Securitisation of Non-Life Insurance Working Party

GIRO 2008

Graham Fulcher (Chair)
Mohamed Afify, Cormac Bradley, Jean Bernard Crozet
David Davies, Will Forster, Susanne Frisby, Paul Fulcher, Visesh Gosrani
Shalin Haria, Cameron Heath, Gillian James, Tim James, Henry Johnson
Mohammad Khan, Angela Koller, Jun Lin, Alex Marcuson, John McCrossan
Melodie Pollet-Villard, Esmee Robinson, Emiliano Ruffini, Thomas Wallace

Zero Beta Assumption Sub-Group

Thomas Wallace

1. INTRODUCTION

This paper is one of a series produced by the GIRO 2008 Securitisation of Non-Life Insurance Working Party.

This particular paper explores the zero beta assumption often cited in relation to non-life insurance securitisations. The paper is in three main sections.

In the first section we give a description of the zero beta assumption and explain its relevance to securitisation.

The second section sets out our analysis of market and catastrophe data. We compare estimated losses arising from US windstorms with data showing the performance of various financial markets during the same periods. Our statistical findings are accompanied by a detailed commentary on the results.

The final section outlines the analysis and conclusions from a number of other papers that are relevant to this topic.

This paper is one of a series of stand-alone but complementary papers produced by the GIRO 2008 Securitisation of Non-Life Insurance Working Party.

The other papers cover:

- a **History of Securitisation** to date including a review of predictions made in prior GIRO papers.
- a review of the important topic of **Basis Risk** within non-life insurance linked securitisations including an example spreadsheet,
- a review of the **Lessons from Sub-Prime** and wider credit crunch for non-life insurance linked securitisation and more widely for non-life insurers,
- a review of **Regulatory Regimes** (particularly capital regime) treatment of non-life insurance linked securitisation,
- a review of the securitisation possibilities for **Other Non-Life Risks and Assets** other than purely catastrophe bonds.

2. OVERVIEW OF THE ZERO BETA ASSUMPTION

2.1. Calculating beta

The beta of an asset helps describe how the return on the asset is related to the return on a portfolio. For a given asset a that is part of a portfolio p the beta is given by

$$\beta_a = \frac{Cov(r_a, r_p)}{Var(r_p)}$$

where

r_a is the return on the asset, and

r_p is the return on the portfolio.

A positive beta indicates that the return on the asset is generally expected to follow the return on the portfolio, whilst a negative beta suggests that the return will run contrary to the portfolio. The size of the beta value indicates the strength of this link.

Where the portfolio p is the market portfolio m, the beta of the asset indicates how it is expected to behave in relation to the market.

2.2. Portfolio construction

Modern Portfolio Theory highlights the importance of an asset's beta in portfolio construction. Rational investors are expected to seek the highest expected return for a given level of risk, or the lowest level of risk for a given expected return. If we consider the return on an asset to be a random variable, then we can measure risk as the variance or standard deviation of the return.

Through diversification, combinations of assets can give the same return as an individual asset with a lower level of risk. Investors will therefore seek the combinations of assets (or portfolios) that enhance return and reduce risk. Assets that are uncorrelated with the existing portfolio will provide the greatest diversification benefit and the greatest reduction in risk, whilst potentially maintaining the overall expected return.

As the beta of an asset is a measure of the correlation of its return with that of the portfolio, assets with a low beta value are desirable when constructing a portfolio. As we discuss in the following section, non-life insurance linked securities are generally assumed to have a beta value of zero, making them attractive to investors in the capital markets.

Furthermore, some studies suggest that correlations between returns on assets increase in periods of market stress. If the beta values of insurance linked securities remain low or even decrease in such periods, the benefit of including them in a portfolio may be even greater.

More detailed information about beta and its application to the Capital Asset Pricing Model and Modern Portfolio Theory is widely available.

2.3. The zero beta assumption

Non-life insurance linked securities are normally assumed to have a low or zero beta value. Such a beta would indicate that returns on these securities are uncorrelated with the market.

This assumption is usually justified by the reasonable observation that financial market events cannot cause natural events such as windstorms and earthquakes. However, this does not account for the impact of catastrophes on the markets. There are a number of possible links to consider with varying financial effects:

- Demand for reconstruction following a catastrophic event increases production. This could be expected to have a positive impact on shares in the construction sector and other relevant areas.
- Direct impact of events on financial centres could have the opposite effect, limiting economic activity and damaging investor confidence.
- Consumer confidence could suffer as a result of an event affecting populated areas, with a subsequent reduction in spending and economic growth.
- Disruption of other (non-financial) commercial areas reduces output. For example, a hurricane passing through the Gulf of Mexico may hinder oil production with an associated fall in the value of energy stocks. However, the reduction in supply could increase the level of some commodity markets as oil prices rise.
- Catastrophe bond spreads could widen in response to volatility in conventional securities, resulting in mark-to-market losses for bondholders. In contrast with the other effects discussed here, this would be an example of financial markets causing mark to market losses on insurance securitisations.

These potential effects are recognised by market participants. Niklaus Hilti, a catastrophe bond specialist at Bank Leu, writes:

> *"You have to bear in mind that a correlation is normally dependent on two interrelated factors, i.e., a correlation is bi-directional. In the case of catastrophe bonds, however, the correlation is mono-directional because a negative financial market will never be able to trigger a hurricane! In exceptional circumstances, there might be an undesirable outcome to this mono-directional correlation. For example, an earthquake in Silicon Valley would impact on the NASDAQ or a strong quake in Tokyo would affect Japanese bonds. Typically, however, the opposite is the case: capital markets benefit from natural disasters in the sense that GDP rises and consumption increases."*

Liquidity and collateralisation also contribute to the level of correlation with the market. Secondary markets for non-life insurance linked securitisations are smaller and less liquid than markets for most major assets, which may isolate securitisations from other market movements. If catastrophe bonds become more widely traded and are seen as less of a niche area, correlations with other asset classes may increase. Market recognition of the change in correlation would have a significant effect on returns.

