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HEDGING STRATEGIES USING CATASTROPHE INSURANCE OPTIONS

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abstract

For several years there has been discussion in the insurance industry of the need for additional capital sources to participate in insuring the financial risk posed by natural catastrophes. A number of methods for accessing the capital markets have been introduced and some insurers are using these to hedge exposure to catastrophe loss. We will summarize some of the discussion and describe some of the methods proposed. We will then focus on one of these methods, the use of catastrophe insurance options. We will give the results of simulations which may serve as a guide to insurers interested in using these options as part of their risk management strategy and also as an indication to investors of the value of these instruments as a new component of an investment portfolio.

1 *The need for new capital.*

In September, 1992 a new plateau was reached in loss from a single natural catastrophe in the United States. Hurricane Andrew devastated much of Florida's southern Dade County causing 25 billion dollars of property loss. Eleven billion of this represented insured loss. In 1994 the insured loss from the Northridge California earthquake was 12.5 billion dollars. In January, 1995 the earthquake in Kobe, Japan caused over 100 billion dollars in property loss. Less than 4% of this loss was insured.

With its current level of capitalization, the insurance industry would suffer severe dislocation should a catastrophe the magnitude of the Kobe earthquake strike the United States where insurance coverage is more complete than in most developed countries. The industry is capitalized at somewhat over 200 billion dollars and faces claims risk measured in trillions. The need for additional capital has been recognized for several years and a number of methods have been proposed - some are currently in use - for locating new agents to bear some of the risk of loss from natural catastrophe.

2 *New methods for securing insurance risk.*

The solution to the problem described above lies in tapping the capital markets for the needed capital. Current approaches for doing this include debenture financing, surplus notes, bonds, standby lines of credit and insurance derivatives.

For example, in 1995, the Florida Residential Property and Casualty Joint Underwriting Association was negotiating a 1.5 billion dollar line of credit with a consortium of investment banks and Nationwide Insurance entered into a 4oo million dollar contract with Morgan Guaranty Trust Company to help finance its catastrophe exposure for the next decade.[1] Also bonds have been offered the proceeds of which would replenish insurer's funds after a catastrophe loss. One such bond offers a return of ten percentage points or more above that of U.S. Treasury bonds.[2] A severe catastrophe loss could result in bondholders forfeiting interest and possibly even some or all of the principal of the bonds.

A somewhat different approach to the problem is offered by the Catastrophe Risk Exchange (Catex). This concept was developed by Samuel Fortunato, a former New Jersey insurance Commissioner. Catex transactions involve the transfer or exchange of risks among insurers or reinsurers. They solve part of the problem not by adding capital to the industry but by providing a tool which allows insurers to diversify, and thus balance, risks.

The final source we discuss and the central object of this paper is insurance derivatives. Insurance derivatives - catastrophe insurance futures and options - were first introduced by the Chicago Board of Trade in 1992. The initial version of catastrophe insurance derivatives was based on quarterly catastrophe loss estimates determined by the Insurance Services Office (ISO) using reports from a selection of insurance companies. The futures contract value was $25,000 times the ratio of losses to premium. The total premium for the quarter and region of the contract was also estimated by ISO and was announced by the CBOT prior to the start of trading for each catastrophe contract. Changes in the futures price were thus due entirely to changes in the amount of expected catastrophe loss. The above ratio was capped at 2 and thus the maximum payoff from a futures contract was $50,000.

Catastrophe insurance futures failed to generate much interest and trading was halted in 1995. Options based on these futures had more success. These were most frequently purchased as spreads - that is buying a call at one strike value and simultaneously selling a call at a higher strike value. A 20/40 insurance call option spread would pay zero if the final loss ratio was less than 20% and would pay $250 per point for each point above 20 to a maximum of $5,000 (20 points times $250). The success of option spread trading relative to futures trading was likely due to their similarity with the protection afforded by reinsurance layers. Nevertheless, these options did not attain general acceptance as a hedging tool in the insurance industry. One problem may have been lack of confidence in the premium estimate. It was based on the most recent statutory annual statements filed by the reporting companies. A more serious problem could occur in reporting the final loss estimate. This estimate was based on claims reported by the end of the third month after the loss quarter. If a late

[1]Reuter Insurance Briefing, 24July, 1995.

