Catastrophe Insurance, Dynamic Premium Strategies, and the Market for Capital[1]

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1. INTRODUCTION

The purpose of this paper is to revisit the problem of the non-insurability of catastrophe risk. The paper focuses on questions surrounding the insurability of earthquake risk in the State of California, but the analysis may be applied to problems of insuring any natural disaster risk (for example the risk of hurricanes).

The paper argues that there is nothing in the nature of catastrophe risk as such which prevents the operation of a private market of insurance. To be viable, however, this market must solve the problem of matching a smooth flow of annual premiums to a highly non-smooth flow of annual losses. Current institutional arrangements do not provide incentives to solve this problem, hence the withdrawal of many insurance firms from this market. This does not mean that the difficulty (a capital market problem, not an insurance problem) cannot be overcome, and we offer a few suggestions.

We believe that framing the problem of catastrophe insurance as a capital market problem rather than a problem in pure insurance may be of value to regulators for two reasons.

1. In prior approval states, regulators are frequently called upon to evaluate requests for premium increases following a natural disaster. By thinking of this request as an attempt to solve a problem of inadequate capital (rather than a problem of increased risk) regulators can evaluate this (often politically sensitive) request with the relevant economic tools.
2. Since there seems to be some consensus that private markets cannot provide catastrophe insurance, regulators in catastrophe-prone states are beginning to design state-run catastrophe insurance schemes. Also regulators are frequently asked to comment on and assist in the design of Federal Catastrophe Insurance legislation. If State and Federal schemes are to avoid the problems faced by the private market, it seems essential to know exactly what these problems are.

The paper will conclude by examining the recently proposed California Earthquake Authority Bill in the light of our discussion of capital market reforms.

2. IS EARTHQUAKE RISK UNINSURABLE?

There seems to be no agreed upon definition of an uninsurable risk. The insurance literature, however, often identifies two factors which are viewed as impediments to the successful operation of a private insurance market.

i) The insured risk is too large in some sense.

ii) The probability of loss is not susceptible to precise actuarial calculation.

Important as these factors are, we will now argue that neither the size of the risk nor imprecise probability estimates have prevented the successful operation of risk sharing markets in the past [2]

Consider, for example, one of the oldest lines of business, marine insurance. Marine insurance could, in principle, generate large losses. A hurricane, or an act of war, could affect many ships at the same time. Moreover, accurate assessment of the probability of weather-related risks has only become available recently. Yet a market for marine insurance operated among the ancient Greeks and Phoenicians, and flourished in London from as early as the 17th Century.

What factors permitted the operation of a private market in marine insurance when prima facie this line suffers from the same uninsurable characteristics, size and imprecision of risk, as earthquake insurance? The answer to this question lies in the particular institutional arrangements which marine insurers made for accessing capital markets in the event of a large loss.

These arrangements took two forms. In the older form, the so called contract of bottomry, a

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[2] This point seems to have first been made by Karl Borch [1990] who noted (p. 315) the emergence of viable private insurance arrangements for commercial aircraft and commercial satellite risk. Both of these lines involved potentially huge losses and neither had any history of loss from which to assess probabilities.

lender advanced the ship-owning merchant the full cost of the voyage as a loan. If the voyage was successful, the ship-owner repaid the bank at an interest rate which included a premium to reflect the risk of loss. If the ship was lost, the loan was forgiven.

In the second form, syndicate insurance [3], say as practised at Lloyds, a ship-owner's broker insured the hull and cargo with a Lloyds' syndicate of Names . A Name was an individual who had shown the existence of substantial wealth. Each name pledged the full extent of this personal wealth in the settlement of potential losses.

Note that in both of these institutional arrangements the fund for settlement of losses was clearly defined. Indeed, in the case of the contract of bottomry, the fund for settlement of losses had already been advanced, and in this case there is no distinction between a bank and an insurance company.

The major problem with the modern contract of catastrophe insurance is that no pool of capital is allocated to meet high losses even in the case in which these high losses are expected.[4] [5] We turn now to an examination of why this rather surprising situation arises.

3. DYNAMIC PREMIUM STRATEGIES, CAPITAL ADEQUACY, AND THE LIMITED LIABILITY CORPORATION

There are three features of the modern contract of insurance which work against the creation of an estimated liability as the basis for paying future losses. We discuss each in turn.

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[3] It is argued by historians of insurance that the institutional arrangements changed from bottomry to syndicate insurance because the necessarily high interest rates charged in the contract of bottomry ran afoul of the Catholic Church s prescriptions on usury.

[4] As Robert Hunter wryly comments on the Florida hurricane insurance market, In a locale whose major university football team is called the Hurricanes, the question is not whether a hurricane will strike but when and how big. Hunter [1994], p. 476.

a) Accounting Requirements

As is well known, standard accounting practices in property/casualty insurance preclude an insurance corporation from setting up an estimated liability against a loss which has not yet occurred, even though the occurrence of that loss at some time is a certainty, see e.g. Mooney and Cohen [1991][6]

Of course nothing prevents an insurance company from adding any catastrophe loading it wishes to its premium (subject to regulatory approval) but there is no way that the corporation can set up an estimated liability reflecting the catastrophe risk. In principle, all of the unassigned capital is available to pay such losses, but this capital is also necessary for other purposes such as premium growth.

