Capital Market Solutions to Terrorism Risk Coverage: A Feasibility Study

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Abstract

In the aftermath of the September 11, 2001 terrorist attack, insurers and reinsurers began to exclude terrorism coverage from their standard commercial polices or to offer terrorism coverage at prohibitive premium levels. This action forced the federal government to step in and pass the Terrorism Insurance Act in November 2002. The Act has a three-year sunset provision and the prospects of it being re-conducted are uncertain. As a result, the void in terrorism risk coverage may be partly filled by private initiatives involving alternative risk transfer or risk financing instruments. This paper intends to evaluate risk pooling and risk transfer alternatives for terrorism coverage. In particular, it discusses whether capital markets could substitute to the insurance industry in providing coverage for terrorism risk, and at what price. Based on the previous findings, this paper then suggests possible combined public/private initiatives to finance terrorism risk.

Introduction

The U.S. insurance industry has long faced the spectrum of large unexpected losses from natural catastrophes such as hurricanes and earthquakes. However, the September 11, 2001 terrorist attack clearly demonstrated a new form of catastrophic risk of man-made origin. The damages in property and life are now well known as estimates of insured losses deriving from this event range from $40 to $54 billion. The 9/11 terrorist attacks renewed the capacity problem faced the insurance industry in the underwriting of large catastrophic risk. In that regard, this paper explores the feasibility of capital market alternatives to the conventional insurance mechanism, and analyses whether the capital market could provide extra capacity to absorb terrorism risk.

The insurance capacity issue was first raised in the aftermath of 1992's devastating Hurricane Andrew. However, it was partly forgotten or ignored as the market for insurance and reinsurance catastrophic coverage softened in the second half of the 1990's. Nevertheless, the World Trade Center attacks rekindled concern about the industry's capacity due to the severity of losses, and particularly, the possibility of a new kind of catastrophic loss event. The capacity issue is especially relevant for reinsurers. A 2001 report published by Risk Management Solutions ("RMS") estimated that, on average, less than 35% of the overall gross insured losses in the Andrew (hurricane) and Northridge (earthquake) disasters were paid by reinsurers. This contrasts with losses paid in connection to the 9/11 attack. A 2002 report from the Insurance Information Institute ("III") estimated that 67% of the insured losses were covered by the reinsurance industry. Moreover, it is important to point out the terrorist losses were not limited to "traditional" property exposures or business interruption as is typical of natural events. According to the III report, 46% of the total claims related to the September 11 terrorist event were related to casualty, liability and life insurance exposures.

Given the potential severity of the terrorist risk capacity problem, U.S. Congress adopted the Terrorism Insurance Act in November 2002. The Act called for insurance companies to retain in 2003 an amount equal to 7% of the premiums they collected the previous

year. The percent deductible rose to 10% in 2004 and is scheduled to increase to 15% in 2005. In the event of a terrorist attack, the Federal government would cover 90% above the deductible with insurance companies financing the other 10%. The Terrorism Insurance Act has a three-year sunset provision and, in the absence of a major terrorist act, may not be re-conducted.

The proposed research analyzes the limitations of the traditional insurance pooling mechanisms for terrorist risk and discusses whether terrorism risk could be transferred to the capital markets via securitization of terrorist risk. Can capital markets realistically fill the void left in terrorist coverage? What are the lessons learned from the emergence of catastrophe-linked securities? What will it take for investors to offer synthetic terrorism insurance coverage in place of insurers?

The first section of this paper discusses reasons why the customer risk-pooling mechanism of insurance companies may not be appropriate in the case of terrorism. We then evaluate the success of existing capital market instruments designed to securitize the risk of natural catastrophes and we draw conclusions on the feasibility for capital markets to securitize insurance risk. In particular, we propose simple simulations to determine the risk-return elements of securitizing terrorist risk and to infer the premium cost attached to this form of synthetic insurance. Finally, this paper suggests possible combined public/private initiatives to finance terrorism risk.

Terrorism Risk and the Limitations of the Conventional Insurance Mechanisms

In their traditional role, insurance companies shift the risk inherent to each individual to a pool of similarly exposed individuals. Customer pools enable the sharing of losses by all members of the group. Insurance companies are willing to pool risks when their customers' future losses may reasonably be estimated and when risk is uncorrelated among the members of the pool. Under the *law of large numbers*, the larger the data set measuring the extent of past losses and the larger the group of policyholders, the more accurate is the statistical estimate of future losses. Therefore, employing the law of large numbers gives insurance companies confidence that they have collected enough to sustain potential losses.