[2]New York Times, May 15, 1995.

quarter catastrophe occurs and claims are slow in developing the final claims ratio for the purpose of deciding the option payoff could be low relative to the actual final claims ratio. This problem occurred in the March, 1994 contract period, the period of the Northridge earthquake. The settlement ratio was low and the contract payoff did not truly reflect the actual claims loss. This may well have been a major cause of the demise of ISO catastrophe insurance options. These also ceased trading in 1995 but were replaced in September, 1995 by a new version which corrects some of the problems inherent in ISO options.

3 *PCS options.*

The version of catastrophe insurance derivative introduced in September, 1995 by the Chicago Board of Trade is the PCS option. These options are index options with the index measuring the amount of catastrophe claims in the region and period of the contract. There are nine regional contracts (East, Southeast, Northeast, Midwest, West, Florida, Texas, California, National) and the loss period is a quarter for most contracts. The exceptions are the Western and California contracts which have annual loss periods. The index is updated daily by Property Claims Service (hence PCS option) with each index point representing one hundred million dollars in catastrophe losses. The contracts are available with either a six month or twelve month development period. Most of the trading involves the longer development period. With the earlier (ISO) derivatives only one estimate of the final settlement loss ratio was given prior to the expiration date of the contract. Thus PCS options go a long way toward solving two of the problems with ISO derivatives - sparse information and early settlement date.

For pricing and payoff on these options each index point represents \$200. Almost all of current trading involves option spreads. Thus a bid of 4 on a 20/40 spread is an offer to pay \$800 for a contract whose maximum payoff will be \$4,000, the amount the contract will pay if the index settles at 40 or above. The buyer is buying a 20 call and selling the (less expensive) 40 call.

Let us illustrate by an example how PCS options can be used by insurers to hedge exposure to catastrophe claims losses. Suppose that an insurer with heavy exposure in the Southeast wishes to cede \$10 million of its catastrophe loss exposure above a retained amount of \$5 million but that the only acceptable reinsurance available is the layer \$5 million in excess of \$10 million. The Southeastern PCS option contract may be used to fill the gap. In order to do this the company must know its market share in the region and must correlate its loss experience with that of the industry. Suppose the company has a .5% market share and that it calculates that its loss ratio will be 95% of the industry's on average. The correspondence between the bounds of the protection layer desired and PCS option attachment points is : \$5 million corresponds to

$$\frac{5million}{.005 * .95} = 1.05 \ billion \ or \ 10.5points$$

Similarly, \$10 million corresponds to 21 points. Now PCS option contracts are available only at attachment points which are multiples of five so the 10/20 spread contract would be used for the hedge. The number of contracts required is

$$\frac{5million}{(20-10) * 200} = 2500 \ contracts$$

Now let us see the effect of the hedging strategy. Suppose that the Southeastern index settles at 16. The payoff for each contract will be \$1,200 yielding a total payoff of \$3 million. If the company's estimate of its relative loss ratio was accurate, the company would receive claims of \$8,075,000. Thus \$3 million of the \$3.075 million in the layer is recovered from the PCS option payoffs. The hedge is not perfect because of the restriction to strike values which are multiples of five.

4 *A simulation study.*

Our purpose is to test a number of strategies for hedging catastrophe losses by using PCS options. To this end we have developed a program which simulates a number of different loss distribution scenarios and produces an option price process which responds to the loss experience during the life of the contract. The program then calculates, for each strategy, the rate-on-line for traditional reinsurance which would give the same financial outcome as the hedging strategy using PCS options. The purpose is to help insurers to decide if these derivative securities are an appropriate tool for hedging catastrophe claims exposure.

The strategies employed are:

1. *Buy and hold.* The attachment points and the number of spreads purchased are determined as in the example of the previous section and the position is maintained throughout the contract period.
2. *Readjust periodically.* Here each month the position is adjusted so that the ratio of the number of contracts held to the original number purchased in creating the hedge is the same as the ratio of the current expected claims for the period to the expected claims at the beginning of the contract period. However the maximum number of contracts held is restricted to the number purchased in creating the hedge. (In practice, adjustments would also be made as catastrophes occurred or appeared imminent.)
3. *Threshhold readjustment* Adjust as in 2. but only if the expected settlement index changes by more than 10%.

These should be thought of as representative strategies. It is easy to incorporate additional hedging strategies in the program. In particular, we tested a strategy which permitted the hedger to buy above the initial number of contracts - this may be thought of as a speculative strategy as we are no longer merely hedging the original protection layer.

