Motor Working Party

The future of the motor insurance market

Contents

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1. Introduction

The future of the motor insurance market is a potentially vast topic. We decided to limit the scope of this paper to the UK private motor market from an insurer's perspective. We consider the key issues that are likely to have a significant influence in determining which insurers will be successful in future.

The changing shape of distribution is discussed with a summary of the factors affecting the broker and direct writing channels. A comparison of the relative advantages of direct writers and broker insurers is included. This is followed by an outline of marketing issues for a direct writer that covers marketing costs and discussion of various marketing and advertising methods.

The next section provides a review of recent trends in overall market profitability. A brief analysis of the expense ratios of two leading direct writers is used to discuss the relative profitability of direct writers and broker insurers. This is followed by a discussion of the factors that are likely to lead to consolidation in the insurance sector.

A discussion of factors affecting claim costs and an outline of current legal developments involving the Ogden tables is included and an actuarial approach to projecting potential Ogden exposures is briefly described. Internal claim management issues relating to large claims are outlined and the opportunities offered by structured settlements are discussed.

Underwriting developments are discussed in the following section which covers redlining, the potential impact of the Disability Discrimination Act, lifestyle rating and a summary of no claims bonus and its potential future development.

The paper ends with a section on technical analysis that outlines current pricing practice and describes mathematical tools which may be used by actuaries to extend the scope of actuarial work in the motor market. The techniques described are neural networks, genetic algorithms, expert systems, cluster analysis, data mining and spatial analysis. Possible applications are outlined for each technique.

2. Distribution

2.1 Spread by channel

The following table shows the spread of private motor premium income by distribution channel from 1990 to 1994. The total UK private motor annual written premium is around £5.5 billion. The number of motorists is around 21 million, but it is estimated that 10% of drivers are uninsured. The business is shared between Lloyds and the company market, with around 15% of exposures written by the Lloyds market.

Year	Brokers	Direct	Tied Agents	Miscellaneous
1990	76%	12%	11%	1%
1991	73%	13%	12%	2%
1992	71%	16%	12%	1%
1993	69%	20%	10%	1%
1994	63%	25%	10%	2%

Source: ABI statistical bulletin: General Insurance Statistics: Sources of premium income 1990-1994

Brokers consist of intermediaries registered by the Insurance Brokers Registration Council (IBRC) and non-IBRC independent intermediaries including some banks and building societies. IBRC intermediaries account for around 80% of the total broker market share.

Direct is all business where no intermediary is involved including direct mail and newspaper coupon business; the vast majority of this business is through telesale direct response operations. Since 1990, direct writers have more than doubled their total market share from 12% to 25% mainly at the expense of brokers. This growth is phenomenal given that it starts from a base of less than 1% in 1986.

Tied agents consist of staff agents and tied agencies that may have panels of up to 6 insurers. Staff agents account for approximately 80% of the total tied agency market share Miscellaneous consists of business sold as an add-on to some other non-insurance transaction.

2.2 Factors affecting the broker channel

2.2.1 Formation of telebrokers

A number of telephone-based brokers who market themselves to the public and use relatively small insurer panels have been formed since 1993. Typically, they are set up as single site operations to eliminate branch overheads. The initial technology and marketing costs are high and there has been at least one failure to date. In a number of cases insurers delegate underwriting and processing to telebrokers to reduce costs. Telebroker marketing tends to emphasise price competitiveness and the ability to obtain the best price from a number of insurers.

2.2.2 Duplication and cash flow lags in the intermediary sector

Typically, transactions made in broker offices are duplicated by insurers. There is also a cash collection delay and brokers are usually given 30 days of credit from the date that accounts are requested by the insurer. In practice, brokers receive substantially more credit because of processing backlogs by both brokers and insurers.

Delegated schemes allow intermediaries to issue policies and carry out mid-term adjustments whilst maintaining their own records for each insurer. These arrangements can expose insurers to a loss of underwriting control. Historically, delegated schemes have operated on a manual bordereau basis, but as the volume of business written in this way increases it is becoming more important for insurers to obtain computer files of underwriting data. An alternative sometimes employed is for the broker to input policy details directly on the insurer's systems. Under these arrangements the insurer faces audit and control issues.

2.2.3 Electronic data interchange (EDI)

EDI is a form of electronic trading under which brokers transmit messages detailing insurance transactions to insurers. In principle, the whole cycle of policy administration can be transacted on EDI. Under EDI, the broker is able to produce full documentation at the point of sale. This eliminates the administrative duplication caused by the issue of temporary cover notes by brokers and the subsequent production of full policy documentation by the insurer. EDI has the following potential advantages:

- reduction of processing duplication
- reduction of communication lags
- reduction of cash flow lags
- insurers can reduce processing overheads
- standardisation of business processes
- improvement in broker service

The use of EDI has increased significantly over the last two years from 9% of total intermediary business in 1993 to around 20% in 1995. EDI-only and discounted-EDI policies have been developed by some insurers. One insurer trades only on EDI.

At present only a very small number of insurers transact EDI on a full-cycle basis. This is partly because only 2 software houses offer this facility. The potential benefits of EDI cannot be fully realised unless it is operated on a full-cycle basis. It is anticipated that the majority of software houses will be able to offer full-cycle EDI within the next 18 months.

Transmission costs can be significant. Although there are potential efficiency gains, the direct cost benefits can be relatively modest. Insurers may derive maximum potential savings from reduced processing overheads. As the volume of EDI business increases, it is possible that direct cost savings may increase as transmission charges reduce because of economies of scale.

