high return on equities compared to government bonds during the 20th century. As one finance academic and market practitioner notes, "A huge academic literature has tried to reconcile this puzzle … but there is little consensus to date."[1]

The equity risk premium puzzle in fact has two parts. It is not just about the level of equity returns; it is also a puzzle as to why the level of interest rates on 'safe' government assets has historically been so low compared to what economists' models suggest. Any answer to the puzzle must address both parts.

An early attempt to use the incidence of rare disasters in economics was in a 1988 paper by Thomas Rietz.[2] He introduced a low but meaningful probability of market crashes to a standard model for pricing assets. The types of disasters that Reitz considered were big contractions like the Great Depression.

This line of research was revived in recent years with the works of Xavier Gabaix, Jose Ursúa and, especially, Robert Barro[3]. In his first paper published on the topic in 2006, Barro thought of disasters as events in which GDP shrinks by 15% or more. Using this definition, he identified 33 disastrous episodes among OECD countries in the 20th century. All of these events took place between 1913 and 1947.

Most of asset pricing theory in economics relates to consumption rather than GDP. So in a later paper, Barro and Ursúa defined two types of disasters: consumption-disasters which are events in which consumption falls at least 10%; and GDP-disasters in which GDP per capita falls by 10% or more. The two types of disasters are, of course, related and are in fact highly correlated.

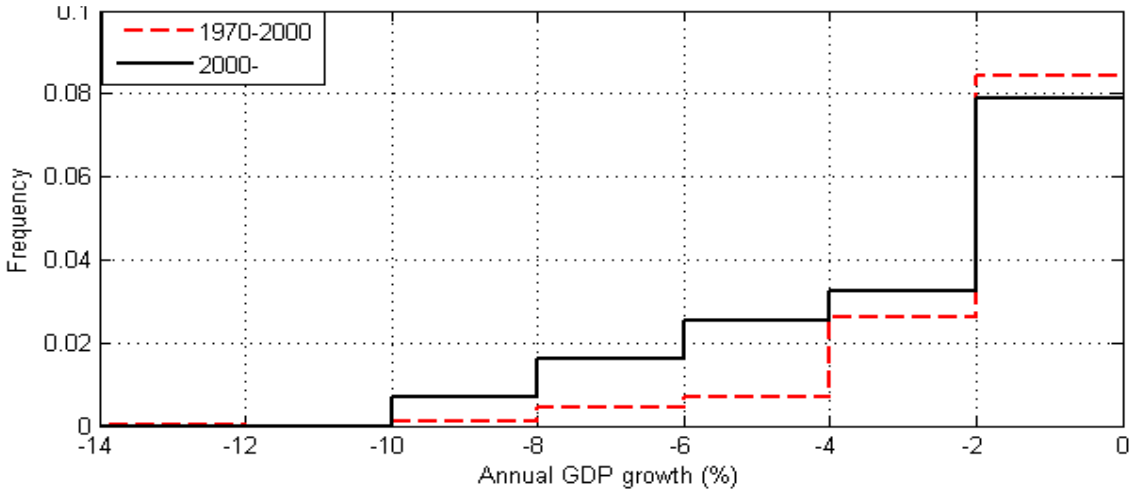
21st century disasters

There were 58 disasters in OECD countries in the 20th century on Barro and Ursúa definition of a decline in economic activity of 10% or more. Many of these were familiar events such as the Great Depression, World War II or the Spanish civil war, and were concentrated overwhelmingly in the first half of the century. Only two of the 58, just 3½% of the total number, fell during 1950-2000 (these were in Finland and Iceland).

There is no formal and agreed definition of a disaster. One can change definition and alter the precise arithmetic and numbers of disasters—for example, by focusing on declines in consumption rather than GDP, or using larger changes in activity as the cut-off. The exact measure used is less important than the idea that disasters are sharp and abnormally large declines in economic activity. Regardless of definition, a key point remains—there was a steep decline in the incidence of disasters in industrialised economies in the second half of the last century.

[1] Ilmanen, A. (2011) Expected returns. Wiley: United Kingdom.
[2] Rietz, T. (1988) *The Equity Premium Puzzle: A Solution.* Journal of Monetary Economics, 22, p. 117-131.
[3] See for example Barro, R. (2006) *Rare Disasters and Asset Markets in the Twentieth Century.* Quarterly Journal of Economics, 121, p. 1481-1509; Barro, R. and Ursúa, J. (2008) *Macroeconomic Crises Since 1870.* Brookings Papers on Economic Activity, 2008: p. 255-335; and Gabaix, X. (2012) *Variable Rare Disasters: An Exactly Solved Framework for Ten Puzzles in Macro-Finance.* Quarterly Journal of Economics, 127, p. 645-700.

Chart 1: The left tail of GDP growth density in OECD countries has shifted in recent years



Faced with such a decline, it is natural that estimates of the probability of disasters should fall during the late 20th century. Indeed, the idea that the risk of occasional economic disasters might resolve some asset price puzzles was initially ignored by economists because 'disasters' seemed too rare. This changed after Barro took a closer look at the data in 2006. It might change further as the financial crisis drags on.

Chart 1 shows the left tail of the distribution of annual GDP growth rates for OECD countries for the period 1970-2000 and since. There has been a clear shift in the distribution—the left tail is noticeably 'fatter' because of big declines in GDP in many countries in recent years.

The experiences of a few countries are highlighted in Table 2. This shows figures for GDP growth for a number of countries which have faced severe economic problems. Using quarterly data, Iceland and Ireland have both suffered peak-to-trough declines in GDP of at least 10%, and Greece is likely to join this group once the second quarter GDP figures are published. Italy, Spain and Portugal have suffered smaller, but still substantial falls and activity is declining in all three countries, perhaps continuing into 2013. Falls in output on the scale experienced by these countries feel and are disastrous. Their impact on equity markets, too, is disastrous. Relative to the end of 2007, markets in Spain, Italy and Europe as a whole are down 45%, 45% and 40%, respectively. The Greek equity market is down 90%.

Commentaries about the potential consequences of a Greek exit from the Eurozone, a collapse in the Spanish banking system or a wholesale break-up of the single currency are riddled with near-apocalyptic scenarios. Analysts and economists try to predict both whether these events will take place and what they would mean but few are comfortable making precise forecasts. However, it is clear that such extreme events could have disastrous consequences for financial markets and economies.

