Should the Government Provide Insurance for Catastrophes?

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1. Introduction

The frequency and severity of natural and man-made catastrophes have increased significantly in recent years. Natural catastrophes include events such as hurricanes, earthquakes, floods, and tsunamis; and man-made disasters include oil platform explosions, aviation disasters, and terrorism. As shown in more detail below, prior to 1988, the number of catastrophes rarely exceeded 150 per year, but since 1994, there have been at least 330 catastrophes per year.[1] Of the forty most costly disasters since 1970, 33 have occurred since 1990, and 15 have occurred since 2000, based on price-adjusted data. Hurricane Katrina, which made landfall on September 8, 2005, will be the most costly catastrophic event in history, with projected losses in the range of $40 to $60 billion. The most costly man-made disaster was the September 11, 2001 terrorist attack on the World Trade Center (WTC) in New York, resulting in about $40 billion in insured losses.

The increasing costs of catastrophes have significantly stressed insurance markets. Insurance works best for high frequency, low severity events which are statistically independent and have probability distributions that are reasonably stationary over time. Catastrophic events, and particularly mega-catastrophes such as Katrina and the WTC terrorist attack, violate to some degree nearly all of the standard conditions for insurability. These are low frequency, high severity events and by definition violate statistical independence by affecting many insured exposures at one time. Although considerable progress has been made in modeling natural catastrophes, utilizing both statistical and scientific models, statistical methods are of little use in evaluating losses from

[1]These figures are from Swiss Re (2005). Swiss Re defines a catastrophe as an event that causes a minimal amount of monetary loss or loss of life. In 2005, the monetary threshold for an event to be defined as a catastrophe is $74.9. The monetary threshold is adjusted over time so that the catastrophe count is consistent across years.

terrorism, given that terrorists are continually modifying their strategies and tactics.

Insurance markets tend to respond adversely to mega-catastrophes. Insurers respond to large events, particularly those that cause them to reevaluate their estimates of the probability and severity of loss, by restricting the supply of insurance and raising the price of the limited coverage that is made available. This occurred, for example, following Hurricane Andrew in 1992 and the Northridge earthquake in 1994 and occurred again following the WTC terrorist attacks. Because insurance plays an important role in the economy, instability in the availability and price of coverage generally leads to pressure for government intervention in insurance markets. State governments intervened in Florida and California following Andrew and Northridge, and the widespread availability of windstorm coverage in Florida and earthquake coverage in California seems to be largely attributable to government intervention. The Federal government entered the market for terrorism insurance as reinsurer of last resort through the Terrorism Risk Insurance Act of 2002 (TRIA). Governments in several other industrialized nations, including France, Germany, Spain, and the United Kingdom also have intervened in catastrophe insurance markets.

The objective of this paper is to evaluate the appropriateness of government intervention in catastrophe insurance markets with a particular focus on mega-catastrophes, both natural and man-made. The paper begins with a statistical overview of the recent history of catastrophes and then turns to a discussion of the insurability of such events through the private sector, considering the theoretical criteria usually associated with insurable events. The resources of the U.S. insurance industry and the global reinsurance industry are then evaluated to provide perspective on the insurability of large catastrophes. The last major section of the paper evaluates potential public and private sector solutions to the catastrophe insurance problem, considering alternative risk financing mechanisms such as catastrophe bonds as well as the most promising models for governmental

involvement. The discussion includes an evaluation of the effectiveness of TRIA and the likely effect of renewing or sun setting TRIA on the market for terrorism insurance.

2. Catastrophes: The Recent History

The number of natural and man-made catastrophes since 1970 are shown in Figure 1. The figure indicates clear upward trend in the number of catastrophes; and a linear trend line fitted to the total number of catastrophes has an adjusted R^2 of 0.88. There seems to be a pronounced shift in the data approximately in 1988 and another shift in 1994. Although scientists have not reached consensus on whether the frequency of natural catastrophes such as hurricanes has been increasing, the major reason for the increasing number of catastrophes is the accumulation of property values in disaster prone areas such as California, Florida, the Gulf Coast, and, increasingly, Asia.

The value of insured catastrophic losses from natural and man-made events, adjusted to 2004 price levels, is shown in Figure 2. Because catastrophic events also cause significant losses to uninsured property such as highways, sewer systems, and other infra-structure components, the total value of losses from such events is higher than Figure 2 suggests. However, the insured losses are relevant in evaluating the insurability of such events. Figure 2 shows that, except for the WTC event in 2001, natural disasters cause more insured losses than man-made events. However, the WTC event illustrates that terrorism has added a significant source of volatility that was not previously present. The severity data also show a shift in the late 1980s/early 1990s. Prior to 1988, total insured catastrophe losses never exceeded $10 billion per year, but after 1989, losses have been less than $10 billion in only one year and have exceeded $20 billion in ten of fifteen years. The worst loss year shown is 2004, when losses totaled $49 billion; and 2005 will be even worse due to Hurricanes Katrina and Rita.

The top forty insured catastrophe losses since 1970 are shown in Table 1. Thirty-three of

the top forty losses have occurred since 1990, and fifteen have occurred since 2000. All but three of the top forty losses are from natural catastrophes, and the losses from the WTC terrorist attack are roughly six times the largest previous man-made catastrophe, the explosion and fire on the Piper Alpha oil platform in 1988. The table also shows that the U.S. is the primary source of large catastrophe losses worldwide. In 2004, for example, 67.7 percent of worldwide insured catastrophe losses were from North American, primarily U.S., events (Swiss Re 2005).

Figure 3 places the catastrophe losses in a broader perspective by showing total insured catastrophe losses as percentages of World and U.S. GDP. In relation to World GDP, catastrophe losses were less than 0.05 of 1 percent until the late 1980s and have fluctuated around 0.10 of 1 percent in more recent years. In comparison to U.S. GDP, catastrophe losses were less than 0.20 of 1 percent until the late 1980s and have been above 0.30 of 1 percent in several years since 1990. There is a significant upward trend in both series, with adjusted R^2 values of around 0.35 in linear time trend regressions. An important implication of Figure 3, is that catastrophe losses are large and volatile from the perspective of the insurance industry but are more manageable from an economy-wide or societal perspective.

3. The Insurability of Catastrophe Losses

This section evaluates the insurability of catastrophe losses. The section begins with a discussion of the theoretical criteria for insurability and an analysis of the differences between natural and unintentional man-made catastrophes, on the one hand, and intentional events such as terrorism, on the other. The section concludes with an evaluation of the resources of the insurance and global reinsurance industries and an economic evaluation of the insurance crises anc cycles.

Criteria for Insurability

Individuals are averse to pure risk and are willing to pay amounts greater than the expected

value of losses in return for transferring risk to an insurer.[2] Most businesses, also have a demand for risk transfer, and, like consumers, are willing to pay more than the expected loss in order to transfer risk to another party. The amounts greater than expected losses that individuals and businesses are willing to pay for to transfer risk give rise to gains from trade that motivate the development of the insurance and reinsurance industries.

The role of the insurer is to serve as the recipient of pure risk from individuals and businesses and to diversify risk by pooling the losses of many policyholders. The statistical foundation of insurance is the *law of large numbers*. The role of insurers can be elucidated by specifying a simple statistical model of a risk pool. Let $X_1, \ldots, X_N$ be a random sample from a probability distribution with finite mean μ and variance σ^2. X_i can be conceptualized as the loss suffered by the ith policyholder in a risk pool. It is helpful to assume that the X_i are identically normally distributed, although they are not necessarily independent.[3] The law of large numbers then states that:

$$\lim_{N \to \infty} Pr[|\bar{X} - \mu| < \epsilon] = 1 \qquad \textbf{(1)}$$

where $\bar{X} = \Sigma_i \frac{X_i}{N}$ = the sample mean based on a realization of losses from the N policies and ϵ is an arbitrarily small number. Intuitively, the law of large numbers says that the sample mean becomes arbitrarily close to the population mean as the sample size increases. Thus, the insurer's loss is highly predictable in a sufficiently large sample.

With the normality assumption, we can use the central limit theorem to specify the amount of equity capital needed by the insurer. We assume that insurers hold equity capital to achieve a

[2]This discussion is based in part on analysis in Cummins and Weiss (2000).

[3]The law of large numbers does not require normality. Normality is assumed here because it provides a convenient explanation of the role of equity capital in the insurance market.

specified insolvency probability, ϵ. Insolvency probabilities are not driven to zero because holding capital in an insurance company is costly due to double taxation of dividends, agency costs, regulatory costs, accounting rules, and other factors (Jaffee and Russell 1997). The central limit theorem specifies that the following variable approaches normality as the sample size increases:

$$z = \frac{\sum_{i=1}^{N} X_i - N\mu}{\sigma_N} \tag{2}$$

The parameter σ_N^2 = the insurer's loss portfolio variance, is defined as:

$$\sigma_N^2 = \sum_{i=1}^{N} \sigma_i^2 + 2 \sum_{j=2}^{N} \sum_{i=1}^{j-1} \sigma_{ij} \tag{3}$$

where $\sigma_{ij} = \mathrm{Cov}(X_i, X_j)$. The normal distribution implies that:

$$Pr\left[\frac{\sum_{i=1}^{N} X_i - N\mu}{\sigma_N} < z_\epsilon\right] = 1 - \epsilon \tag{4}$$

where z is the standard normal variate and z_ϵ is the value from the standard normal distribution such that $Pr[\, z < z_\epsilon \,] = 1-\epsilon$. The amount of equity capital needed to achieve a target insolvency probability of ϵ is $z_\epsilon \sigma_N$, assuming that policyholder premiums cover the expected loss, $N\mu$.

The standard normal result for equity capital can be used to illustrate the effects of pooling. Assume that the N risks in the portfolio are statistically independent, so that all of the covariances in equation (3) are zero. Then equity capital per policy is

$$\frac{z_\epsilon \sigma_N}{N} = \frac{z_\epsilon \sigma}{\sqrt{N}} \tag{5}$$

Thus, equity capital per policy goes to zero as N goes to infinity, implying that large insurers

insuring independent risks with reasonably small standard deviations can charge a premium very close to the expected value of loss.[4] We call insurance markets with independent risks, moderate standard deviations per risk, and large N **locally insurable**. The U.S. market for personal automobile insurance is an example of a locally insurable market.

The motivation for reinsurance becomes apparent when we relax the assumptions under which risks are locally insurable. For example, reinsurance markets are likely to be required for risks with large standard deviations and small N, even if we maintain for the moment the assumption that risks are independent. Further motivation for the development of reinsurance markets is provided by relaxing the assumption that risks are statistically independent. If risks are dependent, the amount of equity capital needed per risk to achieve a given insolvency target becomes:

$$\frac{z_\epsilon \sigma_N}{N} = z_\epsilon \frac{\sqrt{N\sigma + N(N-1)\bar{\sigma}_{ij}}}{N} \qquad \textbf{(6)}$$

where $\bar{\sigma}_{ij}$ is the average covariance among the N risks. It is easy to see that the amount of equity capital needed per policy approaches $z_\epsilon \sqrt{\bar{\sigma}_{ij}}$ as $N \to \infty$. If the average covariance is small, the risks may still be locally insurable, but the market outcome is inefficient in the sense that the risk charge per policy has not been reduced to approximately zero.

However, risks that are locally dependent may be globally independent, e.g., the risk of tornadoes in the American Mid-West versus Australia. This provides an economic motivation for reinsurance markets because insurers can reduce their prices relative to competitors by ceding the covariance risk to a reinsurer who can pool the risk with independent risks from other regions of the world. We call risks that are globally diversifiable through reinsurance **globally insurable**.

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[4]Notice, however, that this does not imply that large insurers need no equity capital. The equity capital needed to achieve a target ruin probability of ϵ with independent risks is $z_\epsilon \sigma \sqrt{N}$, which approaches infinity as N goes to infinity.

Implicit in this discussion are some additional criteria for insurability. One important criterion is that N be sufficiently large for the law of large numbers to operate such that the insurer achieves effective diversification either locally or globally. Also important is that σ and $\bar{\sigma}_{ij}$ (if the latter is non-zero) be sufficiently "small," again to ensure that effective diversification takes place. If N is too small or σ and $\bar{\sigma}_{ij}$ too large, then the amount of capital the insurer must hold in order to achieve a sufficiently small insolvency probability may be too large for insurance to be feasible. Essentially, the cost of capital may push the price of insurance above the level that buyers are willing to pay for coverage, eliminating the gains from trade.

Another important implicit assumption is that sufficient data be available to enable the insurer to estimate the parameters of the loss distribution, μ and σ, and the covariances among risks, σ_{ij}, if the risks are not independent. This is a non-trivial requirement, given that real-world risks are not identically distributed such that applicants for insurance have heterogeneous μ and σ parameters. It is well-known that insurance markets can break down due to adverse selection if the insurer is not able to discriminate among risks (Rothschild and Stiglitz 1976). A final requirement is that the loss distribution should be reasonably stationary in the sense that parameters estimated from past data are reasonably good predictors of next period's loss distribution. If the loss distribution is shifting significantly during short periods of time such as one or two years, the insurer will be unable to estimate premiums or the required amount of equity capital, and insurability will break down.

The violation of any of the principal insurability conditions may create situations where risks are neither locally nor globally insurable. However, if other conditions are satisfied, such risks may be **globally diversifiable** through capital markets. Consider the example of events with low frequency and very high severity, where the covariances among the individual risks making up a portfolio are also relatively high. Examples of such risks are unusually severe hurricanes and

earthquakes striking geographical regions with high concentrations of property values. For example, modelers have estimated that a $100 billion event in Florida or California has a probability of occurrence in the range of one in one hundred (i.e., a "return period" of 100 years). The capacity of the insurance and reinsurance industries may be inadequate insure such events.

However, events of this magnitude are small relative to the market capitalization of securities markets. Thus, by introducing securitized financial instruments representing insurance risk, catastrophic events in the $100 billion range are diversifiable across the financial markets, even though they may not be diversifiable in global insurance and reinsurance markets. Such events also have relatively low correlations with securities returns, effectively providing an attractive source of diversification for investors. Securitization extends the scope of diversification from insurance and reinsurance markets to the entire securities market, thus breaking down the problem of small N, large σ's, and intra-insurance market correlations, in much the same way as reinsurance can reduce or eliminate the problem of non-insurability on the local level. Diversifying insurance-linked risk across the securities market provides the motivation for catastrophe (CAT) bonds, which are discussed in more detail below.

The final category of risks consists of events that are so severe that they may not be globally diversifiable even through securities markets. It has been estimated that a severe earthquake in Tokyo could cause losses in the range of $2.1 to $3.3 trillion, constituting from 44 to 70 percent of the GDP of Japan (Risk Management Solutions 1995). While it is possible that global securities markets could absorb a significant fraction of such a loss, the full loss is unlikely to be fully diversifiable. I call such events **cataclysmic** or **globally undiversifiable**.

Losses from mega-terrorism events may also fall into the globally undiversifiable category. Such losses are similar in many ways to losses arising from war, which are generally not amenable

to private market insurance or diversification solutions. In addition to sharing the problems of small N and large μ and σ with mega-losses from natural hazards, terrorism losses also pose the problem of being very difficult to estimate. Modelers have made significant progress in estimating losses from natural hazards. Modeling firms such as Applied Insurance Research, Equicat, and Risk Management Solutions have developed highly sophisticated models of natural hazard losses based upon both statistical data and scientific models of hurricanes and earthquakes. The models have been parameterized using detailed mappings of exposures across the U.S. and in other major countries. The hurricane and earthquake perils are sufficiently stable in a statistical sense to give modelers confidence in the ability of their ability to predict the frequency and severity of future events and to enable insurers to use the models to manage their exposure to catastrophic risk.

Terrorism events are inherently much more difficult to estimate than natural catastrophes. Little statistical data exists that can be used to estimate the parameters of loss distributions. Data on terrorism activities obtained by the government are confidential for national security reasons and hence not available to insurers to assist in estimating premiums and loss exposure. Moreover, terrorists constantly change strategies and tactics, making any predictions from past data inherently unreliable. Terrorists are likely to engage in "target substitution," shifting their attention to targets that receive the least amount of security. Although some progress has been made in modeling the severity of mega-terrorism events, based on scientific knowledge about the effects of nuclear and conventional explosions and biological and radiation hazards, little information exists that can assist insurers in estimating the probability of terrorism losses. The possibility that terrorists could use weapons of mass destruction raises potential losses from mega-terrorism to levels far exceeding the potential losses from even the largest natural catastrophes.

Another major difference between terrorism and other types of catastrophes is that the

frequency and severity of terrorist attacks are significantly affected by U.S. governmental policy. U.S. foreign policy directly impacts the motivation and likelihood of terrorist attacks from different militant factions. U.S. domestic policy and the success of governmental homeland security programs also affects the mitigation of terrorist attacks – both in preventing such attacks and mitigating the magnitude of any attack that does occur. Moreover, much of the information required to predict terrorist events is likely to remain highly classified and unavailable to those outside of agencies such as the FBI and CIA. In fact, one of the arguments proffered in support of a federal role in the provision of terrorism insurance was that terrorism events represent a negative externality of the national security policies of the sovereign government. Thus, there are significant reasons to believe that government may have to be the insurer of last resort, at least for mega-terrorism events.

Insurance Industry Resources, Cycles, and Crises

As mentioned, insurance works best for high frequency, low severity, relatively stationary, independent events with good data such as automobile accidents. For such events, insurers can accurately estimate premiums and the amounts of equity capital that must be held in order to reduce insolvency probabilities to acceptable levels. Even for larger, less frequent, more risky events such as commercial liability lawsuits, insurance can also be effective most of the time. However, there are significant questions about the ability of the insurance industry to deal with the largest catastrophic events. For various reasons, it is infeasible and inefficient for the industry to hold sufficient capital to finance losses arising from very high severity, low frequency events (Jaffee and Russell 1997). This section provides an overview of the resources of the U.S. property-casualty insurance industry and the global reinsurance industry to gauge the industry's capability to sustain losses from mega-catastrophes.

The total resources of the U.S. property-casualty insurance industry are shown in Figure 4.

In 2004, the industry held about $400 billion in equity capital and collected premiums of about $440 billion. Although this might seem to be more than enough to withstand a catastrophic loss of $100 billion, in fact most of the premiums represent expected loss payments for lines such as automobile insurance, commercial liability, and workers' compensation insurance. The amount collected for homeowners insurance, the line most exposed to natural disasters, is only about 12 percent of the total. Moreover, the $400 billion in equity capital represents the total amount held by insurers writing all lines of business in all states. Only a fraction of the total would be available to pay catastrophe losses in high exposure states such as California and Florida because insurers not writing business with catastrophe exposure in those states could not be called upon to pay claims.

Cummins, Doherty, and Lo (1999) investigated the capacity of the U.S. property-casualty insurance industry to respond to large catastrophic events during the late 1990s. They considered the aggregate resources of the industry nationwide and also the resources of insurers writing business in the catastrophe-prone state of Florida as well as the correlation of losses among companies, another factor in determining the capacity to respond to catastrophic events. The results indicated that the industry could pay more than 90 percent of the losses from a $100 billion loss event. However, a loss of this magnitude would have caused the failure of approximate 140 insurance companies. This would be by far the largest failure rate in the post-1900 history of the U.S. property-casualty industry and would significantly destabilize insurance markets.