As a result of EDI, insurers face underwriting and administrative issues because of mismatches between the data transferred by brokers and that accepted by their systems. EDI therefore results in an increased dependence on the quality of broker input and requirements for regular broker audits and the use of standard procedures.

Particular issues affecting the development of EDI include the following:

- EDI messages are currently transmitted using a standard format; this has restricted progress because the procedure to update the standard can be lengthy.
- If the Polaris initiative succeeds, it will have a significant influence on industry standards and should enable greater flexibility in product development although delays in updating industry standards are unavoidable.
- Both broker and insurer investment are required to develop EDI and the eventual number of brokers that will invest in EDI is currently uncertain
- The Insurance Ombudsman has placed an increased emphasis on point of sale as against point of claim underwriting. Widespread broker access to market databases is required to achieve this in the broker channel. The most effective way to achieve this may be through EDI. These facilities have not been developed in current EDI offerings, but software houses are beginning to consider the possibilities.

2.2.4 Polaris

Polaris is an initiative to streamline the procedure by which broker insurers amend their rates on the quotation systems produced by software houses. It was initially sponsored by a group of 7 insurers, but the number of participants is now increasing. At present insurers have to advise and check rate changes with each of a large number of software houses. Each software house also carries out development work to update their systems. The aim of Polaris is to provide a standardised interface between insurers and the main broker quotation systems.

Polaris is based on two products:

- Productwriter interfaces with each insurer's computer system and enables insurers to design, amend and validate rates without having to re-specify and test the rates for each software house.
- Run Time Environment accepts Productwriter software and converts it to each software house's system thereby eliminating development work by the software houses for each rate change.

At present only 2 of the smaller software houses are developing Polaris interfaces. The larger software houses are in the process of negotiating terms prior to commencing development work.

2.2.5 Client ownership issues

The expected contraction in the number of intermediaries may lead to purchases of brokerages by both insurance companies and other intermediaries. Insurers with direct operations may perceive an opportunity to purchase broker portfolios and transfer renewal business into their direct operations. The purchase of the RAC's broker operations by Guardian provides a recent example of this. When intermediaries purchase brokerages or mergers take place, panel changes are a strong possibility.

Under these scenarios, client ownership issues can arise for both the purchaser and insurers on the acquired brokerage's panel. Under typical standard agency agreements, insurers reserve the right to deal direct with policyholders in specified circumstances including termination and contravention of the agreement by the broker. The largest intermediaries usually have individually negotiated agreements. Under many of these agreements the intermediary reserves the right to cancel the agency and retain full client ownership rights. In practice intermediaries do not go through the formal cancellation process, but place renewal business with other insurers.

There is no general legal precedent establishing whether intermediaries or holding insurers have client ownership, because of the complexity of the issues and the range of agency agreements across the market. Under standard agency agreements, case law indicates that a holding insurer has the right to make renewal offers to its policyholders, but the intermediary has the right to access its clients and make sales offers which may be in competition with the holding insurer.

2.2.6 Broker Direct

Towards the end of 1994, the Institute of Insurance Brokers (IIB) announced plans to set up an insurance company as a response to their loss of market share and the establishment of direct operations by a number of composites. The plan was that the new company would write net rated business through member brokers using EDI and would be capitalised with £55 million which would be sought from international investors. The project has been delayed and the expected launch date is now January 1997. A Lloyd's corporate capital venture is also being considered as an alternative method of establishing the company.

2.2.7 Consolidation

There are around 5,000 brokers in the UK consisting of regional chains and high street brokers writing mainly personal lines business. In recent years there has been an increasing rate of insolvency among this group. Mergers among smaller regional chains are a continuing trend. Many of the larger regional chains are seeking growth through acquisition of distressed brokers. Among the national chains, the current trend is for branch networks to be reduced and operations transferred to large telesale operating centres.

2.2.8 Other factors

Net rated products have been developed which enable the broker to charge their client a discretionary commission. Introducer products have also been successfully developed which pay a lower commission on renewal, but the insurer deals directly with the policyholder for all post inception administration.

Competitive pressures lead intermediaries to "churn" renewal business between members of its panel. There has been a recent trend towards an increasing number of off-screen deals as insurers have sought to maintain market share as the rates have softened. It is worth noting that broker retention rates are at similar levels to direct writers although broker insurer retention rates are typically considerably lower.

2.3 Factors affecting direct writers

There is expected to be a decline in the number of direct writers. However, their overall market share is anticipated to continue increasing albeit more slowly than in the recent past. Rising acquisition costs are eroding the potential cost advantages of direct writing although this is offset for well-established players by high retention rates. This trend is partly because of the rising number of direct writers resulting in increased marketing costs for the same "share of voice".

Due to the relatively large number of direct writers in the market it is increasingly difficult for new companies to grow rapidly on a profitable basis. The financial dynamics of direct writing are somewhat different to broker insurers because of the relatively high retention rates experienced by direct writers. This results in significantly higher potential customer lifetime value for direct writers compared to broker insurers. Long term direct marketing strategies with acquisition costs being amortised over a number of years are therefore common.

In accounting terms this usually results in front end losses for a company seeking rapid expansion because deferral of acquisition expenses is only on a one year basis. Obviously, a substantial immediate cash investment is also required to fund marketing costs. As the direct market consolidates, this capital requirement is likely to create a strong barrier to entry by new companies.

The profitability of the newer direct writers is unclear at present. For composites with recently established direct writers it is common to read references in recent financial statements to the volumes of business being carried out direct, but there is little or no comment on profitability.