In addition, collateralisation with cash prevents the significant collapses due to gearing of market movements seen with mortgage-backed securities (albeit in exchange for an inefficient structure of holding very liquid assets in an illiquid catastrophe bond).

This paper only considers the securitisation of natural catastrophe risks. The lack of correlation between economic or world events and losses on a securitisation is not as clear for man-made disasters. This factor may have contributed to the lack of issuances of bonds covering terrorism risks.

We have also excluded ‘working layer’ cover from this paper. This would be a securitisation for which a trigger event would be expected to occur relatively frequently. Reinsurance cover of this kind is not uncommon, but expectations in financial markets dictate comparatively lower default rates than most standard (low frequency) catastrophe bonds. Products where losses are expected to occur more frequently than this will therefore be unattractive to investors.

2.4. Limitations of beta

The utility of the zero beta assumption is dependent upon the validity of the Capital Asset Pricing Model. There are a number of well documented issues with the CAPM, including:

- The model assumes that returns on assets are normally distributed.
- Variation in stock returns is not fully explained, and low beta stocks may offer higher returns than the model would predict.
- CAPM assumes that all investors have access to the same information and share a common view on the expected risk and return of assets, but attitudes towards niche assets such as insurance linked securitisations may be relatively variable.
- The market portfolio is unobservable and is usually represented by an index, meaning that the CAPM may not be empirically testable (see Roll’s Critique; Richard Roll, 1977).

Concerns over the use of the CAPM have led to development of alternative portfolio management theories. The Fama and French Three Factor Model extends the CAPM to include size and value factors. The former allows for the observation that small cap stocks tend to outperform large cap stocks. The latter models the outperformance of value stocks compared with growth stocks. This reduces the dependency on the market risk factor (beta).

2.5. Spreads on non-life insurance linked securities

Fixed income financial instruments (such as bonds) are often described by their yield, which indicates the return available on the investment. As the risk-free rate could be earned on instruments that are considered totally secure, the relevant part of the return is the spread over the risk-free rate.

The yield (and therefore the spread) is linked to the price of the instrument. A low-risk, liquid or desirable instrument will have a high price and therefore a low yield. A high-risk, illiquid or otherwise undesirable instrument will have a low price and therefore a high yield.

Most non-life insurance securitisations are issued with a large spread relative to other similarly rated instruments. However, these instruments should be attractive to investors due to their assumed low beta values and issuances are typically oversubscribed. Such circumstances should lead to higher prices and therefore lower spreads over the risk-free rate. Some of this premium being paid by the parties ceding risk will compensate investors for the lower liquidity of catastrophe bonds compared with other instruments, but at present these securitisations appear to be good value.

Goldman Sachs securitisation pricing data suggests that catastrophe bond spreads increased after Katrina but have fallen slightly in the following years. Other studies show catastrophe bond spreads remaining relatively unchanged in recent years. This suggests that investors currently view catastrophe bonds as pure risk exposure, limiting financial contagion during the credit crisis. Spreads may be expected to reduce further as non-life insurance linked securitisations become more common, but any effects may be disguised by other factors affecting supply and demand (such as the softening or hardening of the conventional reinsurance market).

3. ANALYSIS OF MARKET AND CATASTROPHE DATA

3.1. Introduction

This section sets out our investigation into historical data of market movements and catastrophic events. We first describe the data used in the study, including adjustments made. We then provide details of our approach and the results of our analysis, followed by a commentary on the key features and conclusions.

We have also considered the limitations of such studies and provided some anecdotal examples of links between catastrophic events and market movements. Finally, we have indicated some alternative approaches that can be adopted to performing such an analysis.

3.2. Data and adjustments

The catastrophe data for this study was taken from Pielke at el (2008). This paper provides estimates of economic damage resulting from hurricane landfalls along the Gulf coast and Atlantic coast of the United States from 1900 to 2005. The key feature of this analysis is the methods used to ensure that the estimates are consistent over time, therefore allowing comparison of losses between different historical periods.

The base hurricane loss data from a previous Pielke and Landsea (1998) paper are adjusted using two different methods. Both approaches attempt to allow for inflation (the change in the value of money over time) and exposure (the change in the volume of assets at risk of a given event over time). Exposure adjustments follow changes in wealth, population and housing units, scaling losses to the level that would be expected if the same event occurred today.

Whilst inflation adjustments are necessary to allow comparison of losses in standard currency units, the exposure adjustments are not required for this investigation. The links between catastrophic events and financial markets suggested earlier focus on actual economic losses: the economic impact of a hurricane occurring in 1900 does not depend on the number of housing units in the affected area in subsequent years. To allow for this we have taken the base data and applied only the inflation adjustments proposed in the paper.

The authors define economic damage as the direct losses associated with a hurricane's impact as determined in the weeks (and sometimes months) after the event (Changnon 1996; Downton et al 2005). Whilst this differs from insured losses, it is suggested that insured losses are normally around half the economic losses from an event. In any case, economic losses provide a good indication of the impact of a catastrophe and therefore provide a sound basis for this investigation.

The market data used for this study has been taken from the Barclays Equity Gilt Study 2007. This provides historical annual price and income data for equities, government bonds, corporate bonds, index-linked bonds and cash, extending back to 1899 in some cases. In addition to the numerical data, the publication also provides interesting analysis and commentary on various topics.

The study provides indices for both price and income (where applicable) of each instrument. It also calculates the average total annual return on an investment for each combination of investment year and realisation year. We have used the price indices (adjusted for inflation) as a reasonable representation of market movements.

We have compared the catastrophe data with price indices for US and UK equities. We would expect any correlation to be most evident with US equities, as this is where the effect of US windstorms should manifest most directly. Many other similar investigations have used the S&P500 index for the same purpose.

Whilst the effects may not be as direct for UK equity markets, we would expect some links between movements in the US and UK markets and the globalisation of more recent years could result in UK companies being directly affected by US windstorms. However, domination of UK companies in the index should reduce the correlation with such events.