Unlike many conventional risks, however, terrorism risk does not lend itself well to the customer pooling mechanism. First, terrorism risk is difficult to quantify because no historical database is available to predict terrorism losses. Although there have been a handful of man-made disasters in the U.S. that could qualify as terrorists acts (criminal fires, Los Angeles riots, The Oklahoma bombing), there is not an underlying body of data related to terrorist-induced property losses. As a result, insurance companies cannot utilize the law of large numbers to formulate good estimates of potential losses. Instead, companies are forced to make subjective inferences of losses based upon *ad hoc* criteria. These forecasts have little predictive capability. In fact, insurance companies have reduced their offering of terrorism coverage because they are unable to reliably predict

the occurrence of terrorist events. One can argue that natural disasters are also generally unpredictable, yet insurance companies did not cease to offer catastrophe insurance.[1]

In addition, in the case of natural disasters, even in the absence of historical occurrence information, it is possible to simulate catastrophic events based on their own characteristics, and to assess the financial impact they would have on a particular community. The problem with terrorism risk is that the inputs needed to simulate the financial and business consequences of a terrorist attack are unknown. There is no wind factor or fault line characteristics attached to a terrorist event, and predicting the next tools used by terrorists to launch a new attack is extremely difficult. Nevertheless, recent studies have attempted to address the modeling and quantification of terrorism risk. Major [2002] suggests that terrorism risk differs in kind from natural catastrophe risk because of the human element. In his opinion, human intent (by terrorists) and human intelligence (by counter-terrorists) can be modeled using game theory and search theory. Woo [2002], while acknowledging the difficulty in predicting a terrorist event, suggests that tools like complexity theory can help identifying the business and financial consequences of terrorism acts. Although these studies open new doors in the prediction and quantification of terrorism risk, the complexity and sophistication of the tools proposed might nevertheless deter insurance companies from undertaking terrorism coverage.

The difficulty of quantifying terrorism risk, combined with the fact that the assumption of homogeneous risk exposures does not hold in terrorism risk, leads to underestimation of futures losses. As a result, insurance companies must maintain a significant amount of surplus beyond the premium collected. This could prove difficult for many companies. Mutual companies, which are less able to raise external funds, may end up charging extra premiums to their customers. This could raise the cost of terrorism insurance to prohibitive levels for the public. Even stock companies could have trouble raising capital as existing or potential stockholders may reject investing in companies that undertake such unconventional risks. Therefore, terrorism risk requires new risk-underwriting alternatives, as this paper now discusses.

Capital Markets as Potential Underwriters of Terrorism Coverage

The need for additional capital to underwrite terrorism risk points to a potential role of the capital market. Will investors be willing to engage in terrorism coverage via the securitization of terrorism risk? And if so, could the capital market undertake this risk more efficiently than the insurance industry?

The need for extensive capital suggests the need for risk transfer, as opposed to risk pooling. In *risk transfer*, risk bearing is removed from entities exposed to risk, and transferred to others not exposed to it but nevertheless willing to accept it and provide the reserves necessary to absorb it. Those who accept the risk, then, would not be the pool of

policyholders, but instead, outside professional risk takers. This risk transfer function is appropriate to the capital market, which has a long history in risk management.

In theory, capital markets are good candidates to undertake terrorism risk coverage. Capital markets have long been underwriters of risk. Investors place funds to earn a "risk premium", or a payment for assuming risk. While financial and business risks differ from risks that relate to perils to property, the risk underwriting process is the same. Just as with business and financial risk, capital market investors are enticed into insurance risk by the expectation of profit, i.e., a risk premium for their services. Investors manage this risk not by pooling, but instead, by diversifying their holding of risky assets in order to reduce the overall risk of their portfolio.

The willingness of capital market investors to assume terrorism risk can have important benefits:

- ***Additional Capacity***. If capital markets could effectively augment the insurance industry in providing terrorism coverage, the extra capacity they would provide would lessen the upward pressure on premiums. The capacity argument was a big factor in the development of insurance-linked securities and derivatives in the mid-nineties.

- ***Lower Production Costs***. Capital markets may introduce efficiencies in the underwriting, monitoring, and settling of terrorism insurance. If so, premium costs of terrorism insurance could be lower, as the risk analysis function separates itself from the risk bearing function. Terrorism risk exposures could be pooled by originating entities in the capital market. These entities could, in turn, create and issue new insurance-linked securities against the pool. The originating financial entity undertakes the risk analysis function required in evaluating the potential terrorism risk exposure, and the investor in the securities issued by the pool becomes the bearer of the risk. This principle has been already effectively applied in mortgage securitization. Financial institutions efficiently provide the risk analysis when they originate mortgage loans as the initial lender. Then they sell these instruments to outside investors that bear risk but cannot evaluate it as efficiently as they can.