2.4 Comparison of direct writers to broker insurers

2.4.1 Direct writing

Advantages

- direct underwriting control
- direct control of data quality
- ability to price tactically and adjust prices rapidly
- full price structure unavailable to competitors
- immediate feedback on conversion rates
- direct bond with policyholder
- faster cash flow by avoiding intermediaries and processing delays
- no processing duplication
- cross-sell and up-sell opportunities of own products to customer base at low marketing cost
- large players can establish barriers to entry

Disadvantages

- increasing front end marketing costs
- need for streamlined procedures can lead to inflexibility in underwriting and product design; hence the general focus on standard risks
- increasingly difficult to establish strong brands given the growing number of players
- broker insurers which set up direct operations face potential conflict with brokers

2.4.2 Broker insurers

Advantages

- distribution through a large number of brokers
- non-commission marketing expenditure low
- commission cost is directly related to premium volume
- underwriting and product design flexibility

Disadvantages

- dependent on broker for underwriting integrity
- lag in receiving data
- lag in cash flow and bad debt exposure
- lack of flexibility in pricing
- need to deal with many software houses
- administrative duplication
- exposure to broker failures
- branding and customer loyalty weak as consumer may perceive broker as service provider

2.5 Other forms of distribution

2.5.1 Affinity schemes

Affinity schemes are perceived as a means of attracting mass enquiries with above average retention rates. Common affinities include employment, clubs, leisure organisations and car franchises. The affinity provider usually benefits from commission which may be different to standard rates. Underwriting issues can arise if there is a large proportion of risks unacceptable to the insurer within the group. Brokers often use delegated arrangements to sell own brand products.

2.5.2 Banks and building societies

Traditionally, banks and building societies have concentrated on the household insurance and the long term savings market by exploiting cross-selling opportunities arising from mortgage provision. Historically, these sales have been on an intermediary basis, but in recent years some banks and building societies have established life insurance companies.

Due to recent changes, building societies are now able to own a general insurance company and some are actively pursuing this route under various arrangements including partnerships with established insurers. Although the current focus is on household insurance it is likely that in future banks and building societies may increasingly target the motor market.

2.5.3 New distributors

New entrants could come from:

- retailers with strong brands which are trusted by consumers
- businesses which can offer motor insurance as an add-on to their core services such as Kwik-Fit
- major manufacturers or repairers may try to exploit their brands to become insurance distributors

3. Direct marketing

3.1.1 Overview

Advertising costs are the main barrier to entry for a direct writer. The typical established direct writer spends around 10% to 15% of premium on marketing costs. Commission rates fall in a similar range for broker insurers. Direct response and name awareness advertising are the two main forms of marketing. For a medium sized direct insurer, the annual marketing budget is likely to be in the region of £5 million to £10 million. The majority of the budget is spent on advertising.

Although new methods are being developed, traditional media such as newspapers, motoring magazines, television, telephone directories, radio and bill-boards remain core. Television and press are typically seen as an investment in both name awareness and direct response advertising. Costs are usually allocated between the two forms of advertising on a broad basis.

The difficulty of accurately measuring the benefits of name awareness advertising restricts the ability to allocate marketing costs on a precise basis. Most medium sized direct insurers find it cost effective to be in national newspapers most of the time and have a presence on minor television channels. Except for the largest insurers, prime-time television advertising is out of reach for both cost and service reasons.

3.1.2 Direct response advertising (DRA)

DRA solicits a response from the consumer and takes the form of a message endorsing the product, followed by an instruction to phone for a quotation. DRA will only generate a response if the message is received by consumers when they are considering buying insurance. Typical DRA media include the newspapers, television, direct mail and telephone directories.

Prior to embarking on an advertising campaign, expected response profiles and the capacity of the insurer to handle responses should be co-ordinated. For example, the response from television or radio advertisements is almost instant and therefore requires the ability to cope with sudden sharp peaks in response. In contrast the response from direct mail is usually spread over a number of weeks.

The response from DRA advertisement campaigns is measurable and it is normal to test particular advertisements or marketing approaches by measuring response and conversion rates. Response profiles are estimated and monitored for each media to provide feedback into the capacity planning process.

3.1.3 Name awareness advertising

The aim of name awareness advertising is to make the public familiar with the insurer so that it is regarded as a natural reference when individuals purchase insurance. Its non-specific nature means that almost any media can be suitable. However, insurers increasingly use a targeted approach in deciding which methods to adopt. Although surveys are sometimes used, it is extremely difficult to measure the effectiveness of name awareness campaigns.

3.1.4 The message

Most motor insurance advertisements still emphasise low price. However, some insurers and brokers have attempted to differentiate themselves by promoting added value benefits such as free courtesy cars during off-road repair. Significant features have been widely copied by competitors raising the overall level of service to the consumer. A targeted approach to higher value cover is likely to be most successful, but this increases administrative complexity if an insurer wishes to make a range of product offerings.

3.1.5 Television advertising

Television advertising is usually purchased on a campaign basis. Campaign costs can be around £2 million for a period of 3 to 12 months depending on the weight of the campaign. The insurer will choose to vary the weight and timing of its campaign to match its servicing capability and planned marketing activities using other media.

Costs for individual slots are principally dependent on rating which is measured per thousand of audience and the length of the advertisement. The pricing structure is extremely complex and can depend on whether the advertisement is at the start, middle or end of the commercial break. The potential range of costs is from £50 to in excess of £100,000 per slot. Typical off-peak satellite slots can cost around £900.

Bucket shopping is an option under which the insurer may purchase last minute slots which have remained unsold at a substantial discount of between 30% to 50%. The main disadvantages of this approach are its lack of focus and the loss of control by the insurer of response timing.