The aggregate equity capital of the global reinsurance industry is shown in Figure 5. The figure indicates that equity capital increased significantly in 2003, from about $250 billion to roughly $340 billion. The capital numbers are somewhat misleading, however, because they represent the total equity capital of companies writing reinsurance. There are many companies participating in this market, such as ING, AIG, and AXA, that also write significant amounts of

coverage in the primary insurance market. Hence, the equity capital for most companies supports both their primary insurance and reinsurance obligations. In addition, as in the U.S. insurance market, most of the equity capital is committed to support coverage in high frequency lines of business. The premiums of global reinsurers were about $164 billion in 2003 (Standard & Poor's 2004). Unlike the equity capital figures, the premium numbers are indicative of business written in the reinsurance market. However, most of the premium total represents funds collected for high frequency lines of business. To put the equity capital totals in perspective, Figure 5 also shows the ratio of worldwide catastrophe losses, based on Swiss Re (2005), as a ratio to the equity capital of global reinsurers. CAT losses can amount to a significant proportion of equity capital, reaching approximately 16 percent in 1999 and 2003.

Insurance markets are subject to cycles and crises which can be triggered by shifts in the frequency and severity of losses in high frequency lines of business as well as investment losses and catastrophes. The underwriting cycle refers to the tendency of property-casualty insurance markets to go through alternating phases of "hard" and "soft" markets. In a hard market, the supply of coverage is restricted and prices are rise; whereas in a soft market, coverage supply is plentiful and prices decline. The consensus in the economics literature is that hard and soft markets are driven by capital market and insurance market imperfections such that capital does not flow freely into and out of the industry in response to unusual loss events (Winter 1994, Cummins and Danzon 1997, Cummins and Doherty 2002). Informational asymmetries between capital providers and insurer management about exposure levels and reserve adequacy results in high costs of capital during hard markets, such that capital shortages can develop. Insurers are reluctant to pay out retained earnings during soft markets because of the difficulty of raising capital again when the market enters the next hard market phase, leading to excess capacity and downward pressure on prices.

Hard markets are usually triggered by capital depletions resulting from underwriting or investment losses. The three most prominent hard market period since 1980 resulted from the commercial liability insurance crisis of the 1980s, the catastrophe losses due to Hurricane Andrew in 1992 and the Northridge earthquake in 1994, and the WTC terrorist attack of 2001. The 1980s liability crisis was triggered by an unexpected increase in the frequency and severity of commercial liability claims accompanied by a sharp decline in interest rates in the early 1980s, and the catastrophe and terrorist crises were driven by catastrophic losses of unexpected magnitude. Each crisis not only depleted insurer capital but caused insurers to reevaluate probability of loss distributions and to reassess their exposure management and pricing practices.

The U.S. property-casualty insurance underwriting cycle is shown in Figure 6. The figure plots two important operating ratios for the industry – the *underwriting profit ratio* and the difference between the *overall operating ratio* and 100. The underwriting profit ratio is the difference between 100 and the industry combined ratio, which is the sum of the loss ratio (losses incurred divided by premiums) and the expense ratio (operating expenses divided by premiums). If the combined ratio exceeds 100 percent, the industry is paying out more in losses and expenses than it is taking in premiums, i.e., it is incurring an underwriting loss; and if the ratio is less than 100 percent, the industry is making an underwriting profit. The combined ratio is a useful indicator of performance, but it is not a very good indicator of overall profitability because it does not consider investment income. The overall operating ratio corrects for investment income by subtracting the ratio of investment income to premiums from the combined ratio. If the overall operating ratio is less than 100, the implication is that insurers are making profits when both underwriting and investment results are considered, and if the ratio exceeds 100, insurers are realizing overall losses.

Figure 6 reveals the impact of the impact of the liability crisis of the mid-1980s and the

catastrophe crises of 1992-1994 and 2001. The underwriting loss in 1984 was about 18 percent of premiums, and the overall operating ratio indicated a net loss of about 7 percent of premiums in that year due to liability claims. In 1992, the underwriting loss, mainly due to Andrew, was 15 percent and the overall operating ratio showed an overall loss of about 4 percent of premiums. The underwriting loss due to the WTC attack was also about 15 percent of premiums and the overall operating loss was about 6.5 percent. With losses of this magnitude and volatility, it is not surprising that insurers restricted supply and raised prices following these events.[5]

Another indicator of recent underwriting cycle activity in the U.S. is provided by survey data collected by the Council of Insurance Agents and Brokers. The Council conducts a quarterly survey of its members to determine the changes in commercial lines insurance prices, based on policies renewing in each quarter. The average rate changes from 1999 through 2005 are shown in Figure 7. The figure shows that prices had been increasing significantly even before September of 2001, and the prices in umbrella liability insurance and commercial property spiked after 9/11. However, beginning in early 2002, commercial insurance prices began to decline sharply, reflecting a softening of the market due to inflows of new capital and improving underwriting profitability.

The underwriting cycle interacts with the level of capitalization in the industry. A relative measure of the capitalization is provided by the *premiums-to-surplus ratio*, the most widely-used measure of leverage for this industry.[6] The premiums-to-surplus ratio since 1980 is graphed in Figure 8. The ratio was about 1.5 in the early 1980s and then declined steadily to less than 0.7 in

[5]It is also noteworthy that the underwriting profit ratio is negative most of the time. This is an expected result in terms of insurance financial pricing theory. Premiums reflect the expected discounted value of claims and operating expenses whereas losses and expense are reported at undiscounted values. Hence, even under normal circumstances, an underwriting loss is the expected outcome.

[6]Surplus or policyholders' surplus is the industry's terminology for equity capital.

1999, before increasing again due to the hard market and 9/11 claims in the early 2000s. The sharp decline during the 1990s has been attributed to over-capitalization in the industry as well as to the need for additional capital due to increases in the volatility of losses, particularly in liability insurance and property catastrophe lines of business (Cummins and Nini 2002). A deterioration in the premiums-to-surplus ratio is often associated with the onset of a hard market phase of the cycle.

Because profitability in reinsurance markets mirrors the results in primary insurance markets and because underwriting cycles also exist in most other industrialized countries, the global reinsurance market is also subject to underwriting cycles. The cycle in the worldwide catastrophe reinsurance market is shown in Figure 9, which plots the *rate on line* index in this market. The rate on line is a price measure that is obtained as the ratio of the premium for a reinsurance policy divided by the maximum possible payout under the policy. The rate on line index increased from just over 100 in 1991 to approximately 375 in 1993, due to losses from Hurricane Andrew, which cost about $20 billion in 2004 dollars. The rate on line then declined steadily until 1999 and increased sharply following the WTC attacks and a general hardening of insurance markets into the early 2000s. The decline after Andrew reflected improvements in catastrophe modeling and exposure management in the industry as well as significant inflows of new equity capital, particularly into new and pre-existing insurers located in Bermuda.

Further evidence of the reinsurance underwriting cycle is shown in Figure 10, which plots the combined ratio and return on revenue ratio for the global non-life insurance industry. The combined ratio spiked at about 115 in 1992 and again at nearly 130 in 2001; and the return on revenue, which also reflects investment earnings, tends to be the reverse mirror image of the combined ratio. The losses incurred during crisis periods lead reinsurers to raise prices and restrict supply while they recapitalize and reevaluate pricing and exposure management strategies.

The existence of cycles and crises implies that the insurance industry goes through periods when risk-bearing capacity is limited. Although usually triggered by high volatility lines of business such as commercial liability and property catastrophe coverages, the effects of a hard market extend to all lines of business including generally predictable lines such as automobile insurance and workers' compensation. Thus, capacity shortages can occur even in high frequency, low severity lines of business, emphasizing the difficulty faced by the industry in consistently providing capacity for low frequency, high severity losses.

4. Public and Private Sector Solutions to Financing Catastrophic Risk

This section discusses public and private sector solutions to financing the risks of natural catastrophes and terrorism. The section begins with a discussion of catastrophic risk (CAT) bonds, an innovative approach to securitizing catastrophe risk. The discussion then turns to an evaluation of public sector solutions to the catastrophic risk problem. The discussion begins by reviewing public sector mechanisms currently in place in the U.S. and other industrialized nations. The section concludes with an evaluation of the Terrorism Risk Insurance Act of 2002 (TRIA) and recommendations regarding the need for governmental involvement in the future.

Catastrophic Risk (CAT) Bonds

Following Hurricane Andrew in 1992, efforts began to access securities markets directly as a mechanism for financing future catastrophic events. The first contracts were launched by the Chicago Board of Trade (CBOT), which introduced catastrophe futures in 1992 and later introduced catastrophe put and call options. The options were based on aggregate catastrophe loss indices compiled by Property Claims Services, an insurance industry statistical agent. Contracts were available based on a national index, five regional indices, and three state indices, for California, Florida, and Texas. The contracts were later withdrawn due to lack of trading volume. Insurers had

little interest in the contracts for various reasons, including the thinness of the market, possible counterparty risk on the occurrence of a major catastrophe, and the potential for disrupting long-term relationships with reinsurers. Another concern was that the contracts were subject to excessive basis risk, i.e., the risk that payoffs under the contracts would be insufficiently correlated with insurer losses. A study by Cummins, Lalonde, and Phillips (2004) confirms that basis risk was a legitimate concern. They found that most insurers could not hedge their exposure to Florida hurricane risk very effectively using contracts based on a statewide index but that all but the smallest insurers could hedge effectively using four intra-Florida regional indices.

Another early attempt at securitization were contingent notes known as "Act of God" bonds. In 1995, Nationwide issued $400 million in contingent notes through a special trust – Nationwide Contingent Surplus Note (CSN) Trust. Proceeds from the sale of the bonds were invested in 10-year Treasury securities, and investors were provided with a coupon payment equal to 220 basis points over Treasuries. Embedded in these contingent capital notes was a "substitutability" option for Nationwide. Given a pre-specified event that depleted Nationwide's equity capital, Nationwide could substitute up to $400 million of surplus notes for the Treasuries in the Trust at any time during a 10-year period for any "business reason," with the surplus notes carrying a coupon of 9.22 percent.[7] Although two other insurers issued similar notes, this type of structure did not achieve a significant segregation of Nationwide's liabilities, leaving investors exposed to the general business risk of the insurer and to the risk that Nationwide might default on the notes.

The structure that has achieved a greater degree of success is the catastrophic risk (CAT) bond. CAT bonds were modeled on asset-backed-security transactions that have been executed for

[7]Surplus notes are debt securities issued by mutual insurance companies that regulators treat as equity capital for statutory accounting purposes. The issuance of such notes requires regulatory approval.

a wide variety of financial assets including mortgage loans, automobile loans, aircraft leases, and student loans. The first successful CAT bond was an $85 million issue by Hannover Re in 1994 (Swiss Re 2001). The first CAT bond issued by a non-financial firm, occurring in 1999, covered earthquake losses in the Tokyo region for Oriental Land Company, the owner of Tokyo Disneyland.

A CAT bond structure is shown in Figure 11. The transaction begins with the formation of a single purpose reinsurer (SPR). The SPR issues bonds to investors and invests the proceeds in safe securities such as Treasury bonds. Embedded in the bonds is a call option that is triggered by a defined catastrophic event. On the occurrence of the event, proceeds are released from the SPV to help the insurer pay claims arising from the event. In most bonds issued to date, the principal is fully at risk, i.e., if the contingent event is sufficiently large, the investors could lose the entire principal in the SPV. In return for the option, the insurer pays a premium to the investors. The fixed returns on the Treasuries are usually swapped for floating returns based on LIBOR or some other widely accepted index. Consequently, the investors receive LIBOR plus the risk premium in return for providing capital to the trust. If no contingent event occurs during the term of the bonds, the principal is returned to the investors upon the expiration of the bonds.

Insurers prefer the use a SPR to capture the tax and accounting benefits associated with traditional reinsurance. Investors prefer the use of a SPR to isolate the risk of their investment in the secured assets or liabilities from the general business and insolvency risks of the insurer, thus creating an investment that is a "pure play" in catastrophic risk. As a result, the issuer of the securitization can realize a higher return from the sale of assets or liabilities through segregation. The transaction also is more transparent than a debt issue by the insurer, because the funds are held in trust and are released according to carefully defined criteria. The bonds also are attractive to investors because catastrophic events have low correlations with returns from securities markets and

hence are valuable for diversification purposes (Litzenberger, Beaglehole, and Reynolds 1996). However, it is not clear that this lack of correlation would exist for the $100 billion plus "Big One." It is possible that such a large event might have repercussions that could drive down securities prices, creating systematic risk for CAT securities.

In the absence of a traded underlying asset, insurance-linked securities have been structured to pay-off on three types of variables – insurance-industry catastrophe loss indices, insurer-specific catastrophe losses, and *parametric* indices based on the physical characteristics of catastrophic events. The choice of a triggering variable involves a trade-off between moral hazard and basis risk. Securities based on insurer-specific (or hedger-specific) losses, often called indemnity CAT bonds, have no basis risk but expose investors to moral hazard; whereas securities based on industry loss indices or parametric triggers greatly reduce or eliminate moral hazard but expose hedgers to basis risk. Most recent CAT bond issues have been parametric. This is somewhat problematical from a regulatory perspective because U.S. insurance regulators have ruled that indemnity CAT bonds qualify as reinsurance for accounting and regulatory purposes but have not yet approved non-indemnity bonds as reinsurance.

CAT bonds are an innovative financing solution.[8] However, although there have been approximately 120 bonds issued to date, the amount of risk capital that has been raised remains small relative to the global reinsurance market. The number of issues and risk capital raised are shown in Figure 12, which shows a total of about $10 billion raised by March of 2005. In comparison, the equity capital of the global reinsurance industry and the U.S. property-casualty insurance industry are approximately $350 billion and $400 billion, respectively. However, the potential for the use of securities markets to finance catastrophic risk is significant. The amount of

[8]However, the concept is actually not a new one. It is similar to the practice of *bottomry* which dates at least to classical Greek and Roman times. In a bottomry contract, the lender extended a loan to finance a voyage. If the ship returned to port, the loan was repaid with interest, but if the ship sank, the loan was forgiven.

asset-backed securities outstanding is nearly $2 billion (Bond Market Association 2005).

Because of the as-yet unrealized potential of the CAT bond market, it is of interest to explore the possible reasons for the limited amount of risk capital raised to date. One possible explanation is that the bonds appear expensive relative to conventional reinsurance. Structuring a CAT bond deal requires significant expenditures on professional expertise from investment bankers, accountants, actuaries, and lawyers. In addition, the spreads on the bonds have tended to be high – often several times the expected losses on the bonds. For example, Cummins, Lalonde, and Phillips (2004) tabulate spreads on CAT bonds issued from 1997 through March of 2000 and find that the median ratio of bond spread to expected loss is 6.77. The well-known United Services Automobile Association (USAA) bond issued in 1997 had a spread over LIBOR of nearly 600 basis points for its principal-at-risk tranche.

In spite of the high costs of the early bonds, prices have been declining. Investment banks have been able to reduce transactions costs as they have gained experience with the bonds and with other insurance-linked securitizations. In addition, the spreads on the bonds have been declining. This pattern is shown in Figure 13, which plots the average spread on CAT bonds and the average expected loss on the left axis and the ratio of the spread to the expected loss on the right axis, from the third quarter of 2001 through the fourth quarter of 2004. Spreads were averaging 600 basis points at the beginning of the period shown in the figure but had declined to about 450 basis points by the end of 2004. In addition, the ratio of the spread to the expected loss declined from around 7 in 2001Q3 to about 3.5 in 2004Q4.

Possible explanations for the high risk premia on the bonds include investor unfamiliarity with the contracts (a "novelty" premium), the low liquidity of the contracts issued to date (a liquidity premium), and investor uncertainty about the accuracy of the models used to estimate expected

losses of the reinsurance (a "model risk" premium).[9] In addition, although the catastrophic events observed in the United States before the mid-1990s have been uncorrelated with returns in securities markets, this may not be true of a mega-earthquake in California or even a hurricane of the magnitude of Katrina. Thus, the spreads may also reflect a "stealth-beta" premium.

Another rationale sometimes given for the limited size of the CAT bond market is lack of investor interest. Although that may have been true at one time, recent data suggests that there is broad market interest in CAT bonds among institutional investors. This is shown in Figure 14, which shows the percentage of new issue volume by investor type in 1999 and 2004. In 1999, insurers and reinsurers were among the leading investors in the bonds, accounting for 50 percent of the market, i.e., insurers were very prominent on both the supply and demand sides of the market. However, in 2004, insurers and reinsurers accounted for only 7 percent of demand. Money managers and hedge funds bought 56 percent of the 2004 bond issues, and dedicated CAT bond mutual funds accounted for 33 percent. The declining spreads and increasingly broad market interest in the bonds provide some indication that the bonds may begin to play a more important role relative to conventional reinsurance.

There are also regulatory and accounting obstacles that may be preventing more widespread usage of CAT bonds, as discussed in Jaffee (2005). As mentioned, the NAIC currently does not allow non-indemnity CAT bonds to be treated as reinsurance for regulatory accounting purposes. A second obstacle is that there is currently some uncertainty about whether SPRs need to be consolidated on insurers' GAAP financial statements under new rules regarding "variable interest

[9]The expected losses under CAT bonds are estimated by catastrophe modeling firms such as Applied Insurance Research and Risk Management Solutions. These firms have developed elaborate and highly sophisticated simulation models which simulate catastrophic events using meteorological and seismological models along with actuarial and other modeling approaches. They have constructed extensive data bases on the value of property exposed to loss in the U.S. and other major countries.

entities" that were adopted post-Enron. Finally, CAT bonds have not been granted the tax-free conduit status that is available in the mortgage-backed and asset-backed securities markets. Thus, CAT bond SPRs generally must be located in off-shore tax havens such as Bermuda, potentially raising transactions costs. One relatively non-intrusive way that government could make more risk capital available would be to remove these regulatory impediments.

Besides the CBOT CAT options and CAT bonds, other capital market solutions to the catastrophic loss financing problem have been introduced, including catastrophic equity puts (Cat-E-Puts). Unlike CAT bonds, Cat-E-Puts are not asset-backed securities but options. In return for a premium paid to the writer of the option, the insurer obtains the option to issue preferred stock at a pre-agreed price on the occurrence of a contingent event. This enables the insurer to raise equity capital at a favorable price after a catastrophe, when its stock price is likely to be depressed. Cat-E-Puts are likely to have lower transactions costs than CAT bonds because there is no need to set up a SPR. However, because they are not asset-backed, these securities expose the insurer to counterparty performance risk. In addition, issuing the preferred stock has a dilution effect on the value of the firm's existing shares.[10]

Government Involvement in Catastrophe Insurance Markets

The difficulties faced by insurance markets in financing catastrophic risk have given rise to pressures for government to become involved in the market. Government involvement usually occurs when there has been a major failure in private insurance markets. In the U.S., the current markets for hurricane coverage in Florida and earthquake insurance in California exist largely due

[10]For further discussion of capital market approaches to financing catastrophic risk, see Anderson (2005), Pollner (2001), and Swiss Re (2001).

to state government intervention following Andrew and Northridge.[11] Governments in other industrialized countries also have intervened in catastrophe insurance markets. In 2002, the U.S. Federal government intervened to create a market for terrorism insurance by adopting the Terrorism Risk Insurance Act of 2002 (TRIA).[12] Although TRIA is set to expire at the end of 2005, even if it is not renewed it provides some valuable lessons about the need for and effect of government provision of terrorism insurance. Governments of several other industrialized countries have also intervened in the terrorism insurance market. This section provides a review of the principal government programs designed to correct market failures affecting the availability of insurance for catastrophic risk. Because these programs have been subject to book-length treatment elsewhere (especially in OECD 2005a and 2005b), the discussion of specific program characteristics will be brief. The discussion also emphasizes the programs adopted in the U.S.