One set of precise forecasts was produced by ING and reported in Der Spiegel.[4] ING economists forecast that every Eurozone country would suffer a GDP decline in excess of 10% within two years of a total break-up of the euro. This would represent an extreme left tail event in Chart 1. Strategists at Credit Suisse produced similar estimates and assigned the event a 10% probability, way above the historic incidence of disasters.[5]

Table 1: GDP changes in selected European countries

	GDP peak	Change in GDP		JP Morgan/OECD forecasts	
		Maximum	To date	2012	2013
Greece	2008 q2	-9.9%	-9.5%	-5.3%	-1.3%
Iceland	2007 q4	-15.0%	-6.2%	3.1%	2.7%
Ireland	2007 q4	-12.5%	-11.3%	0.1%	2.1%
Italy	2008 q1	-7.0%	-6.0%	-2.2%	-1.0%
Portugal	2007 q4	-5.2%	-5.2%	-3.2%	-0.9%
Spain	2008 q1	-4.9%	-4.3%	-1.4%	-0.8%

Source: Fulcrum Asset Management, JP Morgan, OECD

Disasters and asset prices

A primer on asset pricing

To aid our thinking about disaster risk, it is helpful to develop a small model and framework. This clarifies key issues and, though simple, provides useful insights. The box starting on page 7 gives technical details of the model. Here we concentrate on the core argument and its implications.

We start with basic ideas about asset prices. Financial assets are valued for two reasons. The first is the income they provide in the future. The higher the stream of future income of an asset, the higher its price when all else is equal.

The second reason assets are valued is insurance. Assets that provide a return when other income is low are more valuable than assets that pay the same amount when income is high. The more risk-averse people are, the more they value this insurance property of assets.

In the model, investors have a choice of investing in equities, bonds and bills. They try to maximise their income and smooth their consumption.

Introducing disasters

The model builds on the one used by Barro to explain the equity risk premium. Disasters, defined as a large contraction in income and hence consumption, can strike and cause equities to lose a fraction of their worth. The increase in disaster risk has two effects on equities. First, their expected future payoff falls. Second, as equities and consumption are more likely to experience sharp falls, their expected co-movement increases. This is doubly bad for equities as they are doing a poor job of helping investors smooth income. As a result, this leads to lower equity prices when disasters become more likely.

Disasters also threaten to hit bonds. As disasters loom, the probability of default on bonds increases. However, provided the probability of default remains low in the event of a disaster, investors will still find bonds attractive as they provide stable and largely

[4] *The Disastrous Consequences of a Euro Crash*, Spiegel Online, http://www.spiegel.de/international/europe/fears-grow-of-consequences-of-potential-euro-collapse-a-840634-2.html, 26 June 2012. The ING report this draws on is Cliffe, M., *EMU Break-up: Pay now, pay later*, ING Financial Markets Research, 1 December 2011.

[5] *Global Equity Strategy—Euro-area crisis: scenarios and solutions*, Credit Suisse, 29 May 2012.

safe returns when consumption is low. In other words, investors are willing to pay a premium to hold bonds because they still view them as safe havens despite the increase in the risk of default. It is this insurance property of bonds that make them attractive when disaster risk is high, despite the decrease in their expected future payout.

One can now see how the introduction of disasters helps resolve the ERP. The threat of disasters increases the required rate of return on equities because of the chance of a big negative shock to GDP and a corresponding decline in dividends. Moreover, although disasters increase the probability of default on bonds, the required rate of return on bonds is reduced if this increased default risk is not too large. Combining the two effects can yield the observed equity risk premium.

An important feature of this model is that the effects do not require any increase in risk aversion. It is risk itself, rather than risk aversion, which changes as the likelihood of disasters increases. Investors are responding rationally to this risk. Therefore, unwinding these effects requires more than a change of attitudes among investors; it requires a change in data and perceptions of risk.

Bond-equity correlation

This argument to resolve the ERP allows bonds to become riskier in the event of a disaster. Bonds become more risky, but their relative riskiness compared to equities declines.

However, once we allow for the possibility of default in this framework then the behaviour of bonds spans a whole spectrum. At one end of this spectrum, the probability of default is low and bonds behave like a safe haven or risk-free asset as in standard asset pricing models. In this case, the rational flight to safety increases the price of bonds and lowers yields. At the other extreme, the probability of default is high, and bonds become as risky as equities in a disaster-struck world. As with equities, investors will then demand a high rate of return on risky bonds if they fear disasters because the assets will no longer offer protection against a fall in investors' income. Bonds must fall and yields increase to provide this return.

Somewhere between these two extremes, there is a change in default probability where bonds switch from being a highly valued safe haven in a world threatened by disaster to equity-like risky assets that require a high rate of return for investors to hold them.

This suggests that the correlation between bonds and equities will be linked to default probabilities and disaster risk in the following sense. Suppose there is a period in which disaster risk is increasing and default probability is also rising. If the increase in the latter is large enough, this will push equities and bonds down together, implying a positive bond-equity correlation. Suppose that once this period is over, default probability stabilises but the risk of disaster continues to increase, then this will push equities down but bonds up, implying a negative correlation between equities and bonds in the subsequent period.

To summarise: in an environment with increasing risk of disaster, a rise in default probability above a certain amount would create a negative correlation between equity and bonds returns. Once that threshold is crossed, the correlation switches from negative to positive. Whether this switch is temporary or permanent depends on what happens to

default probability thereafter. If it is falling or stable while disaster risk is increasing, then correlation is likely to switch back to negative. If, on the other hand, default probability is increasing, then the correlation should remain positive.

In reality, we do not expect the two probabilities to be completely independent. More often than not, a rise in disaster risk tends to be associated with an increase in default probability. We therefore expect that, once it begins, a positive bond-equity correlation is likely to persist, unless the threat of disaster recedes.

Resolving the default swap spread puzzle

While disasters were initially introduced by economists as a solution to the ERP, the approach also sheds light on many other asset pricing puzzles. In a recently published paper, Gabaix shows that this framework can solve ten puzzles in macro-finance including the ERP.[6] Our analysis about the relationship between default risk and bond-equity correlation suggests the framework might resolve another puzzle concerning credit default swap spreads.