3.1.6 Newspaper advertising

Newspaper advertising charges vary widely. As a broad guide, quarter page advertisements in the weekday editions of national papers cost between £1,000 and £5,000. Most advertisements are priced on the basis of volume and social class of readership. Insurance companies may have quite different criteria based on the age range or geographical coverage. Hence, the most effective advertisements are not necessarily the most expensive.

3.1.7 Direct mail

Direct mail is being increasingly used by the direct writers to exploit cross sell or re-solicitation opportunities using the insurer's customer database. New prospects are solicited using lifestyle and renewal date mailing lists in order to achieve a degree of targeting. Costs including lists for new prospects can vary between £0.30 and £0.60 per mailing piece depending on volume and the nature of the marketing pack.

Response rates for new prospects are usually between 1% and 5% and depend principally on the proposition, accuracy of targeting and quality of the mailing list. Substantially higher response rates are possible from warm prospects, particularly when re-soliciting past policyholders.

Alternative marketing propositions are tested for each mailing campaign to identify a champion marketing pack that is the lead business generator. Challenge packs are regularly tested to provide a framework for ongoing improvement.

3.1.8 Directories

The cost of directory advertisements varies with coverage and size, but is relatively inexpensive. The cost of national coverage is can be around £100,000 to £250,000 for mainstream directories depending on the size of the advertisement.

3.1.9 Sponsorship

Sponsorship is largely a form of name awareness advertising and may be very costly and ineffective unless followed up as part of a wider marketing campaign. Sponsoring a major sports event can maximise publicity at a high price. Sponsoring an individual competitor is cheaper, but will generally only receive maximum publicity if the competitor is successful. The choice of event or competitor to sponsor is typically aligned to the brand values of the insurer and its target market.

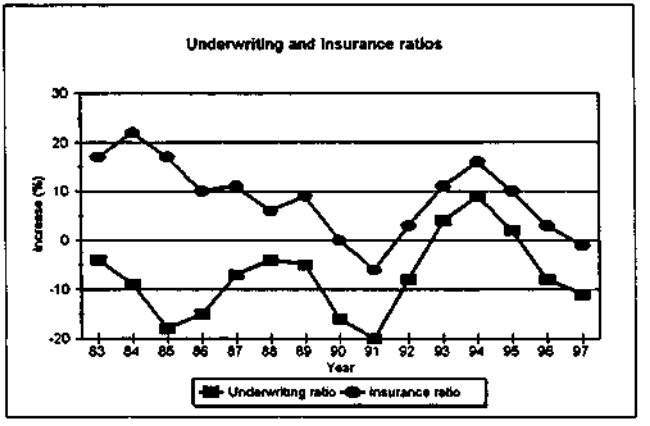
3.1.10 House magazines

House magazines are becoming more common as a method of bonding policyholder and company although the effectiveness cannot be accurately measured. Costs per unit are volume dependent, but can be as low as £0.60 per unit for a run of 250,000 copies. Special offers including member-get-member schemes and discount vouchers are common customer loyalty incentives. The main potential benefits to the insurer are improvements in retention rates and increases in referral business.

4. Profitability

4.1 Historic cycles and margins

The UK private motor market is notoriously cyclical. This is illustrated by the following graph of underwriting performance since 1983 for a large sample of motor insurers. The graph shows underwriting and insurance returns for a large sample of motor insurers from a recent stockbroker's report. The underwriting return is the underwriting result divided by net written premium based on DTI returns. The insurance result adds a notional investment return to the underwriting result.



Published underwriting results for motor should be interpreted with caution. Overall trends are of more relevance than the absolute figures primarily because the results depend on the strength of each company's reserves and the basis used for allocating expenses. The expense allocation basis is particularly relevant when interpreting DTI return data. It should be understood that expenses are usually allocated to classes on a broad basis. Obviously, similar comments apply to the insurance result, with the added proviso that the allocated investment returns are notional. Given the limitations of the publicly available data, it is almost impossible to accurately assess the overall profitability of motor insurance. However, the trends can give valuable insights.

Investment returns during the 1980's were historically high and the underwriting performance during this period was generally worse than during the current cycle which is taking place in an environment of reduced nominal investment returns. Although underwriting profitability was at record levels in 1994, overall profitability did not match the peak in 1984 because of lower investment returns. The expected return to overall loss in 1997 has been rapid compared to the 1984 peak which declined into overall loss only in 1991. The return to profitability is forecast to be gradual and modest.

Over-capacity, structural change and lower investment returns appear to be reducing overall profitability in the 1990's. A return to the consistent levels of overall profitability experienced in the 1980's is unlikely to occur until capacity is shaken out of the market. It should be noted that the analysis includes Direct Line which was substantially more profitable than the remainder of the market whilst writing a significant volume of the business during the 1990's. Hence the profitability of the rest of the market has been even lower in the latest cycle than indicated by the graph.

4.2 Relative profitability of direct writing and broker insurers

Direct Line's rapid growth and high profitability in recent years has led to a widespread perception that direct writing is inherently more profitable and efficient than writing business through brokers. Direct Line's DTI motor expense ratio of 11% in 1994 is commonly quoted as evidence of the potential efficiency of direct writing companies.

The following table shows expense ratios as published in the DTI returns for Direct Line and Churchill for motor and all classes combined in recent years. These two companies where selected because of their leading positions in the direct writing sector. The difference between Direct Line's motor and whole account expense ratio is substantial. Direct Line's motor expense ratio of 11% should therefore be interpreted with caution. Churchill is dominated by motor business and there is little difference between the motor and whole account expense ratios.

