Insurance Futures and Options

The Working Party gained direct and valuable experience in the need to hedge positions. At least 3 meetings were adversely affected by circumstances beyond the working party's control. Snow ruined one meeting, the rail strike another and finally one meeting was adversely affected by one member suffering a broken arm and another being involved in a taxi accident. As a result of these mishaps the working party only considered the three separate issues; the current position, pricing problems and trading strategies. These can essentially be regarded as four separate topics and have not been drawn together as a whole cohesive document.

The first item provides an update of the current position, the second reviews the current academic contributions to considering option of future pricing. Essentially this endeavours to translate, with considerable difficulty, financial options theory to insurance options. The third paper suggests a more conventional insurance approach and how credibility theory might be applied to solve the problem. This might be regarded as providing a pointer forward rather than being a vigorous academic treatise. Finally there is discussion of possible trading strategies. It is hoped that these papers will be read in conjunction with previous years paper and will provide an interesting discussion even if it does not contribute much to insurance academia.

1   Progress of the Chicago Board of Trade (CBOT) Contracts

Trading has switched from futures to options. By the end of December 1993 CBOT ceased reporting the volume of futures traded, due either to the low number being traded or the complete absence of trades. The options trading has been via call option spreads. These involve the simultaneous sale and purchase of call options leaving the buyer with a "layer" of cover (a detailed description is given below. The attraction to the embryonic market of this limited liability trade is that it allows traders to control their exposures much more effectively. It is evident that the volume of trading has been building up, particularly for Eastern September 1994 spreads, which cover the east cost hurricane season.

CBOT is also publishing indicative prices for (unlimited) call and put trades. These commenced at a level that was well out of the money, but the range is expanding.

A Western contract was introduced with effect from 10 December 1993, but there appears to have been little interest in the contract.

The following extracted from the CBOT newsletter provides more information:-

CBOT CATASTROPHE INSURANCE CALL OPTION SPREADS

Insurance call option spreads allow a hedger, a reinsurer / insurer interested

in transferring its catastrophic risk exposure, to buy a "layer" of protection between two attachments points (or "strike prices") which are chosen by the hedger. Most of the spreads that have traded are based on 20 point intervals are ranging between 20/40 and 100/120. Each 20 point interval represents a layer of "protection" of $5,000 (20 point x the value of each point, $250).

Lets take a look at an example. If a company wanted to protect its third quarter 1994 Eastern exposure against hurricane risk, it could buy a 60/80 September Eastern option call spread today (the September Eastern contract tracks 3rd quarter losses for the eastern region of the US). A 60/80 Eastern call spread translates to a 60% and 80% industry loss ratio based on approximately $6 billion premiums (based on 1994 Eastern contract), which approximates industry reported losses between $3.6 and $4.8 billion. One transaction might be executed on the CBOT trading floor for the customer to buy a "60/80 September Eastern Call Spread", although it would result in a purchase of a September Eastern 60 call and the sale of a September Eastern 80 call.

A hedger pays a premium for purchasing this call option spread and the seller receives the premium for assuming the risk of selling the spread. Assume the premium for the 60/80 spread is 4 points ($1,000). Therefore, the buyer is purchasing a 20 point ($5,000) layer of protection for 4 points or £1,000.

If aggregate losses for the Eastern contract are below the lower attachment point of 60% or $3.6 billion at the time of settlement, the call spread has no value and will return nothing to the purchaser. If the aggregate losses at the time of settlement are above 80% or $4.8 billion, the buyer of the call spread would receive the maximum possible return from this strategy which is the difference between the 60/80 attachment points and the premium paid (20-4) 16 points. Of course, the buyer would also be compensated by the seller against losses at any point between the 60% and 80% loss ratio minus the premium paid. If losses were at 75%, the buyer would be compensated the difference between the lower attachment point, 60%, and the actual settlement price of 75%, minus the premium paid (15-4) which is 11 points.

As you can see there are great similarities between this option call spread example and a layer of aggregate excess-of-loss reinsurance. The 60/80 call spread would translate to a "20% in excess of a 60% loss ratio". The 4 point premium for the spread translates into a quarterly rate on line of 20% (premium / maximum limit: 4/80-60).