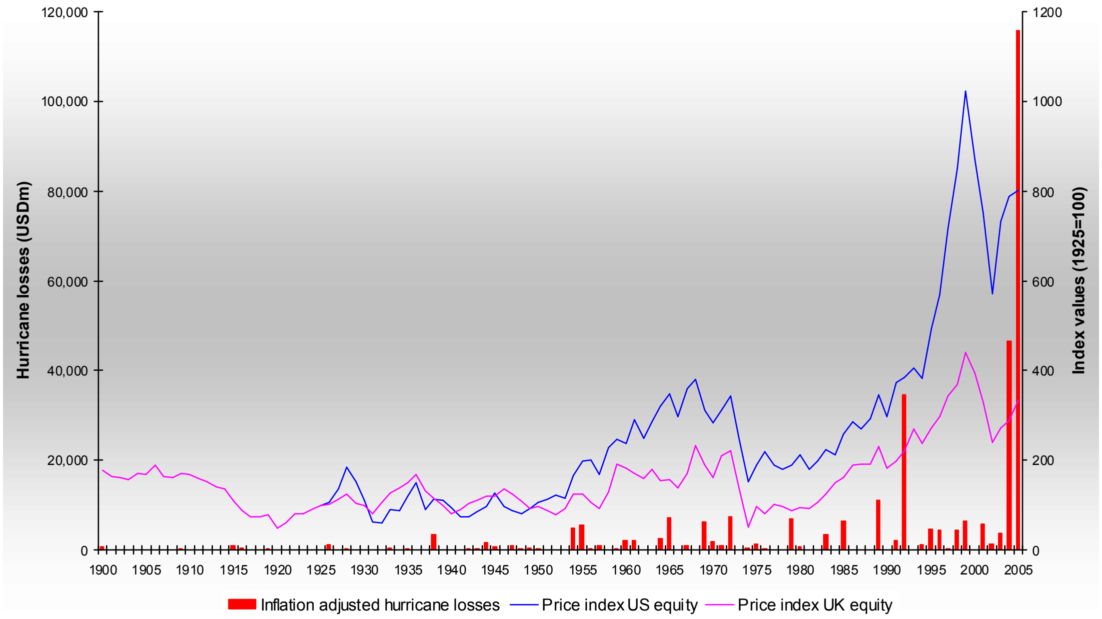
We have not considered other instruments, including the US bond price index. Bonds will have some exposure to US events and are not unrelated to the US stock market (as exemplified by the ‘flight to quality’ often seen in times of market turmoil where investors move capital from equities into highly rated bonds). However, bond prices are usually determined by factors such as credit risk, inflation premiums and the risk-free rate, meaning the effect of external events such as catastrophes should be more limited than with equities.

These data are attractive both due to the large volume available and the careful construction of the indices. For example, the historical equity indices are produced using a weighted arithmetic index based on market capitalisation as employed in the Financial Times Actuaries Indices and the FTSE 100. This avoids a number of issues with the alternative techniques used by other current indices, such as the Dow Jones Industrial Average.

3.3. Quantitative analysis

To get a first impression of the data we initially plotted the total hurricane losses in each year and overlaid the corresponding stock market price index values (Figure 1). Whilst it is difficult to make any sensible conclusions about correlations from the resulting chart, it does appear to demonstrate the anticipated close relationship between the US and UK equity markets.

Figure 1: Equity indices and hurricane losses 1900-2005



The chart does demonstrate how most historical hurricane losses, even when adjusted for inflation, are dwarfed by the few 'tail' events such as the 2004 and 2005 seasons. As an aside once the housing unit/population adjustment is also included this pattern is altered with only Katrina of the 2004-5 Hurricanes making the top 10 fully normalised losses. Interestingly, Hurricane Andrew in 1992 is almost equivalent to the combined total of Hurricanes Charley, Frances, Ivan and Jeanne in 2004 before any adjustment for increases in exposure levels during the intervening years.

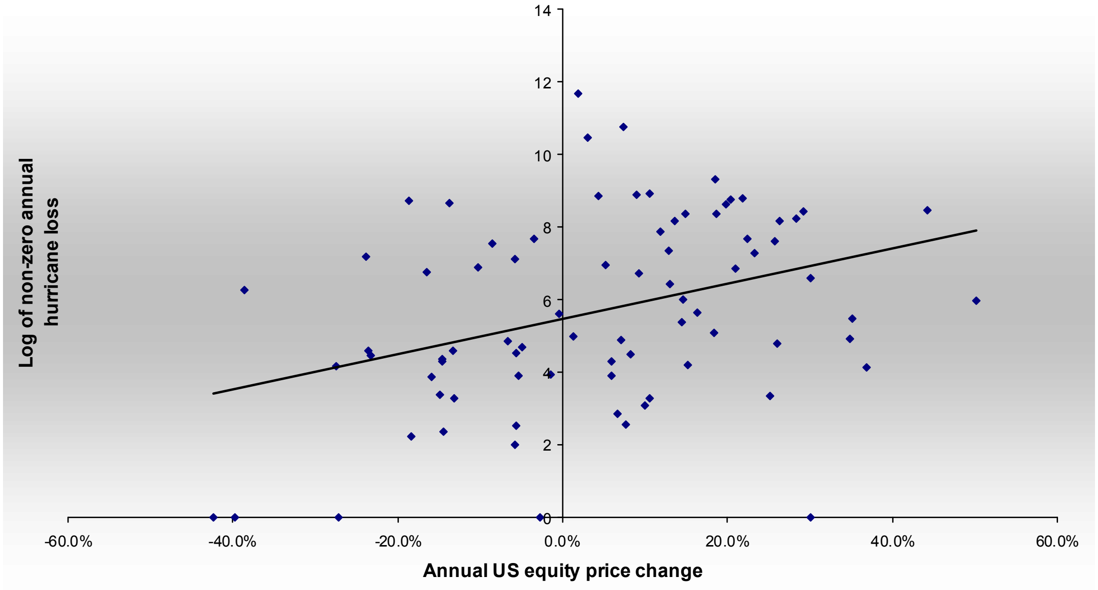
To investigate correlations we have concentrated on the annual change in the equity price index. Whilst there must be some slight positive bias to these figures (evident in the upward drift of the index over time) we have assumed they are close to being normally distributed and therefore appropriate for this use.