Financial year	1994	1993	1992	1991	1990
Direct Line - *whole company*					
Net written premium £m	608	410	213	124	84
Expense ratio	21%	20%	25%	29%	34%
Direct Line - *motor only*					
Net written premium £m	491	341	162	85	55
Expense ratio	11%	12%	17%	22%	26%
Churchill - *whole company*					
Net written premium £m	136	118	70	35	17
Expense ratio	26%	25%	25%	37%	63%
Churchill - *motor only*					
Net written premium £m	131	116	69	35	17
Expense ratio	26%	26%	26%	37%	63%

Published expense (including commission) ratios for broker only companies vary from around 20% to just under 40%. These overall expense ratios suggest that the best run broker insurers can compete against direct writers on purely expense terms. However, the majority of broker insurers will have to rationalise their operations if they are to survive in the long term.

4.3 Future trends

Direct writing companies have a number of significant advantages over broker insurers as set out in section 2.4. However, the broker insurer advantage of variable marketing costs that are directly related to premium is significant. Direct marketing will require an increasing capital commitment to finance marketing costs to achieve growth in a market in which the distinctions between individual direct companies and telebrokers are becoming increasingly blurred.

Despite the difficulties of direct marketing, pressure will remain on the broker channel to minimise duplication and to improve service standards. This pressure will intensify as the direct market consolidates into a small number of large players. The key to broker insurer survival is the effective use of IT and the forging of stronger partnerships with brokers. This may mean fewer, but larger, brokers each using fewer insurers.

Greater standardisation within the broker sector and possible consolidation of software houses would also appear inevitable. These trends suggest that both brokers and their insurers will continue to consolidate and the smaller non-niche insurers will probably be forced to withdraw from the market. The market is likely to remain cyclical but barriers to entry in both the broker and direct sectors may lead to lower volatility in the underwriting cycle.

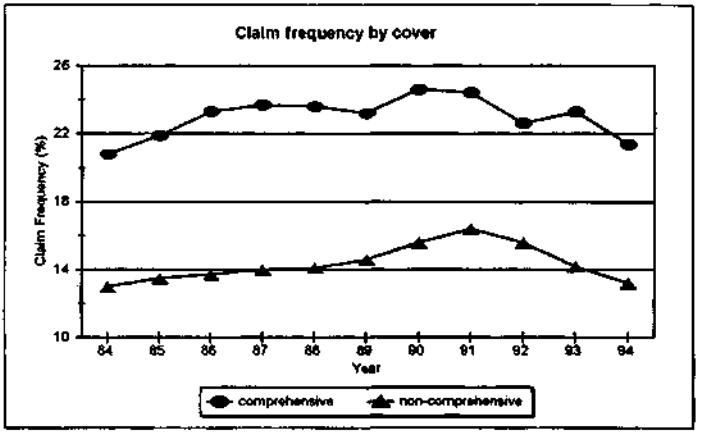
5. Factors affecting claim costs

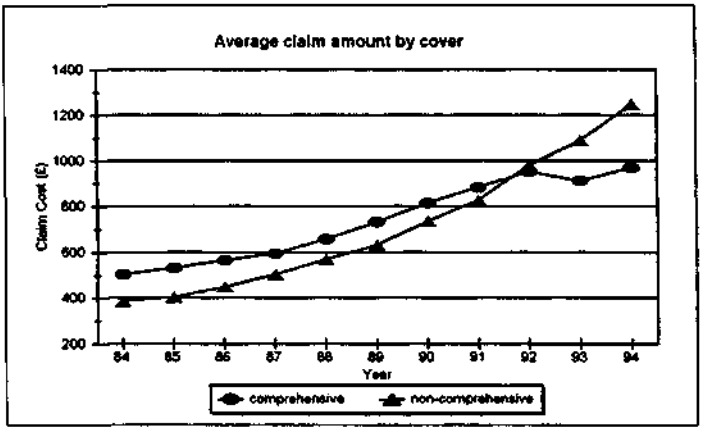
5.1 A recent history

In 1993 the industry abandoned knock for knock agreements under which insurers would pay for own-damage repairs to comprehensive policyholders regardless of fault. The change does not alter overall claim costs, but knock for knock insurers with a higher than average non-comprehensive mix became worse off because of an effective loss of subsidy.

The inclusion of windscreens in MOT tests at the start of 1993 added a substantial volume of small claims. This resulted in a reduction of average claim costs during 1993 for comprehensive business. The slight overall increase in comprehensive frequency during 1993 is due to the distortion caused by windscreen claims. The reduction in frequency since 1991 is largely due to declining theft frequency.

The following graphs show trends in overall claim frequency and average claim costs from 1984 to 1994. For reference, Appendix A sets out the figures underlying the graphs.





5.2 External environment

5.2.1 Manufacturers' influences

Manufacturers have responded to consumer demand by improving the security and safety devices provided as standard on new cars in recent years. Deadlocks, immobilisers and alarms are now fitted as standard in many cars. This has helped to reduce car theft in recent years. Press reports and recent experience suggest that thieves now target 4 and 5 year old vehicles that preceded the security improvements on new cars.

Anti-lock brakes, side impact protection, air-bags and seat belt technology all combine to improve vehicle safety. There is little available data on the actual effect of these features. However, interesting conclusions can be drawn from the DOT road accident figures for recent years. These show a greater reduction in fatalities than serious injuries. It is plausible that additional safety devices are contributing to this effect by transferring fatalities to serious injuries. An additional factor is the considerable advancement of paramedic treatment at the roadside and the continuing improvement in medical care for serious injuries. Although the reduction in fatalities is very encouraging, the trend in serious injuries is the most significant factor from a claim cost perspective.