It is instructive to examine this issue in the light of the work of the recent Florida Academic Task Force on Hurricane Catastrophe Insurance. This task force surveyed insurance companies on the question of the size of the insurance surplus available to meet hurricane losses in the State of Florida, both with respect to their own capacity and with respect to the capacity of the industry as a whole. Among the responses were:

STATE FARM INSURANCE - VINCENT J. RIO III, COUNSEL

State Farm does not have a definitive number for the maximum capacity of the private insurance industry. State Farm can dedicate approximately $1 billion in retention plus their co-pay in excess of the retention for claims associated with a Florida hurricane

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[5] We do not mean to suggest that the large size of the losses for catastrophe risks is not a problem for this market. Our point is that the large size of losses has not *per se* disabled insurance markets in the past.

[6] Some insurance corporations clearly recognize that this accounting rule has undesirable features for a corporation's annual reports. Thus Zenith National Insurance Corp. Annual Report, 1994 p 27, "Property Insurance exposes Zenith to the risk of significant loss in the event of major adverse natural phenomena known in the industry as a catastrophe. These catastrophes may cause significant contemporaneous financial statement losses, since catastrophe losses may not be accrued in advance of the event. "

catastrophe.

ALLSTATE INSURANCE COMPANY - DAVID G. NADIG, COUNSEL

The total capacity for the private insurance industry and the CAT (Florida Catastrophe Fund) fund to pay claims for a Florida hurricane without impairment is $14 billion ($10 billion and $4 billion, respectively). Allstate can dedicate $1 billion of its capital and surplus to pay claims for a Florida Hurricane catastrophe.

It would be a very interesting follow up question to these corporations to ask what process was used to come up with these numbers. For example, these answers might be contrasted with the answer given by the Westfield Companies.

WESTFIELD COMPANIES - JACK ADORNETTO, SENIOR VICE PRESIDENT

The Westfield Companies do not have an answer as to the maximum capacity of the private insurance industry, but they do suggest that the results of hurricane Andrew be used as a gauge. Additionally, the Westfield Companies do not allocate capital and surplus by states or territories, therefore an amount as to how much they can allocate to pay claims for a Florida hurricane catastrophe can not be provided.

Obviously, whatever principles govern U.S. accounting rules with regard to property casualty insurance, they do not include providing an estimated liability reflecting policyholder claims against the company's assets in the event of a catastrophe.

b) Cash Surplus and Takeovers:

Even if the insurance company could set up a liability, however, the fact that insurance is offered by a limited liability company whose stock is freely traded in the open market works against such set asides.

It is instructive to consider the case of the Chrysler Corporation. This company tried to self insure against a catastrophe, the down turn in the business cycle and its effect on Chrysler revenues, by accumulating a large stock of cash (over $7 billion). This stock of cash, however,

attracted the attention of a corporate raider (Mr. Kirk Kerkorian) who had no real complaints about the quality of Chrysler's management of the automobile business, but who felt he had much better uses for Chrysler's catastrophe cash. [7]

The same fate could easily befall a publicly traded insurance corporation which accumulated cash assets that were not encumbered by corresponding liabilities. There seems nothing in the rules of the corporate game to prevent a raider from buying such a company, taking its cash, and closing shop. Also, if this insurance company is a wholly owned subsidiary of another company, there is nothing in law to prevent the parent company from treating its insurance offspring as a convenient source of cash. Indeed, given that a catastrophe does not occur in a given year, the cash could be allocated to any corporate purpose, including shareholder dividends.[8]

The legal benefits bestowed by limited liability make this problem worse. With limited liability an unscrupulous corporation could simply distribute its earned catastrophe premiums as dividends if there is no loss, then declare insolvency if a catastrophe hits. The recent declaration of bankruptcy by Dow Corning in the face of liability claims arising from breast implants provides obvious parallels. All of which is to say that the incentive structures associated with the publicly traded limited liability corporate form are not conducive to the sound provision of catastrophe insurance.

c) Annual Premiums and Annual Losses:

Assuming that we are correct that accounting rules and public limited liability structures work

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[7] For a discussion of the role of free cash in generating takeover bids see Jensen [1986].

[8] It could be argued that mutual insurance companies would be immune to takeover risk. However, consumer advocates or insurance regulators might force mutual companies to distribute some of their retained earnings. Furthermore, insurance regulators might attempt to stop attempts to siphon cash from an insurer, but it is doubtful an insurance company would want to depend on such "protection" (in this regard, also see Klein[1995].)

against the private provision of catastrophe insurance, it is surprising that there has been no call for changes in these areas. We believe that there is a third feature of insurance markets which (taken together with the absence of major catastrophes for a number of years) held back discussion of the problem of expected loss reserving.

Put simply, for all lines of insurance, with the one exception of catastrophe insurance, there is no need to create estimated liabilities for expected losses because expected losses can be paid out of current premiums. Consider the typical insurance corporation s dynamic premium strategy as examined by, for example, Brockett and Witt [1982] and Venezian [1985].

The corporation has a target loss ratio LR* with LR*<1 to cover administrative and other costs. The corporation chooses this year s premium rate Ð(t) so that this years loss rate LR(t) approaches LR* as closely as possible.