- ***Risk Diversification***. Investors may further diversify the overall risk in their portfolio of assets by combining insurance risk with financial risk. A few studies performed in the late nineties have shown that capital markets participants, by allocating a small percentage of their assets in catastrophe bonds, create a more efficient portfolio, in the Markowitz sense.[2] Generally, the returns on securities that have a payoff triggered by losses resulting from a natural disaster display a low correlation with stock and bond returns. Whether or not this diversification element would work in the case of terrorism is not clear. The U.S. stock market fell as a result of the 9/11 terrorist attacks while bond markets remained fairly stable.

The Past Record of Insurance-Linked Capital Market Instruments

Insurance-linked capital market instruments have been in existence for a decade. While they originally targeted natural catastrophes, their experience nevertheless sheds light on the potential for capital markets to underwrite terrorism risk. The particular characteristics of these innovations are discussed below. Moreover, the actual experience with these instruments is evaluated in an attempt to glean inferences as to how terrorism-specific capital instruments may perform.

Background

Capital market products available to the insurance industry first appeared in December 1992 when the Chicago Board of Trade (CBOT) introduced the first exchange-traded derivatives instruments with a payout linked to industry insured losses. Soon thereafter, insurance securitization developed, mostly in the form of catastrophe (CAT) bonds. Below is a description of the specific characteristics of these two instruments:

Exchange-Traded Insurance Derivatives. The CBOT Catastrophe Insurance futures contracts were designed to allow insurance or reinsurance companies to hedge insured losses resulting from catastrophic disasters, such as earthquakes and hurricanes. The losses relevant to these contracts were not specific to individual insurance companies, but rather, included in an index of losses sustained by the insurance industry as a whole. Therefore, these instruments can be best defined as hedge tools for generalized catastrophe risk. In 1995, the CBOT restructured the futures contracts as cash options, enabling the contract to mimic traditional layers of reinsurance. Insurance companies could, in effect, purchase synthetic layers of reinsurance from capital market investors. Today, insurance-linked derivatives are no longer offered on any exchange.

Insurance-Linked Securities: Insurance-linked securities like CAT bonds usually carry a coupon income tied to a variable short-term rate. Investors who invest in such instruments may forego part or all of the coupon income and may even face a loss of the principal invested if a catastrophe arises and triggers compensation to the insurer or the re-insurer who originally issued the bond. Insurance risk, then, is transferred to capital market investors who, in exchange for bearing the risk arising from catastrophic disasters, receive a higher nominal coupon return on these investments than they would from investing in traditional corporate bonds. When the payout is triggered by the insured losses of an insurance company's actual portfolio of business, insurance-linked securities are called *indemnity-based* or *company-specific* instruments. When the payout is triggered by the performance of a broad, industry-based index, insurance-linked securities are referred to as *index-based* or *non-indemnity* based instruments.

Insurance-Linked Capital Market Instruments: The Track Record

The benefits of insurance-linked securities and derivatives as alternatives or complements to traditional reinsurance have been well documented.[3] By channeling additional capital to the insurance industry, these products can add to the current insurance market capacity and, when not crucially needed in a soft market, they certainly provide increased *potential* market capacity. As a result, they can offer surplus relief and allow insurers to more efficiently invest excess capital in higher return projects. Capital market solutions in terrorism coverage may also add to or substitute for insurance capacity.

The inclusion of insurance-linked securities or derivatives may increase the risk/reward profile of an investment portfolio. As explained earlier, studies have shown that capital market participants, by allocating a small percentage of their assets in catastrophe bonds, create a more efficient portfolio. Generally, the returns on securities that have a payoff triggered by losses resulting from a natural disaster display a low correlation with stocks and bond returns. It is worth pointing out, however, that in rare cases, a catastrophe can greatly impact an economy. For instance, in Japan, the large economic losses resulting from the 1994 Kobe earthquake caused a steep decline in the Nikkei index.

Despite all of its theoretical advantages, the market for insurance-linked transactions has remained noticeably small. At the height of their popularity, the CBOT products had an open interest of about 10,000 options. Trading then dwindled, and today, there is no active derivative market. The market for other insurance-linked securities has also grown very slowly, despite upbeat reports provided by entities involved in insurance securitization (see, for instance, a recent report by Guy Carpenter [2004]).

In previous articles, Bouriaux [2001], and Bouriaux and Russell [2002] addressed the common factors that have limited the growth of insurance securitization: dual coincidence of wants between issuers of and investors in the securities, low secondary market liquidity and an unfavorable regulatory treatment. The following is a summary of previous discussions contained in the above-cited papers.