California and Florida. The California and Florida programs are noteworthy in that they do not involve the direct government provision of insurance but the creation of quasi-governmental entities that are not supported by taxpayers. Following the Northridge earthquake in 1994, the market for earthquake insurance in California collapsed as private insurers stopped writing coverage. The California legislature responded in 1996 by creating a quasi-public entity, the California Earthquake Authority (CEA), to provide earthquake insurance to Californians. The CEA is not a governmental agency but operates under constraints mandated by the legislature. Specifically, the

[11]Other states, such as Alabama and Louisiana, have also established residual market property insurance facilities analogous to the one in Florida; and many other states have Fair Access to Insurance Requirements (FAIR) residual market plans to provide insurance to buyers who cannot find coverage in the voluntary insurance market. I focus here on the California and Florida plans because of their prominence and especially significant exposure to large catastrophes.

[12]In the U.S., the Federal government also provides flood insurance through the National Flood Insurance Program, operated by the Federal Emergency Management Agency. The issues involved in the flood program are somewhat different from those in the types of insurance subject to mega-catastrophes. Accordingly, the flood program is not part of this analysis.

policies written by the CEA are earthquake "mini-policies" designed by the legislature that provide less extensive coverage than provided by private insurers pre-Northridge. The legislature also mandated that coverage be provided at sound actuarially-based prices, although these have been "tempered" somewhat such that policyholders in high-risk areas are subsidized. The legislature also required that the CEA be funded by capital contributions of about $700 million from private insurance companies licensed in California in lieu of requiring them to write earthquake insurance. The CEA had claims paying ability of about $6.9 billion at the end of 2004 (Price-Waterhouse-Coopers 2005). Putting this in perspective, recall from Table 1 that the Northridge earthquake caused insured losses of $17.8 billion in 2004 dollars. However, because of the mini-policy and the fact that fewer residences have earthquake insurance now than before 1994, it is probable that the CEA could withstand damages on the scale of Northridge.

Since the creation of the CEA, private insurers have reentered the California earthquake market. In 2004, approximately 150 companies wrote non-zero earthquake insurance premiums in California (California Department of Insurance 2005). Of the total of $985 million in California earthquake premiums written in 2004, however, the CEA accounted for 47.3 percent. Although private insurers have returned to the market, it is generally to write insurance in relatively low risk areas of the state (Jaffee 2005). Nevertheless, the design of the CEA, and especially its mandate to charge actuarially-justified premium rates, has had the effect of not crowding-out the private sector. Something of a puzzle in the California market, however, is that only a small proportion of eligible property owners actually purchase the insurance. In the homeowners market, for example, 33 percent of eligible properties purchased earthquake insurance in 1996, the CEA's first year, but only 13.6 percent had insurance in 2003. The rationale usually given for the low market penetration is that most buyers consider the price of insurance too high for the coverage provided, even though

premiums are close to equaling the expected losses estimated by modeling firms (Jaffee 2005).

As in California following Northridge, the hurricane market in Florida was significantly destabilized by Hurricane Andrew in 1992. In response to insurer attempts to withdraw and reprice windstorm coverage following the event, the state placed restrictions on the ability of insurers to non-renew policies and on rate increases. To provide an escape valve for policyholders who were unable to obtain coverage, the state created the Florida Residential Property and Casualty Joint Underwriting Association (FRPCJUA), a *residual market facility*. Insurers doing business in the state were required to be members of the facility, which insured people and businesses who could not obtain property coverage from the voluntary insurance market. The FRPCJUA was empowered to assess insurers if premiums are not sufficient to pay claims, and there was no explicit government backing. A similar residual market facility was formed to provide "wind-only" coverage along the coast – the Florida Windstorm Underwriting Association.

In 2002, the two residual market plans were merged to form the Citizens Property Insurance Corporation, a tax-exempt entity that provides coverage to consumers and businesses who cannot find coverage in the voluntary market. Citizens operates like an insurance company in charging premiums, issuing policies, and paying claims. If premiums are insufficient, it has the authority to assess insurers doing business in the state to cover the shortfall. It also has the ability to issue tax-exempt bonds if necessary. Citizens was severely stressed by the four hurricanes that hit Florida in 2004, as it struggled to handle the massive numbers of claims that were filed. In 2004, Citizens wrote $1.4 billion in premiums, accounting for 34% of the Florida property insurance market. Unlike California earthquake, the market penetration of property insurance coverage in Florida is very high, in part because mortgage lenders require mortgagors to purchase insurance.

To provide additional claims paying capacity, Florida also created the Florida Hurricane

Catastrophe Fund (FHCF), a state-run catastrophe reinsurance fund designed to assist insurers writing property insurance in Florida. Insurers writing residential and commercial property insurance in the state are required to purchase reinsurance from the FHCF based on their exposure to hurricane losses in the state. The FHCF does not have state financial backing. However, it is operated as a state agency and is exempt from Federal income taxes, enabling it to accumulate funds more rapidly than private insurers. In addition, the fund has the authority to assess member insurers within limits in case premiums and reserve funds are insufficient and also has the ability to issue tax exempt bonds because of its status as a state agency. The catastrophe reinsurance issued by the fund kicks in after an industry retention of $4.5 billion, and the fund has claims paying ability of about $15 billion. The FHCF was instrumental in stabilizing the property insurance market following the 2004 hurricane season.

The California and Florida experience shows that governments can play an important role in making insurance available without directly committing taxpayer-provided funding. These program also have the virtue of not crowding out private insurers, although it is possible that the mandatory purchase feature of the FHCF may have crowed out some private reinsurance. However, because these are government mandated and designed programs, they probably are not as efficient as purely private market solutions.

The Terrorism Risk Insurance Act of 2002. Prior to the September 11, 2001 terrorist attacks, terrorism was generally covered by most property-casualty insurance policies. In fact, the risk was considered so minimal by insurers that terrorism was usually included at no explicit price. Likewise, international reinsurers generally covered primary companies for terrorism as part of their reinsurance coverage; and, in fact, the reinsurers paid most of the claims resulting from the WTC attack. After 9/11, however, reinsurers began writing terrorism exclusions into their policies. A

majority of those contracts renewed during the first quarter of 2002 (GAO 2002), leaving primary insurers with virtually no opportunity to reinsure their exposure. As a result, the primary insurers' exposure to terrorism risk increased, motivating primary insurers to seek to write terrorism exclusions into their own policies. Recognizing that substantial exposure to terrorism risk without adequate opportunities for reinsurance could pose insolvency risks, state insurance regulators rapidly approved terrorism exclusions. By early 2002, insurance regulators in 45 states had approved the use of terrorism exclusions which allowed insurers to exclude from their standard commercial insurance coverage any losses arising due to a terrorist event.[13]

In February 2002, the GAO gave Congressional testimony providing "examples of large projects canceling or experiencing delays have surfaced, with the lack of terrorism coverage being cited as the principal contributing factor" (GAO 2002, p. 9). According to a survey by Council of Insurance Agents and Brokers, in the first quarter of 2002, the market for property-casualty insurance experienced "sharply higher premiums, higher deductibles, lower limits and restricted capacity from coast to coast and across the major lines of commercial insurance."[14] In November 2002, Congress responded to these problems by passing the Terrorism Risk Insurance Act of 2002 (TRIA). Through TRIA, the Federal government required property-casualty insurers to offer or "make-available" terrorism insurance to commercial insurance customers and created a Federal reinsurance backstop for terrorism claims.

TRIA established the Terrorism Insurance Program within the Department of the Treasury.

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[13]An exception to the general exclusion of terrorism from commercial insurance policies following 9/11 is coverage for workers' compensation insurance. Workers' compensation is mandated by state law to cover work injuries from all causes, and the states did not revise the workers' compensation laws to allow terrorism exclusions. Terrorism exclusion also were not introduced for personal lines policies such as automobile and homeowners insurance.

[14]Council of Insurance Agents and Brokers, Press Release, April 16, 2002, Washington, DC.

The program, which expires on December 31, 2005, covers commercial property-casualty insurance, and all insurers operating in the U.S. are required to participate. Insurers are required to "make available property and casualty insurance coverage for insured losses that does not differ materially from the terms, amounts, and other coverage limitations applicable to losses arising from events other than terrorism" (United States Congress 2002, p. 7). The legislation thus nullified state terrorism exclusions and requires that insurers offer terrorism coverage. The wording of the Act implicitly omits coverage of chemical, biological, radiological and nuclear (CBRN) hazards, which are not covered by most commercial property-casualty policies.

For the federal government to provide payment under this Act, the Secretary of the Treasury must certify that a loss was due to an act of terrorism, defined as a violent act or an act that is dangerous to human life, property or infrastructure, and to have "been committed by an individual or individuals acting on behalf of any foreign person or foreign interest, as part of an effort to coerce the civilian population of the United States or to influence the policy . . . of the United States Government by coercion" (United States Congress 2002, p. 3). Acts of war are excluded, and losses from any terrorist act must exceed $5 million before the Act takes effect.

If a loss meets these requirements, the loss is shared by the insurance industry and the Federal government under the deductible, copayment, and recoupment provisions of the Act. The coverage structure of the Act is diagramed in Figure 15. In 2005, each individual insurer has a terrorism insurance deductible of 15 percent of its direct earned premiums from the prior calendar year. Above this amount, the federal government pays for 90 percent of all insured losses. However, law provides for mandatory recoupment of the federal share of losses up to the level of the "insurance marketplace aggregate retention limit," which is $15 billion in 2005. This recoupment is to occur through "terrorism loss risk-spreading premiums," a premium surcharge on property-

casualty insurance policies in force after the event with a maximum surcharge of 3% of premiums per year. In addition, the Treasury Secretary has the discretion to demand additional recoupment, taking into account the cost to taxpayers, the economic conditions of the commercial marketplace, the affordability of insurance, and "such other factors as the Secretary considers appropriate." In other words, the Treasury Secretary could choose to recoup 100 percent of federal outlays under this program through *ex post* premium surcharges. The total, combined liability of both the government and private insurers is capped at $100 billion.

Government Catastrophe Insurance In Other Countries. This discussion provides a brief overview of the government role in catastrophe insurance in other countries based on OECD (2005a) and (2005b) and other sources. Insurance programs for natural disasters are discussed first, following by terrorism programs.

In many OECD countries, governments use tax revenues to establish pre-funded disaster relief funds. This approach is used in countries such as Australia, Denmark, Mexico, the Netherlands, Norway, and Poland (Freeman and Scott 2005). In several of these countries, the government provides compensation only for losses that cannot be privately insured. This approach is somewhat similar to the disaster relief funding provided by the Federal government in the U.S.

Several countries have established government insurance programs to provide coverage for natural disasters. The government collects premiums in return for the coverage, and private insurers generally market the policies and handle claims settlement and other administrative details. An example is Consorcio de Compensacion de Seguros (CCS), which was established by the Spanish government in 1954. CCS is a public corporation that provides insurance for "extraordinary risks," including both natural catastrophes and terrorism. The extraordinary risks coverage is mandatory and is provided as an add-on to private market property insurance policies. A premium is collected

for the coverage, which is passed along to CCS by the private insurers.

Another approach, somewhat similar to TRIA, is for the government to act as a reinsurer rather than a primary insurer as it does in Spain. An example is France, which has two programs, the National Disaster Compensation Scheme (CAT NAT) and Fonds National de Garantie des Calamites Agricoles. CAT NAT is backed by a state-guaranteed public reinsurance program, Caisse Centrale de Reassurance (CCR), which provides unlimited government backing for catastrophe losses. Catastrophe insurance is mandatory for all private non-life insurance policies. Insurers can then reinsure the risk with CCR, which essentially serves as reinsurer of last resort. Premium surcharges for the catastrophe insurance are set by the French government.

Another example of the government as reinsurer is provided by the Japan Earthquake Reinsurance Company (JER), which reinsures natural hazards such as earthquakes and tsunamis in Japan. All earthquake insurance written by private insurers in Japan is reinsured with the (JER). Reinsurance coverage is based on a layering approach such that 100 percent of the loss in the lowest loss layer (up to 75 billion yen) is borne by private insurers, the loss is split evenly between private insurers and government between 75 billion and 1.0774 trillion yen, and paid 95 percent by government between 1.0774 and 4.5 billion yen (Freeman and Scott 2005).

According to the OECD (2005b), there are governmental terrorism insurance programs in eight OECD countries – Australia, Austria, France, Germany, the Netherlands, Spain, the U.K., and the U.S. These are presented in detail in OECD (2005b), especially chapter 5, so only the high points are summarized here. All of the programs were established after the September 11, 2001 terrorist attacks except for the Spanish program, where coverage is provided by CCS, and the U.K. program, which was established in 1993 in response to Irish Republican Army terrorist attacks. The programs vary along several important dimensions, including coverage layers and amounts, the

limitations on the liability of private insurers, whether a premium is charged for the government reinsurance, and whether the plan is temporary or permanent. In the following, I give examples based on the most prominent plans rather than attempting a comprehensive analysis.

In December 2001, a new reinsurer called Gestion de l-Assurance et de la Reassurance des Risques Attentats et Actes de Terrorisme (GAREAT) was established to reinsure terrorism risk insurance written by private insurers. The French government acts as reinsurer of last resort, providing unlimited reinsurance coverage through CCR. As is common in conventional catastrophe reinsurance, government terrorism reinsurance coverage is provided in a sequence of layers. The first layer of €400 million of coverage is provided by the private insurers who participate in GAREAT. In 2005, there are two layers of private market reinsurance, providing limits of €1.2 billion excess of the €400 million primary layer and a second layer of €400 million excess of €1.6 billion. Above €2 billion, unlimited coverage backed by a government guarantee is provided by CCR. As with other catastrophe insurance in France, terrorism coverage is mandatory for all property insurance. A premium is collected for the government reinsurance, which is remitted to the government. The plan is temporary and currently set to expire at the end of 2005.

In Spain, terrorism insurance is provided under the CCS program. Therefore, it is mandatory for all non-life insurance. There is no layering. All extraordinary risks coverage is ceded to CCS, which is backed by an unlimited government guarantee. Policyholders pay a premium surcharge for the coverage provided by CCS, including terrorism coverage. The program is permanent.

In Germany, a specialist insurer, EXTREMIS, was established in 2002 to provide terrorism insurance. The program is set to terminate at the end of 2005. Coverage is not mandatory in Germany, and demand for terrorism insurance in reportedly very low. The first €2 billion of coverage is provided by private insurers and reinsurers, and there is excess reinsurance coverage (€8

billion excess of €2 billion) provided by the German government in return for a premium. The annual maximum indemnity for each client is limited to €1.5 billion.

In the U.K., a mutual reinsurance company, Pool Re, was established in 1993 to provide terrorism reinsurance to insurers writing insurance in the U.K. Pool Re has a retrocession arrangement with the British Treasury to provide the ultimate layer of reinsurance. The first layer of coverage is provided by primary insurers, up to £75 million per event or £150 million per year (in 2005), industry-wide. Coverage is then provided by Pool Re up to the full amount of its resources. Coverage for events that exhaust the funds in Pool Re is provided by the government, in return for a premium.

Among the eight OECD terrorism programs covered in OECD (2005b), only Austria's does not involve some form of government insurance. Among the seven programs with government backing, five are temporary and four have fixed expiration dates. Government reinsurance is unlimited in France, Spain, and the U.K. Among the countries with limits on the liability of the government reinsurance, the highest limit is in the U.S. TRIA program. Among the programs with government backing, only the U.S. program does not charge a premium for the reinsurance, although the Treasury secretary has the authority to seek recoupment of losses exceeding the industry participation limits. The lack of a premium is a defect in the U.S. program because it has the effect of crowding out private reinsurers, who cannot compete with free coverage.

An Evaluation of TRIA. In making the case for TRIA, the President and Congressional and business leaders argued that the lack of terrorism insurance was having an adverse effect on important segments of the economy, citing cancelled or postponed construction projects, downgrades of commercial and multi-family mortgage securities, and other deleterious effects. However, the evidence was mostly anecdotal and solid evidence of a macroeconomic impact from

the restrictions on terrorism insurance during 2002 has been hard to find. One paper that looked at several macroeconomic time series such as bank construction lending and new construction put in place did not find any noticeable interruption in trends that had pre-existed September 11, 2001 (Brown, et al. 2004).[15] Nevertheless, the general assumption has been that restrictions on terrorism insurance are bad for the economy, providing a rationale for a Federal role. This section briefly considers the macroeconomic impact of TRIA, analyzes TRIA's success in restoring the market for terrorism insurance, and evaluates the likely impact if TRIA is not renewed.

Brown, et al. (2004) provide evidence on the expected economic effects of TRIA by investigating the stock price reaction to the Act's adoption on the industries most likely to be affected by terrorism insurance. They conduct a standard event study of eleven TRIA-related news announcements, culminating in the President's signing the bill into law on November 26, 2002. The stock price impact on affected industries of the bill's passage by Congress on November 20, 2002 is representative of the general conclusions of the study. The results, shown in Figure 16, reveal that TRIA's passage had an adverse impact on the stock prices of firms in the insurance, banking, REIT, and transportation industries and a negative long-window impact on public utilities. Only in the construction industry is there any evidence of a positive stock price impact from TRIA, and this effect is not statistically significant. The results imply that TRIA's passage caused the stock market to reduce its estimates of expected future cash flows in nearly all affected industries.

It is relatively easy to explain the negative stock price reaction of property-casualty insurers to the passage of TRIA. Prior to TRIA, the availability of terrorism insurance was sharply curtailed revealing that many insurers did not believe they could write terrorism insurance at a profit,

[15]A paper by Hubbard and Deal (2004) purports to show that the expiration of TRIA would have a significant adverse impact on the macroeconomy. However, the paper appears to have been written as an advocacy document, and the analysis is not very convincing.

especially in high hazard areas. TRIA reversed the coverage restrictions and required insurers to offer coverage that they manifestly did not want to provide and, moreover, exposed insurers to significant potential losses from TRIA's deductible, co-payment, and recoupment provisions. Although TRIA left the pricing of terrorism insurance to the private market, states do regulate insurance prices and attempts by insurers to avoid providing coverage by offering insurance only at excessive prices would have attracted adverse regulatory attention. Consequently, as shown further below, a considerable amount of terrorism insurance has been offered under TRIA that probably would not have been available in the absence of the Federal "make available" rule.

Because the purchase of terrorism insurance is not mandatory under TRIA, it is more difficult to explain the adverse stock price reaction in industries that are buyers rather than sellers of insurance. At first glance, the Act provided firms in these industries with a no-obligation option to buy terrorism insurance that may not have been available otherwise. However, a more thoughtful look reveals some possible reasons for the negative stock price reaction. Brown, et al. (2004) provide two possible explanations. A first explanation a type of "Samaritan's dilemma" problem. That is, the Act may have reduced market expectations with respect to future federal assistance for firms and industries affected by terrorist events by substituting a Federal reinsurance program for a potentially more open-ended implicit government commitment. The second explanation is that TRIA may have created insurance market inefficiencies by preventing or delaying the development of more efficient private market mechanisms for financing terrorism losses, especially because no premium is charged for the Federal reinsurance. A third possible explanation, which conflicts somewhat with the Samaritan's dilemma argument, is that TRIA implicitly excludes coverage for the CBNR hazards, which have the potential to cause the most severe losses.

Although initial reports indicated that take-up rates (the percentage of buyers who accept

insurers' mandatory offers of terrorism insurance) under TRIA were very low, more recent data reveal that significant amounts of terrorism insurance have been purchased under TRIA. There have been three major surveys of take-up rates. Marsh & McLennan (2004, 2005a) surveyed their clients in 2004 and 2005 to provide information on terrorism insurance and take-up rates. The results are shown in Figure 17, which provides quarterly take-up rates based on approximately 2,400 Marsh clients from 2003Q2 to 2004Q4. The take-up rate increased from 23 percent in 2003Q2 to 48 percent in 2004Q4. Thus, the large firms which constitute Marsh's clientele demonstrated a significant demand for terrorism insurance, especially in 2004.