Conversely, the hurricane data used here imply a severity distribution with a significant positive skew, as is usual for most loss distributions. To give an approximately consistent comparison with the price index movements, we have used logarithms of the hurricane losses in our calculations. To do this we excluded those years with zero total hurricane losses, as the logarithm of these is not defined. However, as there were only six such occurrences between 1926 and 2005 this should not be material.

By using logarithms in this way we should be comparing two normally distributed variables, allowing us to use standard correlation calculations. As an alternative we also considered using rank correlations, where the hurricane losses and movements in equity indices are ordered by size then compared. By removing skew and other features from the data it is easier to calculate correlations on a consistent basis. The rank correlations were always larger than those calculated using the standard data.

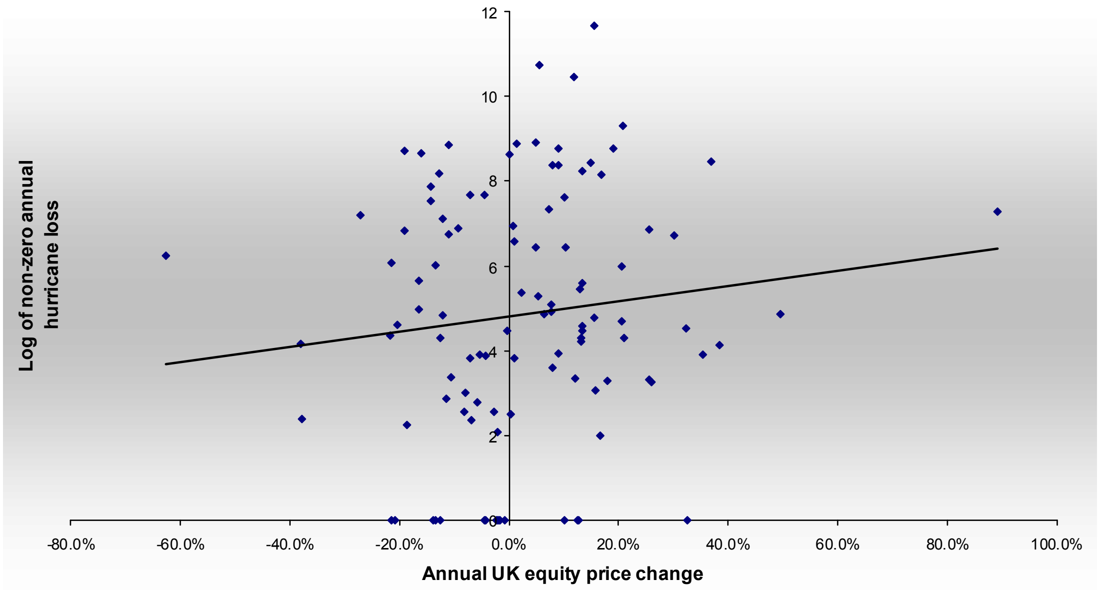
We calculated the correlation coefficient between the logarithm of the hurricane losses and the annual change in the US equity market to be 0.275. The comparison is represented visually in Figure 2. Whilst this is not a particularly high level of correlation, it is a notable deviation from the zero beta assumption. The factor suggests that the occurrence of hurricane losses and equity gains coincide to some degree, rather than market falls following catastrophes and would correspond to a negative beta.

Figure 2: Hurricane losses against US equity price change ($\rho = 0.275$)



We performed the same analysis for UK equities, shown in Figure 3. The availability of data allowed the time period under consideration to be extended to include the years between 1900 and 1925. In this case the correlation coefficient was significantly lower at 0.074.

Figure 3: Hurricane losses against UK equity price change ($\rho = 0.074$)

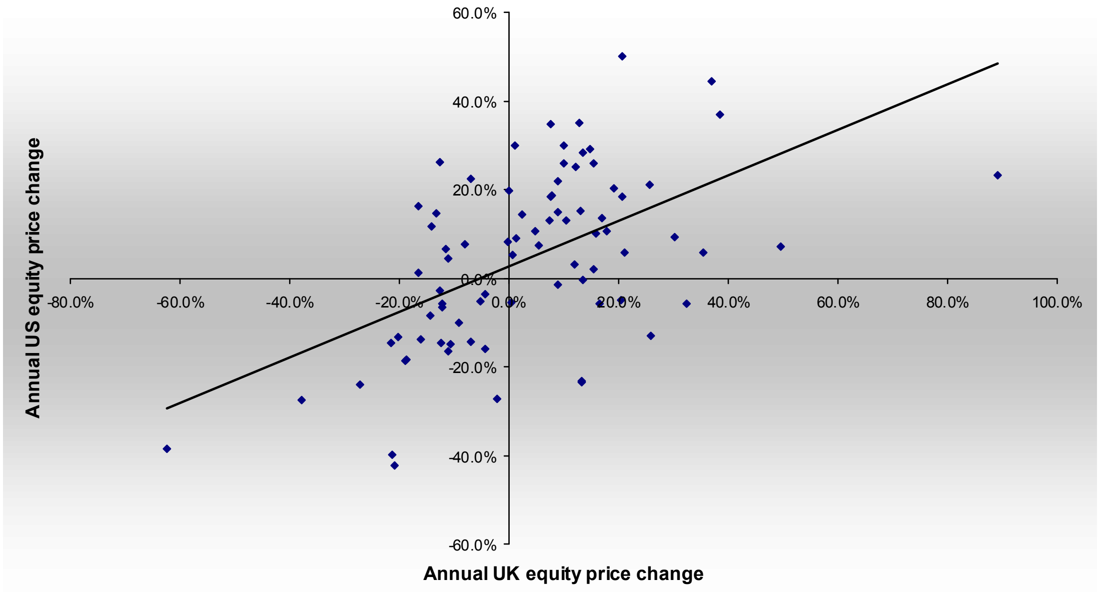


To ensure that this was not the effect of introducing additional years to the sample, we recalculated the coefficient using only data from 1926 to 2005. This reduced the figure to 0.037.