The loss distributions employed in the simulations are either gamma or Pareto distributions. Parameters for the distributions are determined by the method of moments using PCS index simulated settlement calculations. These are available for the years 1949 through 1995 and in the simulations given here, only the values for the last 15 years are used. We use a six month development period for the purpose of these simulations (thus a total contract period of nine months) and spread the total claim distribution among the months of the contract period in various ways attempting to capture likely claims processes. In particular, in most cases a large percentage of the expected claims are assigned to the loss quarter. In some cases a single month will be assigned most of the expected claims for the entire contract period - a very possible outcome for the southeastern September contract where a major hurricane could account for all of the catastrophe claims for the contract.

The pricing process is somewhat of a problem. There is not much market data available since these options have been trading for only one year. Also, there is no generally accepted theoretical model for pricing these options. Our approach in these simulations is to begin with the market price of the contract. We then follow a rather complex set of rules for adjusting the price each month in response to the loss experience for that month. Roughly, the price autoregresses to the final settlement value of the contract.

We will now present some outcomes of our simulation program. In all of the tables below, the Pareto distribution has been used to model the catastrophe claims process. Table 1 gives an example of the result summary of a single run of the program. Tables 2 and 3 give the monthly details of two trials selected from this run. In these simulations transaction costs of $15 per call contract are included.

The body of table 1 lists the payoffs from PCS spread contracts held at the expiration date of the contracts and the rates-on-line for traditional reinsurance which would have led to the same final financial result. As expected, in trials in which the contracts end up out of the money the strategies which involve selling contracts when loss experience is favorable usually give a better outcome than buy-and-hold. On the other hand, the buy-and-hold strategy will frequently do as well or better in trials which result in a payoff. To some extent the adjust strategies can become sell low – buy high strategies. That is after divesting some contracts after favorable experience a catastrophe late in the loss quarter may require a buy back at much higher prices. Nevertheless, in the long run the second and third strategies do much better than the first. The difference is usually more pronounced than in the example illustrated in table 1.

Table 2 gives the monthly development of trial 15 of the run summarized in table 1 while table 3 does the same for trial 19. Note that the figures given in columns 2 through 5 of tables 2 and 3 are index points. Thus the settlement

Payoff_1	ROL_1	Payoff_2	ROL_2	Payoff_3	ROL_3
0	.186	0	.185	0	.186
0	.186	0	.160	0	.160
10000000	.186	10000000	.186	10000000	.186
0	.186	0	.121	0	.119
0	.186	0	.138	0	.139
0	.186	0	.094	0	.093
51 95711	.184	5195711	.194	5195711	.184
0	.186	0	.179	0	191
4658482	.176	4658482	.176	4658482	.176
5796704	.193	5796704	.193	5796704	.193
0	.186	0	.206	0	.207
0	.186	0	.130	0	.136
0	.186	0	.126	0	.127
0	.186	0	.126	0	.133
0	.186	0	.118	0	.118
10000000	.186	10000000	.186	10000000	.186
0	.186	0	.105	0	.105
0	.186	0	.109	0	.109
10000000	.186	8355756	.330	8766110	.288
4560172	.174	4560172	.279	4560172	.279

Table 1: Number of trials: 20. Hedge layer(in millions): 10/20. Expected settlement value: 20.0. Market share: .005. Relative loss ratio: .92. Pareto assumption. Initial number of contracts: 2000. Call spread: 20/45. Initial price:4.5. Average rates-on-line: Strategy 1. —.185; Strategy 2. — .167; Strategy 3. — .166

month	claims	accum. claims	settlement est.	price	purchases/sales	
					strategy 1	strategy 2
1	2.32	2.32	16.32	4.5	(368)	(368)
2	.86	3.19	11.19	4.3	(514)	(514)
3	10.41	13.59	15.59	.5	441	441
4	.37	13.96	14.96	.5	(63)	0
5	.13	14.09	14.89	.5	(7)	0
6	.01	14.11	14.71	.5	(19)	0
7	1.81	15.92	16.32	.5	161	73
8	.07	15.99	16.19	.5	(13)	0