Basis Risk

Successful securitization of risk generally arises when the product structure meets the needs of both the issuer of the security and of the investor in the security. In the case of existing insurance-linked securities, there appears to be a lack of "dual" coincidence of wants between the insurer and the investor: instruments with a payout triggered by the performance of a referenced loss index ("index-based" instruments) are more attractive to the investor than instruments with a payout tied to an insurance company's own results ("indemnity-based" instruments). Why? Because the use of industry loss index as a payout trigger to a transaction minimizes adverse selection and also likely to lower investors' costs in evaluating company-specific underwriting and financial results. On the other hand, insurance companies may not receive full indemnity when using index-based products as risk transfer instruments. The possibility of a partial indemnity occurs because index-based securities have an element of basis risk embedded in them.

The issue of basis risk has been extensively discussed in research papers and by the National Association of Insurance Commissioners ("NAIC") Insurance securitization Task Force[4]. Although relatively new in insurance markets, basis risk is well known in the financial markets, as it represents a risk inherent in all commodity and financial transactions based on a standardized financial asset or commodity, or on an index of these. The issue *per se* is not the *existence* of basis risk, but *its assessment and quantification*. Once thoroughly quantified, if possible, basis risk in a financial transaction can be minimized and almost eliminated via "over-hedging" or "under-hedging." [5]

The novelty here is that, so far, insurance securitization has been mostly limited to the development of indices of losses resulting from catastrophic or weather-related events. It is much more difficult to assess the exposure risk of an individual insurance company and to relate it to the insurance industry as a whole than to assess the price risk or interest risk of a specific bond and to compare it to that of a generic 6% coupon, 30 year Treasury bond issue.

Lack of Liquidity

Another element that has contributed to the slow growth of insurance securitization is the lack of liquidity in both the securities market and in the derivatives market. Secondary market trading volume in CAT bonds and other over-the-counter instruments is very low. The lack of liquidity in these markets can be attributed to a few factors. First, the "nature of the beast": to date, most of the insurance securitization efforts have targeted the catastrophe area. Although some catastrophe modeling companies firms (Applied Insurance Research, Risk Management Solutions or EQE) have specialized in attempting to relate catastrophic events simulations and their potential financial impact on an insurer's or reinsurer's book of business, it is a fact that most catastrophes, whether weather-related or man-made, are extremely difficult to predict. Consequently, an investor will experience difficulty in pricing any security with a payout triggered by a catastrophic loss. In contrast, it is much easier to price, trade, or invest in mortgage-backed securities or stock options, since these instruments have more predictable payoffs. In addition, low liquidity may be explained by the absence of a neutral trading environment truly open to anyone who wants to participate in this market. The CBOT suffered from a rigid membership structure that prohibited direct access to insurers and to some investors. In the over-the-counter market, only institutional investors have access to CAT bond offerings.

Unfavorable Regulatory Treatment

A final factor that may have contributed to the slow growth of insurance securitization is the fact that, so far, insurance linked derivatives or securities have not benefited from a regulatory and accounting treatment similar to that of traditional reinsurance. Although state regulators, notably in New York and Illinois, have seemed to favor proper accounting for indemnity-based insurance-linked securities, the jury is still out on how to

account for index-based insurance securities or derivatives. The NAIC has also started to tackle accounting issues related to weather derivatives.[6]

In conclusion, while, in theory capital market risk transfer instruments have the potential to provide additional capacity in catastrophe insurance or reinsurance, their growth has been hampered by factors inherent to the risk covered (disasters), low secondary market liquidity and external factors such as an unwelcoming regulatory framework. Whereas these factors also apply to terrorism risk is discussed below.

Implications for Terrorism Risk

What does the past experience with insurance-linked capital market instruments imply for terrorism risk? The past record of insurance securitization strongly suggests that new instruments must address the previously cited shortcomings: basis risk, the lack of sufficient market liquidity, and an unwelcoming regulatory framework.

Unfortunately, the nature of terrorism risk will likely accentuate the basis risk issue. The favorite terrorist targets are likely to be large "trophy buildings", major sports stadiums, high traffic bridges, and so forth. This implies that a company specializing in insuring small, strip shopping centers in mid-size cities may not effectively hedge if the underlying loss index only includes likely terrorist targets.

As a result, the extreme nature of basis risk may foster the development of instruments tied to customized loss exposures. Such lack of standardization would hamper secondary market trading liquidity.

All in all, the past record may not bode well for the development of insurance-linked capital market instruments directed to terrorist risk. The experience with instruments directed to natural catastrophes has not been stellar, and perhaps disappointing in the eyes of many observers. Moreover, the general nature of terrorist risk may accentuate the limiting factors of the existing natural-catastrophe instruments.