The benefits in using CBOT call option spreads are that a) customisation of the attachment points b) the maximum loss or gain is known at the time the trade is executed c) call spread, like any futures or options position, can be offset at any time prior to expiration d) temporary coverage can be obtained

e) all transactions are guaranteed by the Chicago Board of Trading Clearing Corporation.

2 Pricing Insurance Futures And Options

2.0 Overview

In the 1993 Working Party paper, we gave an outline of how traditional Futures and Options contracts were valued, and went on to describe the limitations of these pricing models for Insurance Futures and Options. In this section we give a brief re-cap of the reasons why many traditional pricing models cannot be applied and go on to describe some approaches that have since been put forward to overcome these.

2.1 Re-cap of the Problems of Traditional Methods of Valuation

Insurance Futures are based on an accumulation of loss payments over a period. Most other Futures are based on the price of an asset or commodity at the end of a period. The classical relationship between the Spot price and the Futures price therefore does not hold, so traditional methods of valuing Futures cannot be applied. Many methods of valuing futures assume that the process being valued has a log-normal distribution at the end of the period. Whilst the underlying claims process may be approximated by a log-normal distribution, the accumulation of these (log-normal) claims is not log-normal.

The underlying model for valuing many different types of Option is that the process driving, say, the price of an equity is a Wiener process. This broadly means that the price will vary up and down in some random way, and the level in the future does not depend on the past. This does not fit with the way in which Futures prices move. Once the price has jumped to a given level, the future price will depend on the past. Also, Insurance Futures will be subject to large random jumps up as, say Catastrophes happen, but not equally large random jumps down as Catastrophes do not happen. This does not tie to the random symmetric variation of a Weiner process. Many traditional methods of valuing Options are therefore scuppered for Insurance Options.

2.2 Approaches That Have Been Put Forward

We observed that Insurance Futures are based on an accumulation of loss payments over a period, they therefore have similar characteristics to an Asian option. In a paper, of which we have only seen a preliminary version, "An Asian Option Approach To The Valuation of Insurance Futures Contracts", Cummins and Geman describe how techniques of valuing Asian Options may be applied to the valuation of insurance Futures. This approach is expanded on in a little bit more detail in section 2.4.

In another paper "Insurance Futures Contract: Concept, Hedging and Comparison with Reinsurance", by Bricheux, Henaff, Kharroubi and Werren, the authors look at extending the Ang and Lai equilibrium model of insurance pricing to value the Futures contract. Using traditional mean-variance analysis they arrive at an optimal hedging position for an insurer.

2.3 What is an Asian Option?

Asian Options are Options where the pay-off depends on the average price of the underlying asset during the life of the Option (or at least during part of the life of the Option). They may be more appropriate in some cases than traditional Options - for example, if one has a stream of cash-flows over a period of time in a foreign currency, a treasurer would be more interested in the average exchange rate over a period than the particular exchange rate at a given point in time.

Asian Options tend to be popular with thinly traded assets, such as gold and other commodities. One can use such Options to guarantee that the price paid for an asset over a period of time is not less than the strike price at the end of a period for example.

Asian Options tend to be tricky to value, because of the complications in looking at the distribution of an arithmetic average. A geometric average of a series of log-normal distributions is log-normal, but an arithmetic average is not. Some people have approached the problem of valuing Asian Options by approximating arithmetic averages with geometric ones and applying traditional techniques, but the results may be misleading. Others have used numerical procedures to approximate the results.

2.4 How Can Asian Options Be Used To Value Insurance Futures?

Cummins and Geman express the price of a Futures contract as the expectation, in a risk-neutral probability space, of its settlement value. They then split this into:

the expected value of the losses
less
the expected value of the difference between the losses and the
Insurance Futures cap, subject to a maximum of zero.