Default risk can be measured by CDS spreads. Higher CDS spreads imply greater risk of default over the maturity of the CDS contract. An implied probability of default can be extracted from CDS spreads by assuming a particular recovery rate for investors in the event of a government default; this is standard practice in analysis of CDS prices. Default risk is also priced into bonds with, other things equal, increased default risk raising bond yields.

The puzzle is why we sometimes observe a rising CDS spread on a bond and a simultaneous fall in the bond yield.

The disaster framework explains this puzzle—a rising default risk (and CDS spread) with falling bond yields is one of its key features. It is exactly the process we described for bonds which are considered largely safe despite the increase in their default risk. That relative safety pushes yields down even though bonds' absolute riskiness has increased.

A summary of the empirical implications

The disaster framework is straightforward and intuitive. While it does not provide point estimates or forecasts of prices or returns, it has clear implications that can be tested and used to shed light on apparent puzzles. The key implications are as follows:

1. Bonds that have low probability of default have unusually low yields when disasters become more probable.
2. Low-risk bonds can have falling yields and rising CDS spreads.
3. As disaster risk increases, there is some size of change in default risk or CDS spread below which bonds behave like a safe haven and have returns negatively correlated with equities. Above that level, bonds become a risky asset and the correlation with equities switches to positive.
4. As the disaster risk continues to increase, the positivity of bond-equity correlation will persist if the implied default probability continues to worsen. If the latter stabilises or falls, then correlation can become negative again.
5. Equity risk premia increase in a world with higher perceived risk of disasters.

[6] Gabaix (2012) op cit.

As noted earlier, the implications for equity markets are beyond the scope of this paper. We now consider evidence for the first four implications.

An asset pricing model with disaster risk

In this box, we illustrate the rare-disaster asset pricing framework and how it helps solving the equity premium puzzle and sheds light on the behaviour of bonds when disasters become more likely. We do this through a simple two-period, three-state version of the model.

The central pricing equation is $p_t = E_t[m_{t+1}x_{t+1}]$

This says the price of any asset is equal to its expected future payoff, x_{t+1}. The payoff is discounted by a factor, m_{t+1}, which depends on how individuals value consumption in different states of the world and on their risk aversion. For the purpose of this illustration, the only thing we need to know about the discount factor is that it is negatively related to consumption growth, so that assets that pay in low consumption states are highly valued, and that it is positively correlated with risk aversion.

We consider two alternative scenarios in each of which there are different possibilities. In one scenario disasters do not happen and the 'good' and 'bad' states of the world are equally likely. In the second scenario disasters are possible and happen 10% of the time. Table 3 gives the payoffs to assets in different states of the world under each scenario as well as the probability of each state. As a general remark on notation, upper case letters have higher values than their lower case versions (so, for example, M>m); and larger subscript values indicate larger numbers (eg, M_2>M_1).

Table 2: Elements of the disaster model

	Alternative scenarios		Description of state	Consumption growth	Discount factor	Payoff		
	No disasters	Disasters possible				Equity	Bills	Risky bond
Three possible states of the world	50%	50%	Good	+	m	E	F	F
	50%	40%	Bad	-	M_1	e_2	F	F
	—	10%	Disaster	--	M_2	e_1	F	$(1-q)F+qb$

q is the probability of default and b is assumed to be less than F

Asset pricing when there is no disaster risk: The equity premium puzzle

Consider the case when disasters are not permissible within the model. Using the main pricing equation, the prices of equity and bonds in this case are:

$$\text{Price of equity when there is no disaster risk} = 0.5\,mE + 0.5\,M_1 e_2$$

$$\text{Price of bond when there is no disaster risk} = 0.5\,mF + 0.5\,M_1 F$$

And the difference between the two prices is:

$$\text{Equity minus bond prices when there is no disaster risk} = 0.5\,m(E-F) + 0.5\,M_1(e_2 - F)$$

The equity premium puzzle (ERP) says that in order to explain the observed difference in returns between bonds and equity, M_1 needs to be much larger than m. This can only happen by imposing an extreme level of risk aversion, so extreme that it is considered unreasonable by economists.

Equity behaviour in disasters: Resolution of the ERP

Allowing for disasters in the model simply means that the distribution of consumption growth has fat tails, and extremely bad events can happen with non-negligible probabilities. In this setting, and given the probabilities we assumed in the Box Table, the equity price is:

$$\text{Price of equity when disaster is possible} = 0.5\,mE + 0.4\,M_1 e_2 + 0.1\,M_2\,e_1$$

Equity price is lower in disasters because its payoff is hit hardest in this state, which is exactly the time when payoffs are most valuable. The difference between equity and safe bond prices now is:

$$\text{Equity minus bills prices when disaster is possible} = 0.5\,m(E-F) + 0.4\,M_1(e_2 - F) + 0.1\,M_2(e_2 - F)$$

It is easy to see how introducing disasters resolves the ERP: The possibility of disasters allows for the introduction of states where consumption is very low, and therefore payoffs in these states are extremely valuable. In the event of disasters, equities are hit hard while bonds become a highly valued safe haven. This in turn results in an increase in the required rate of return of equities relative to bonds, resolving the ERP without increasing risk aversion levels. It is important to note that risk aversion (ie the value of M_1 relative to m) needs not be extreme; the introduction of disaster possibility allows for the high valuation of bonds relative to equities for moderate levels of risk aversion.

Risky bond behaviour

The analysis above assumes that disasters affect only equities through a negative jump in their dividends stream. One can argue that disasters also affect bonds by increasing the likelihood of default. We therefore have two types of bonds: bills which are 100% safe; and risky bonds which can default with probability q in the state of disaster, but are otherwise safe. How do the prices of these two assets change relative to their no-disaster prices?

First, it is clear that the price of bills should be higher when disasters are possible than when they are not, for the simple reason that they provide insurance and safe payoff in a bad state of the world when consumption is low and payoff is highly valued.