According to Brockett and Witt [op cit.] and Venezian [op cit.] corporations choose a feedback rule which sets the ratio of average losses of over past few years (AL_t) to total premiums (P_t) equal to LR*. For example, in a typical case the company might use a three-year moving average of losses:

$$\frac{L(t-3)+L(t-2)+L(t-1)}{3} = AL_3(t) \text{ and set}$$

$$\frac{AL_3(t)}{P(t)} = LR^*$$

The precise averaging feedback rule which the company uses is not important. What is important is that if the time path of losses L(t) is reasonably smooth, the resulting time path of premiums will be reasonably smooth and the actual loss ratio will also be reasonably smooth and less than 1 in value. In this case it is both possible and appropriate for the company to pay today's losses out of today's premiums, even though today's premiums were collected to pay for future losses.

Of course some capital is necessary to cover unexpected losses, but the quantity of the needed capital is small if the loss pattern is smooth and in this case the joint stock limited liability firm is a viable corporate form, no estimated liability being needed to cover future losses.

In the case of earthquake insurance (or catastrophe insurance more generally) the annual pattern of losses is highly non smooth and dynamic premium strategies based on a few years of experience will not lead to loss ratios anywhere close to one. In bad years these loss ratios could be very large requiring a large stock of capital.

This point can be easily seen by examining Table 1. This Table shows the loss ratio over time by line, measured as a percent. As can be seen, for all lines except earthquake the industry has been largely successful in keeping loss ratios below 1, (percent below 100). In the case of multiple peril crop and homeowners multiple peril the ratio did exceed 1 in several years reflecting the catastrophe (hurricane) element in this line. A pure hurricane line would show a similar pattern to the earthquake line. This pattern of loss ratio is also clear from earthquake data in the State of California, see Table 2.

The fundamental problem of catastrophe insurance thus seems clear. Unlike every other line of insurance, the contract of catastrophe insurance, as presently structured, requires that the seller have access to a large amount of capital in every year in which the contract stands. [9] Since such large pools of capital do not exist, firms have withdrawn from this market. We now turn to an analysis of possible reforms in this market which will permit non-state provision of insurance in this line.

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[9] This point has been made by Sean Mooney who compares the geographical diversification provided by say fire insurance with the intertemporal diversification required by catastrophe insurance, Mooney [1995].

4. A PRIVATE MARKET IN CATASTROPHE INSURANCE?

If a purely private market in catastrophe insurance is to be viable, it must solve the fundamental problem of the mismatch between the size of annual premiums and the size of the expected loss. This can be done in one of two ways. The premiums can be adjusted to the losses, or the losses can be adjusted to the premiums. We discuss each case in turn.

a) Accumulating Premiums to Meet Losses

The science of earthquake prediction is currently so underdeveloped, (see e.g. Hopes for Predicting Earthquakes, Once So Bright, Grow Dim - New York Times, August 8, 1995) there is no hope at present of predicting when or where the next large loss will strike. For the sake of discussion, suppose we assume that it is certain that a $30 billion earthquake will hit California in the next 30 years, and suppose we consider an insurance company with 10% of the market, i.e. a company facing a $3 billion loss. What premium strategy ought this company to pursue?

Because of the absence of stability in loss experience, any premium policy based on averaging recent losses clearly will not work. One obvious recommendation would be to divide the $3 billion into equal annual premiums of $100 million . (For simplicity we ignore time value of money issues). If these premiums can be unambiguously earmarked and set aside, perhaps being placed in a trust subsidiary,[10] it will eventually provide coverage against the $3 billion loss.

As is clear, this arrangement provides no help if the $3 billion loss should occur in the first year of operation. (Think of the example of the 20th Century Insurance Company which had the misfortune to enter the earthquake market in the year of the Northridge earthquake). Since the

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[10] A wholly owned subsidiary would be in effect a captive of the insurance company, performing the same self-insurance function that captives perform for their parent companies. Similar tax issues would then arise.

funds are earmarked as earthquake premiums, it may be possible for an insurance company to borrow against them if an earthquake occurs in the early years. This might enable this arrangement to be viable, but since such borrowings use the capital market to bring the losses to the premium, it is better discussed under the second head. If there is no access to capital markets, there is simply no way that an insurance company can accumulate premiums fast enough to guarantee that it will have sufficient cash to meet a catastrophic loss.

Given that no premium strategy can guarantee solvency in the short run (in the absence of capital markets), it is of some interest to know what strategies insurance companies actually follow when they set premiums for this line. In particular it is interesting to examine why insurance companies typically raise rates substantially following a catastrophe. For example, following Hurricane Andrew in the Miami area, average rates have increased 65% between 1992 and 1995. Following the Northridge earthquake 101 insurance agencies requested rate increases ranging from 17.30% (Calfarm) to 585% (American Reliable). State Farm, for example, requested a 97.2% increase and was granted a 65% increase.

This question is clearly of interest to Commissioners in prior approval states. How should they deal with such a premium rate increase request?

Based on our prior discussion, it seems that a Commissioner cannot dispose of this request until the insurance company answers two related questions.

1. What dynamic premium strategy were you using before the catastrophe?
2. What new information relevant to this strategy is provided by the occurrence of the catastrophe?

Unless it is known how the occurrence of the earthquake affects the company's dynamic premium strategy, it is difficult to see how a rate increase request can be discussed on a rational basis.

Suppose this information is provided. If the dynamic premium strategy already reflects full information regarding an earthquake's likelihood and cost, there can be no justification for a rate increase just because the event has happened. By analogy, stock prices do not fall when a corporation's earnings fall, if a fall in earnings has been forecast by the analysts who follow this stock.