The first element of the above expression can be interpreted, up to a constant factor, as an Asian Option, where one is averaging the losses over a period. In some circumstances, the value of the Asian Option so obtained can be expressed in closed form. In most cases though, only its Laplace transform can be derived. The manipulation necessary to obtain this Laplace transform of the key part of the value of the Insurance Future is based on previous work by Geman ("The Implications of the Forward Neutral Probability Measure in the Stochastic Analysis of Interest Rates") and Geman

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& Yor ("Bessel processes, Asian Options and Perpetuities").

In the latest copy of Cummins and Geman that the Working Party has seen, the authors profess to having made progress in the analytical inversion of the Laplace transform, and hope to be able to present some numerical results of the fruits of their labour.

The approach taken could be criticised for choosing a model for the loss process that leads to an analytically intractable solution; other similar models could be chosen for which solutions exist. It is also not clear how the leap from the real world to the, more convenient, risk-neutral world is made.

As the reader might have guessed, using Asian Options to value Insurance Futures is a bit of a nightmare! There seems to be little benefit in reproducing the mathematics of the techniques in a paper such as this. The interested reader is referred to the publications we have indicated above.

2.5   What Are People Doing In Practice To Value Insurance Futures And Options?

Clearly, from the volumes traded, people are not doing very much. We gather that where people have attempted to price the Insurance Futures, they have made crude guesses at likely catastrophe loss-ratios of the various contracts. The lack of precision in this process is reflected in large bid-offer spreads.

For the Insurance Options, some more sophisticated work, of a confidential nature, has been done. Much of the pricing though has again been of a crude nature, based on a bowdlerized Black-Scholes formula.

3 An Insurance Approach To Pricing An Insurance Futures Or Option Contract

The following indicates the steps to a solution of the problem using a credibility framework:-

1   At the outset the expected value of the contract using the conventional insurance pricing approach is the expected value of claims to the layer. The basic information is available to evaluate this. Any reinsurance actuary would have no problem in doing the necessary calculations. Let this value be C.

2   At the expiration of the contract the value is clearly the price of the contract as traded in the market. Let this be P.

3   The standard actuarial rating formula is $(1-Z) C + ZP$ where C is the a priori estimate and P the a Posteriori estimate. (More usually the Z would be applied to a claims estimate and P the pure premium).

4   The insurance option pricing problem is then reduced to determining Z. Z should be a function of the elapsed time of the contract. Since Z must o $\leq$ Z $\leq$1 the proportion of time elapsed of the contract fulfils this function. However the choice of Z should prove to be a fruitful subject for research.

5   To that extent external information becomes available during the life of the contract we should add a term C' to allow for estimates of cost of large catastrophes e.g. a hurricane occurs. Thus the value would $(1 - Z) C + (1 - Z) C' + ZP$. C' would be an "insurance estimate" of the cost of the hurricane.

    A variation on this would be to have a different credibility factor for C'. This is not considered further here but is another interesting topic to research.

6   The formula in 3 can be rewritten as $1 - Z (C - P)$. The greater the difference between $(C - P)$ probably means that more credence probably should be given to P. A non-linear function Z is therefore possibly appropriate. Indeed unconventional credibility non-linear functions are usually appropriate.

    An approach along these lines may prove instructive in evaluating the problem rather than conventional pricing methodology.

4   Trading Strategies

We note first that a major characteristic of an insurance future for a buyer thereof is that although both upside and downside are limited, the potential upside is very much greater than the potential downside. In this fashion, futures resemble insurance contracts providing protection against adverse experience, so might appeal to potential buyers of insurance. In similar fashion, the writing of insurance futures might appeal to potential risk-bearers such as sellers of insurance.

Possible players:

To reduce exposure by buying: To gain exposure by writing:

Insurers	Insurers
Corporate Capital	Corporate Capital
Names	Names
Insurance Shareholders	Insurance Shareholders
Insurance Buyers	Finance Houses

To take the possible **BUYERS** in turn:

Insurance companies may wish to offset their exposure to e.g. property business in the eventuality of a windstorm, in place of traditional reinsurance.