For risky bonds, recall that their price in a no-disaster world is:

$$\text{Price of bond when disaster is impossible} = 0.5\,mF + 0.5\,M_1 F$$

Suppose now that if there is a default on risky bonds (which happens with probability q), then they pay an amount b, which is lower than the amount initially promised, F. Given these assumptions and the central pricing equation, we get:

$$\text{Price of bond when disaster is possible} = 0.5\,mF + 0.5\,M_1 F + 0.1\,M_2[(1-q)F + qb]$$

In order to understand how the price of risky bonds changes when we enter into a world where disasters are possible compared to a safe world, let us consider two extreme examples.

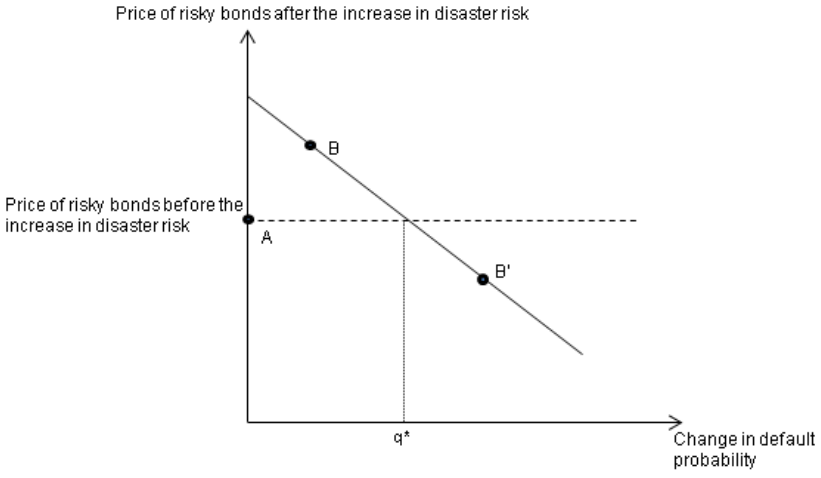
When $q = 0$, the difference between post and pre-disaster prices is $0.1\,M_2\,F$, which is positive. In other words, because risky bonds behave like safe bills, they become more valuable in a world threatened by disaster and low consumption than in a safer world with no disasters.

At the other extreme, when $q = 1$, the difference between post and pre-disaster prices is $0.1\,M_2\,(b - F)$, which is negative since b is assumed to be smaller than F. In this extreme case, risky bonds are as risky as equities in the event of disaster because they lose part of their value with certainty. Like equities, their price should be lower in a world when disasters are possible.

So at one extreme, risky bonds behave like safe bills and their value is higher in a disaster-threatened world. At the other extreme, risky bonds are as risky as equities and their price should be lower than their price in a world where disasters are impossible. Moreover, the pricing equation tells us that between the two extremes, the price falls in a straight line crossing the no-disaster price somewhere in the middle.

If the change in the probability of default is low, then risky bonds will still be considered as safe haven by investors and their price should increase as disasters become more likely. This is illustrated by a move from point A to point B in the Box Chart below. At one point when the change in default probability is large enough, risky bonds lose their safe haven status and investors view them as risky entities whose price must fall as disasters become more eminent. In the chart below, this is represented by a move from point A to point B'. Furthermore, there is a change in default probability which leaves bond price unchanged as disaster risk increases. This is represented by point q*. It is worth noting that q* is independent of the change in disaster probability.

Box Chart 1: The change in the price of risky bonds as disasters become more probable



Bond yields, default spreads and correlations

Low bond yields

As we explained at the outset of this report, a key motivation of this work is to explain lower yields in 'core' government markets through an increased incidence and risk of economic disasters. That bonds are overvalued has become a common refrain. For example, economics Nobel Prize winner and New York Times columnist, Paul Krugman, wrote recently that "I constantly encounter people claiming that high bond prices and hence low interest rates are just a bubble."[7]

A standard approach to valuing bonds would look at real yields, the level of short-term interest rates, some measure of risk and, perhaps, government deficits or debt levels. Models based on these frameworks are invariably estimated using data over the past few decades, and typically indicate that yields are too low in core government bond markets.

These models do not explicitly take into account disaster risk. Instead, an historic estimate of this risk is implicitly embedded in the way equilibrium or 'fair value' bond yields are linked to variables such as inflation, budget deficits or debt levels. As a consequence, changes to disaster risk are not captured. If this risk increases and bond yields fall as in our model, standard frameworks would show yields below 'fair value'. Moreover, unless there was an explicit attempt to adapt the framework and take this greater risk into account fair value would remain above the true equilibrium level.

A simpler approach to assessing bonds is just to look at the level of real yields. On any measure, real yields have fallen substantially and are currently negative across the yield curve for core bond markets such as the US and Germany. In a world in which there is a significant possibility of disaster, real yields do not need to be positive. Investors might rationally choose to invest in bonds despite negative real yields because of a fear of the potential losses on other investments such as equities. The same reasoning can help explain and justify negative nominal bond yields in a growing number of markets.

This is more than an argument about bonds providing a temporary 'safe haven'. It suggests a potentially long period in which yields could remain abnormally low. During this period they would offer little apparent benefit but provide substantial protection against the risk of large losses in states of the world where equities do very poorly.[8]

Another standard framework for considering bond yields is the 'expectations hypothesis' which explains them in terms of future short-term interest rates and some 'term premium'. The term premium is the difference between the level of bond yields and the path of short-term rates expected over the life of the bond. It provides an estimate of the additional return an investor receives in return for the risk on the bond. Usually, this premium is positive.

[7] Krugman, P., Interest Rates: Varieties of Errors, in New York Times, www.nytimes.com, 19 June 2012.

[8] Such an argument can also explain why investors might be willing to buy government bonds even if they fear 'financial repression'. This is the use by governments of a range of explicit and implicit tools to reduce levels of indebtedness without the pain of fiscal retrenchment or default. It is a common policy when debt is high. See, for example, Reinhart, C. and Sbrancia, M. (2011) *The liquidation of government debt*, National Bureau of Economic Research working paper no. 16893. The one exception here concerns the use of inflation to reduce indebtedness.

The true level of the term premium is not observable as we cannot accurately measure expectations of interest rates over long time horizons. There are, though, many ways of estimating the premium and there is a general consensus it has declined markedly in recent years and is abnormally low and even negative for many maturities.

All these traditional ways of assessing yields—whether model-based, historic real yield comparisons, or expectations of future short rates—can give misleading signals if disaster risk has increased. At the very least, traditional methods should be complemented by approaches that try to understand disaster risk. The accompanying box makes a stab at quantifying the impact of higher disaster risk on bond yields.