Capital Market Underwriting of Terrorist Risk: A Simulation Analysis

In this section, the authors present simulations of the risk/reward tradeoff faced by investors who may consider underwriting terrorism risk in search of profit. These simulations are based on a Capital Market Line methodology and are presented here as a simple exercise that highlights the range of premiums (or returns) required by capital market participants interested in providing synthetic terrorism coverage.

Risk-Reward Analysis

For capital markets to successfully underwrite terrorist risk, investors must be adequately compensated with returns for investing in insurance-linked securities. Adequate returns are possible when premiums charged for terrorism coverage are high enough to cover the potential insurance losses and still provide an adequate payment to investors. Nevertheless, the premiums cannot be so high as to make insurance synthetically provided by the capital markets prohibitively expensive.

Usually, the actual or realized one-period holding return rate, R, for any type of investment equals:

$$R = \frac{\text{Cash Flow to Investor}}{\text{Amount Invested}} - 1 \qquad (1)$$

For traditional financial securities, such as stocks or bonds, the amount invested is the upfront dollar cost of the investment (i.e. the current market price of bonds or of shares of stocks) and the future cash flows are dividends or interest payments and any capital appreciation (depreciation) in the value of the security.

In the case of insurance-linked securities, however, future cash flows are derived from insurance risk exposures rather than business and financial risk exposures. Assume that a private or public entity pools many terrorist risks and then "securitizes" that risk so that it may be transferred to capital market investors. This private entity can take various forms, from a reinsurance company that holds a diversified portfolio of terrorism-related insurance risks, to a state or federal insurance pool, or even a mutual fund that specializes in investments in terrorism risks. While the particular type of security or instrument issued by the entity is not specified, it is still possible to evaluate the risk-return characteristics of such investment. Finally, we assume that the investor compares the return of his investment in insurance risks with that of a diversified portfolio of stocks. In other words, in this simple model, we view holdings of insurance-linked securities as an alternative investment for investors. This stems from our earlier discussion which questions whether an investor can further diversify his investment portfolio by adding terrorism-linked securities.

The total amount invested by the entity issuing the insurance-linked security consists of the total premium charged to the insurer's customers or to the insurer itself (if the security is issued as a substitute to reinsurance), plus the capital (principal) paid by capital market investors to acquire shares or units of the security. This excess capital is collected to absorb potential claims in excess of the amount of premium charged.

The cash flows (CF) received by the investors in the insurance-linked security equal:

$$CF = P + I - C - L \qquad (2)$$

Where:
P = premium collected from the insurer or from the insurer's customer
I = interest paid on the insurance-linked security
C = underwriting and operating costs
L = paid claims ("Loss")

Note that the dollar amount of premium is a percent of the dollar amount of the risk exposure. For instance, if an entity writes an insurance policy with $10 million worth of risk exposure, a 3% premium translates into $300,000. The dollar amount of paid claims is also a percent of the dollar amount of the risk exposure. In addition, the interest received is based on the total amount of capital invested (i.e. premium charged plus capital provided by the investors). Also assume that the insurance-linked security is fully funded, i.e. that the sum of the premium collected plus the amount of capital invested in by capital market participants equal 100% of the underwritten risk exposure, E.

Therefore, the actual or realized one-period holding return rate R_{ins} on an insurance-linked investment equals:

$$R_{ins} = \frac{P + I - C - L}{E - P} - 1 \qquad (3)$$

Where E-P represents the principal invested by the investor in the security.

Clearly, as for any type of investment, there is a risk/return trade-off. Principally, the risk associated to insurance-linked investments is the uncertainty regarding actual paid loss. If premiums collected and interest earned are greater than operating costs and paid claims, the cash flow to insurance investors is positive and the rate of return is positive. However, if operating expenses and insurance claims overcome the premiums plus interest, the cash flow is negative and the rate of return is negative.

The lack of certainty related to loss claims means that, ex ante, the investor must require a rate of return on the insurance-linked security that must at least equal the required rate return of any optimal security portfolio composed of a combination of the risk-free financial security and a Markowitz efficient portfolio of risky financial securities, such as stocks or corporate bonds.

Call E (R_p) the expected return of the optimal financial security portfolio described above, and STD (R_p), the risk associated to this portfolio, measured by the standard deviation of its returns. Traditional capital market theory dictates that investors willing to accept higher risk in their portfolios should require a higher expected return. In other words:

$$E(R_p) = a + b * STD(R_p) \qquad (4)$$

Where a and b are parameters in this capital market line equation.