Advantages	-	lower credit risk
	-	lower cost
Disadvantages	-	less of a match to liabilities

Similarly, **Lloyd's syndicates** may wish to offset their exposure to e.g. property business in the eventuality of a windstorm, in place of traditional reinsurance. The advantages and disadvantages would be similar to those above. However, the spread of business might well be less, because of the broker-driven nature of the Lloyd's market, and the mismatch of liabilities would be correspondingly greater.

Similar advantages and disadvantages would apply to **Corporate Capital** at Lloyd's in the absence of appropriate reinsurance at the Syndicate level. However, it is unlikely, after the trouble at Lloyd's in recent years, that any Syndicate would "go bare" to an appreciable extent. Even those **Individual Names** who did have the financial standing to become members of a well-regulated options exchange would be unlikely to have the time or inclination, although insurance **futures** might have their appeal.

Insurance shareholders, institutional and individual, "complete the square". The mismatch of liabilities would be likely to be less than Lloyd's players; however, like the Lloyd's players, neither institutions nor individuals would be

likely to have the inclination (nor the financial status, in the case of individuals) to become members of a well-regulated options exchange, although insurance **futures** might have their appeal.

This "square" is not quite square, however, as there is a fundamental difference between insurance company shareholders and participants at Lloyd's namely the issue of limited versus unlimited liability. The downside of going "bare" is limited for insurance company shareholders. Indeed, modern portfolio theory would seem to imply that an insurance company should not take out any reinsurance cover <something to do with diversifiable risk, if I recall correctly> and that individual shareholders should conduct their own reinsurance if they want to reduce their risk. Due to, inter alia, economies of scale, practicability, market entry costs (cheaper to keep a company in business than to start a new one) and lack of individual insurance expertise on the part of the individual shareholder it turns out that in practice it is entirely reasonable for insurance companies to buy their own reinsurance; however, this does raise the question of best policy for e.g. a Bermudan pure catastrophe reinsurer: should it take out reinsurance (even by means of catastrophe futures) or should it let its (big Swiss or American) shareholders buy their own catastrophe futures? (subject of course to regulatory approval an so on.)

Insurance buyers may have some use for catastrophe futures if their exposure (or a clearly definable and separately insurable subset thereof) matches to a reasonable extent that of an index; however, this must be unlikely except for (regional or) nationwide operators e.g. McDonald's in the US.

Looking now at possible **SELLERS**:

For a seller, an insurance future, when it first comes to market, has a much greater potential downside than upside. Consequently the financial strength of a seller should be substantially more than that of a buyer to mitigate the risk of default. (In practice, however, do the rules of future exchanges make such a distinction?)

Insurance Companies are in the business of taking on risk. However, their business also comprises receiving claims, issuing policies, paying claims etc as well as pure underwriting. (Indeed, many may argue that insurance companies are not that good at underwriting...) In other words, much of their expenditure - and therefore much of the value they add - has little to do with the bearing of risk per se. Furthermore, the bearing of risk is more capital-intensive than many of the company's other functions. It would seem, therefore, that unless a company finds itself with some under-used capital, it would be unlikely to write many insurance futures (particularly in the UK, where insurance capital is often used for paying shareholder dividends rather than for the conduct of insurance business).

On the other hand, this leaves the possibility of a company set up specifically to write insurance futures, much in the way that capital has flowed to Bermudian Cat Cos. This will depend in particular on the capital and other regulatory

requirements (as well as the skills base, local beer quality etc., c.f. Ryan, J., "The Future of the London Market", LMAG March/April 1994). Such specialist companies would correspond to **Corporate Capital** at Lloyd's. (Perhaps this indicates the institutions to be targeted?) Two particular attractions for such companies would be:-

- ☺ the ease with which the insurer can jump in and out of the market as rates harden or soften (compared to traditional insurance, based on broker relationships)
- ☺ the limited liability - margin has to be financed, but only up to the limit of the company's assets.

Individual Names, on the other hand, with unlimited liability, would not have the latter incentive to write insurance futures. Similarly for **individual holders** of insurance company shares. To limit the downside, **institutional investors** would rather invest in a company writing insurance futures than write futures directly.