A rate increase may be justified if the occurrence of a major earthquake can be shown to increase the likelihood of another major earthquake. There seems no scientific basis on which to make this argument at this time. (We exclude aftershocks.) Indeed, some seismologists feel that once a major earthquake occurs, the probability of another one is lower. In this case, we might expect premiums to fall following a major quake.

A rate increase may also be justified if the earthquake losses demonstrate that the expected losses are now higher than was expected before the earthquake. For example, the Northridge earthquake revealed that some forms of office construction were less able to withstand an earthquake than previously thought.

A rate increase cannot be justified simply on the grounds that the size of the earthquake loss was large. For example, suppose population shifts in the 1980's increased the risk exposure in the Northridge area. This fact must have been known to insurers before the earthquake took place and should be already reflected in any rational dynamic premium strategy.

It is also the case that even if an earthquake contains new information regarding size of loss, the dynamic premium strategy should smooth this new information over whatever time period the company is using as its estimate of the time between losses. This can have perverse consequences. For example, if the findings of the engineers following the Northridge earthquake lead to building code changes which over the long run make the average building more likely to withstand a major

earthquake, the average loss exposure is actually reduced by an event which reveals unexpected structural weakness. This would require a reduction in the level of premiums. As can be seen, the process of rationally evaluating requests for rate increases following an earthquake is highly complex when the firm is pursuing a policy of accumulating the premiums to meet losses. The process is made decidedly more simple if the firm has used capital markets to bring the losses to the premiums.

It is important to add that the structure and level of catastrophe insurance premiums can also be an important factor in determining the amount of mitigation that property owners carry out in order to reduce their losses. It seems likely today that property owners carry out insufficient mitigation because the premium structure provides limited incentive to do so. We suspect that the greater use of capital market instruments will make the structure of premiums more transparent to policyholders, with the result that greater mitigation efforts will be reflected in lower insurance premiums.

b) Adjusting Losses to Premiums: The Role of Capital Markets

We have just seen that the early hit problem rules out the payment of losses out of premiums in the early years of a catastrophe insurance line. To guarantee payment of losses, therefore, it is essential that the contract of catastrophe insurance be linked in some way to the market for capital. There are a number of ways in which this is currently being attempted, and we discuss each of these in turn. In the next section we propose a new source of capital.

1 Reinsurance

The contract of reinsurance is the traditional means by which an insurance company reduces the size of its potential losses. Catastrophe reinsurance capacity has recently grown sharply, the

Bermuda market now being estimated to have a capacity of $3.5 billion. The contract of reinsurance, however, is not a magic potion by which we solve the problem of giving incentives to publicly traded limited liability companies to set aside large liquid surpluses.

In the contract of reinsurance, total annual premiums P and total losses L are split up and held by the direct insurer and the reinsurer according to some sharing rule. The repackaging of P and L can be shown to be in general beneficial to both the primary insurer and the reinsurer, but it cannot avoid the iron law of arithmetic that when the contracts of insurance and reinsurance are considered together, the ratio of losses to premiums, L/P, in any one year is what it was before the reinsurance and is, in the case of catastrophes, potentially high.

Reinsurance does not of itself solve the problem of providing capital to meet such a case, though by repackaging the risk in a more attractive form, it may induce more capital to enter this line. However, when this capital is provided by limited liability joint stock companies, all the problems discussed above are just pushed back one stage into the laps of the reinsurers. If rates in this market fall, there is nothing to prevent a reinsurer from taking its capital and exiting.

At Lloyds, unlimited liability and a three year open book accounting period prevented this capital flight, but, after 300 years, Lloyds has now instituted limited liability for some of its risks. Without committed capital, the reinsurance market is just as open to problems of financial solvency as the primary market.

2 Act of God Bonds

Recognizing that committed capital is one of the keys to viability, a number of investment banks have developed bond instruments which provide capital to an insurance company in advance of a catastrophe. Since these instruments will only be exercised in the event of a catastrophe they are known as Act of God bonds.

For example, Guy Carpenter and Company, a unit of Marsh and McLennon, offers bonds that pay interest at 10% above Treasury rates, bondholders being required to forgive the loan in the event of a catastrophe. Nationwide Mutual Insurance Company, in a deal arranged with J. P. Morgan and Salomon Brothers, have created a trust subsidiary which has issued $400 million worth of bonds, the proceeds of this issue being placed in Treasury Bonds which were used as collateral for the issue. In the event of a catastrophe these Treasury Bonds would be liquidated and Nationwide will substitute its own corporate notes.

Although both of these arrangements are treated as financial innovations, they are nothing more than modern versions of the Roman contract of bottomry discussed earlier as one of the capital arrangements which makes private catastrophe insurance viable.

If this modern version of bottomry is to expand, it is essential that the bonds be priced correctly. Because payments are uncorrelated with the market, modern portfolio theory would suggest that the risk premium necessary to induce investors to hold a small fraction of their portfolio in such assets is small.[11] Under the assumptions of the capital asset pricing model, this would make the required rate of return on these bonds approximately equal to the return on Treasuries. To generate this required rate of return the posted interest rate would have to be high enough to offset the loss of principal if a catastrophe occurs.