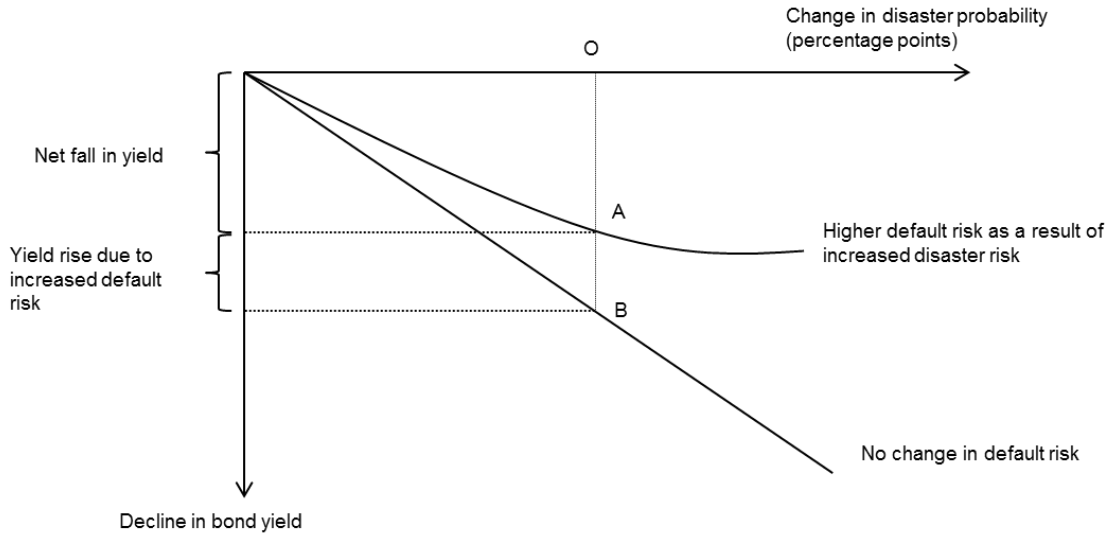
Quantifying the impact of disaster risk

A detailed attempt to quantify the impact of disaster risk is beyond our scope here. However, simple calculations can illustrate its potential impact.

A starting point for calculations is the formula for pricing bonds in the research papers from Barro.[9] This depends on a number of factors including the risk aversion of investors, the losses to equities in the event of a disaster as well as the probability of disaster and the probability of government default in that event.

Making sensible assumptions about some of these variables, the formula can be calibrated for different levels of disaster and default risk. The chart below shows the different effects. The straight line through the origin shows the link between increased disaster risk and falling bond yields assuming no increase in default probability. A rise in the latter in some proportion to the increase in disaster risk drags this line down progressively as the latter rises. The higher default probability therefore tempers the fall in yields because it reduces returns to investors in the event of a disaster, making bonds somewhat less attractive. The overall fall in yields as a result of the greater disaster risk represented by point O is less by an amount equal to the vertical distance AB.

Box Chart 2: The change in bond yields as disaster risk increases



[9] Barro (2006) op cit, and Barro, R. and T. Jin (2011) *On the size distribution of macroeconomic disasters*, Econometrica, 79, p. 1567-1589.

We focus on ten year German bond yields and start with the estimate of historic disaster risk from Barro of 3.8% and a level of default probability of just 2% (over ten years). If we assume that disaster risk increases by, say, one third to around 5% and default probability increases to 10%, the level of yields falls by almost 80bp.

An alternative calculation is to assume that before the financial crisis, disaster risk was perceived to have been lower than the long-run historical average because of both the fall in the number of disasters in the second half of the 20th century and the 'Great Moderation' from the late 1980s during which output volatility declined. We assume disaster risk was believed to be 2% rather than 3.8%, though clearly other numbers are possible. Suppose that since the onset of the 'Great Recession' in 2008, investors have revised their estimate of disaster risk back up to, say, 2.8% (which is still lower than the long-run historical frequency). This would reduce bond yields by around 70bps.

One can think of these magnitudes as changes in 'fair value' for bonds as a result of higher disaster risk, and compare them with a standard bond valuation framework. The SUDOKU framework used by Goldman Sachs is one such framework.[10] According to this, ten year German bond yields are currently 50bp below equilibrium.[11] Greater disaster risk can comfortably account for this. US ten year yields are 100bp below fair value in the SUDOKU framework. This discrepancy can easily be explained by a rise of just 20% in disaster risk from its historical mean (with a rise in default risk from 2% to 5%).

Therefore, bond yields do not appear too low if one assumes even moderately greater disaster risk—modest increases in risk can explain the levels of core government bond yields relative to standard valuation frameworks.

These calculations show the importance of disaster risk to the level of yields. In turn, this poses a question. If the decline in bond yields in core markets such as the Germany and the US can be explained by a modest rise in disaster risk, what role is there for other factors such as QE to influence yields? It is commonly held that the Federal Reserve's policy of QE has pushed down yields, with typical estimates in the range 40-100bp.[12] Calibrating models suggests disaster risk can explain the decline in yields without any role for QE.

It would be unwise to read anything definitive into the calculations here. They are illustrative only, as an attempt to gauge the possible magnitude of the effect of disaster risk. The key conclusion is that such risk can have a big influence and might have pushed yields below standard measures of value. In turn, if higher disaster risk persists or increases, one should expect yields to remain low or even fall further.

[10] Garzarelli, F., Verstyuk, S., and M. Vaknin (2006) *The Bond Yield Sudoku*, in *The Foreign Exchange Market*, Goldman Sachs Economic Research.
[11] Garzarelli, F., Ardagna, S., Burgi, C., and G. Cole, *Euro area: Policy Choices and Market Impacts*, Fixed Income Monthly, June 2012, Goldman Sachs Global ECS Research.
[12] See, for example, Williams, J., *Unconventional Monetary Policy: Lessons from the Past Three Years*, Federal Reserve Bank of San Francisco Economic Letter, 3 October 2011.