If the expected rate of return of the insurance-linked security E (R_{ins}) exceeds or is lower than the expected risk-required return rate on the optimal portfolio of financial securities, then:

$$E(R_{ins}) - E(R_p) = \alpha \quad (5)$$

where α represents the excess rate of return of the insurance-linked security over the optimal portfolio of financial securities. Given the probability distribution of possible insurance losses, the value of α will depend upon the amount of insurance premium collected-- high premiums collected would lead to a positive α , low premiums collected would lead to a negative α.

Efficient capital market theory dictates that α = 0, which indicates no arbitrage opportunities between both types of instruments. As a result, there is a unique premium (P) that generates "appropriate" returns to insurance-linked investments (assuming values for I, C, and L). In order to find the appropriate premium for terrorism insurance, we will use a trial and error method to simulate different premium levels until α becomes substantially close to zero.

Simulations

The simulations procedures are as follows:

- Since there is almost no historical record of terrorism losses, these have to be simulated. We developed ten hypothetical probability distributions for terrorism-induced property losses, which are formulated to simulate the returns to investors. These distributions are all lognormal, showing the possibility of large, unexpected losses. Lognormal distributions seem to model terrorism losses well, based on the assumption that from the terrorists' standpoint, the greater the loss, the more "successful" the terrorism act. As result, the loss severity distribution of terrorism losses should be skewed towards heavy losses. Appendix A shows the loss ratios and respective probabilities for each of the specified distributions. Note that the severity of loss risk diminishes in moving from Distribution 1 to Distribution 10.

- The probability distributions for losses easily translate into a probability distribution of expected returns to investors in insurance-linked securities. Using equation (3) above, we compute the return rate on insurance-linked securities for each loss outcome within a particular loss distribution assumed. To perform the calculation, we first make an *original* assumption for the premium charged (say, 3% of $10 million underwritten loss exposure or $300,000) and we make three sets of assumptions for interest I and cost C: a pessimistic assumption of low interest earned (2% of total amount invested) and high operating costs (40% of premiums), a middle-of-the-road approach assumption (interest equal to 4% of the total amount invested and operating costs of 30% of premiums), and an optimistic approach (interest equal to 6% of total amount invested and operating

costs of 20% of premiums). We can then compute the expected return rate E (R_{ins}) and the standard deviation of returns STD (R_{ins}) of the insurance-linked security for each loss distribution.

- We then compute the expected return for the optimal portfolio of financial securities E (R_p), by empirically estimating equation (4). The parameters *a* and *b* in equation (4) are estimated using historical annual return information from 1970 to 2002 using the Ibbotson-Inglefield database for an optimal portfolio of financial securities composed of U.S. Treasury bills and of stocks included in the S&P500 index. The required rate on return on the insurance-linked security E (R_{ins}) can then be computed for a risk level set to be equal to that of the optimal portfolio of financial securities.

- The final step is to find the premium level, P, which forces α to equal 0 in equation (5). We use a trial and error method with different assumptions of P, starting with P = 3% (as explained above) until a particular P is found to force α to 0. This algorithm expresses the appropriate premium as a percent of the dollar value of underwritten risk exposure.

Simulation Results

Tables 1, 2, and 3 in Appendix B present the premiums that the entity issuing the insurance-linked security must charge in order to offer the required return rate on the insurance investment, given the risk of the assumed loss distributions. These tables are derived using the methodology described above. Premiums are indicated as rate-on-line, that is, as the dollar cost of the insurance divided by the underwritten risk exposure. For instance, if one paid $100,000 to receive $10 million of protection in the value of the property insured, the premium expressed as rate-on-line would be 1%.

Each table reflects a different assumption regarding the interest rate earned and the costs of administering the capital market insurance function. (i.e., costs other than loss claims paid). Table 1 takes a pessimistic approach of a low interest rate earned (2%) and a high cost of administration (40% of premiums). Table 2 takes a middle-of-the-road approach, assuming interest at 4% and costs of 30% of premium. Table 3 takes an optimistic approach, assuming an interest rate of 6% and costs of 20% of premiums.

Each table shows the range of premiums that an entity securitizing terrorism risk must charge for covering the entire amount of property insured, based on the assumed loss distributions. The premium amounts can reach stunningly high levels, varying from 5% for the most benevolent assumption of losses and optimistic assumptions of interest earned and administrative costs (table 3, distribution 10), to 74% for the most malevolent assumption of losses and pessimistic assumptions of interest rates earned and administrative costs (table 1, distribution 1).