On the other hand, portfolio managers may be reluctant to hold these assets either because they believe modern portfolio theory does not apply to an asset with such a skewed return distribution, or because of purely behavioral concerns with the nature of this instrument. If these pricing issues can be resolved, however, Act of God bonds and their like would seem to be an important

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[11] Since catastrophe insurance market failure is frequently viewed as a problem of size, recall that the value of traded stocks in the US alone is over $5 trillion so that a $50 billion catastrophe loss is only 1% of this market.

potential source of new capital to the line.

It is also worth noting that the interest paid on these bonds will be a business expense to an insurance company. If this interest rate rises, this provides a justification for a premium increase in prior approval states. More generally, the more an insurance company uses the capital market, the less it needs to follow a dynamic premium strategy and the easier it is to determine whether or not a rate increase is justified. This is one of the benefits of separating out the capital and risk aspects of catastrophe insurance.

3. Catastrophe Futures and Options

The Chicago Board of Trade introduced catastrophe futures and options on December 11,1992.[12] These contracts have been very lightly traded, and in response to this, the C.B.O.T. on September 29, 1995 introduced 9 new catastrophe options, 1 National, 5 Regional, and 3 State (Florida, Texas, California). The substitution of option contracts for future contracts has at least somewhat improved the situation.[13]

For our purpose the primary questions raised by these new markets are:

i) Will option markets lead to significant injections of new capital into the catastrophe insurance line?

ii) Are these contracts structured so that performance is guaranteed in the event of a large loss?

Certainly the experience to date is not encouraging. The basic problem seems to be finding takers on the call writing side of the contract. Apparently there is no obvious reason to use these

[12] For a discussion of these contracts see Hoyt and Williams (1995)

[13] See Cummins and German [1989] and Harrington et. al [1995] for discussions of why the catastrophe futures contracts did not perform well.

contracts as a hedge against an earthquake not occurring.

If option contracts are to be successful, it seems clear that they must attract more than purely speculative capital. In addition it would seem to be necessary that the pricing of these contracts be reasonably understandable. It may be argued that one of the major reasons for the success of stock and interest rate option contracts was the simultaneous development of the Black/Scholes option pricing model, Black and Scholes [1973], which allowed market participants to detect "under" and "over" priced options and trade accordingly.

At the present time no such tool exists for pricing catastrophe options. The Black/Scholes pricing argument is based on the fact that in a small amount of time the movement in the price of the asset on which the option is written (the primary asset) is such that this price movement can be completely hedged with one other asset, the option itself (the derivative asset).[14]

The dynamics of catastrophe losses (these losses being the primary asset in the catastrophe options market) differ completely from the dynamics of stock prices. Catastrophe losses have sample paths which are usually zero but which are sometimes very large. This gives a very skewed distribution, even in a short period of time, so this risk cannot be fully hedged with only 2 assets. It would seem that a new and potentially far more complex option pricing theory needs to be developed for catastrophe options, and until this theory is developed it is unlikely that trading capital will flow into this market in any sizable amount.

The second question which arises relates to the ability of the C.B.O.T. to ensure performance on this contract in the event of a large catastrophe loss. Insufficient guarantee of contract

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[14] Technically, in a small amount of time the primary asset has a return distribution with only two moments, a mean and a variance. The derivative asset, therefore, also has two moments, a mean and variance and is uncorrelated with the primary asset. This allows the possibility of a hedge, see e.g. Russell [1988].

performance in the event of a large loss was listed as a major reason for not using this market in a survey of insurance firms, D'arcy and France [1992].

Contract performance issues are dealt with by the C.B.O.T. through a clearing house (the Board of Trade Clearing Corporation, B.O.T.C.C.) which is a separate entity from the C.B.O.T. This clearing house has three instruments with which to try to ensure financial solvency,

1) Performance Bond Margins
2) Marking to Market
3) A fund of capital and committed credit.

We examine each of these in turn.

1. Performance Bond Margins: The C.B.O.T. requires its members to deposit performance bonds in the form of liquid capital. The size of this performance margin is based on the net position of the firm and its customers. Typically the size of these margins is determined by a system called S.P.A.N. (Standard Portfolio Analysis of Risk). The principle underlying S.P.A.N. is that market participants should deposit sufficient margin to cover the one day loss their portfolio might reasonably incur. (See PCS Options, A Users Guide C.B.O.T. [1995].)

The C.B.O.T., however, recognizing the special capital needs of catastrophe options, applies S.P.A.N. only to the purchase of calls and the purchase and writing of puts on this contract. A separate special margin is required for the writing of naked (uncovered) calls. To be able to write a naked call, the investor must deposit 20% of the difference between the strike price and the maximum possible loss. The C.B.O.T. offers two types of option contracts, a small cap contract with a maximum index value of 200, and a large cap contract with a maximum index value of 500. Each point of the index corresponds to a reported loss of $100m, so the small cap contact hits its maximum value when there is catastrophe with losses equal to or in excess of $20 billion.

Consider, as an example, an investor who writes 100 naked calls on the small cap contract (maximum value = 200) at a strike price of 10. This investor would be required to post a margin of $760,000 calculated as follows:

100 (number of contracts) x 190 (maximum loss-strike price) x $200 (dollar value of an index point) x 0.20 (margin percent).

On the other hand, if a $20 billion catastrophe occurs, the writer of this call option must deliver $3,800,000.