As a larger proportion of the earlier years have been excluded due to the hurricane losses being zero, and the UK equity market generally fell during this time, introducing the additional years may result in some distortion of the calculations. Making some arbitrary substitution (such as a zero or negative value) for the log of zero catastrophe losses increases the calculated correlation coefficient, suggesting that any distortions are likely to result in the true level of correlation being underestimated.

To provide some comparison for the correlation levels observed, we also considered the correlation between annual price changes on US and UK equity. As might be expected, there is a relatively clear pattern of correlation ($\rho = 0.546$) as shown in Figure 4.

Figure 4: US equity against UK equity price change ($\rho = 0.546$)



As an additional check on the data we considered possible delays in the effect of catastrophic events. Calculated correlation coefficients between hurricane losses and the movements in financial markets one, two or three years later were low, indicating that any effect is limited. This is not unexpected with annual time periods.

3.4. Commentary

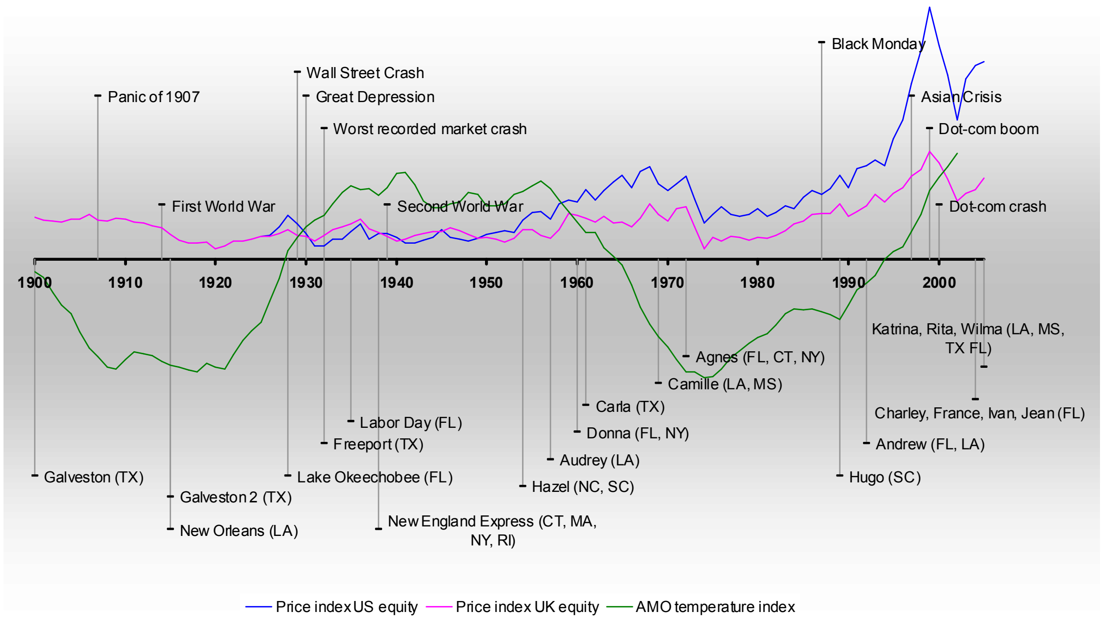
What does this analysis mean for the zero beta assumption? Whilst it is difficult to determine a beta value without converting the hurricane data into an annual gain or loss (such as by producing an index), the apparent non-zero correlation level should correspond with a non-zero (in this case negative) beta.

Given this result, how does this analysis differ from the various other studies considered? The most important component is the data, which often uses a catastrophe index (such as the Property Claim Service index on which Chicago Board of Trade catastrophe options are based) and a standard market index such as the S&P500. In addition, the time periods considered are often shorter than in our study, in some cases focusing only on a number of days rather than years. A selection of other analyses is discussed in section 4 below.

Of course, the complexity of the financial markets brings its own difficulties with the myriad factors affecting returns. Our relatively basic study does not control for any other influences, such as political and economic events. This leads us to consider how such events may have distorted our results.

Figure 5 shows the equity indices of Figure 1 against a timeline of hurricanes and other major events. The largest hurricanes (mostly categories four and five) and the Atlantic Multidecadal Oscillation (AMO) sea temperature cycle are indicated.

Figure 5: Hurricane and stock market activity 1900-2005



The following paragraphs discuss the movements in the US equity index, hurricane activity and other known drivers.

1925-1938

Speculation during the early part of this period led to significant stock market growth, followed by one of the largest crashes in history as the credit-driven boom collapsed. The war economy fuelled the eventual recovery in the late 1930s.

Against this backdrop, the Lake Okeechobee hurricane at the start of the fall in 1928 and the two that occurred during the subsequent gradual upturn seem incidental.

1939-1945

Wartime economics, with so many extreme influences, are unlikely to be fully representative of more general trends. In addition, hurricane activity during this period was limited.

1946-1969

Overall strong growth in this period punctuated by a number of sharp falls show some instability in the post-war economy. Although the four major hurricanes of the period appear to coincide with the upswings, the duration of the market increases would suggest other influences may have been involved. Generally speaking this was a period of high stock market returns (in a protracted post war boom and as the

US became the World's dominant economy) and heightened hurricane activity (due to an extended warm phase of the Atlantic Multi-Decadal Oscillation).

1970-1990

There was a 20-year relative lull in windstorm activity associated with a cold phase of the Atlantic Multi-Decadal Oscillation beginning around 1970.

Although, Hurricane Agnes in 1972 preceded the major crash of 1973-1974, the latter was caused by various economic issues and in particular compounded by the 1973 oil crisis.

Black Monday in 1987 was another global phenomenon, resulting in the largest one-day percentage decline ever recorded. The causes of the crash are still debated, though the Great Storm in the UK (not shown in our data) is thought to have compounded the effect due to its physical effect on traders (see below).