Table 2: Trial 15; Final accumulated costs: (1)1,800,000 (2)1,073,771 (3) 1,075,076. Final transaction costs: (1)60,000 (2)107,564 (3)101,842. Equivalent rates-on-line (1).186 (2).118 (3).118

month	claims	accum. claims	settlement est.	price	purchases/sales	
					strategy 1	strategy 2
1	3.53	3.53	17.53	4.5	(247)	(247)
2	4.98	8.51	16.51	4.4	(102)	0
3	69.70	78.21	80.21	25	0	0
4	.15	78.36	79.36	25	0	0
5	.16	78.52	79.32	25	0	0
6	.15	78.66	79.26	25	0	0
7	.02	78.68	79.08	25	0	0
8	.41	79.09	79.29	25	0	0

Table 3: Trial 19; Final accumulated costs: (1)1,800,000 (2)1,488,490 (3)1,578,371. Final transaction costs: (1)60,000 (2)70,465 (3)67,403. Equivalent rates-on-line (1) .186 (2) .330 (3) .288.

estimate of 16.32 in row one of table 2 means that, at the end of the first month, the final expected claim amount for this contract is about 1.6 billion dollars. The price for the contract at this time is \$900. We have set a minimum price for these contracts of .5 points or \$100. Thus, after the final month of the loss quarter with accumulated claims of 13.59 and a lower attachment point of 20 the contract price remains at .5.

Note that in trial 19 a large catastrophe in the third month caused the value of the contract to increase to the full spread, 25 points. Because of this strategies 2 and 3 do not call for purchases. To do so would merely be to give up transaction costs. Since these two strategies have sold contracts at the end of months 1 and 2 they are not as well hedged as strategy 1 and hence have an inferior outcome. Again, however, we stress that a strategy should be selected for the long term outcome.

In our next three tables we give rate-on-line results using various values for the inputs. Each line of the tables represents a run of twenty trials. Tables 4, 5, and 6 use relative claims ratios .9, 1, and 1.1 respectively. In each table we vary the expected claims (E_Cl), variance for the total claims for the contract period, hedge layer in millions of dollars (B1/B2), and market share. The appropriate spread for the hedge is then given along with the market price (M) for the contract. The final three columns of the table give the equivalent rates-on-line for each of the three strategies. The expected claims and the variances have been chosen to reflect realistic values for some of the PCS contracts. The PCS settlement calculations were used in choosing these values.

Not all entries in these tables represent realistic hedging opportunities. For example, in row 8 of table 4 a 10/20 spread is called for and the claims expectation is 16.4 points leading to a price of 9 for a 10 point spread. In the real world an insurer with a 1% share in this market would not be interested in hedging the 10 million/20 million layer.

5 *Advantages and Disadvantages of PCS Option Hedging.*

If a liquid market develops, the use of PCS options by insurers will offer a number of advantages over reinsurance. First, they provide a standardized contract. There is no negotiation with a reinsurer. Second, there will be rapid execution. Third, the insurer will be able to adjust the hedge throughout the contract period in response to claims experience.

The biggest disadvantage in comparison with the use of reinsurance is the effectiveness of a PCS hedging strategy. If the estimate of relative claims ratio is far from the actual outcome the PCS hedging strategy could prove quite unpleasant – or quite pleasant depending on the direction of the discrepancy. A second problem is price determination. Although a number of academic papers have addressed the question of theoretical pricing models for insurance derivatives (see references), there is not yet a generally accepted method. The user must look at the market price and try to determine whether – at that price – the product is superior to the use of reinsurance. The regulatory environment also presents a problem. Currently, only three states – Illinois, California, and New York – accept these options as a hedge against catastrophe losses. There appears to be even less willingness to allow insurers to be sellers of these options in an effort to participate in markets in areas in which the insurer is not currently doing business. These difficulties can be overcome by insurers able to participate through offshore affiliates.