Further evidence on terrorism insurance take-up rates is provided by a set of surveys conducted by the U.S. Department of the Treasury (2005) as part of its Congressional mandate to provide an evaluation of TRIA's effectiveness. The Treasury survey is a valuable companion to the Marsh survey because it also included smaller firms. The results, shown in Figure 18, indicate that the take-up rate increased from 27 percent in 2002 to 54 percent in 2004. This provides further evidence that a strong demand for terrorism insurance has existed under TRIA. The 2002 results are also important because they reveal that terrorism insurance did not disappear between September 11, 2001 and the passage of TRIA. In fact, significant amounts of coverage were being offered and purchased during this period, even though no Federal reinsurance was in effect.

The final source of evidence on terrorism insurance take-up rates is a survey conducted in 2004 by the Mortgage Bankers Association (2004). The Association surveyed the commercial and multifamily mortgage market to determine the prevalence of terrorism insurance protection for properties covered by these types of mortgages. The results, shown in Figure 19, revealed that lenders require terrorism insurance for the vast majority of mortgages – such insurance is required for mortgages accounting for about 94 percent of loan balances. Of the $616 billion in loan balances

where terrorism coverage was required, insurance was purchased for $548 billion or 89 percent. The survey also asked respondents to estimate how much insurance would be in place if TRIA did not exist, and the results indicate that only $132 billion would be covered by terrorism insurance absent TRIA. Although it is not clear how accurate this counter-factual estimate is, the results do indicate the respondents' belief that TRIA plays a major role in creating a supply of terrorism insurance.

The pricing of terrorism insurance was also analyzed in the Marsh and U.S. Treasury surveys. Results from Marsh (2005a) are presented in Figure 20. The figure indicates that terrorism insurance constituted between 4 and 5 percent of total commercial property insurance premiums for the Marsh clients included in the survey and that prices increased in 2004 for larger properties. However, even at the 2004 levels, prices do not seem unreasonable in a relative sense. Figure 21 provides information on the absolute values of terrorism insurance prices from the Marsh survey. Terrorism insurance premiums represented 0.01 percent of insured value for relatively low-valued properties, dropping to about 0.004 percent for the largest properties.

The results from the Treasury surveys are summarized in Figure 22. Perhaps surprisingly, the results reveal that many insurers were still not charging an explicit price for terrorism insurance following the enactment of TRIA. In 2002, about 80 percent were not charging for terrorism cover, but this had dropped to 40 percent by 2004. Including both the zero price and positively priced insurance, terrorism accounted for about 1 percent of total property insurance premiums in 2002, rising to approximately 2 percent in 2004. Considering only the positive-premium terrorism insurance, the terrorism premium was about 3 percent of total premiums in 2004. Hence, the price of terrorism cover does not seem to be exorbitant under TRIA.

Finally, I turn to an evaluation of what the terrorism insurance market might look like without TRIA. Some evidence helpful in making this evaluation is provided in the U.S. Treasury

surveys. In addition to terrorism insurance that is reinsured under TRIA, which is limited to acts of foreign terrorism, some insurers also write *non-certified* terrorism coverage, which insurers against events such as domestic terrorism which are not covered by TRIA. The percentages of insurers writing certified (i.e., TRIA-reinsured) coverage and non-certified coverage in 2003 and 2004 are shown in Figure 23.[16] The results are rather striking – approximately 90 percent of insurers were writing certified terrorism coverage in both 2003 and 2004, but only 40 percent wrote non-certified coverage. Given that non-certified (i.e., domestic) terrorism events are generally viewed as less risky than foreign terrorism, these results may suggest that no more than 40 percent of insurers will continue to offer terrorism coverage for foreign terrorism if TRIA expires.

The Treasury also queried responding insurers about their 2005 renewals that extend into 2006, when TRIA may no longer be in effect. Fifty percent of the respondents indicated that they are not providing terrorism coverage for the segment of the policy period extending into 2006 "that is roughly similar to TRIA coverage" (U.S. Treasury 2005, p. 75). Of these respondents, 55 percent excluded terrorism altogether in 2006, 22 percent had a contingent exclusion for terrorism going into 2006, and 24 percent included coverage that was not comparable to TRIA coverage. These results do not bode well for the availability of terrorism insurance coverage once TRIA expires.

To conclude the discussion of the effectiveness of TRIA, the Act has had the effect of making terrorism insurance widely available throughout the economy. The fact that about half of policyholders do not buy terrorism insurance seems to be more a reflection of the fact that many policyholders do not have significant terrorism exposure rather than a belief that terrorism prices are too high. In fact, terrorism coverage is being made available at princes representing only a small proportion of total property insurance premiums. However, because the government reinsurance is

[16]This distinction is not meaningful in 2002 because Federal terrorism reinsurance did not exist for most of the year.

being provided for free, it is likely that the current prices mainly reflect insurer expected losses under the deductible and co-payment provisions of TRIA. Thus, prices can be expected to rise significantly once insurers have to buy private market reinsurance or bear the risk themselves, dampening demand for coverage.

The survey results also suggest that availability of terrorism insurance is likely to decline sharply if TRIA is not renewed. This could be a temporary decline until private market solutions begin to emerge. However, the experience with catastrophic risk insurance in California and Florida suggests that many buyers, especially in high risk areas, will not be able to obtain terrorism insurance without some form of government involvement in the market. Although such involvement does not necessarily imply that the government should serve as reinsurer of last resort, the experience of other OECD countries suggests that some form of government reinsurance may be needed in order to sustain the market for terrorism coverage in the future.

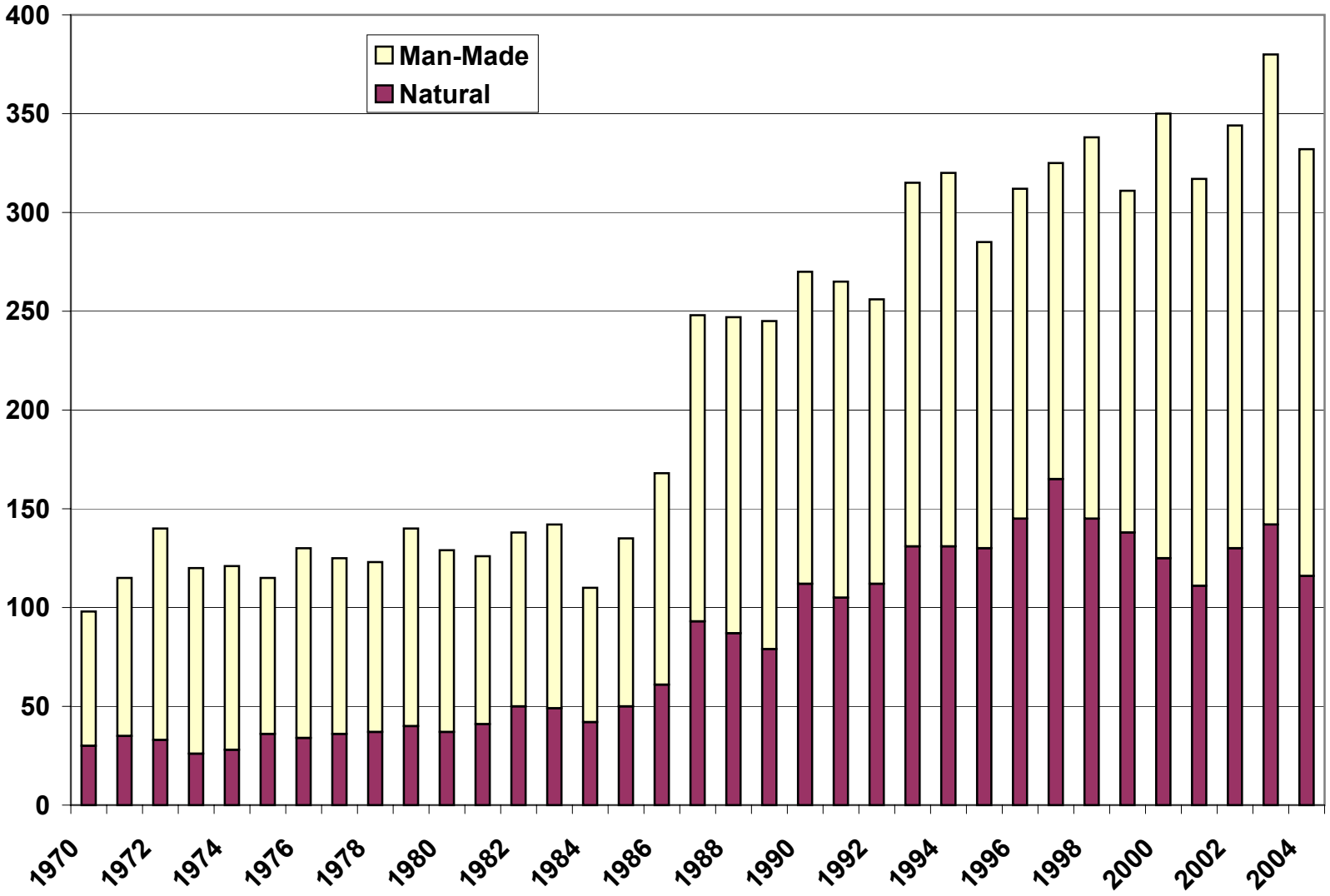
5. Evaluation of Government Involvement Mechanisms

[To be written]

6. Conclusions

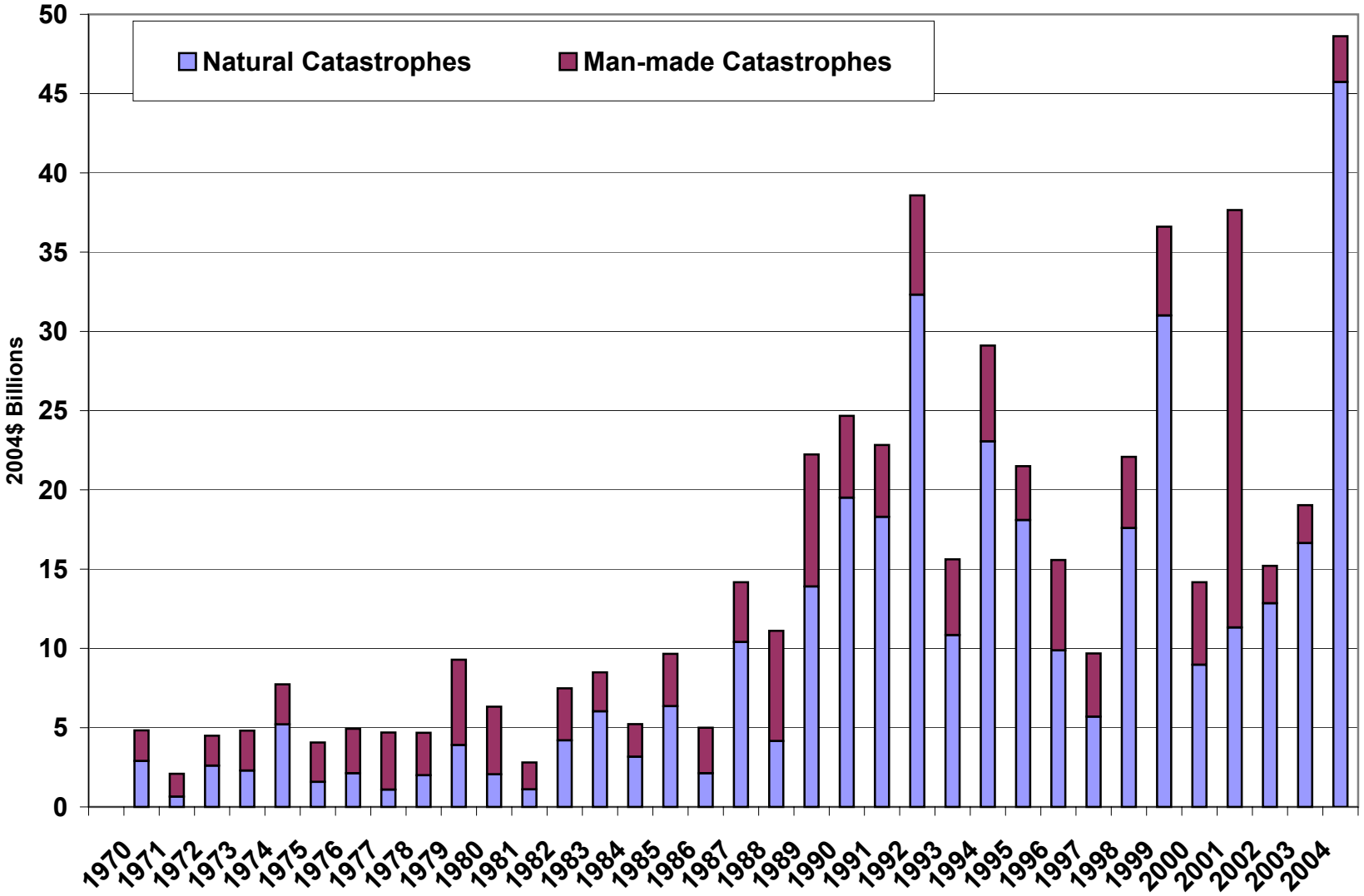
[To be written]

Figure 1: Number of Catastrophes: 1970-2004



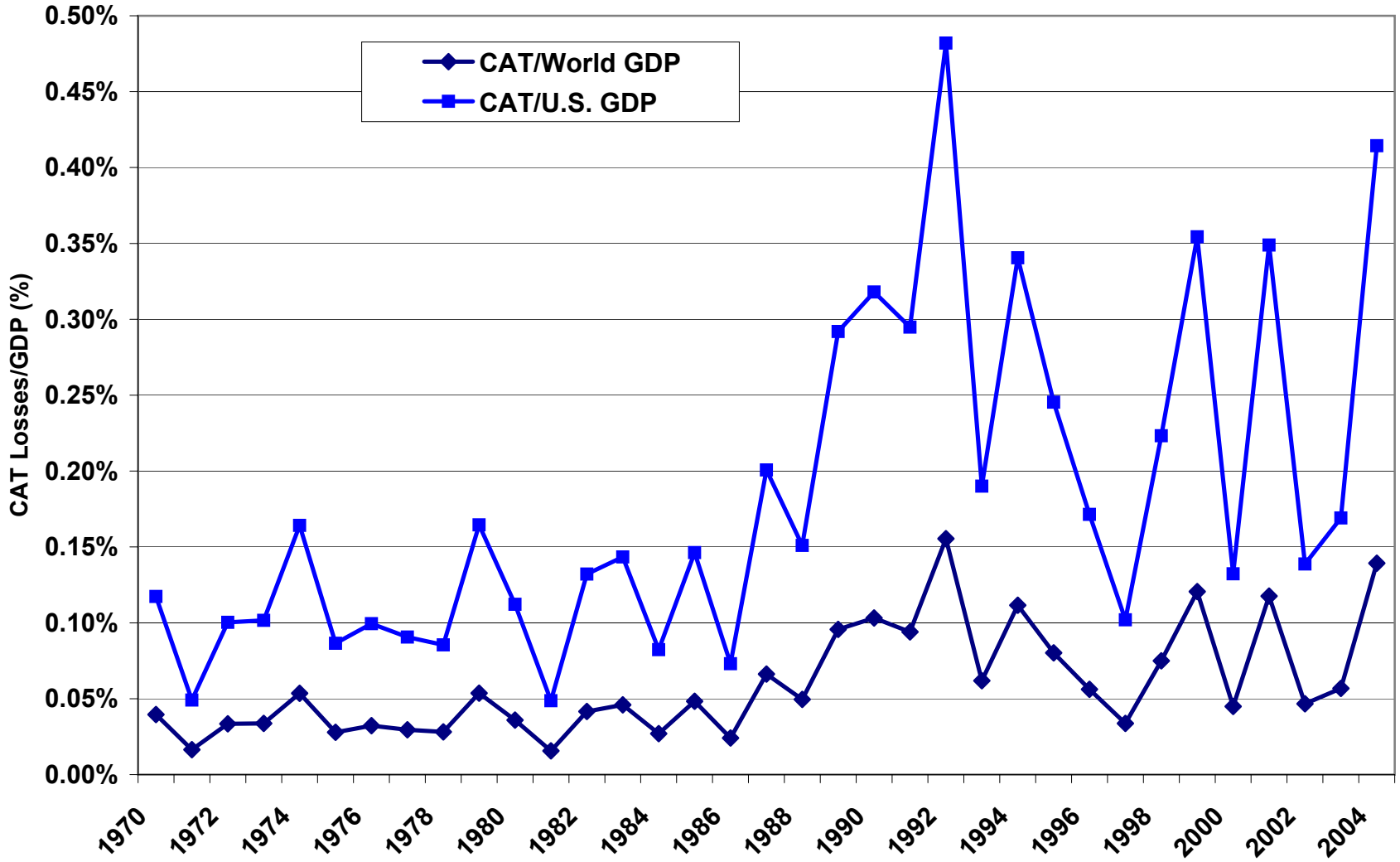
Source: Swiss Re.

Figure 2: Worldwide Insured Catastrophe Losses: 1970-2004



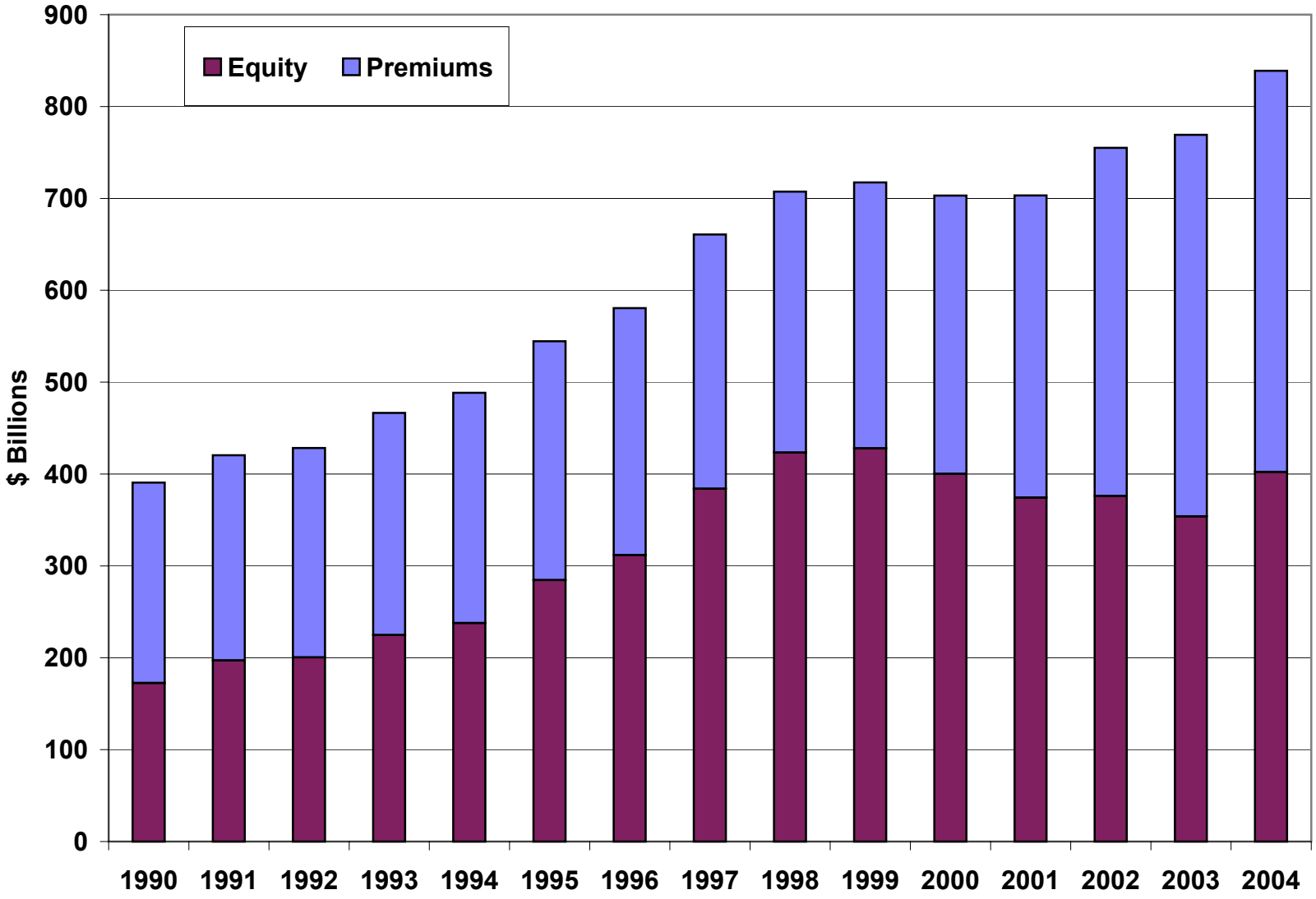
Source: Swiss Re (2005).