In this case, the margin is inadequate in the amount of $3,040,000. Clearly this raises legitimate questions about the adequacy of the 20% rule, and to some extent the C.B.O.T. has recognized this by requiring that traders who write more than 25 naked calls have their names and circumstances reported to the Board.[15]

2. Marking to Market. For any asset where price movement in a small amount of time is not large, marking to market provides early warning of potential financial difficulties before these difficulties become large. Indeed the C.B.O.T. states The single most distinguishing feature of futures and options markets - and the most vital procedure for maintaining the financial integrity of the markets - is the daily settlement of gains and losses. The B.O.T.C.C. marks all open positions to market twice daily C.B.O.T. [1995].

Again, however, we must note that a catastrophe option is not written on a typical asset. The daily movements in the California Catastrophe Option, for example, are likely to be close to zero, reflecting the non-predictability of earthquakes. On the day of an earthquake, however, the price will take a large jump. Marking to market provides little advance warning of financial difficulty in

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[15] This section is based on telephone discussion with Mr. Bruce Domash, Margin Division C.B.O.T.

this case.

3. The Capital Position of the B.O.T.C.C. In the event that an investor does not meet his obligations, the legal obligation to meet a margin call lies on the C.B.O.T. clearing firm which made the trade. If this firm cannot find the necessary capital, the B.O.T.C.C. takes over the liability for performance. The B.O.T.C.C. has total capital of $140m and further committed credit of $300 million. This total sum, $440 million, would seem to be rather small, given the huge potential losses in this market.

All in all it seems fair to say that, although catastrophe options and futures are an innovative way of trying to attract capital to the catastrophe insurance line, their prospects for success seem dim. Moreover, the value of the primary asset underlying this derivative, (the size of the catastrophe loss) has such a different pattern of stochastic price movement from the price pattern of all other primary assets whose derivatives are traded on the C.B.O.T., it is clear that special attention must be given to the question of the capital adequacy of those who write calls in this market. The C.B.O.T. clearly recognizes this, but legitimate questions remain whether, any more than the reinsurance market, the futures/options markets solve the problem of having sufficient capital on hand if the big one hits.

In conclusion, capital market solutions to the catastrophe insurance problem are very appealing for several reasons. First, they deal with the two basic sources of the problem, namely adequate capital to bear the risk and adequate liquidity to pay claims. Second, they simplify the issue of premium-setting, since the cost of obtain capital and liquidity from the capital markets can be treated directly as a business expense that should be included in the premium. Third, as pointed out in Kunreuther, Hogarth, and Meszaros [1993], the use of capital sources would help reduce the "risk premium" that insurance companies currently include in their pricing of catastrophe risks. In

other words, this is an additional reason why use of the capital markets can help lower the level of catastrophe insurance premiums.

5. AN ALTERNATIVE SOURCE OF CAPITAL

In a catastrophe, the major source of loss is damage to residential and commercial property. For example, in the Northridge earthquake, of the $12.5 billion in insured loss $6.5 billion was damage to residential property alone (California Department of Insurance estimate). It is therefore somewhat surprising that so much energy has been devoted to attracting capital to the catastrophe line through fairly esoteric instruments such as futures and options, whereas virtually no attempt has been made to extract capital from the traditional source of funding for construction, the mortgage banking industry.

Certainly the mortgage lending industry has deep enough pockets. In 1994, for example, total outstanding mortgage debt in the household sector in the U.S. was $3,162 billion of which private financial institutions held $2,310 billion, Board of Governors of Federal Reserve System [1995]. A loss to residential property such as in the Northridge earthquake ($6 billion) is within the margin of error of these numbers. The problem is how to link this traditional source of construction finance to the construction losses which follow a catastrophe.

With the continuing breakdown of the Federal Regulation separating the bank and insurance industries, it may not be long before contracts of property bottomry, in which a bank writes down a loan by the quantity of loss in the event of an earthquake, adjusting the mortgage rate upwards to take account of the risk, become feasible. Banking and insurance still remain separated, however, so here we explore a more modest proposal for linking mortgage and insurance markets.

Suppose a catastrophe loss occurs, and consider an insured who suffers significant structural damage, say $50,000 or more above deductible. In the current arrangement for loss settlement, the

insured receives a check from the insurance company in full settlement of the loss.

In many cases, however, those insured will only have limited equity in their property. These individuals use the proceeds of the insurance claim to pay off their mortgage, then immediately re-enter the mortgage market to finance the rebuilding of their new home / apartment complex / strip mall, or whatever.

This early full repayment of the original outstanding mortgage loan is not a necessary part of the resettlement process. The original mortgage lender would be perfectly happy to receive the annual stream of payments associated with the original loan, the only problem being that now the asset securing this loan has lost value. However, if the bank could be persuaded to substitute the credit worthiness of the insurance company (secured perhaps against some part of future premium streams) for the bricks and mortar of the building, the size of the immediate payments required of the insurance company would be reduced. Instead of making a capital payment equal to the size of the loss, the insurance company would make a stream of mortgage payments, and these could be paid from current premium receipts.

Obviously the details of such a scheme require further analysis, but the general point stands. There already exists a large well developed market to supply capital to the construction industry. For construction losses following a catastrophe, this is the natural market for amortizing the construction loss. Once the loss is amortized, the problem of paying it out of current premiums resolves itself.