E_Cl	Var	B1/B2	Share	Spread	M	ROL_1	ROL_2	ROL_3
23.0	2386	10/20	.005	20/45	12.0	.46	.42	.42
23.0	2386	20/40	.005	45/90	4.0	.09	.08	.08
23.0	2386	20/40	.01	20/45	12.0	.47	.40	.40
23.0	2386	50/100	.005	110/220	4.0	.04	.03	.03
23.0	2386	50/100	.01	55/110	3.5	.07	.07	.07
23.0	2386	50/100	.03	20/35	9.0	.61	.51	.51
16.4	813	10/20	.005	20/45	7.0	.27	.24	.24
16.4	813	10/20	.01	10/20	9.0	.88	.65	.66
16.4	813	20/40	.005	45/90	3.0	.07	.06	.06
16.4	813	20/40	.01	20/45	7.0	.27	.22	.22
16.4	813	50/100	.005	110/220	3.5	.03	.03	.03
16.4	813	50/100	.01	55/100	3.0	.06	.05	.05
16.4	813	50/100	.03	20/35	6.0	.41	.37	.37
11.5	43	10/20	.005	20/45	5.0	.20	.18	.18
11.5	43	10/20	.01	10/20	6.0	.55	.53	.53
11.5	43	20/40	.005	45/90	2.5	.06	.05	.05
11.5	43	20/40	.01	20/45	5.0	.20	.16	.16
11.5	43	20/40	.03	5/15	9.0	.84	.68	.68
11.5	43	50/100	.005	110/220	2.8	.03	.03	.03
11.5	43	50/100	.01	55/110	2.3	.05	.04	.04
11.5	43	50/100	.03	20/35	2.8	.21	.18	.18
8.4	262	10/20	.005	20/45	3.5	.15	.13	.13
8.4	262	10/20	.01	10/20	6.5	.63	.53	.53
8.4	262	20/40	.005	45/90	2.5	.06	.05	.05
8.4	262	20/40	.01	20/45	3.5	.15	.12	.12
8.4	262	20/40	.03	5/15	8.5	.82	.61	.60
8.4	262	50/100	.005	110/220	2.5	.02	.02	.02
8.4	262	50/100	.01	55/110	2.0	.04	.04	.04
8.4	262	50/100	.03	20/35	2.5	.18	.15	.15
5.0	12	10/20	.005	20/45	2.5	.11	.09	.09
5.0	12	10/20	.01	10/20	2.5	.26	.22	.22
5.0	12	20/40	.005	45/90	1.5	.04	.03	.03
5.0	12	20/40	.01	20/45	2.5	.11	.09	.09
5.0	12	20/40	.03	5/15	5.0	.47	.40	.40
5.0	12	50/100	.005	110/220	2.0	.02	.02	.02
5.0	12	50/100	.01	55/110	1.5	.03	.03	.03
5.0	12	50/100	.03	20/35	2.0	.15	.13	.13

Table 4: Rate-on-line computations with relative claims ratio of .9

E_Cl	Var	B1/B2	Share	Spread	M	ROL_1	ROL_2	ROL_3
23.0	2386	10/20	.005	20/40	11.0	.56	.47	.47
23.0	2386	20/40	.005	40/80	4.0	.10	.09	.10
23.0	2386	20/40	.01	20/40	11.0	.56	.45	.45
23.0	2386	50/100	.005	100/200	4.0	.04	.04	.04
23.0	2386	50/100	.01	50/100	3.5	.07	.06	.06
23.0	2386	50/100	.03	15/35	15	.75	.59	.60
16.4	813	10/20	.005	20/40	6.5	.33	.34	.34
16.4	813	10/20	.01	10/20	9.0	.92	.66	.66
16.4	813	20/40	.005	40/80	3.5	.09	.08	.08
16.4	813	20/40	.01	20/40	6.5	.33	.31	.30
16.4	813	50/100	.005	100/200	3.5	.04	.04	.04
16.4	813	50/100	.01	50/100	3.2	.07	.05	.05
16.4	813	50/100	.03	15/35	10.0	.50	.43	.44
11.5	43	10/20	.005	20/40	4.5	.23	.20	.20
11.5	43	10/20	.01	10/20	6.0	.62	.53	.53
11.5	43	20/40	.005	40/80	3.2	.08	.08	.08
11.5	43	20/40	.01	20/40	4.5	.23	.20	.21
11.5	43	20/40	.03	5/15	9.0	.91	.78	.77
11.5	43	50/100	.005	100/200	3.2	.03	.03	.03
11.5	43	50/100	.01	50/100	3.0	.06	.06	.06
11.5	43	50/100	.03	15/35	7.5	.38	.32	.32
8.4	262	10/20	.005	20/40	3.0	.16	.13	.13
8.4	262	10/20	.01	10/20	6.5	.67	.56	.56
8.4	262	20/40	.005	40/80	3.0	.08	.06	.06
8.4	262	20/40	.01	20/40	3.0	.16	.13	.13
8.4	262	20/40	.03	5/15	8.5	.86	.61	.61
8.4	262	50/100	.005	100/200	2.2	.02	.02	.02
8.4	262	50/100	.01	50/100	2.2	.05	.04	.04
8.4	262	50/100	.03	15/35	4.0	.20	.16	.16
5.0	12	10/20	.005	20/40	2.3	.12	.11	.11
5.0	12	10/20	.01	10/20	2.5	.27	.23	.23
5.0	12	20/40	.005	40/80	1.6	.04	.04	.04
5.0	1.2	20/40	.01	20/40	2.3	.12	.11	.11
5.0	12	20/40	.03	5/15	5.0	.51	.42	.43
5.0	12	50/100	.005	100/200	2.0	.02	.02	.02
5.0	12	50/100	.01	50/100	1.5	.03	.03	.03
5.0	12	50/100	.03	15/35	2.7	.14	.12	.12