Figure 3: CAT Losses Relative to World and U.S. GDP



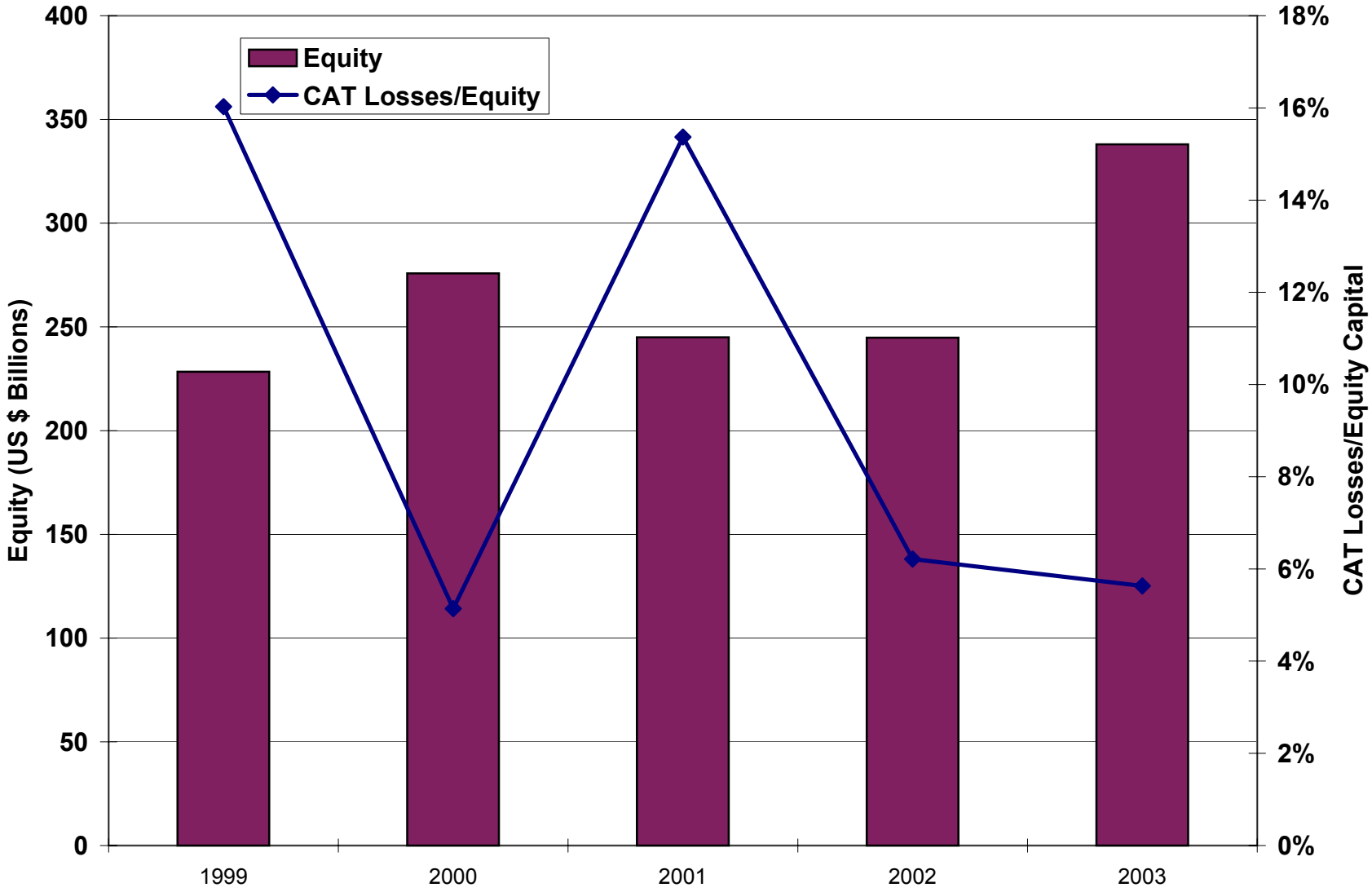
Sources: Catastrophe losses, Swiss Re (2005). World GDP, The World Bank. U.S. GDP, U.S. Department of Commerce.

Figure 4: U.S. Property-Casualty Insurance Industry: Total Resources



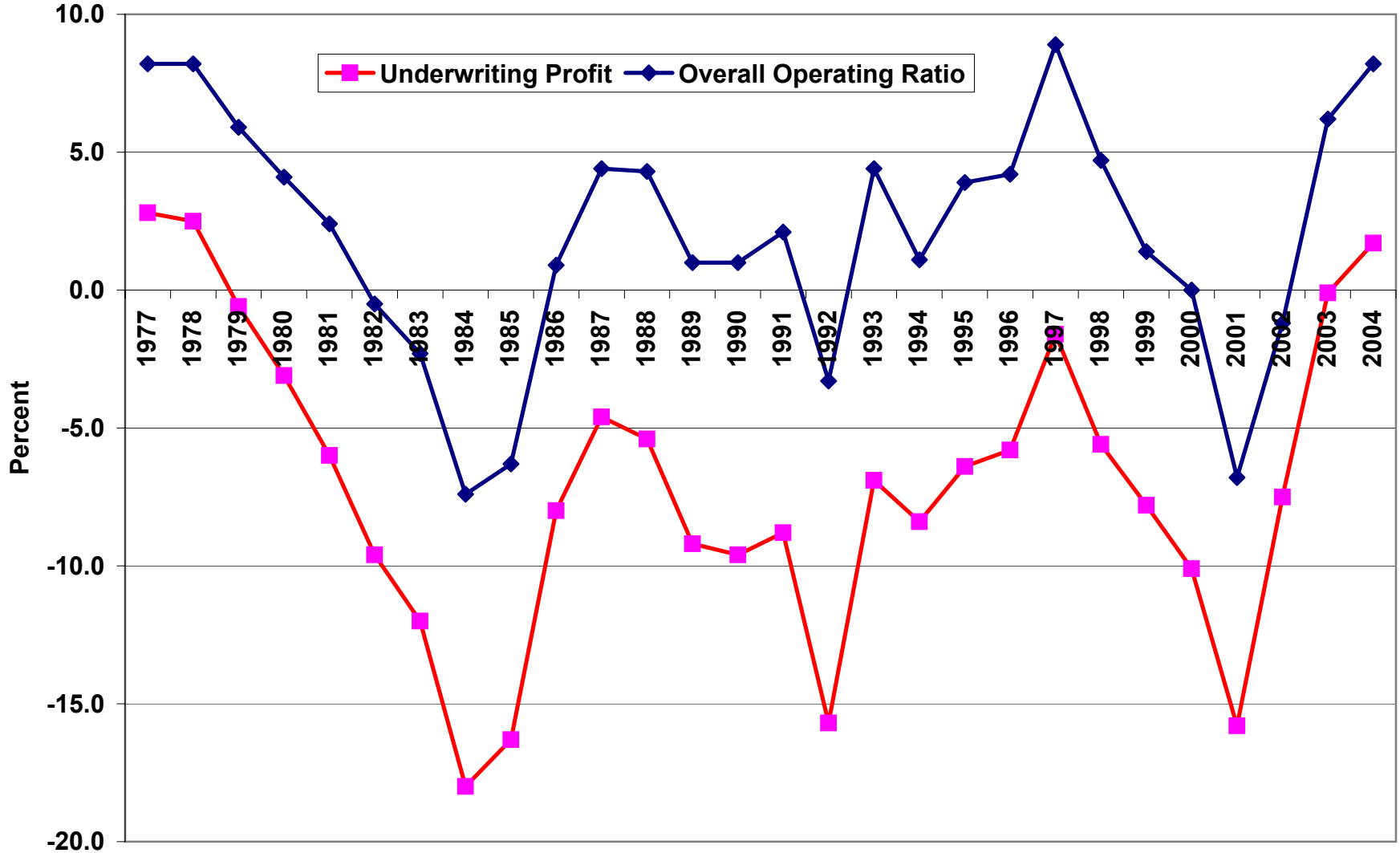
Source: A.M. Best Company, *Best's Aggregates and Averages*, various years.

Figure 5: Global Reinsurers: Aggregate Equity Capital and CAT Lossess



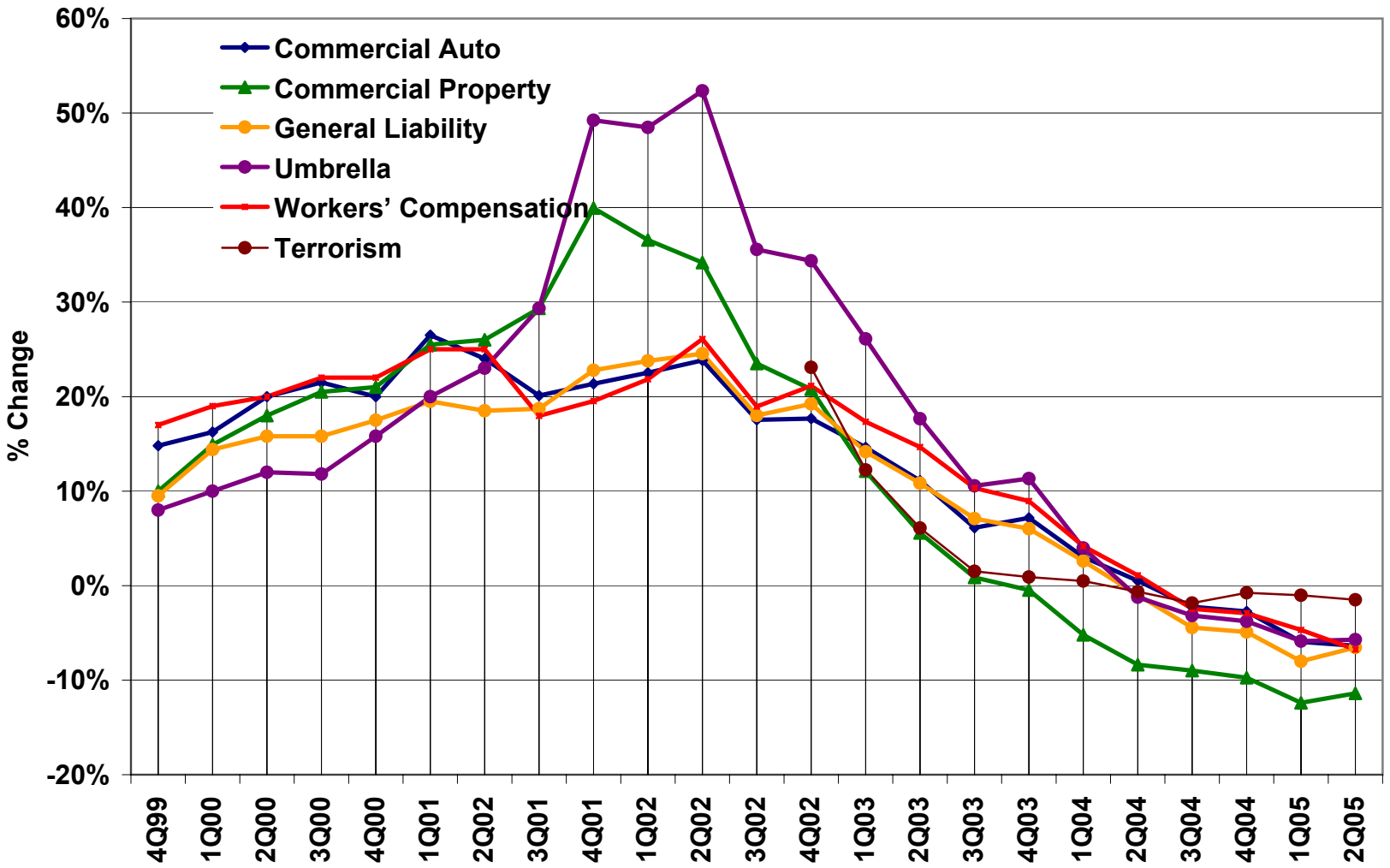
Source: Standard & Poor's, *Global Reinsurance Highlights* , various years.

Figure 6: U.S. Property-Casualty Underwriting Profit and Overall Operating Ratio



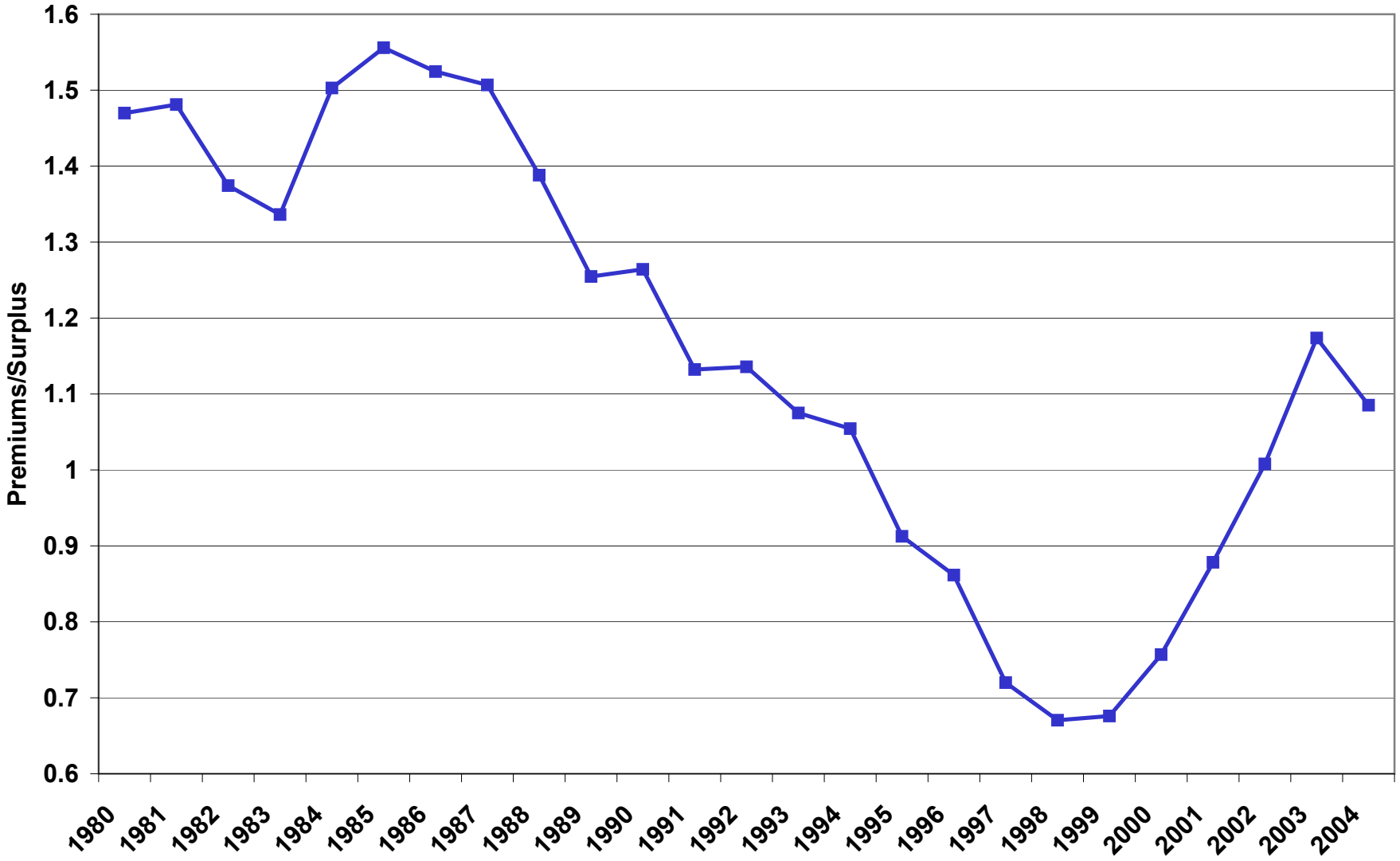
Source: A.M. Best Company, *Best's Aggregates and Averages* , various years.

Figure 7: Commercial P&C Premium Rate Change By Line



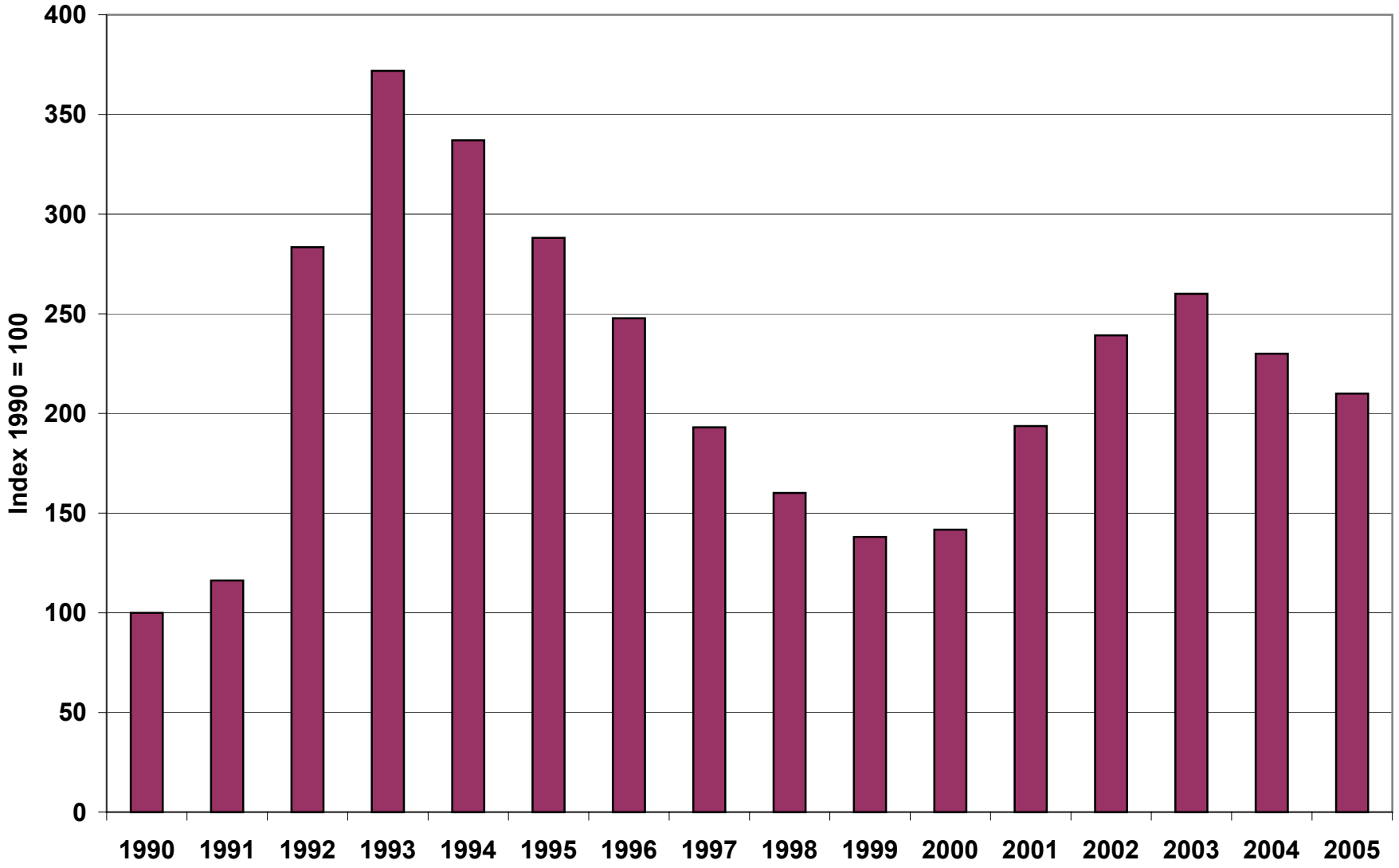
Source: Council of Insurance Agents and Brokers.