Default risk and bond yields

Germany has seen several episodes recently in which default risk has increased as yields have declined. Chart 2 shows five year German government bond yields and CDS spreads. The abrupt decline in yields during late 2008 following the bankruptcy of Lehman Brothers was accompanied by rising risk of default. Last summer as the Eurozone crisis developed, there was an increase in default risk as yields were falling. Finally, continued tensions in Europe this year have pushed yields to record lows as CDS spreads widened.

Ordinarily, one would expect increased credit risk to result in higher rather than lower yields; indeed, this is the textbook case. As was discussed earlier though, our framework explains why the two can move in opposite directions.

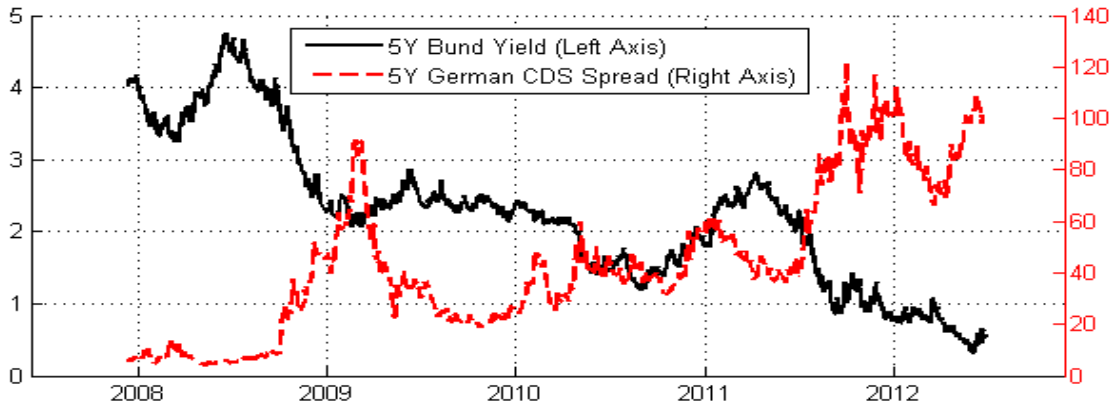
This is not widely appreciated and some investors think it wrong for yields to fall as risk increases. One hedge fund manager was quoted recently as saying "Bunds are attractive to short because they are at historic lows in spite of the fact that the German fiscal position can only deteriorate."[13] Germany's fiscal position and its credit risk are correlated. But credit risk rising and yields falling can be a sensible response to changes in the state of the world and the perceived riskiness of bunds versus other assets. Moreover, this trend could continue. However, it does appear that there is a limit to this process.

Bond-equity correlations

The correlation between bond and equity markets changes over time and, when this happens, the risks of a given portfolio of assets shift. Our framework can help understand causes of changes in correlations.

The degree to which government bonds protect investors in the event of a disaster is the key to their value in our model. Bonds are not entirely safe because of the chance of default. As long as this chance is small, the expected pay-out from bonds in the event of a disaster makes them different to equities and a valuable hedge. But as the risk of default grows, bonds become a less effective hedge against disaster risk and, as a result, less distinct from equities. As we discussed earlier, this can mean the correlation with equities should switch to positive as default risk rises.

Chart 2: Negative correlation between five year German bond yields and CDS spreads

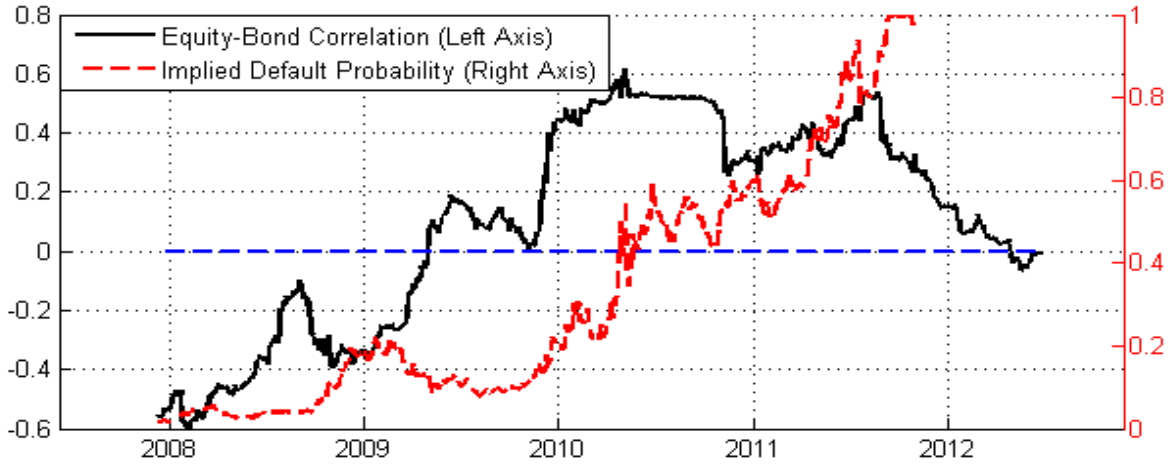


[13] Hedge funds bet on big bunds sell-off, Financial Times, www.ft.com, 19 June 2012.

It is worth asking two questions: first, how high must default risk be for investors to start perceiving sovereign bonds as risky assets causing their correlation with equities to switch from negative to positive? And second, is the switch of bond-equity correlation permanent or temporary?

Charts 3-6 show the implied default probabilities for each of Greece, Spain, Italy and France against the bond correlations with their respective equity markets. The default probabilities are derived from CDS spreads and the correlations are calculated over six-monthly data of daily returns.[14]

Chart 3: Correlation between Greek bonds and equities switched to positive in 2009



[14] We use a standard formula to transform CDS spreads into implied probability of default. Under usual assumption about the recovery rate, which we assume to be 40% for all countries, the probability of default over the life of the contract is an increasing function of CDS spread. Note that the formula would give meaningless probabilities for Greece, which has already defaulted. We therefore cap all implied probabilities at 100%.