Table 5: Rate-on-line computations with relative claims ratio of 1.0

E_Cl	Var	B1/B2	Share	Spread	M	ROL_1	ROL_2	ROL_3
23.0	2386	10/20	.005	20/35	9.0	.63	.52	.52
23.0	2386	20/40	.005	35/75	4.0	.10	.09	.09
23.0	2386	20/40	.01	20/35	9.0	.62	.51	.51
23.0	2386	50/100	.005	90/180	4.5	.05	.04	.04
23.0	2386	50/100	.01	45/90	4.0	.09	.07	.07
23.0	2386	50/100	.03	15/30	13.0	.87	.73	.73
16.4	813	10/20	.005	20/35	6.0	.42	.37	.38
16.4	813	10/20	.01	10/20	9.0	.94	.70	.70
16.4	813	20/40	.005	35/75	3.5	.09	.07	.07
16.4	813	20/40	.01	20/35	6.0	.41	.34	.34
16.4	813	50/100	.005	90/180	3.5	.04	.04	.03
16.4	813	50/100	.01	45/90	3.0	.07	.06	.06
16.4	813	50/100	.03	15/30	8.0	.54	.40	.40
11.5	43	10/20	.005	20/35	2.8	.22	.19	.19
11.5	43	10/20	.01	10/20	6.0	.67	.61	.61
11.5	43	20/40	.005	35/75	3.8	.10	.08	.08
11.5	43	20/40	.01	20/35	2.8	.20	.17	.17
11.5	43	20/40	.03	5/10	5.0	.95	.75	.76
11.5	43	50/100	.005	90/180	3.2	.04	.04	.04
11.5	43	50/100	.01	45/90	2.5	.06	.05	.05
11.5	43	50/100	.03	15/30	6.5	.44	.37	.37
8.4	262	10/20	.005	20/35	2.5	.18	.15	.15
8.4	262	10/20	.01	10/20	6.5	.71	.62	.61
8.4	262	20/40	.005	35/75	3.5	.09	.07	.07
8.4	262	20/40	.01	20/35	2.5	.18	.17	.17
8.4	262	20/40	.03	5/10	4.5	.80	.57	.56
8.4	262	50/100	.005	90/180	2.3	.03	.02	.02
8.4	262	50/100	.01	45/90	2.5	.06	.05	.05
8.4	262	50/100	.03	15/30	3.7	.26	.19	.19
5.0	12	10/20	.005	20/35	2.0	.14	.13	.13
5.0	12	10/20	.01	10/20	2.5	.27	.22	.22
5.0	12	20/40	.005	35/75	2.0	.05	.04	.04
5.0	12	20/40	.01	20/35	2.0	.14	.11	.11
5.0	12	20/40	.03	5/10	3.0	.59	.44	.45
5.0	12	50/100	.005	90/180	2.0	.02	.02	.02
5.0	12	50/100	.01	45/90	1.5	.04	.03	.03
5.0	12	50/100	.03	15/30	3.5	.24	.20	.20

Table 6: Rate-on-line computations with relative claims ratio of 1.1

E_Cl	Var	Spread	Price	Av Payout	Return
16.3	2070	60/80	3.0	.2	.133
17.8	2052	40/60	4.0	1.23	.131
17.8	2052	200/250	2.0	.15	.034
1.7	8	40/60	1.3	0	.058
11.5	1866	80/100	2.5	0	.117
1.0	8	60/80	1.1	0	.048
1.0	8	40/60	1.7	0	.077