Figure 8: U.S. Property-Casualty Insurance Industry: The Premiums-to-Surplus Ratio



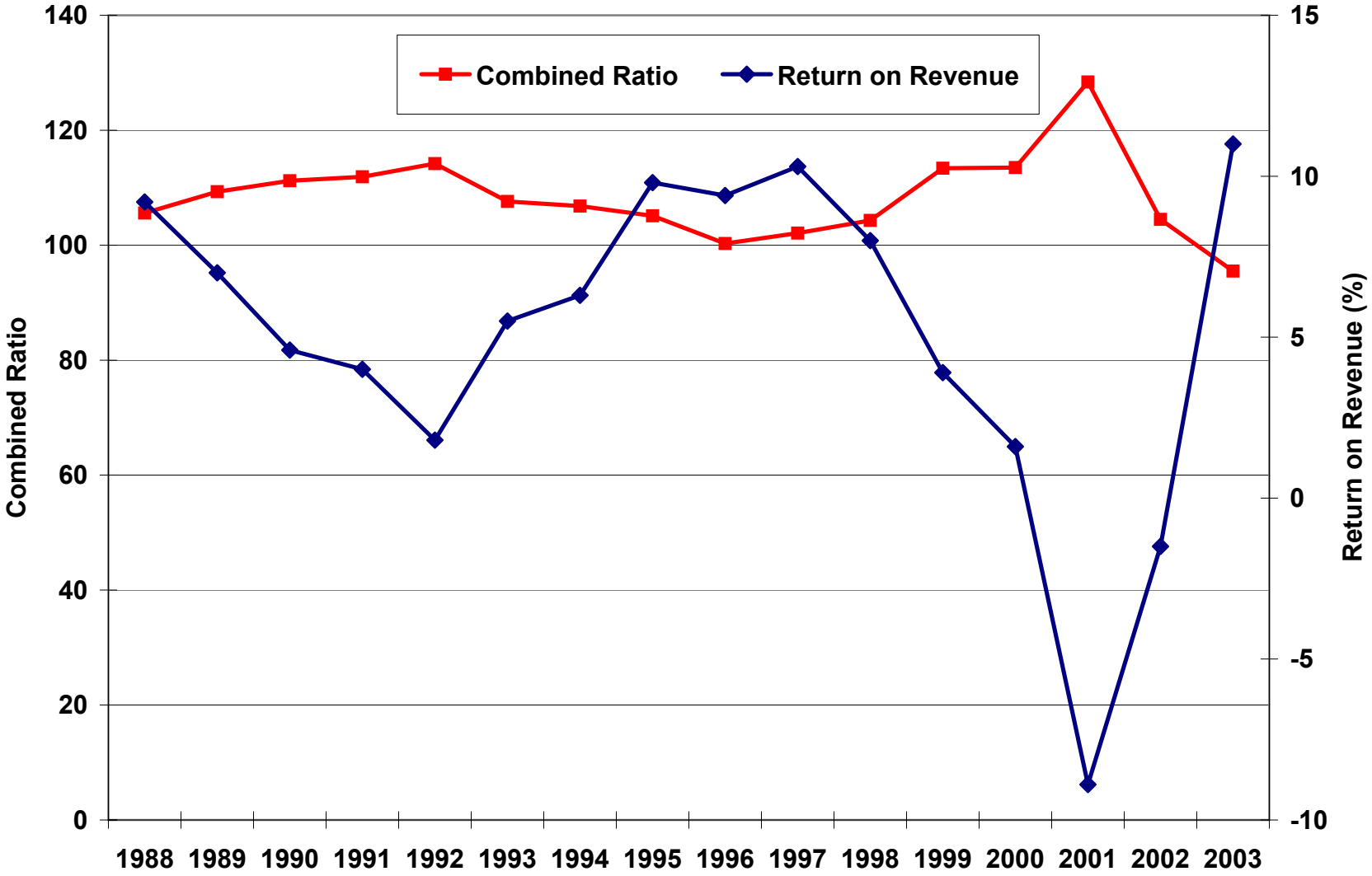
Source: A.M. Best Company, *Best's Aggregates and Averages*, various years.

Figure 9: World Rate-On-Line Index: Catastrophe Reinsurance



Source: Guy Carpenter (2005).

Figure 10: Global Non-Life Reinsurance Industry: Financial Performance



Source: Standard & Poor's Global Reinsurance Highlights, 2004.

Figure 11
CAT Bond With Single Purpose Reinsurer

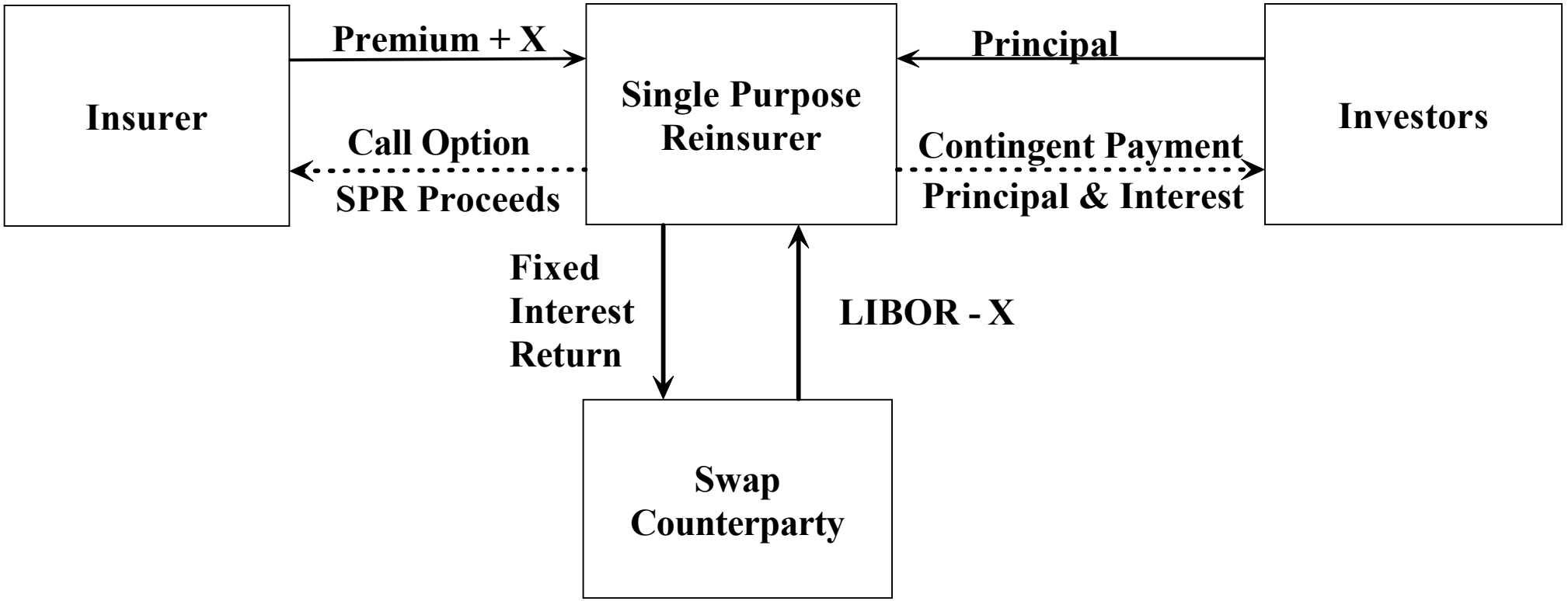
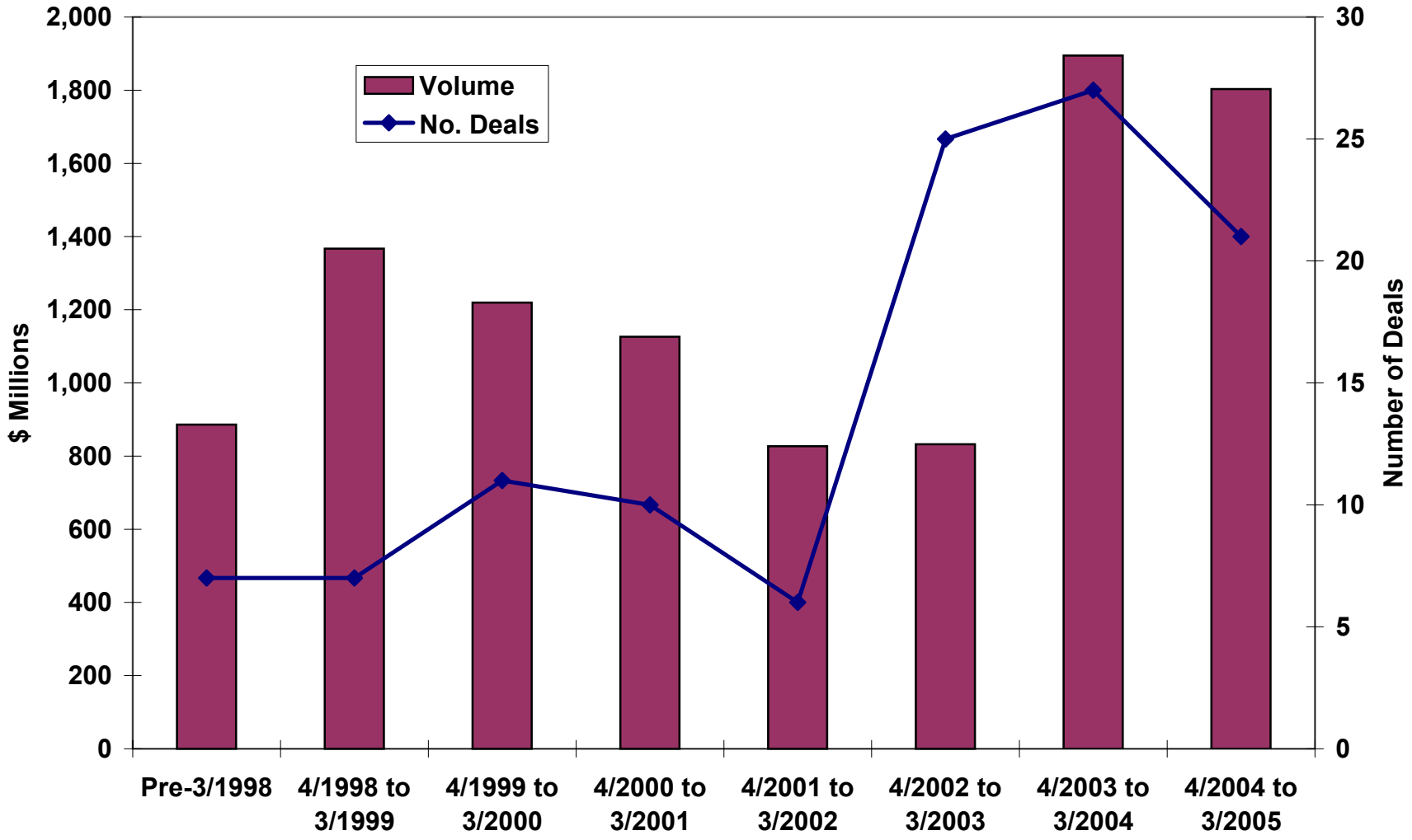
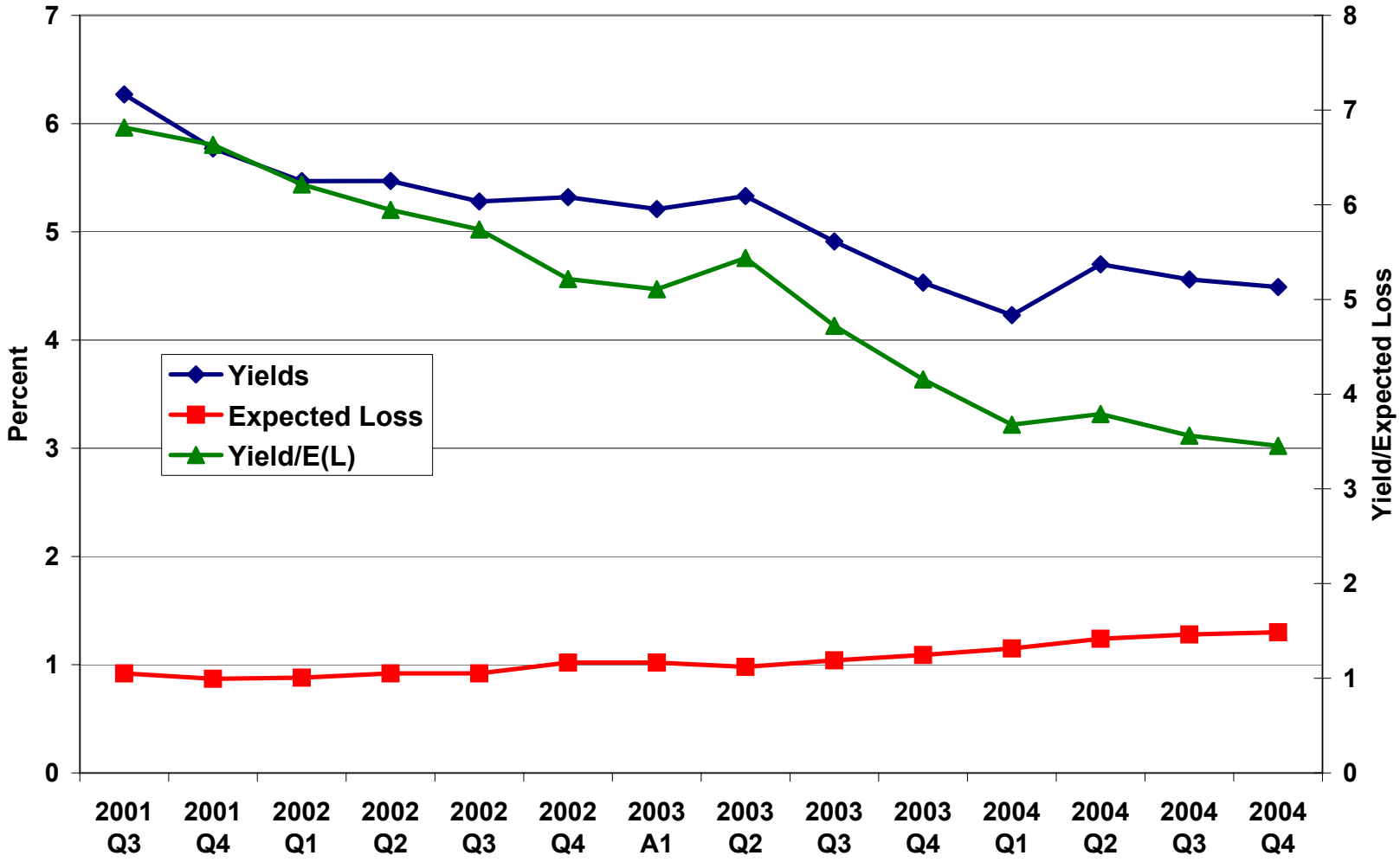


Figure 12: CAT Bonds: New Issue Volume and Number of Deals, 1998-2005



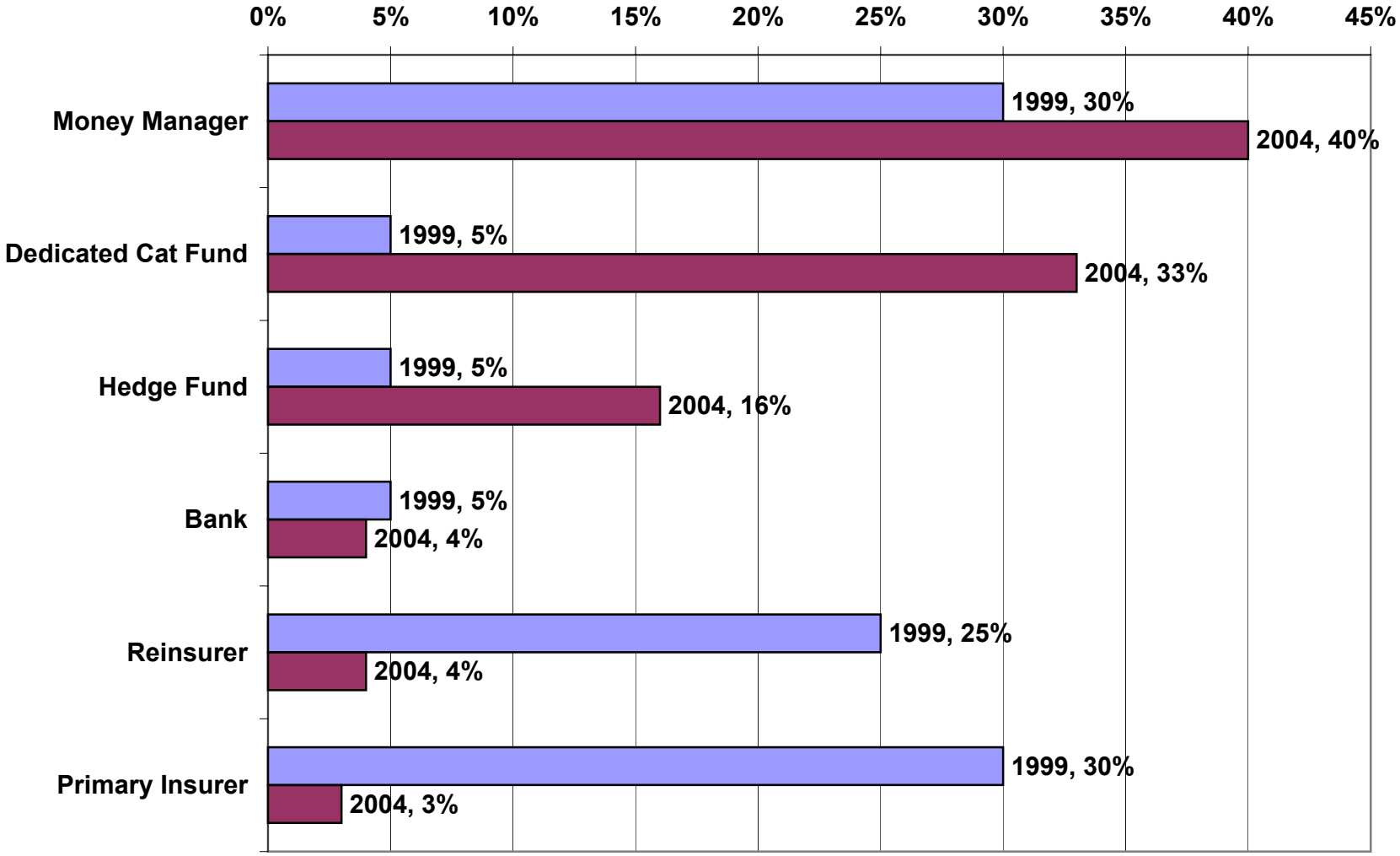
Source: Lane Financial (2005).