Despite road safety improvements, an interesting insight into driving behaviour can be gained from US experience of ABS on anti-locking brakes. This feature was expected to improve claim experience. Data has now emerged which suggests that there is no significant difference in the claim experience of cars with and without anti-lock brakes. This is probably due to a combination of drivers falsely feeling well protected and a lack of understanding of how to use the feature.

5.2.2 Social and economic influences.

The biggest social and economic influence on UK motor claims is probably car crime. Theft frequency has reduced substantially since the early 1990's partly because of security improvements, but mainly because of falls in unemployment. It is possible that theft frequency has already bottomed out and is now increasing.

Drink driving attitudes have also changed considerably over recent years. Public opinion has moved from casual acceptance to a position where drink driving is regarded as socially unacceptable. This change in attitude shows through clearly in the substantial decline in deaths from drink driving accidents from around 1,600 in 1980 to just over 500 in 1994. Despite the improvement, deaths from this cause still account for 14% of total road accident fatalities demonstrating that the problem remains significant.

In recent years claims awareness has increased. Historically, it would have been relatively rare for a third party to claim for things such as car hire costs and minor whiplash injuries would often not be pursued. Such claims are now common and are driven by knowledgeable and aggressive uninsured loss recovery providers and solicitors specialising in motor claims.

5.2.3 Traffic control measures

Traffic controls are continually increasing. Residential shortcuts are being made unattractive by ramps and cameras provide a speeding deterrent on main roads. Speeding is being targeted by Government campaigns with the stated claim to make the practice socially unacceptable. On many dual carriageways opportunities for taking right turns are being systematically removed thereby reducing the potential for drivers to put themselves and others in dangerous situations. The effect on loss costs of traffic control measures is probably impossible to quantify precisely, but the overall effect is probably an improvement in claim experience.

5.2.4 Legal changes

Generally, liability awards are granted on the basis of precedent with change tending to be gradual. However, significant step change does occur occasionally and motor insurers are currently facing such an issue from the recommendations of the working party led by Sir Michael Ogden QC.

The working party, comprising lawyers and actuaries, first reported in 1984 on their investigations into the adequacy of personal injury settlements. Although significant changes were recommended, the Courts were unwilling to depart from established procedures and there was little change. However, the impact of the working party's latest report that was issued in 1993 has been substantial.

The Ogden working party concluded that lump sum settlements for future loss of earnings and future care have historically been inadequate. In principle, the lump sum should provide an amount that compensates for the future loss of the plaintiff. The lump sums are calculated by the application of an expected amount per annum (the multiplicand) to a number of years over which the compensation is paid (the multiplier). The working party took exception to the traditional basis of calculating multipliers and recommended the use of actuarially derived annuity values based on population mortality.

The main issue arising from the working party's recommendations is the implicit interest rate assumption underlying the multipliers used in practice. In principle, the multiplier is an annuity factor with an underlying net real rate of return equal to the expected post-tax return from investment of the lump sum reduced to allow for growth of future earnings and the cost of care.

The interest rate implicit in awards has traditionally been between 4% and 5%. The Ogden working party suggests that the achievement of such a high real net rate of return requires an investment strategy with an inappropriate level of risk given the nature of the investment. It was therefore recommended that awards should be based on risk free returns available from Indexed Linked government securities. This results in a reduction of the interest rate assumption to between 2.5% and 3.5% and significantly increases the cost of lump sum future loss awards.

The Ogden tables are now admissible as evidence in their own right and 3 cases to date have had awards fixed on the basis of risk-free returns. However, this principle is being strongly challenged with the 3 cases being heard in the Appeal Court on 17 June with judgement expected before the end of July. The appeals are founded on the principle that a more balanced and higher yielding investment strategy would be adopted in practice rather than full investment of the lump sum in indexed linked gilts. Regardless of the outcome, it is probable that the issue will ultimately be appealed to the House of Lords.

The effect of the adoption of a reduced interest basis for Ogden multipliers will affect pricing and result in retrospective reserve increases on outstanding claims. Claims affected are unlikely to be below £50,000 and will, by definition, be those taking longest to settle with time being required to assess the extent of injury. As the future loss element is defined from the expected settlement date, the most recent accident years could all be substantially affected. Consequently, the overall cost could be several times that of the current accident year.

The overall effect for an individual company will depend on its underwriting profile and its net exposure as determined by its reinsurance retentions. Portfolios that are focused on high NCB comprehensive business are likely to experience only a small increase in gross claim cost. In contrast, companies that focus on non-comprehensive or young driver business could be significantly affected.

Although potentially significant for some primary motor insurers, the most severe impact is on UK motor excess of loss reinsurers. Risk costs for excess of loss layers could easily rise by substantial multiples of the overall increase in ground up claim costs depending on the layer and underwriting profile of the primary insurer.

5.3 An actuarial approach to projecting potential Ogden exposures

This section sets out a possible approach to assessing potential additional Ogden liabilities under various interest rate scenarios. Given the level of uncertainty involved, the results should be regarded as illustrative. The intention is to give an indication of the scale of potential additional costs. The increase in ground-up costs is heavily dependent on the underwriting profile of the primary motor account. However, the reinsurance increases are likely to be more comparable across portfolios.