Chart 4: Correlation between Spanish bonds and equities switched to positive in 2010 when annual default probability crossed 3%

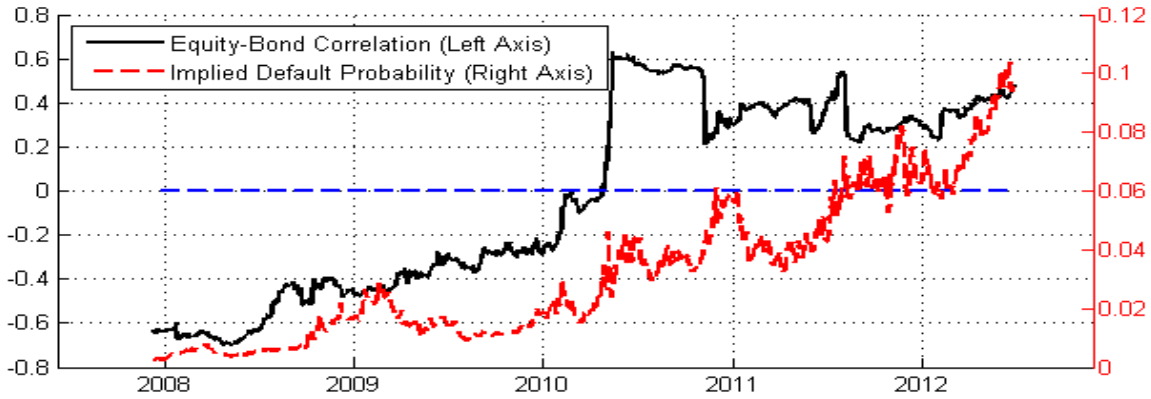
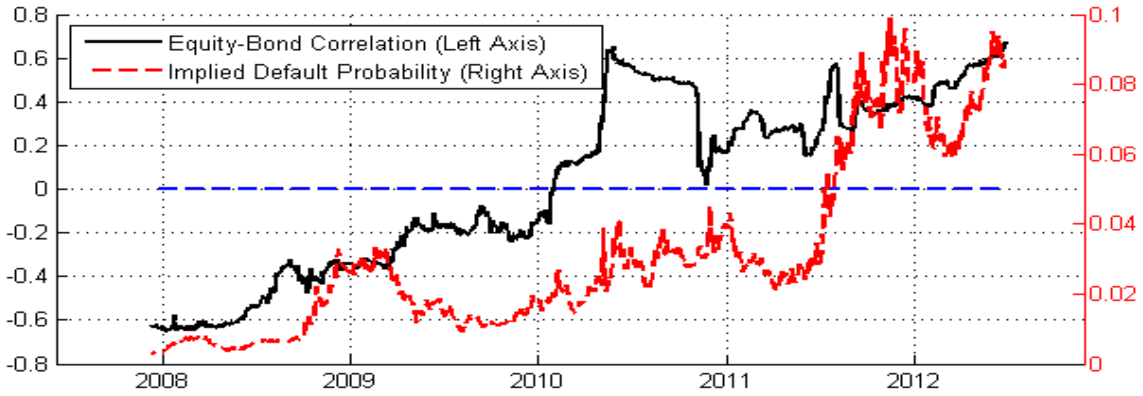


Chart 5: Correlation between Italian bonds and equities switched to positive in 2010 when annual default probability crossed 3%



For each of Greece, Spain and Italy there is a clear upward shift in the correlation as the default probability rises beyond a certain level. The correlation turns from negative to positive as the annual probability rises above around 15% over five years, which corresponds to 3% per annum. To show the patterns more clearly, the former number is used for Greece and the latter for Spain and Italy (as well as for France in Chart 6). Moreover, as default risk continued to increase beyond that point, correlation has never turned negative for these three countries. Bonds have become more like equities. This fits with our model.

The story is similar for France—the correlation broke into the positive territory as the implied annual probability of default was hovering around the 3% mark. However, since then, default probability has not worsened and correlation has started to head back south. Indeed, if one measures correlations over shorter periods than the six months used in the charts, there are signs that it has become negative again.

The timings of the changes in correlations are worth noting. In Greece, the correlation break pre-dated the first bailout package by almost a year.

Chart 6: Correlation between French bonds and equities switched to positive in 2012 as default probability rose.

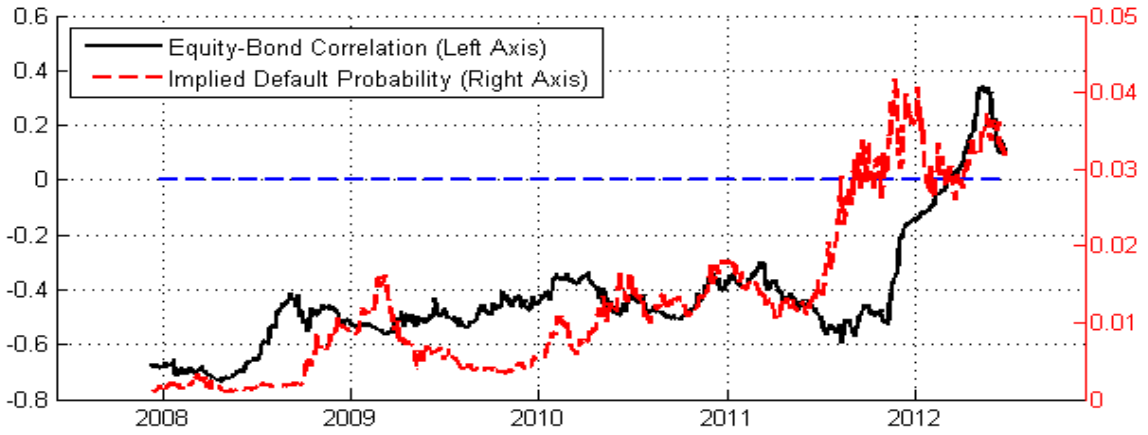
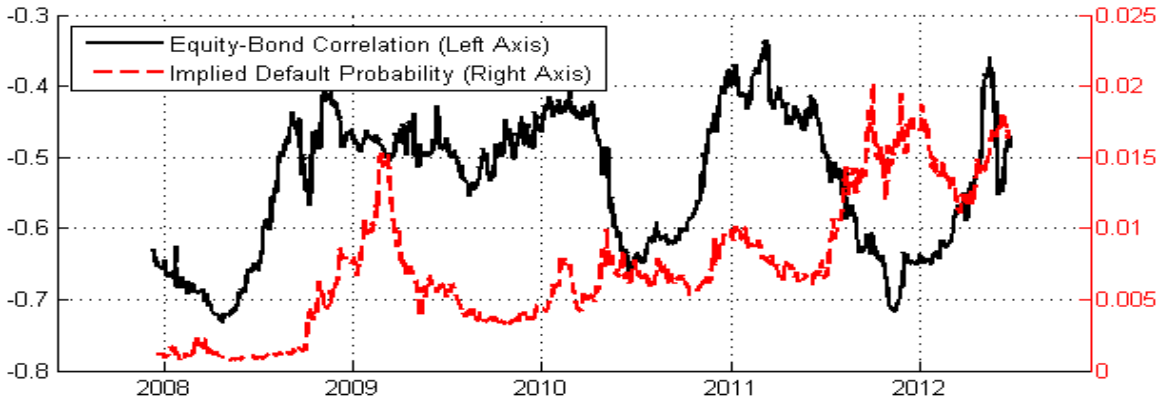