Table 7: Simulation of returns from selling PCS options

6 *Investing in PCS Options*

Catastrophe insurance options will provide a fresh source of capital only if there is a sufficient pool of individuals and institutions willing to participate in the market as sellers of PCS options. The history of catastrophe losses in the U.S. may provide some incentive for investors to participate. First, a comparison of catastrophe losses with stock price movements in the S&P 500 provided by PCS indicates that the two are uncorrelated. (see PCS Options: A User's Guide published by CBOT). These options thus offer a new tool for diversifying an investment portfolio. Second, one can look at the PCS historical index settlement simulations to get some idea of how this investment would have performed had the options been available during the period covered by the simulations. For example, in the 44 years for which these index values are provided the value 20 is exceeded four times in the september quarter in the Eastern region. The years and corresponding settlement values are: 1965 (32.1),1979 (49.7), 1989 (55.0), and 1992 (173.2). Thus the seller of a single 20/40 September Eastern call spread at 5 points in each of these years would have a net gain of $29,580. This is an average gain of $672.27 per contract or 16.8% of the amount at risk ($4,000).

In our final table we give the results of calculations of this type using our simulation program. Again, the Pareto distribution is used and expected claims and variance have been chosen to reflect PCS historical simulations. The price chosen is either an actual price at which the contract traded at the beginning of a loss quarter or an average of bid and offer prices in the case where the contract had no trades near the beginning of the loss quarter. Each table line was generated by a program run of 100 trials. Column 5 of the table gives the average payout per contract expressed in points. This should be compared with the price received which is also expressed in points. The return column is the net gain (with transaction costs included) divided by the amount at risk. Thus, if we ignore transaction costs and rounding, the row 1 return is $\frac{3-.2}{20} = .14$. This measure of return is at best a partial determiner of the quality of the investment. For example, considering row three, in the 44 years of PCS simulation data there is not a single quarterly entry above 200 points. Further, though \$10,000 (50 points) is at risk for each contract, an institution would not tie up \$10,000 cash in margin requirment. Using treasury bonds to meet the margin requirment the 3.4% could be considered a supplement to the return on the bonds.

7 *Conclusion*

The question of whether PCS Catastrophe Insurance Options will play a substantial role in the property/casualty insurance industry remains open. The needed liquidity is not yet there. However, quoting an article by Steven Irvin [3] "Some traders have high hopes for the new derivatives. Says a source at one major investment bank: ' If you track the development of Treasury Future Options, you will find that there was less open interest there than there is here at this stage of the game'." Further, according to Richard Sandor, CEO of Centre Financial Products, [4] "The acid test isn't done yet, one to two years is infancy, two to five years is adolescence. Its after five years that we hit hit the critical juncture...".

¿From reports issued by the Chicago Board of Trade on PCS option markets trading appears to be gaining momentum. The accumulated volume in these contracts from September, 1995 was 6,976 contracts on September 4, 1996 and grew to 12,068 contracts by October 18, 1996. This growth rate indicates some hope for initiating the strategies of this paper.

Although option trading is essentially a zero-sum game, in this instance we do not have two speculators attempting to choose the correct side. Instead we have a natural class of buyers, insurers seeking the best way to assure the stability of their companies and thus providing an opportunity for investors to participate in the property/casualty insurance industry by becomming sellers of insurance options. If in fact this is a win/win situation, the insurance derivative market will have a long future.

References

[1] Berger, Lawrence A., J. David Cummins, and Sharon Tennyson *Reinsurance and the Liability Insurance Crisis.*, Journal of Risk and Uncertainty 5: (1992), 253-272.

[2] Chang, Carolyn W., Jack S.K. Chang, and Min-Teh Yu *Pricing Catastrophe Insurance Futures Call Spreads: A Randomized Operational Time Approach.* Preprint.

[3] Chicago Board of Trade *PCS Options: A User's Guide.* 1995.

[3] Euromoney, January, 1995

[4] Business Insurance, October 31, 1994

[4] Cummins, J. David, and Hélyette Geman *Pricing Catastrophe Insurance Futures and Call Spreads: An Arbitrage Approach.* The Journal of Fixed Income, March, (1995). 46-57.

[5] Embrechts, Paul and Steffen Meister *Pricing Insurance Derivatives: The Case of CAT Futures.* Presented at Symposium on Securitization of Insurance Risk, Atlanta, Georgia, May, 1995.

[6] Lane, Morton and John Finn *The Perfume of the Premium...or Pricing Insurance Derivatives.* Presented at Symposium on Securitization of Insurance Risk, Atlanta, Georgia. May, 1995.

[7] Meister, Steffen *Contributions to the Mathematics of Catastrophe Insurance Futures.* Technical Report, Department of Mathematics, ETH Zürich.