In this case the analysis is based on a portfolio with a strong non-comprehensive bias and includes a substantial non-standard exposure. The ground-up increases are likely to be substantially lower for typical direct portfolios as these have lower bodily injury claim exposures. The model described fits into an overall large claim modelling framework that projects ultimate settlement amounts on individual claims. The basis of projection is the application of grossing up factors derived from historic development patterns to outstanding large claims. IBNR claims are projected by applying expected frequencies to projected average claim costs. An appropriate index of inflation is used to establish large claim thresholds for earlier accident years.

A sample of claims in excess of £50,000 was reviewed by claim staff to specify any expected increases in the settlement costs due to the impact of applying the Ogden Tables on a 3.5% interest basis. A database was established identifying all claims that were reviewed and the identified increases. Large claim projections were carried out excluding the impact of these increases to establish projections excluding the impact of potential additional Ogden costs.

A model was fitted to the reported large claim data in amount bands based on the following components:

- a multiplier uplift factor based on the increase in Ogden multipliers for a male aged 30 using 5% as the interest basis underlying current and past settlements
- the proportion of individual claim settlement cost expected to be affected by multipliers
- a probability factor which estimates the likelihood that a claim in a particular band will be affected by Ogden multipliers
- a grossing up factor to allow for non-large claims which are affected by Ogden multipliers
- an accident year factor which reduces the impact on claims in earlier years

Except for the non-large grossing up and accident year factors, the assumptions were chosen following extensive discussions with Claims staff. The non-large grossing up factor was estimated using the results indicated by the sample. The accident year factors were selected after comparison of the model results to the increases implied by the sample of claims reviewed. The effective assumptions for individual claims within each amount band are summarised in the table below.

Pre-Ogden band		Effective Uplift per claim		
Lower	Upper	@ 3.5%	@ 4.5%	@ 2.5%
50	150	5.7%	1.7%	10.9%
150	200	11.4%	3.4%	21.7%
200	300	13.6%	4.0%	25.9%
300+		16.0%	4.7%	30.6%

The final model assumptions are largely a matter of judgement. However, it was decided to choose parameters that imply increases greater than indicated by the sample to take account of the following factors:

- a number of claims in the sample were not adjusted for Ogden increases by claim staff because it would have been impractical given the uncertainty affecting the claims
- the sample increases are naturally dominated by outstanding claims from the earlier accident years which tend to have lower multiplier proportions than the earlier settlements
- percentage increases implied by the sample were applied to the projected settlement amounts to take account of the development of current estimates to ultimate settlement values

To project IBNR Ogden increases, the individual claim amount distribution was estimated by applying the Ogden increases to both settled and outstanding claims. The increases were applied to both settled and outstanding claims to project the effect of settling all future claims under each interest rate scenario. Accident year factors were applied to the resulting increases for consistency with the reported claim projection basis.

The prospective reinsurance rates were established by random simulation of claim number and individual claim amount distributions for the current accident year. The individual claim amount distributions were fitted using projected individual reported claim settlement amounts. The results are summarised in the following table.

Percentage increases due to Ogden

Interest basis	3.5%	4.5%	2.5%
Current year affected claims only	13%	4%	24%
Current year total ground-up claim cost	3%	1%	5%
XOL unlimited excess £500,000	25%	7%	52%
XOL unlimited excess £1,000,000	38%	12%	77%

The total increase in gross outstanding claim reserves was projected as approximately 4 times the annualised cost on the current year. This multiple depends on changes in exposure for individual insurers and is presented solely to give an indication of potential magnitude.

5.4 Claim cost management

5.4.1 Overview

Insurers can gain competitive advantage by developing cost effective solutions to claim settlement and customer service. Poor claims handling procedures are not only administratively expensive, but lead to increased claim costs through badly negotiated settlements and unidentified fraud.

5.4.2 Identification and control of large claims

Severe injury cases add to the volatility of results with the overall effect somewhat dependent on the level of reinsurance retention and underwriting profile. The largest 0.1% of claims by number for any one accident year can generate in excess of 20% of the total claims cost for a non-comprehensive portfolio and 15% for a comprehensive portfolio. The early identification and proactive handling of large claims are therefore critical to control ultimate settlement costs and ensure that adequate allowance is made in the pricing basis.

The key to early identification and evaluation of severe injury cases is understanding and recognising the common characteristics of large claims. The type of injury is the first key identifier. Quadriplegia, tetraplegia, paraplegia, severe head and spinal injuries all result in dramatic changes in lifestyle combined with substantial future care needs. Claims of this type should ring warning bells and be pursued by the most competent of technical claims staff.

The second key identifier is the capacity for high future earnings. This is driven by a combination of occupation and age with university students and professionals under 30 being prime examples. It is the combination of future earnings potential together with serious disabling injury that generates the most extreme million pound cases.

Late recognition of severe injury cases does not of itself necessarily cost the motor insurer more money. However, it can diminish an insurer's ability to reserve, price and underwrite effectively. Furthermore, the opportunity to minimise claim cost through proactive claim management is reduced.

Early recognition combined with ongoing proactive claims management can help control ultimate cost and provide an early view of potential. This early view can be compared to the historic cost of large claims on an inflation-adjusted basis. After allowing for potential development to settlement, the underlying cost of large claims per unit of exposure can be assessed. This can be compared to the experience indicated by the most recent exposure years. Clearly, the rating basis should be adjusted to include allowance for large losses at the underlying expected level.

5.4.3 Structured settlements

By far the most common method of settling personal injury claims is through payment of a lump sum. In principle, the lump sum equals the value of past and anticipated future loss at the date of settlement. A small but growing number of cases are now settled through a combination of lump sum payment and annuities designed to provide guaranteed future income when it will be required. These are known as structured settlements.