6. THE CALIFORNIA EARTHQUAKE AUTHORITY

Despairing of finding a purely private market solution to the problem of earthquake insurance, the California Legislature, at the behest of the Insurance Commissioner, is developing legislation to set up a California Earthquake Authority (C.E.A.). In broad terms, this Authority will follow

the pattern developed for hurricane funds in Florida and Hawaii.[16]

Under current proposals for the C.E.A., no public money is to be at risk in this authority. The scheme is voluntary, and insurers who agree to participate in the C.E.A. must contribute their earthquake insurance market share of $1 billion. In addition, participating insurers must agree to provide the C.E.A. with their market share of $5 billion in contingent capital. If the C.E.A. accumulates capital in excess of $1 billion, the first $3 billion of committed contingent capital is reduced annually on a dollar for dollar basis. After 10 years this $3 billion commitment is reduced to zero regardless of the state of the fund. The last $2 billion is also reduced dollar for dollar in the event capital in the fund exceeds $6 billion.

The initial committed contingent capital of the C.E.A. is $10.5 billion. This includes the $6 billion of insurance industry capital ($1 billion up front, $5 billion contingent), $2 billion of reinsurance, $1.5 billion of private capital (rate of return offered not to exceed 19%) and $1 billion of contingent State bond capital secured by a levy on earthquake policy holders. This initial $10.5 billion of committed capital may well be reduced to $6 billion of total available capital if no earthquake occurs for 10 years.

Since no public money is at risk, it is interesting to ask how the C.E.A. is able to solve the problem of capital adequacy when the private market by itself has apparently failed.

A close examination of the C.E.A. reveals two facts.

1. Although not in direct receipt of public money, the C.E.A. is in indirect receipt of such funds.
2. The C.E.A. is not selling a contract of earthquake insurance as that term is normally understood in the private sector. The C.E.A. is in fact selling a stop-loss insurance policy, the maximum payoff being capped by the total value of available capital.

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[16] See Collins Center for Public Policy [1995] for a summary description of the Florida and Hawaii plans.

We examine each of these facts in turn.

1. The C.E.A. is attempting to obtain Federal and State tax exemption on its reserves. This tax relief is not currently available to a private corporation. The NAIC Personal Line--Property and Casualty Insurance (C) Committee is developing rules for catastrophe reserves which might allow private firms to obtain equivalent State and Federal tax relief, but prospects for success in this area do not appear bright. This tax relief to the C.E.A. is equivalent to a contribution from the public purse, so the C.E.A. and the private insurance industry are not competing on a level tax playing field.[17]

2. Assembly bill 13, which proposed the C.E.A., states explicitly:

> "If at any time all the authority's available capital has been exhausted, and no source of additional funds such as assessments, reinsurance, or private capital moneys is available to the authority, the board shall draw up and present to the Commissioner a plan to pay claims on a pro-rata basis, or in instalment payments "

In addition the bill states that

> "The State of California shall have no liability for payment of claims in excess of funds available ... [as we have described above] ... Nor is a policyholder eligible for benefits from the California Insurance Guaranty Association. "

To see the implication of this, take a worst case scenario. Assume an early earthquake creates $21 billion in insured losses or a late earthquake (after 10 years when the insurance industry's commitment of contingent capital has been reduced to zero) $12 billion in losses. In either case,

[17] The IRS could continue to deny tax relief to private insurance companies on the grounds that it might be difficult to stop the companies from using the exemption to escape taxes rather than to provide for future catastrophe losses.

policyholders will be paid 50 cents on the dollar or will have their loss payments strung out over time. At the time when individuals buy the insurance they have no idea which it will be.

Clearly a private insurance market could not operate in this manner. Insurance is supposed to be insurance, not insurance up to a point. Of course, this cap feature makes the C.E.A. a very attractive arrangement for the insurance industry in California. By law in California, an insurance company which offers homeowner's insurance must offer the option to purchase earthquake insurance. Because of this linkage, after the Northridge earthquake most of the insurance business in California was withdrawn from the homeowner's line.

The C.E.A. allows private insurers to re-enter the homeowner's insurance market by offering the C.E.A. policy which not only has a large tax advantage but which includes a capital loss cap for private insurance companies which at most can use up $6 billion of their capital and in principle could only use up $1 billion.

This bill, therefore, despite the energy of the Commissioner's office in facilitating its drafting, does not begin to solve the problem of how to find sufficient capital to meet a large loss, and has the odd feature that it reduces the quantity of contingent capital if an earthquake does not occur.

It should be remembered, also, that the C.E.A. carries the imprimatur of the State of California. How many policy holder / voters will be aware of the stop loss features of the policy, and how many will be content with pro-rata or extended payment in the event of a large loss. If / when a large loss occurs, the promise contained in the bill not to access public funds may prove to be a promise which is politically impossible to keep.

7. CONCLUSIONS

In this paper we have examined the causes of the failure of the private market in catastrophe insurance and have examined the conditions which would have to be established to make a purely

private market viable.

We have learned from history that a private market in marine insurance, a market with many catastrophe-like features, was completely viable because it solved what we have shown to be the catastrophe markets fundamental problem, a mismatch between the size of annual premiums and the size of maximum annual losses.

The marine insurance market solved this problem in one of two ways:

a) by advancing all of the capital at risk to the insured at the beginning of the policy, forgiving the loan if a loss occurred or

b) by arranging access to a large pool of capital (the unlimited wealth of the Lloyds Names) with which to pay losses after the event.

Current incentive structures associated with publicly traded limited liability corporations work against these solutions. In particular such firms have no incentive to accumulate a pool of capital from annual premiums since this pool cannot be earmarked to meet catastrophe losses.