Chart 7: German five year default probability is low and correlation between German bonds and equities is still negative



Spanish and Italian government bonds became positively correlated with their respective equity markets around the time of the first Greek bailout in 2010. From this point on they were regarded as having high default risk and more like equities than genuine safe assets. French bonds became positively correlated with equities late last year as the default probability jumped in the wake of anxieties about the Eurozone during the summer.

It is striking that all correlation shifts have taken place at a default probability of approximately 3%, which corresponds to around 200 basis points for a five year CDS. This is true for four countries and on three separate occasions over three years. There appears to be something significant about this level. Consistent with our theory, as markets' perception of the credit worthiness of Greece, Spain and Italy continued to worsen, their bond-equity correlations remained positive.

The story is less clear-cut for France, partly because it breached the five year 15% mark recently and it is not yet apparent whether

default probability is going to remain stable around this level or increase beyond it. Debt dynamics of higher interest rates and fiscal sustainability are catalysts for the continual deterioration in the sovereign credit worthiness, and in the absence of major worries about France's debt, the implied default probability of France might stabilise. That said, the experience of Greece, Italy and Spain suggests that once market confidence is lost, it can cause default probability to spiral upwards.

Chart 7 shows the same data for Germany. There has been no clear shift in correlations in Germany because the default probability is still below the threshold. This helps explain the fall in German bond yields alongside the higher default probability. If the latter had increased beyond the 3% threshold level, bonds and equities would become positively correlated and bond yields would move positively with default risk. (We do not show data for the US where the probability of default remains low and, as a result, has no clear link with the bond-equity correlation.)

A shift could take place in Germany if there were significant steps towards debt mutualisation in the Eurozone with Germany helping to support and underwrite the debt of other countries. German bonds would then no longer be a 'safe' asset and they would become more like equities. One would expect US Treasuries to remain the safe asset in this case. However, at this point also, fears of economic disaster may decline because of changes towards greater fiscal union within the Eurozone. Our model would suggest that yields on the safe asset also rise as disaster risk recedes. Therefore, US Treasury yields should rise with those on German bonds.

The dynamics of Germany also confirm that it is both the level and change of default risk which matters for correlations. There was a marked increase in default risk in late 2008, but correlations remained negative during that time and bond yields fell.

The broad pattern of results confirms our model, but there is clearly more to learn and understand about the interactions between changes in default risk and correlations and why a five year default probability of 15% plays such an important role in influencing relationships.

Conclusion

This article has outlined a simple framework for bond yields which abstracts from a host of factors such as quantitative easing, a possible shortage of safe assets, household deleveraging and increased risk aversion, each of which might be pushing yields down. The insight from our model is that a simple framework in which there is a greater chance of extreme economic events can help explain abnormally low bond yields, rising credit risk alongside falling yields, and changing correlations between bonds and equities as the latter become more 'equity like'.

Financial markets in the major advanced economies enjoyed a period of unusually low disaster risk during the second half of the 20th century. This has changed in the first part of this century during which several countries have suffered large hits to GDP and teetered close to formal 'disasters'. Continued problems within the Eurozone together with high levels of government indebtedness suggest the risk of extreme economic outturns will remain high. If so, disaster risk will continue to influence

bonds and the analysis here provides a useful framework to think through the consequences.

Further work

There are a few missing pieces or extensions to our framework. As already noted, we have not considered the impact on equities beyond noting that the equity risk premium should rise with disasters. Moving beyond this to a statement about equity markets requires us to take a view on long-term growth prospects. We hope to return to this at a later date.

Second, it would be useful to know more about the size of change in disaster risk and its impact on bond yields. Future work might build on the calibrations presented in the box above to produce more comprehensive estimates of the impact of disaster risk.

Finally, we have not considered inflation risk. An alternative to a disastrous shock to economic activity is a jump in inflation. An unanticipated jump in inflation would hit the economy by reducing real incomes and lowering the return on equities. It would also reduce the real value of government bonds. In this sense it would be equivalent to a partial default on government bonds. It is a sufficiently detailed subject that it warrants a separate assessment beyond the scope of the present report.

Martin Brookes & Ziad Daoud

martin.brookes@fulcrumasset.com
ziad.daoud@fulcrumasset.com

Telephone	E-mail
+44 (0) 20 7016 6450	info@fulcrumasset.com

material is subject to change and, although based upon information which we consider reliable, it is not guaranteed as to accuracy or completeness and it should not be relied upon as such. The material is not intended to be used as a general guide to investing, or as a source of any specific investment recommendations, and makes no implied or express recommendations concerning the manner in which any client's account should or would be handled, as appropriate investment strategies depend upon client's investment objectives.

Funds managed by Fulcrum Asset Management LLP are in general managed using quantitative models though, where this is the case, Fulcrum Asset Management LLP can and do make discretionary decisions on a frequent basis and reserves the right to do so at any point.

Past performance is not a guide to future performance. Future returns are not guaranteed and a loss of principal may occur.

Fulcrum Asset Management LLP is authorised and regulated by the Financial Services Authority of the United Kingdom (No: 230683) and incorporated as a Limited Liability Partnership in England and Wales (No: OC306401) with its registered office at 6 Chesterfield Gardens, London, W1J 5BQ. Fulcrum Asset Management LP is a wholly owned subsidiary of Fulcrum Asset Management LLP incorporated in the State of Delaware, operating from 767 Third Avenue, 39th Floor, New York, NY 10017.