The premium charged can be very expensive because they include a risk load beyond the expected losses or paid claims. This risk load represents the percent return that must be

paid to the investor in insurance-linked securities. Given the nature of terrorism risk captured in the fat tails of the assumed lognormal distributions, the risk load imbedded in premiums charged is consequent. Table 4 in Appendix B, which uses premium numbers from table 2 (the middle-of-the-road approach) illustrates this point. The risk loads calculated as the excess premiums over the expected losses show that capital market investors would receive a very high risk premium for their underwriting services. While the above premiums charged by the capital market are high, the protection would likely be forthcoming if there are sufficient numbers of risk-seeking investors. At these high rates, the less risk-averse capital market investors would likely find it compelling to bear the risk. Nevertheless, in most cases, the premium cost is prohibitive. Only under the most benevolent assumptions of terrorism losses are premiums charged by the capital market reasonable. In conclusion, the simple simulations shown in this paper can not support the argument that the capital market provides a *complete* viable alternative to the insurance market in underwriting terrorism risk.

Outlook for Capital Markets and Terrorism Risk

The evidence gathered in this paper is not favorable in recommending that the capital market alone be enlisted to underwrite terrorist risk. First, the record with previous securitization of natural catastrophe risks does not support a successful capital market involvement. Unless capital market instruments may be developed to better hedge basis risk and provide more liquid trading, new instruments directed to terrorism protection will likely meet the same disappointing fate as the instruments designed for natural catastrophes.

The simple simulations shown above corroborate this point; risk transferors will pay a high price to buy terrorist coverage from the capital markets, because there is a significant premium attached to lack of predictability in terrorist losses. As a result, while capital markets may provide additional terrorist coverage capacity to private corporations and/or insurance companies, it will come at a high cost.

In addition, terrorism coverage is a longer tail business, compared to catastrophe coverage, which makes terrorism risk even harder to securitize than catastrophe risk. Insurance market participants generally assume that most claims resulting from a catastrophic event will be paid within twelve months following the event occurrence. Catastrophe-linked securities offered in the capital markets have been designed to compensate the issuer of the security within that time frame. On the other hand, terrorist attacks result in a high amount of liability and workers' compensation claims, which may take years to develop.

Finally, previous experience shows that institutional investors have been reluctant to invest in catastrophe-linked securities because of adverse selection and moral hazard issues. One way to mitigate similar problems with respect to terrorism coverage is for insurance companies to transfer all of their terrorist risk to a pool that would issue

securities with a payout linked to the pool's overall loss. Some countries, such as the United Kingdom and France, have already created terrorism insurance pools, but with governmental backing only. The role of capital markets as a partial guarantor of losses incurred by a pool along with the Federal Government needs to be investigated further.

Public/Private Initiatives to Finance Terrorism Risk

The decision by Congress to pass the Terrorism Insurance Act on November 25, 2002 underscores the extensive social costs associated to inadequate private insurance coverage. It also acknowledges that terrorist acts not only impact properties and people directly involved, but also the larger economy. In this context, government aid is not just a subsidy to insurance companies and their customers but also benefits society and the economy as a whole, so that the use of public dollars to support terrorist insurance may be justified. The Terrorism Insurance Act has a three-year sunset provision and the prospects of it being re-conducted are uncertain. Politicians are known to react to an immediate crisis, but not to hypothetical future situations. If no widespread terrorist event occurs in the next three years, the future of a Federal solution is in doubt. Now is the time to investigate public/private initiatives to finance terrorism risk.

Among new ideas developed is the auction of excess-of-loss reinsurance contracts. A similar initiative was considered in 1996-1997 for natural disasters, but fizzled away because of the Treasury Department's opposition to it.[7] Under the excess of loss reinsurance approach, the Federal government would set a reserve price above which it would sell excess-of-loss reinsurance contracts. The reserve price would be indexed to aggregate industry capital and auctioned in the public markets.

Another concept calls for the government to purchase contingent corporate "catastrophe" bonds issued by the insurance industry. While this idea has merits, the contingent offering could be expanded to individual investors.

The authors of this report envision an alternative solution in which insurance and reinsurance companies could transfer all their commercial terrorism policies to a pool (either state or national), which would issue securities to private investors. This idea will be the topic of a subsequent paper, but it can be summarized as follows: the securities issued would have a payout linked to the pool's loss experience (possibly measured in loss ratio terms) up to a maximum amount (say $40 billion worth of losses). The federal government would become the guarantor of last resort above this threshold.