1991-2002

This decade began with a relatively protracted period of El Nino which dampened the move of the Atlantic Multi-Decadal Oscillation to a warm phase around 1995 and contributed to the limited hurricane activity seen (Hurricane Andrew in 1992 falling in what was actually a year of very low activity). The abnormally strong growth of the period was driven by the technological boom feeding into the markets followed by the subsequent 'dot-com' crash which occurred in a period of few storms.

2003-2005

Once markets had bottomed-out the recovery started in earnest, with significant rises over the remaining three years of our data. This of course corresponded to the largest hurricane losses ever recorded in the infamous 2004 and 2005 Hurricane Seasons. This may have contributed to the positive correlation implied by the data.

Summary

In summary it seems that the unexpectedly high correlation between hurricane losses and high stock market returns appears serendipitous rather than causal. It can be largely explained by reference to the coincidence of independent exogenous factors particularly the broad alignment of the warm/cold/warm phases of the Atlantic Multi-Decadal Oscillation with the post war boom/oil crisis induced stagflation of the 1970-1980s and post 1990 recovery.

As a further example, even after this period, the credit crunch induced stock market falls coincided with an unexpectedly very low level of US landfalling hurricane activity in 2007.

3.5. Limitations of historical studies

There are a number of factors that restrict the relevance of historical data in studies such as this:

- There are significant changes in exposure to catastrophe losses over time. These mainly relate to increased population of high risk areas (such as coastal regions). We have not adjusted for exposure changes in our study as we are interested in the effect of economic losses on financial markets, but exposure changes may alter the number and nature of events that result in future losses.
- The changing market penetration of insurance companies will affect the transfer of economic losses to the insurance markets, and potentially onwards to financial markets. Whilst we have considered economic losses in our investigations, which require no adjustment for market penetration, changes in insured losses over time may have some effects that have not been recognised.
- Effects such as climate change may alter the characteristics of catastrophic events over time.
- Catastrophic losses are usually infrequent events so there will be limited historical data showing the true severity of losses. Analyses may therefore be truncating the distribution of losses or underestimating the size of the tail events.
- Catastrophe bond markets are relatively immature and may change significantly in the future. This could affect the fundamental design and structure of bonds, the triggers used, the volumes of bonds available to capital markets, the depth and liquidity of secondary markets, and the attitudes of investors.
- This paper, and most other studies considered, use annual data for market returns. There is a risk that the effective 'averaging period' inherent in this approach disguises the effects being investigated. Immediate market movements (such as panic-induced crashes) can manifest within days but may be followed by a recovery. Conversely, supply and demand effects may not be recognised for longer periods.

Changes in exposure are likely to have the most significant effect on the characteristics of losses and their effect on the financial markets. The largest actual insured loss between 1970 and 2007 arising from a natural catastrophe (expressed in 2007 values) was Hurricane Katrina at $69m (including losses paid from the National Flood Insurance Program). This is followed by Hurricane Andrew at $24m and the 1994 Northridge earthquake at $20m.

However, increasing exposure in high risk areas (such as the accumulation of high value housing in Florida and other coastal areas) increases the losses that are incurred as a result of catastrophic events. The catastrophe modelling firm AIR has estimated the present day losses that would result from various historical catastrophes (expressed in 2005 values):

- $108bn from the 1906 San Francisco earthquake;
- $88bn from the 1812 New Madrid earthquake; and
- $80bn from the 1926 Miami hurricane.

This analysis is based on simulating the geological and meteorological characteristics of the earthquakes and hurricanes through AIR's latest catastrophe models and using AIR's industry exposure database.

RMS published a very detailed retrospective study of the 1906 earthquake and estimated insured losses as at 2006 of $50-80bn. This is relatively low compared with an estimated economic loss in excess of $250bn, mainly due to the reduction in take-up of residential earthquake insurance since the Northridge earthquake and even since the 1906 event itself.

However, even this may not capture the true scale of potential losses. The same AIR article estimates that a major rupture of the Puente Hills fault near Los Angeles is capable of producing an insured loss in excess of $150 billion; and a Category 5 hurricane impacting the Miami and Fort Lauderdale areas could cause more than $120 billion in insured losses.

Similarly, RMS estimates (including demand surge, secondary uncertainty and with a 5-year near-term view of hurricane frequency) place a one in 100 year probable maximum loss (PML) to the industry from US windstorms at around $120bn and a one in 200 year PML at $160bn. The corresponding figures for US earthquakes are $45Bn and $70Bn.

This suggests that the insurance market may have never really seen the level of severe catastrophic loss that could have a wider adverse financial impact (and which is also the type of loss that catastrophe bonds are currently designed to cover).

Empirical investigations on the correlation between catastrophe bonds and conventional investment returns (even if based on the last 100 years or so of data rather than simply on the 15-20 year period for which catastrophe bonds have been traded) will therefore be limited in the insights they can give and in particular will underestimate the possibility of a positive beta for catastrophe bonds.

3.6. Historical examples

While the above analysis does not provide any conclusive evidence that there are direct causal links between catastrophic events and financial markets, there are a number of interesting anecdotal examples to consider. It is difficult to demonstrate the verity of such claims, but the following accounts help to illustrate the type of correlation that might be seen:

- The most recent authoritative account of the 'Panic of 1907' stock market crash traces its origins back to the April 1906 San Francisco earthquake. Explanations for the contribution of the earthquake to the crash have included: the subsequent rebuilding costs being one of a series of factors leading to a constriction of money supply; insurers being forced to sell securities to realise cash to settle claims; and the burden of claims falling on Lloyd's being one of a series of blows to the UK economy (the global financial centre during the period).
- 'Black Monday' in 1987 followed the 'Great Storm' that struck England on the previous Thursday night and Friday morning. Some commentators have suggested that the physical effects of the storm on London traders (with markets closed on Friday and not all traders in work on Monday) were in part responsible for the fall in stock markets on the Monday. This may have contributed to panic over the weekend among traders who had left positions open then witnessed a drop in the Dow Jones over the Thursday and Friday, and to the dominance of programme trading on the Monday.
- The Tokyo stock exchange fell over both the immediate and medium-term period following the 17 January 1995 Kobe earthquake, at least partly due to the knock-on effects of the earthquake on an already weak economy and vulnerable stock market. Interestingly, the downfall of Barings was accelerated by a short straddle Nick Leeson placed on the 16 January 1995 betting that there would be no significant overnight move up or down in the Nikkei followed by an ever increasing series of bets that the Nikkei would recover.
- Following the 11 September 2001 attacks on New York, the New York Stock Exchange, American Stock Exchange and NASDAQ remained closed until 17 September. At this point the Dow Jones Industrial Average recorded its greatest ever one-day and one-week points fall (equating to more than a 7% and 14% fall respectively). However, we note that the Dow Jones had already fallen by around 15% between May and 11 September and that it recovered by more than 20% from the post WTC position by the end of the year.

These examples may support some of the mechanisms suggested earlier in this paper by which catastrophic losses could affect financial markets, namely:

- Economically significant losses from catastrophes amplifying more fundamental economic or financial market concerns (1906, 1995 and 2001).
- Disruption to financial markets caused by a catastrophic event having both a physical and psychological effect on traders (1987, 2001). Other hypothetical examples of this could include an earthquake affecting Tokyo, hurricane landfall in New York or a failure of the Thames barrier causing flooding in the City of London.

The impact of these events would be enhanced by a more significant catastrophe and a weaker or more uncertain prior state of the economy or financial market. This suggests that the correlation between catastrophic events and financial markets may be greater in extreme scenarios than in those that are more common. This is normally represented by a copula, which allows a non-linear correlation between two variables. In this case we would expect to see correlation that is near zero for most of the distribution, but that increases significantly in the tails of the distributions of outcomes.

3.7. Alternative approaches

This analysis only considers US windstorm losses, partly due to the availability of relevant data. However, this only represents a subset of global catastrophes and catastrophe data, and other appropriate comparisons could be performed:

- Catastrophe indices, such as those produced by the Property Claim Service (PCS) provide a consistent and accessible source of catastrophe data. Indeed, a number of the studies described in section 4 compare PCS index data with the S&P500 index.
- A similar approach could be applied to different geographical regions, such as a comparison of earthquake data with the Japanese stock market. However, in most cases this will be limited by catastrophe data due to the relative infrequency of most events.
- Proposed links between catastrophes and specific sectors of the financial markets, such as the effect of regeneration work on construction companies, could be investigated using indices that focus on that sector. Either a purpose built index or an existing index that is dominated by the given industry could be appropriate.
- The ‘Hobson’s choice’ of annual time periods in the data may disguise some effects that occur over shorter timeframes. Many severe market crashes occur in a matter of days, though they may take much longer to recover. And whilst regeneration work following a disaster may last for years, it is likely to be priced into the markets as soon as expectations have settled. Monthly market movements might capture more of these effects, without the long term averaging effects of annual data and the short term volatility ‘noise’ in daily movements.

4. SUMMARY OF OTHER ANALYSES

4.1. Introduction

The zero beta assumption for catastrophe securitisations has been quoted in numerous publications, the most relevant of which are briefly summarised below. The material in this section is derived from the sources indicated and is not original work.

4.2. Assessing catastrophe reinsurance-linked securities as a new asset class

Robert H Litzenberger, David R Beaglehole and Craig E Reynolds, 1996

Produced in the aftermath of two of the largest insured losses to date, Hurricane Andrew (1992) and the Northridge earthquake (1994), this paper approaches catastrophe linked securities from a first principles perspective. The losses had reduced the capacity of the insurance markets whilst stimulating demand for protection, resulting in significant increases in the cost of standard policies.

Beginning with the valuation of standard excess of loss reinsurance cover, the authors develop a hypothetical insurance linked security based on the catastrophe index produced by PCS. This involves a long position in a standard bond with a short binary call option on a theoretical ‘adjusted historical loss ratio’ (AHLR), which is intended to allow for the increased population densities and market penetration of catastrophe cover in high risk areas. The AHLR relates to results on an ‘excess of loss’ layer that covers the relevant catastrophe index. Forward looking assessments using catastrophe models and historical data approaches are discussed.

To assess the usefulness of these securities in a portfolio, the authors estimate the expected correlation between the calculated returns and the S&P500 and government bond indices over the period from March 1955 to December 1994. The results indicate a slight negative correlation, but as they figures are not statistically significant a zero beta is assumed. According to additional calculations, the returns on the S&P500 are positively correlated with the government bond index.

Given the zero beta assumption, the paper then calculates the optimum holdings of the hypothetical security in various portfolios. This is repeated for a ‘binary’ security, where loss of the principal is wholly dependent on one ‘trigger’ event. The results are summarised in Figure 6.

Figure 6: Optimum holdings of hypothetical catastrophe security

Portfolio type	Weight of cat note in enhanced portfolio	Type of embedded cat exposure Excess of loss (bp)	Binary (bp)
S&P 500 index	1%	11	22
	2%	22	44
Bond	1%	2	4
	2%	4	8
Balanced	1%	13	27
(50% stock/50% bond)	2%	27	53
Rate on line		12.51%	19.25%
Offered return		7.94%	10.85%

This security is extended to a hypothetical 10 year catastrophe bond and compared with existing conventional bonds. Calculated default probabilities place this security alongside B-rated bonds, against which the return on the security suggests that it is expected to provide a superior return in all cases.

4.3. Insurance derivatives: a new asset class for the capital markets and a new hedging tool for the insurance industry

Michael S Canter, Joseph B Cole and Richard L Sandor, 1997

This paper covers similar ground to Litzenberger, Beaglehole and Reynolds as discussed above, and arrives at similar conclusions. After an introduction to options on PCS catastrophe indices and their potential use in hedging insurance risk, the authors discuss features of catastrophe bonds and their attractiveness to investors. Suggested downsides include the loss of leverage (20% margin on PCS index options compared with 100% collateralisation of catastrophe bonds) and the total loss of principal on defaulted bonds when compared with a quoted average recovery rate of 43% on conventional bonds. This latter point has contributed to the availability of principal-protected tranches on some bond issues. Offsetting this is the higher expected return than on similar (high yield) standard bonds.