Figure 13: CAT Bond Absolute and Relative Yields



Source: Lane Financial (2005).

Figure 14: CAT Bonds: Percentage of New Issue Volume Purchased By Investor Type



Source: Swiss Re.

Figure 15: Coverage Under the TRIA of 2002

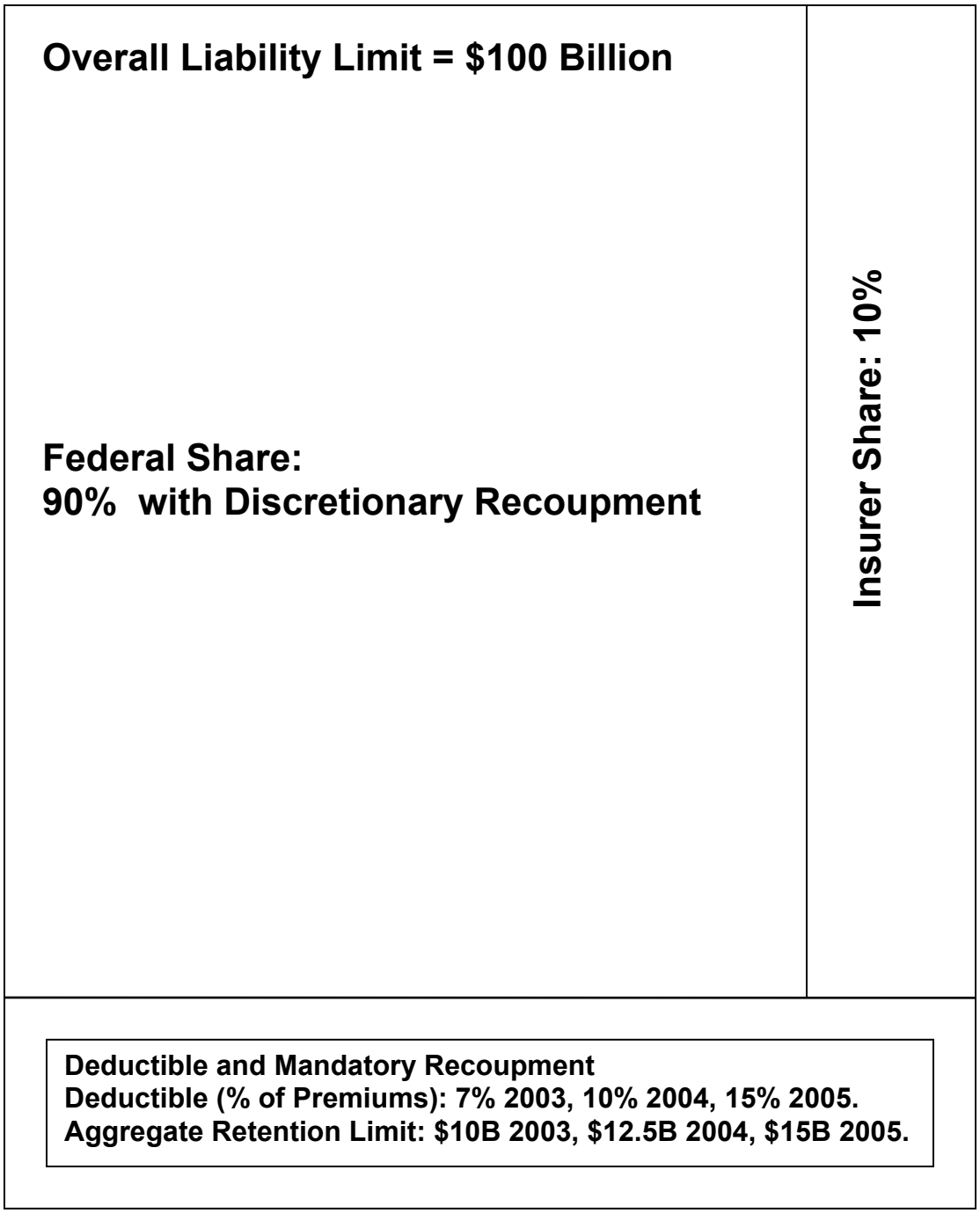


Figure 16: Stock Price Impact of the Passage of TRIA (11/20/2002)

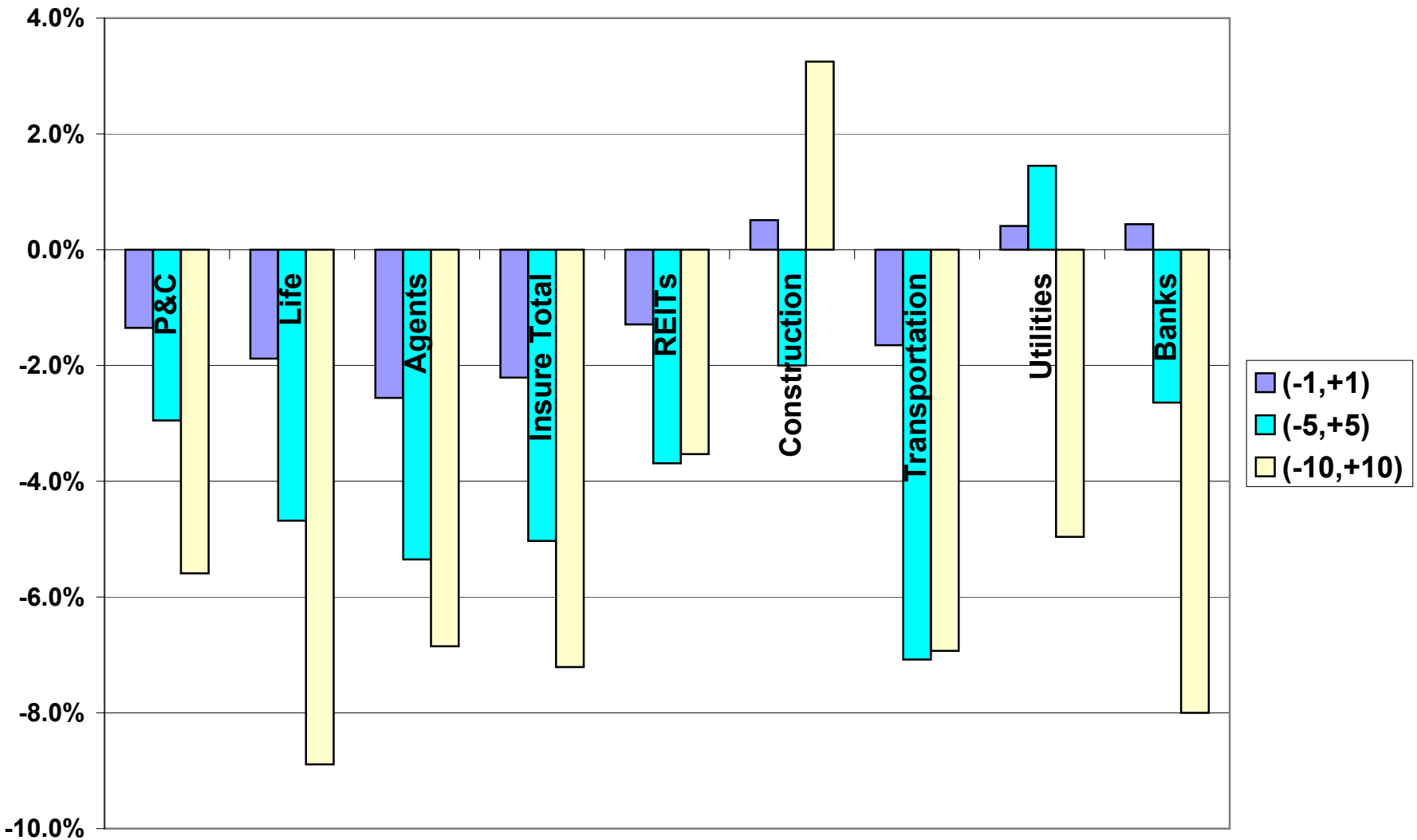
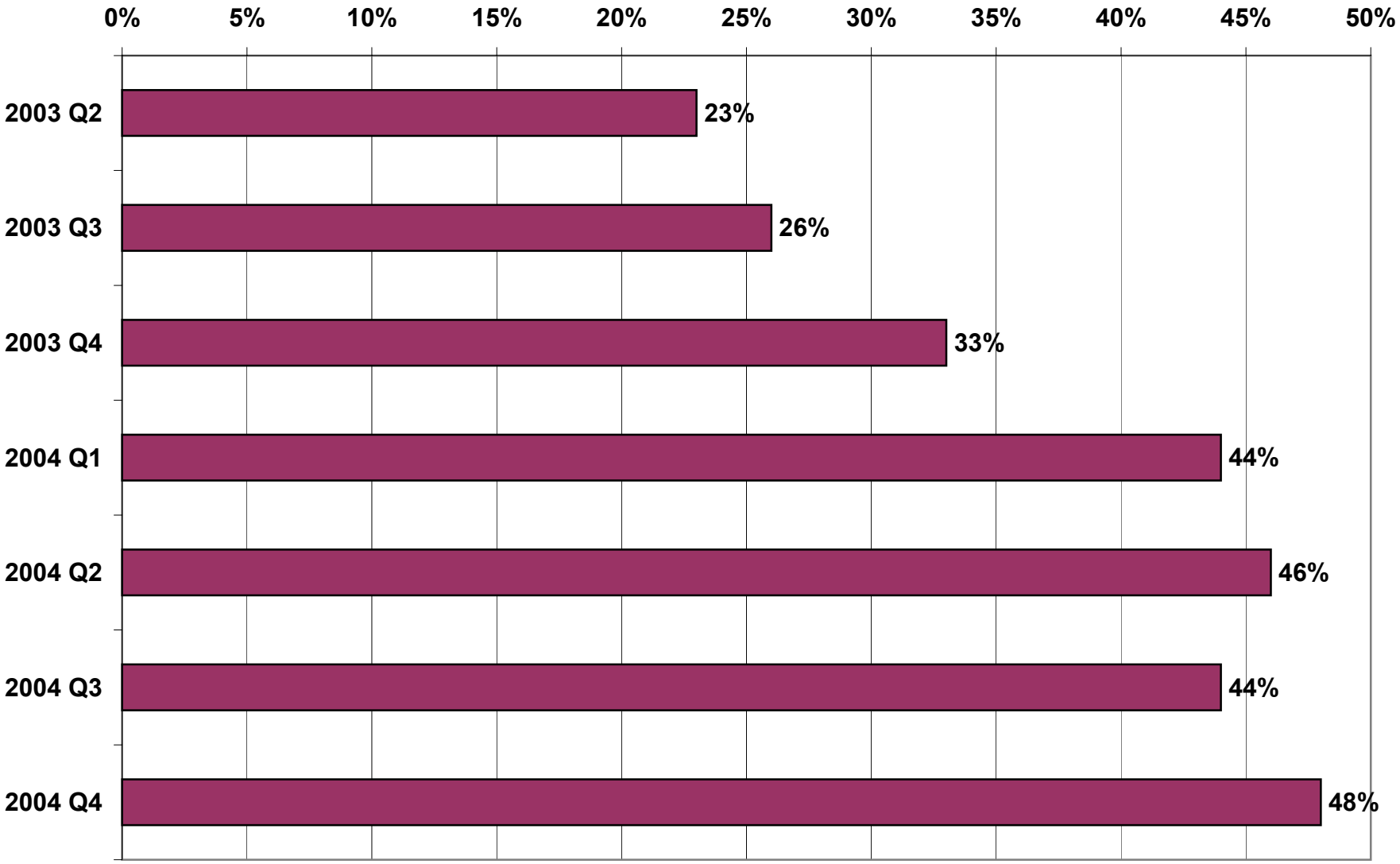
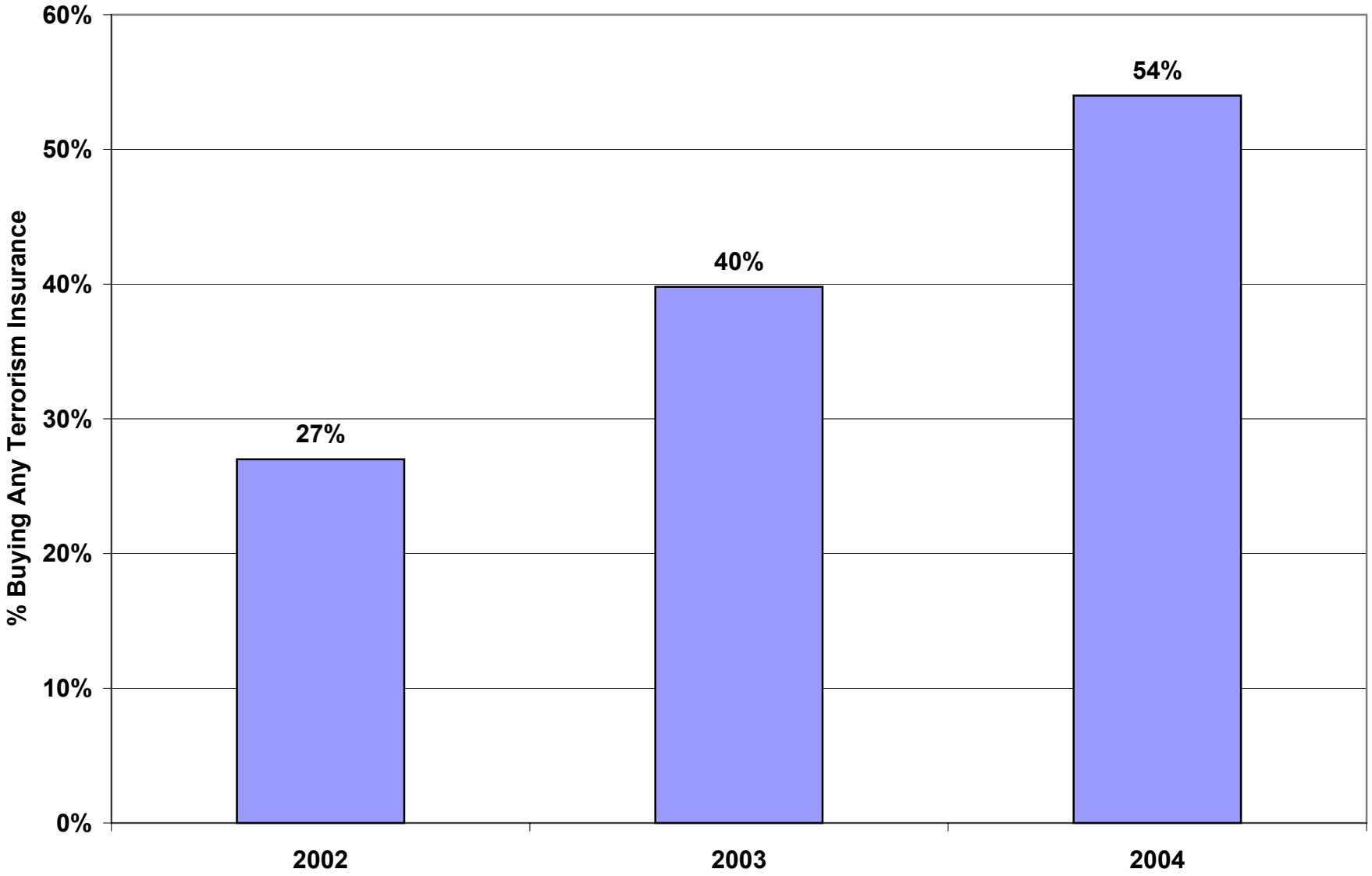


Figure 17:
Terrorism Insurance Take-Up Rates: Marsh & McLennan Estimates



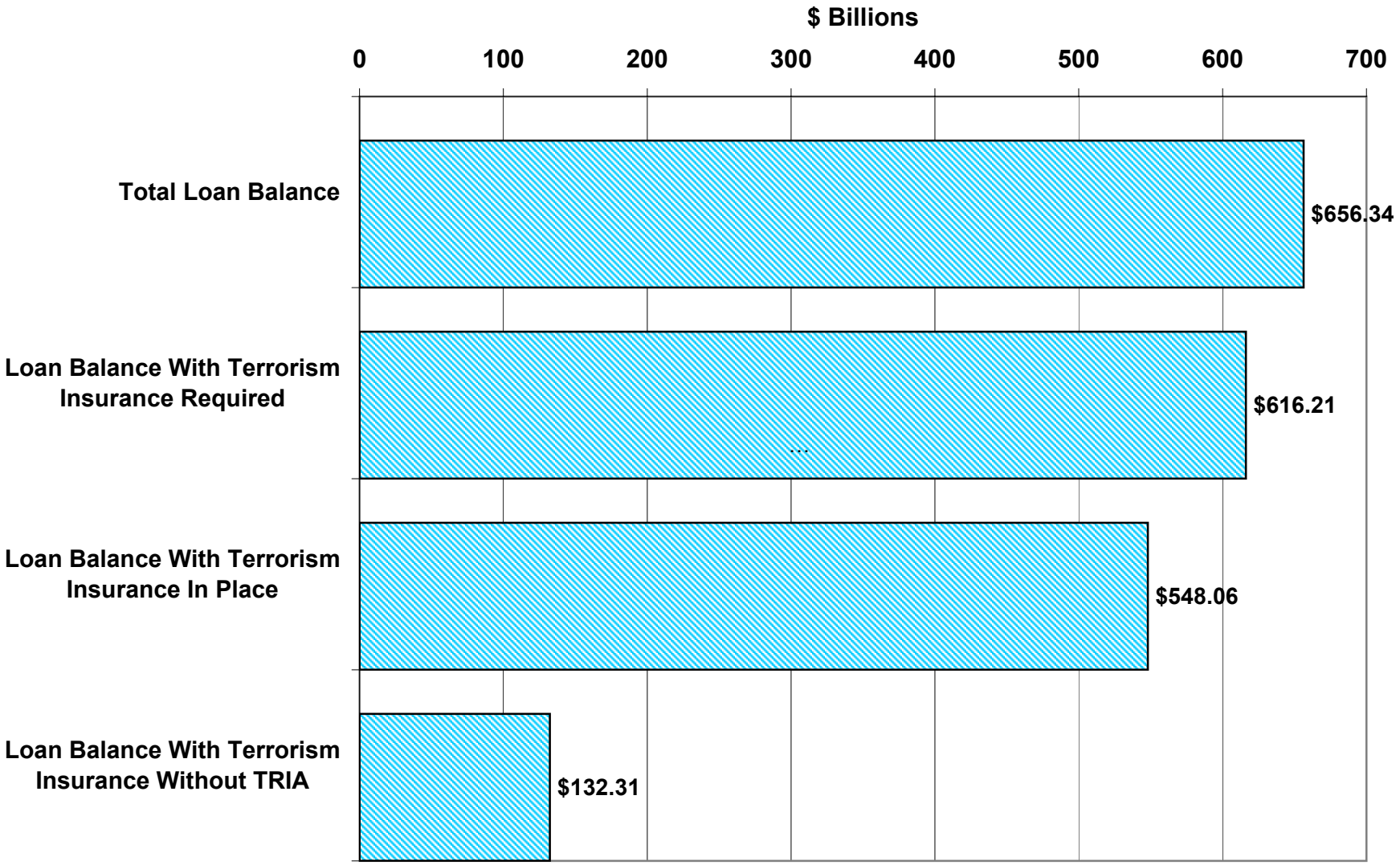
Source: Marsh (2005a).