The securities would have to be issued in small denomination to become attractive not only to large institutional investors but also to retail investors. Bouriaux and Russell [2002] have argued that insurance-linked securities issued in small denomination and possibly traded on an established exchange (for instance, the American Stock Exchange) might attract individual investors. Terrorism-linked securities could also be marketed to the small investor as a "charity" or "war" investment and might become popular as an

alternative to donations because they would have an upside yield potential if no terrorism event occurs. Non-taxability of income received from owning such securities could also boost their attractiveness to investors.

Alternative solutions to direct capital market participation to terrorism risk should be investigated, such as joint public/private initiatives in the vein of the proposed National Disaster Insurance bill introduced in the House of Representatives in 1997, or creations of insurance pools to which U.S. based insurance and reinsurance companies could transfer all their commercial terrorism policies. Such pools already exist in England and in France. These solutions could form the core of a subsequent research paper.

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APPENDIX A
Simulated Lognormal Distributions for Terrorism Risk

Loss probabilities for each simulated distribution (1 to 10)

Loss (% of Exposure)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0.02	0.1	0.1	0.25	0.35	0.5	0.6	0.7	0.9	0.97
0.1	0.05	0.2	0.27	0.18	0.16	0.2	0.2	0.15	0.03	0.01
0.2	0.25	0.25	0.22	0.14	0.11	0.1	0.09	0.06	0.015	0.0006
0.3	0.35	0.2	0.12	0.11	0.09	0.05	0.05	0.03	0.008	0.0006
0.4	0.1	0.1	0.07	0.09	0.075	0.03	0.03	0.019	0.008	0.005
0.5	0.06	0.06	0.05	0.065	0.06	0.02	0.02	0.011	0.007	0.004
0.6	0.04	0.04	0.04	0.05	0.05	0.02	0.02	0.01	0.007	0.003
0.7	0.035	0.025	0.037	0.04	0.04	0.02	0.02	0.005	0.006	0.002
0.8	0.03	0.0125	0.034	0.03	0.03	0.02	0.02	0.005	0.006	0.001
0.9	0.03	0.0065	0.0299	0.025	0.02	0.02	0.02	0.005	0.006	0.0007
1	0.03	0.006	0.0289	0.02	0.015	0.02	0.02	0.005	0.006	0

APPENDIX B

Table 1
Premiums (in % of total risk exposure) on Terrorism-linked Securities
(Pessimistic Assumptions)

Distribution	1	2	3	4	5	6	7	8	9	10
Premiums	74%	57%	65%	63%	58%	44%	40%	26%	21%	11%

Table 2
Premiums (in % of total risk exposure) on Terrorism-linked Securities
(Middle-of-the Road-Assumptions)

Distribution	1	2	3	4	5	6	7	8	9	10
Premiums	62%	47%	54%	52%	47%	36%	32%	20%	15%	8%

Table 3
Premiums (in % of total risk exposure) on Terrorism-linked Securities
(Optimistic Assumptions)

Distribution	1	2	3	4	5	6	7	8	9	10
Premiums	52%	39%	45%	43%	40%	29%	26%	15%	12%	5%

Table 4
Expected Value of Losses and Risk Loads by Loss Distributions

Distribution	Premium % (1)	Expected Value of Loss % (2)	Risk Load (1) – (2)
1	**62%**	**36%**	**26%**
2	**47%**	**26%**	**21%**
3	**54%**	**29%**	**25%**
4	**52%**	**27%**	**25%**
5	**47%**	**24%**	**23%**
6	**36%**	**16%**	**20%**
7	**32%**	**15%**	**17%**
8	**20%**	**7%**	**13%**
9	**15%**	**4%**	**11%**
10	**8%**	**1%**	**7%**

[1] Note, however that, after the occurrences of hurricane Andrew in 1992 and of the Loma Priora earthquake in 1994, some states had to intervene to provide additional catastrophe coverage to the general public. California created the California Earthquake Authority (CEA), and Florida forced insurance companies to create an insurance pool backed by a state guarantee.

[2]Examples of studies that show the risk diversification benefits of insurance-linked securities include Froot [1995] and Litzenberger [1996].

[3] See, for instance, Canter, Cole and Sandor [1997], ISO [1999] and Swiss Re. [1997]

[4] See, for instance, Majors [1996], and Harrington and Niehaus [1999]

[5] The terms "over-hedging" and "under-hedging" refer to the process of transacting a higher or lower number of derivative contracts than the number that would be necessary for a company to perfectly hedge its exposure. Over-hedging and under-hedging examples using catastrophe insurance options can be found in the CBOT PCS catastrophe Options User's guide [1995, page 35-36]

[6] A detailed discussion of the topic is beyond the scope of this paper. An overview and discussion of the regulatory and accounting treatment of insurance-linked instruments can be found in Bouriaux [2001]

[7] See for instance Lewis and Murdock [1996]