Finance Houses, with other experience of futures, might be the most inclined to write futures. Again, because of the skewed risk profile, they would be tempted to do so through a separate limited-liability subsidiary; however, this may not in practice help much, because an organisation of repute might be risking its credibility or good name by letting a subsidiary go down the chute.

Having identified the potential buyers and sellers, we can (finally!) proceed to consider possible trading strategies. Why and when would they write, buy and sell? Would there be a secondary market?

For **Insurance Buyers** such as McDonald's, say, where the exposure over the three-month period is known at the outset, contracts would be purchased at or before the start of a period of exposure and held throughout. **Insurers** seeking to offset risk, where the amount of risk is not completely fixed at the start of the period, because insureds are continually going on or coming off the books, might seek to purchase contracts during the "at risk" period.

The question is, though, who would sell at such a time? Not McDonald's, surely: their exposure hasn't changed! (New contracts cannot be written **during** a period of exposure, can they? Would a writer write himself contracts at the start of a period just so he can sell them partway through? What would the overheads be?).

It is difficult to identify any natural sellers. Furthermore, it is difficult to identify any natural speculators. The price of insurance futures doesn't move day-by-day but is discontinuous when catastrophes occur (or are imminent?); there is not a natural market in the underlying index. Apart from a change in interest rates, the only things which would change one's view of the "correct" price for the futures contract are:

(i)   the occurrence of a catastrophe;

(ii)   change in view of size thereof;

(iii)   change in view of settlement patterns (assuming a catastrophe occurs).

So is Andrew Smith right? (Insurance Derivatives, The Actuary, April 1994). Let us examine his points in turn:-

☺   daily "market-to-market" cash adjustment requires US-based treasury operation (for CBOT); inconvenient daily cash flows

☺   in practice, a sum is lodged with the exchange and the numbers are taken care of by them: cash flows are replaced by book entries

☺   insurer may be over-concentrated in one area of risk => over-exposed

☺   let him reinsure the excess conventionally

☺   insurer may be under-concentrated in one area of risk => buying cover he does not need at a profit to the futures writer

☺   so what? if it's more expensive overall than traditional reinsurance cover, let him take that instead; if it's not, let him not begrudge the futures writer a bit of profit

☺   both the aforementioned circumstances would lead to greater volatility than true reinsurance

☺   let the insured decide whether the cost saving makes the volatility worthwhile. In particular, he may be able to reinsure the difference at a favourable price (a Bermudian company has offered such a product)

☺   no allowance for IBNR on maturity of future

☺   the degree to which this is a disadvantage depends on the volatility of the fraction "incurred at maturity/ultimate"

☺   risk that money is lost on roll-over

☺   unlikely that any balanced investor would expose his capital solely to catastrophe risk

☺   tell that to Centre Cat!

☺   rational investors might sell insurance derivatives and buy equity in insurers and so find themselves back where they started!

☺   not quite: if they invested in sellers with limited liability they'd be better off than when they started. (Also saving insurance company premium

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collection costs, loss adjusting costs etc., but see comments above regarding insurers adding value in those areas)

☺ insider information

☺ the point is conceded - see (ii) above - but such concerns are overplayed: the risk is arguable no greater than in other areas where such concerns are not often voiced. The index is designed to be less than fully riggable: at least 18 contributors, with a defined procedure in place for filing information. (NB if dice are loaded heavily in favour of insurers, who would be the most disadvantaged: buyers or sellers of the options?)

☺ "dynamic hedging" requires freedom from "gapping"

☺ this is the brick wall we hit above - price discontinuity; no trading in the underlying index. This is indeed an impediment to further development of insurance futures insofar as mainstream futures writers are concerned, with cultural barriers against "risk-taking". However, risk-taking lies at the very heart of an **insurance** operation: in such an environment futures could theoretically not just survive but thrive.

In practice, the futures market has been replaced by a market in insurance **options**. Options are generally traded in pairs, analogous to insurance layers, reducing the writers exposure. It would therefore appear that traders have taken the above considerations into account and used their ingenuity to overcome any barriers in their path. The insurance futures and options markets are hardier than they are given credit for.