If a private catastrophe insurance market is to be viable, certain reforms must occur which will enable the market to satisfy one of the two conditions a), b) set out above. Some recommendations follow:

1. It is clear that some way must be found to permit an insurance company to dedicate assets to be used to pay expected catastrophe losses. Like Ulysses, insurance companies must be able to tie themselves to the mast to avoid the siren calls of large pools of cash.

If the firm can do this, there seems to be no reason to deny State and Federal tax exemption to this fund. After all, if precedent establishes that the State and Federal Governments are willing to give a tax concession to Allstate's money if it is voluntarily contributed to the State scheme (the C.E.A.) why would State and Federal Government not give the same tax concession if Allstate places these same funds in a private earmarked trust?

2. The mere existence of such dedicated assets would give insurance companies greater access to the capital market. Used as a security for borrowing, arrangements could be made to repay loans from premiums destined to be invested in dedicated assets.

3. Capital markets have shown themselves willing to provide capital in advance of catastrophes when the price is right, Act of God bonds being the modern version of bottomry. The removal of the barriers between banking and insurance will enable more such contracts to be developed.

4. Construction finance markets can be used to amortize the construction losses of a catastrophe. Again mortgage lenders will require that future premiums be earmarked in some way if these premiums are to replace the lost security of the damaged property. Mortgage lenders might also be more sensitive to real estate retrofitting against catastrophes as a means for mitigating catastrophic losses.

Much intellectual capital is being used at present to try to find other ways to link capital sources to the uses of capital required by catastrophe insurers. There seems no reason to believe that other clever contractual structures will not be found.

On the other hand, the State of California's proposed solution to the problems of the private market, the C.E.A. does not really come to grips with the problem of capital adequacy. By failing to obtain sufficient capital in advance and by diminishing the amount of contingent capital over time, the C.E.A. has not addressed either of the capital adequacy issues discussed as a) and b) above. On the other hand, the C.E.A. does not really offer earthquake insurance. What it offers is capped earthquake insurance, the consequences of the cap to be determined later. Since the C.E.A. will be the major provider of earthquake insurance in the State, it is to be hoped that policyholders understand the limited nature of the coverage being offered. Some taxpayers may well be nervous as to whose pockets will in fact be turned to if a major loss occurs.

The rash of catastrophes in the last 10 years has made most private providers of catastrophe insurance reluctant to provide this line. With the reforms suggested above, however, and a consequent increased level of support from capital markets, there seems to be no reason why a purely private insurance / capital industry cannot provide a catastrophe insurance product which provides full insurance to all policyholders and a reasonable level of profit for all concerned.

Table 1: <u>Adjusted Loss Ratio as a Percent</u>

Line	1991	1992	1993	1994
Earthquake	12.9	9.7	2.9	852.2
Fire	56.6	77.0	53	55.7
Allied	63.3	119.5	81.9	69.7
Multiple Peril Crop	124.2	125.0	167.6	89.5
Homeowners M.P.	76.5	124.5	69.8	72
Commercial M.P.	56.9	78.9	60.4	63.5
Non-liability	N.A.	90.2	61.2	63.8
Liability	N.A.	65.6	59.5	63
Inland Marine	50.7	60.5	59.1	59.3
Workers' Compensation	89.3	84.8	73.5	62.2
Medical Malpractice	59.7	80.9	67.4	55.4
Other Liability	65.6	72.7	70.5	69.5
Product Liability	62.0	82.1	136.5	91.5
Private Passenger Auto Liability	77.2	73.5 84.7	73.4	71.7
No-fault	87.5	72.1	89.5	82.3
Other Liability	75.9		71.3	70.4

Commercial Auto Liability	69.2	66.4	65	66.1
No-fault	59.4	68.5	80	61
Other Liability	69.5	66.3	64.5	66.2
Private Passenger Auto Physical Damage	56.8	56.8	57.8	62.1
Commercial Auto Physical Damage	46.1	48.9	49.6	53.8
Farmowners M.P.	71.9	63.1	72.1	66.8
Ocean marine	80.3	68.1	60.6	58.9
Financial Guaranty	1.3	26.8	6.4	26.1
Mortgage Guaranty	N.A.	54.3	52.5	54.3
Aircraft	100.8	92.9	62.5	88.4
Fidelity	41.8	47.5	32.6	34.4
Surety	22.3	30.1	22.9	33
Glass	33.4	29.5	26.8	25.5
Burglary and Theft	23.9	17.1	19.1	21.2
Boiler and Machinery	54.3	66.1	48.1	56.1
Credit	46.1	26.3	30.4	33.1
Group Accident and Health	70.7	72.4	70	67.6
Other Accident and Health	70.0	67.5	59.6	57.1
Miscellaneous	73.0	79.8	79.3	76.2
U.S. Total	69.6	76.5	67.3	68.8

Source: Best's Review, Various Years

Table 2: California Loss Ratio as a Percent

1971	17.4
1972	0
1973	0.6
1974	3.4
1975	0
1976	0
1977	0.7
1978	1.5
1979	2.2
1980	9.2
1981	0.9
1982	0
1983	2.9
1984	5.0
1985	1.3
1986	9.3
1987	22.8
1988	11.5
1989	129.8
1990	47
1991	17.2
1992	12.8
1993	3.2
1994	2272.7

Sources: A. M. Best. California Department of Insurance. Insurance Information Institute

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