Figure 18: Policyholder Terrorism Insurance Take-Up Rates



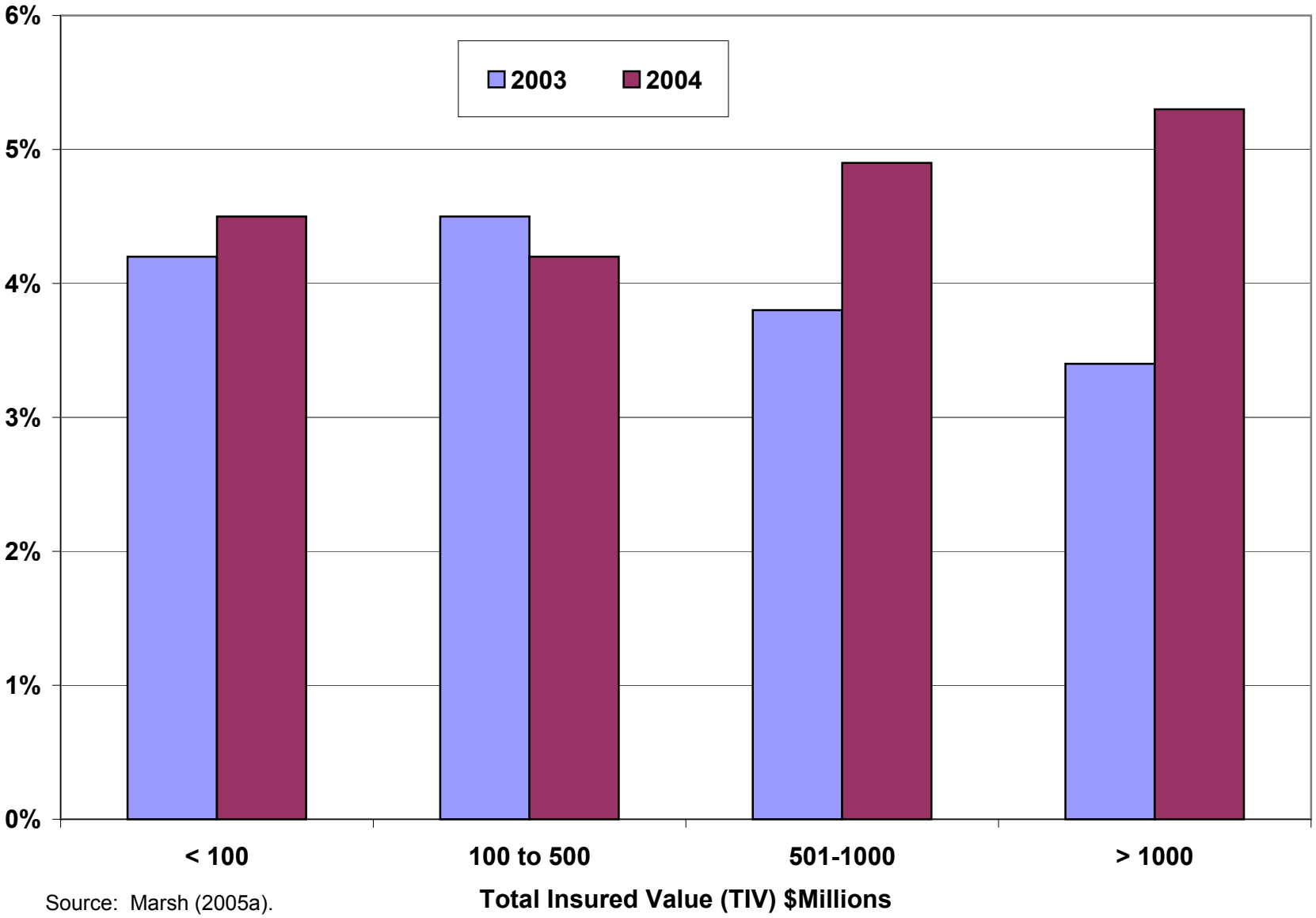
Source: US Treasury (2005).

Figure 19: Terrorism Insurance in the Commercial/Multifamily Mortgage Market: 2004



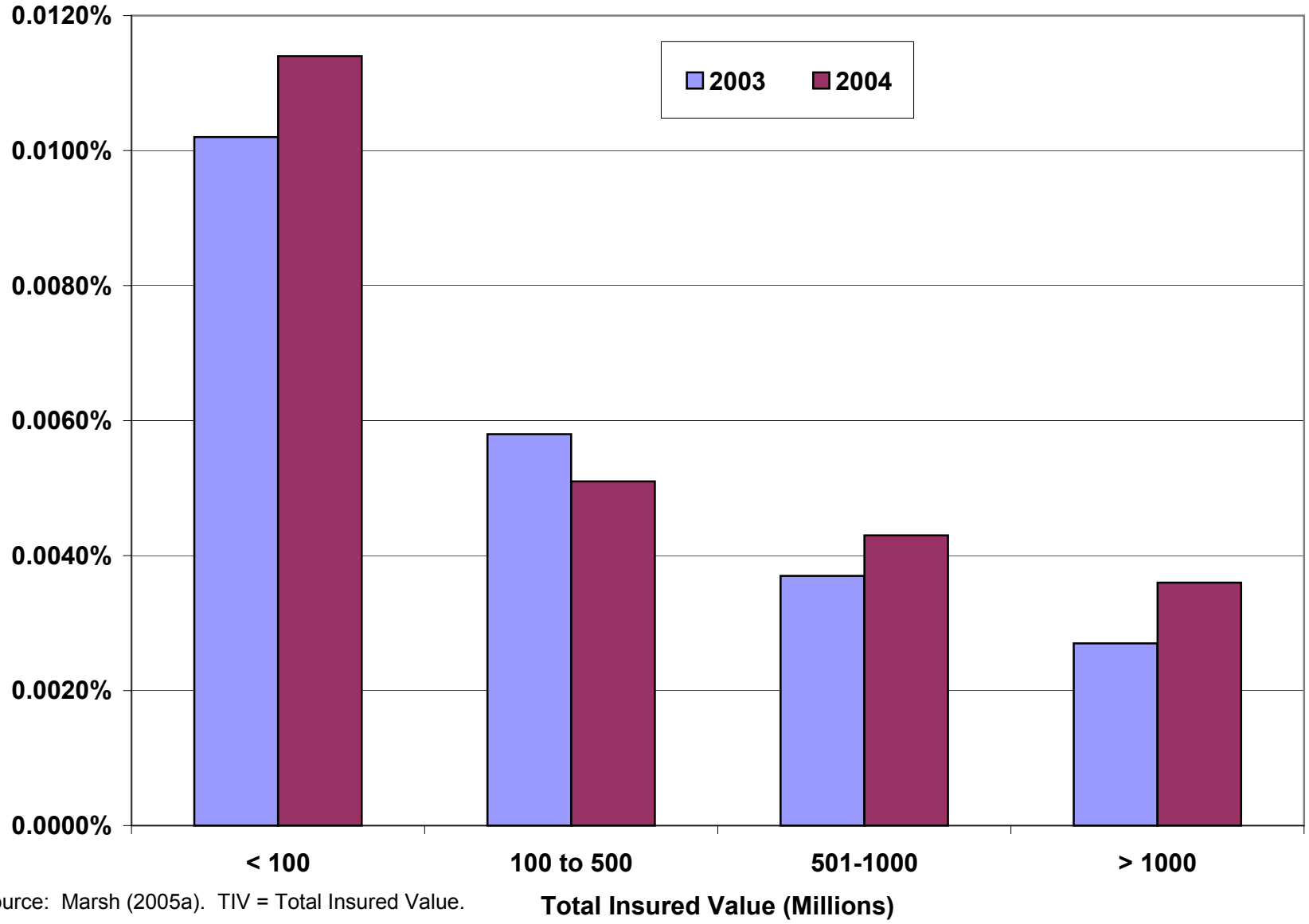
Source: Mortgage Bankers Association (2004).

Figure 20: Terrorism Insurance Price As Percentage of Property Insurance Premiums



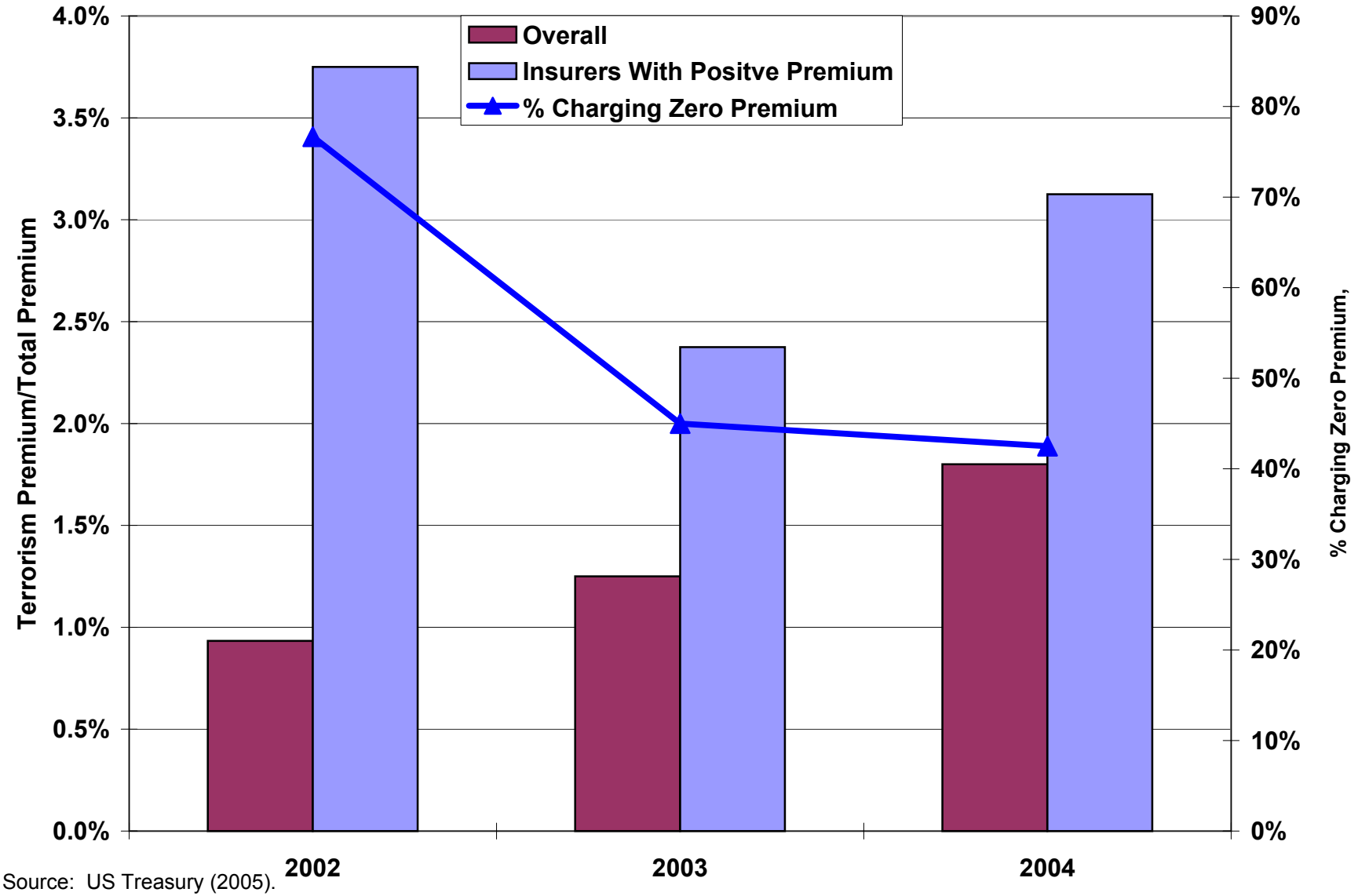
Source: Marsh (2005a).

Figure 21: Terrorism Insurance Pricing: Median Rates by TIV



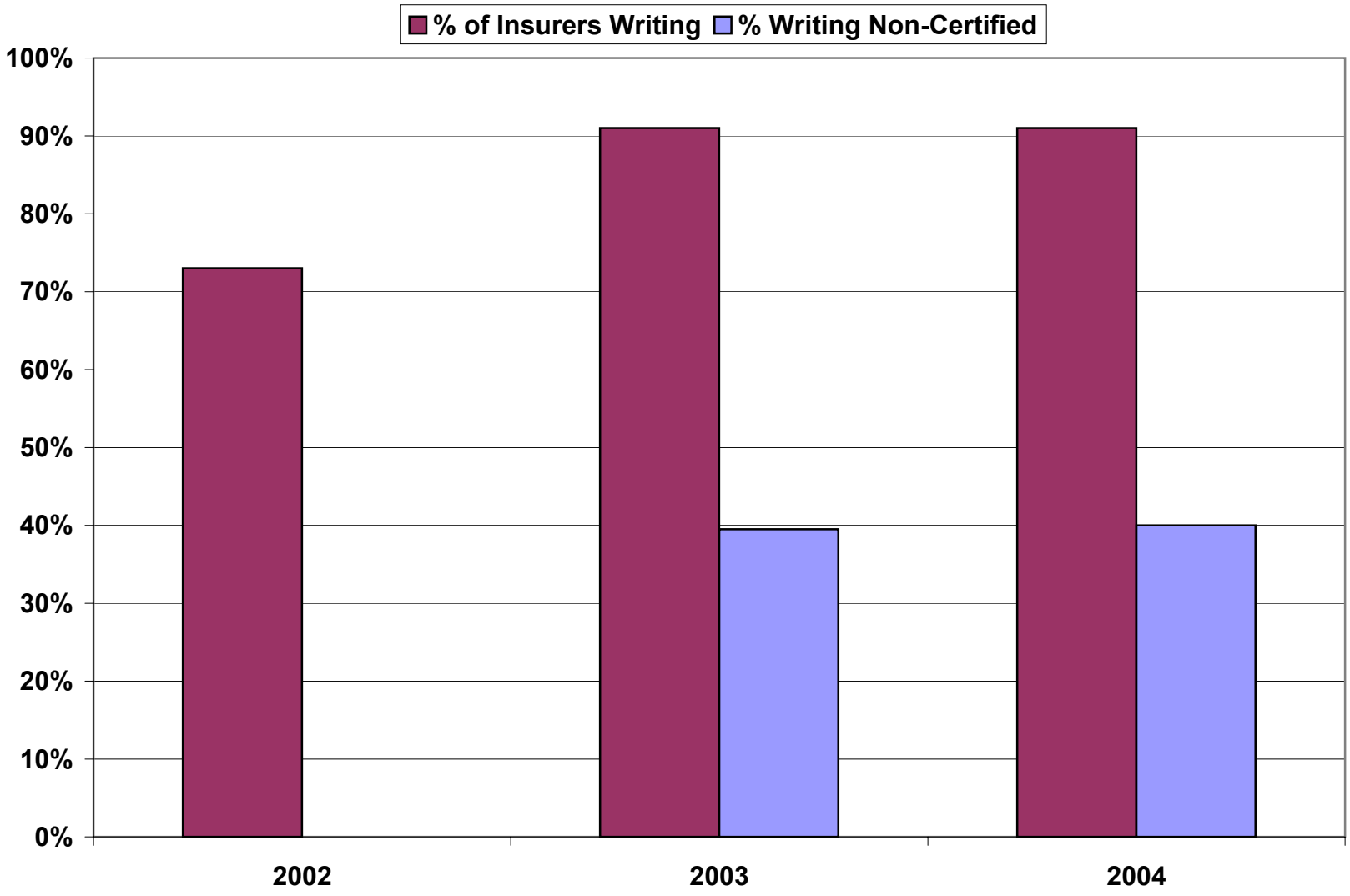
Source: Marsh (2005a). TIV = Total Insured Value.

Figure 22: Average Terrorism Cost Shares (Terrorism Premium/Total Premium)



Source: US Treasury (2005).

Figure 23: Extent of Terrorism Coverage



Source: US Treasury (2005).

Table 1: Top 40 Insured Catastrophe Losses

Insured loss[1]	**Victims**[2]	**Date** (start)	**Event**	**Country**
50,000	1,211	29/8/2005	Hurricane Katrina	US
21,542	43	23/8/1992	Hurricane Andrew	US, Bahamas
20,035	3,025	11/9/2001	Terror attack on WTC, Pentagon and other building	US
17,843	61	17/1/1994	Northridge earthquake (M 6.6)	US
11,000	124	2/9/2004	Hurricane Ivan; damage to oil rigs	US, Caribbean
8,000	24	11/8/2004	Hurricane Charley	US, Caribbean
7,831	51	27/9/1991	Typhoon Mireille/No 19	Japan
6,639	95	25/1/1990	Winterstorm Daria	France, UK et al
6,578	110	25/12/1999	Winterstorm Lothar over Western Europe	France, CH et al
6,393	71	15/9/1989	Hurricane Hugo	Puerto Rico, US
6,000	119	24/9/2005	Hurricane Rita	US
5,000	38	26/8/2004	Hurricane Frances	US, Bahamas
5,000	280,000	26/12/2004	Seaquake (MW 9.0), tsunamis in Indian Ocean	Indonesia, Thailand
4,988	22	15/10/1987	Storm and floods in Europe	France, UK et al
4,613	64	25/2/1990	Winterstorm Vivian	W./Central Europe
4,582	26	22/9/1999	Typhoon Bart/No 18	Japan
4,091	600	20/9/1998	Hurricane Georges	US, Caribbean
4,000	3,034	13/9/2004	Hurricane Jeanne; floods, landslides	US, Caribbean: Haiti
3,585	45	6/9/2004	Typhoon Songda/No 18	Japan, South Korea
3,361	41	5/6/2001	Tropical storm Allison; rains, flooding	US
3,292	45	2/5/2003	Thunderstorms, tornados, hail	US
3,195	167	6/7/1988	Explosion on platform Piper Alpha	United Kingdom
3,065	6,425	17/1/1995	Great Hanshin earthquake (M 7.2) in Kobe	Japan
2,722	45	27/12/1999	Winterstorm Martin	Spain, France, CH
2,677	70	10/9/1999	Hurricane Floyd; floods	US, Bahamas et al
2,603	59	1/10/1995	Hurricane Opal	US, Mexico
2,535	38	6/8/2002	Severe floods across Europe	Europe
2,358	26	20/10/1991	Forest fires which spread to urban areas, drought	US
2,347	–	6/4/2001	Hail, floods and tornados	US
2,289	246	10/3/1993	Blizzard, tornados	US, Mexico, Canada
2,154	4	11/9/1992	Hurricane Iniki	US, N. Pacific Ocean
2,019	23	23/10/1989	Explosion in a petrochemical plant	US
1,958	–	29/8/1979	Hurricane Frederic	US
1,927	39	5/9/1996	Hurricane Fran	US
1,916	2,000	18/9/1974	Tropical cyclone Fifi	Honduras
1,883	100	4/7/1997	Floods after heavy rain in Central Europe	Poland, Czech Rep.
1,860	116	3/9/1995	Hurricane Luis	Caribbean
1,759	6	27/4/2002	Spring storm with several tornadoes	US
1,746	350	10/9/1988	Hurricane Gilbert	Jamaica, Mexico
1,730	30	18/9/2003	Hurricane Isabel	US, Canada

[1] Property and business interruption, excluding liability and life insurance losses. Losses in 2004 U.S. dollars.

[2] Dead and missing

Source: Swiss Re, Economic Research & Consulting, *sigma* 1/2005. Katrina and Rita estimates are mid-point of the loss range estimated by Risk Managmeent Solutions in early October 2005.

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