To assess the relationship with stock market movements the paper compares the annual percentage change in the PCS national index (based on catastrophe losses) with the change in the S&P500 from 1949 to 1997. The calculated correlation is not significantly different from zero (a correlation of -0.05 and a t-value of -0.33). This leads to the conclusion that options on the PCS index can be considered to have a beta of zero compared with stock markets. Other asset classes and measures of catastrophe losses are not considered.

4.4. Do natural disasters affect the stock market?

John Brynjolfsson and Matt Dorsten, 2007

http://europe.pimco.com/LeftNav/Viewpoints/2007/Natural+Disasters+8-07.htm

There are a number of key differences between this paper and other studies considered.

- The analysis suggests that there is some evidence (though not statistically significant) that stock markets actually rally after a natural disaster.
- The events of 11 September 2001 are introduced to consider the effects of man-made disasters.
- A shorter time period (1989 to 2005) is used.
- The analysis focuses on the period immediately surrounding a disaster.

Whilst the authors note that natural disasters 'destroy insurance capital, interrupt business operations, and cost people their homes', they also provide the following reasons why there may be a positive effect on markets:

- The federal government usually provides assistance to disaster regions, including cash payments, low-interest rebuilding loans, and unemployment benefits.
- The Federal Reserve can lower interest rates.
- Insurance companies inject billions of dollars of assistance and claims payments.
- GDP calculations generally do not subtract the cost of disaster losses (and resulting rebuilding activity may actually increase GDP).
- Insurance markets frequently harden after disasters allowing the industry to collect higher premiums.

The paper considers the level of the S&P500 index on the 30 days before and after 10 major US natural disasters (primarily windstorms but including the Loma Prieta and Northridge earthquakes). The mean index levels before and after the events are compared to identify any coincident changes, with the test indicating that the index levels were slightly higher after the event than before. However, the results were not statistically significant leading the authors to conclude that there is no effect on the level of markets.

This paper takes the theme further than those considered above to include a man-made disaster. When the terrorist attacks of 11 September 2001 are included in the tests the data indicate at a high confidence level that index values after the events are below those beforehand. The authors comment that natural disasters 'are in a different class' from man-made events, but avoid reaching any conclusions about the effect of man-made events alone based on a single data point.

4.5. Financial innovations for catastrophic risk: catastrophe bonds and beyond

Milken Institute, 2008

http://www.milkeninstitute.org/pdf/FnclInnovsCatBondsApr08.pdf

One of the most recent investigations into the securitisation of non-life insurance risks, this document was produced after the 2007 credit crisis and consequently provides some of the most useful insights into catastrophe bond behaviour. Comparisons of BB-rated catastrophe bonds and a comparably corporate bond index from January 2005 to September 2007 showed a continued rise in catastrophe bond returns even as the index suffered substantial falls. Correlations with various asset classes calculated over a similar period show values of 0.22-0.26 for fixed income products, but near-zero values for equities (S&P500) and gold.

The paper also looks at the factors influencing the size of the non-life securitisation market, discussing both supply and demand constraints. A plot of return against risk for a variety of asset classes shows catastrophe bonds providing the greatest reward, but transaction costs and the retention of basis risk may be keeping issuances at low levels. Other indicators of stagnant demand include catastrophe bond spreads, which have remained relatively flat whilst spreads on conventional bonds follow those on asset-backed securities to ever higher levels.

Investors have their own issues with these securities. Credit ratings are typically below those normally targeted in the capital markets and portfolio managers are unwilling to deal with the complexity of the underlying risks. Diversification away from US windstorm and catastrophe bonds being placed as a legitimate investment class could attract buyers, as might an increase in liquidity and transparency in the secondary markets.

REFERENCES

In preparing this paper we have made use of the following sources of information. References to previous studies are included explicitly within the text.

OVERVIEW

Credit Suisse

http://emagazine.credit-suisse.com/app/article/index.cfm?fuseaction=OpenArticle&aoid=131287&lang=en

2006 article "Speculating a worst case scenario"

ASSET RETURN DATA

Barclays Capital/Barclays Global Investors

Equity Gilt Study 2007

HISTORICAL LOSSES

Swiss Re

http://www.swissre.com

Swiss Re's annual SIGMA reports contain detail on historical losses (including revaluation to today's prices).

AIR (Applied Insurance Research)

http://www.air-worldwide.com

In September 2006 AIR published an article "What Would They Cost Today? The Estimated Impact of Historical Catastrophes on Today's Exposures".

RMS (Risk Management Solutions)

www.rms.com

On the 100th anniversary of the 1906 quake RMS published "The 1906 San Francisco Earthquake and Fire: Perspectives on a Modern Super Cat".

Normalised hurricane damage

http://sciencepolicy.colorado.edu/prometheus/archives/disasters/001326new_paper_on_normali.html

"Normalized Hurricane Damages in the United States: 1900-2005" by Pielke, Jr., R. A., Gratz, J., Landsea, C. W., Collins, D., Saunders, M., and Musulin, R, published in the 2008 Natural Hazards Review

The URL above provides links to the paper and the underlying dataset. Note that the study uses economic rather than insured losses, and suggests that as a crude rule of thumb insured losses should be roughly half the economic loss.

1907 panic

"The Panic of 1907: Lessons Learned from the Market's Perfect Storm" by Robert F. Bruner, Sean D. Carr

Influences on past hurricane activity

www.actuaries.org.uk

(follow links for General Insurance and then Past GIRO papers)

The 2006 GIRO Catastrophe Modelling Working Party (Fulcher et al) paper provided the sources for our data on Atlantic Multi-Decadal Oscillation and El Nino Southern Oscillation as well as giving details on how these influence hurricane activity.