Although common in the USA, structured settlements have been very slow to gain popularity in the UK. Historically, they have been administratively cumbersome. However, the main stumbling block is that most plaintiffs prefer lump sums. Their potential use is restricted to cases with significant future care or future loss elements. The minimum lump sum threshold is probably around £100,000.

Although lump sum settlements include the present value of future care and loss elements, there are potential cost advantages to insurers from purchasing the equivalent annuities. The providers of such annuities are a growing number of life offices. Each quoting life office will require medical reports for severely injured claimants. If both the plaintiff's solicitor and the insurer can agree the multiplicand, then the most competitive quotation can be taken to guarantee the necessary future payments. It is possible that a life office may take a more pessimistic view of mortality than would be agreed between the plaintiff and insurer.

Another potential advantage is the tax treatment of structured settlements. Payments from the insurer including future annuity payments are made tax-free. In contrast, lump sum settlements are based on after-tax investment returns. A third potential advantage can come from the interest assumptions implicit in the annuity quotes obtained. A life office may take a slightly mismatched position or offer the benefit of its annuity fund's tax position resulting in an interest rate that is higher than that implicit in the lump sum alternative.

It is easy to see why the adoption of Ogden Tables and index linked government stock net yields as the basis for lump sum settlement could make structured settlements substantially more attractive to insurers. Lump sum settlement costs for future loss cases will increase significantly, but the basis for structured settlements will be unaffected.

However, structured settlements cannot be forced onto plaintiffs. The biggest hurdle insurers will continue to face is selling the annuity route as attractive and equitable to plaintiffs faced with the alternative of a very substantial lump sum.

6. Underwriting developments

6.1.1 Redlining

Redlining gets its name from the practice of drawing red lines on maps to indicate areas where companies will not do business for social or geological reasons. In insurance it describes the practice of identifying types of risk that a company does not wish to underwrite.

Redlining is most likely to occur in the motor market in cases where the risk is non-standard. The definition of non-standard varies by insurer as it refers to risks for which insurers are not prepared to quote standard terms. This typically results from any of the following features.

- cars which are unusually expensive, significantly modified, or not usually available in UK specification
- drivers who are either very old or very young or have unusual medical conditions and disabilities
- occupations such as entertainers, pub landlords or professional sportsmen
- poor claims history
- multiple driving convictions and or bans

Typically, direct insurers will only underwrite standard risks in order to streamline quotation procedures. Direct insurers use key screening questions at the beginning of phone calls to minimise time spent on ineligible risks. Non-availability of insurance is not an issue at present in the UK market. However, public perception may be affected by the focus of direct writers on tightly defined standard risks.

Most non-standard risks are underwritten in the broker market through a number of specialist non-standard insurers. The specialist nature of the non-standard market may support higher expense and profit margins. However, this is offset by extra administrative and underwriting costs.

6.1.2 Disability Bill

The Disability Discrimination Act was passed at the end of 1995 and will be implemented on a phased basis. The parts of the bill that affect the motor insurance industry are expected to come into force at the end of 1996. There are around 6 million drivers classified as disabled or as having medical conditions by insurers in the UK of whom an estimated 4 million experience difficulty in obtaining motor insurance.

The Disability Bill for motor insurance implies that the differential pricing of insurance consequent on physical disability may no longer be legal. Pricing is controlled in two respects:

- extra administrative costs must be shared among all policyholders

- loadings for disabled drivers must be statistically justified

Statistical evidence may be based on the experience of the insurer or third party research. However, the following restrictions would appear to limit the ability of the industry to obtain statistical evidence:

- no grouping of disabilities is permitted
- different medical conditions must be considered separately and where appropriate should be sub-divided according to factors such as severity, prognosis, progression of the condition or level of disability
- third party research should not have been conducted primarily for the purpose of differentiating disability experience.

The industry response to the Bill is currently unclear. The Bill may prevent all insurers except possibly the largest from writing disability business on anything other than normal terms.

6.1.3 Lifestyle rating

A number of insurers use additional rating factors related to the lifestyle of the proposer such as:

- homeowner or non-homeowner
- tenure at current address
- marital status
- credit score or some proxy using geodemographic measures; the use of credit scoring involves data protection issues and proxies are commonly used

Some insurers also operate differential pricing on the basis of premium payment frequency. Complications with the Consumer Credit Act can be avoided by presenting the additional charge as an administration fee.

6.2 No claims bonus (NCB)

NCB is a standard feature of the motor insurance market in the UK. NCB scales vary across the market but entitlement is mutually recognised. A typical NCB scale is shown below:

One year:	25% discount
Two years:	40% discount
Three years:	50% discount
Four years:	60% discount

Drivers earn an extra year of bonus for each year they remain without fault claims up to a maximum of four years, but lose two years of bonus for each fault claim. Fault claims are defined as claims where the cost cannot be reclaimed from a third party, including theft claims and claims where no fault can be determined. Windscreen claims are usually ignored for bonus purposes.

Bonus protection that maintains the level of bonus unless the policyholder has two fault claims in the same year, or three in three years may be purchased. It is generally only available on maximum bonus and typically costs an additional 15% of premium.

A number of variations of NCB exist in the market, examples are:

- introductory discounts for policyholders with nil NCB
- an extra layer above the four year bonus; a number of companies offer 65% or 70% for five years bonus to selected policyholders e.g. ages 50 and above
- loyalty bonus under which a non-transferable bonus is built up over several claim-free years
- no-fault bonus under which bonus is only lost for a claim known to be the fault of the insured; this can lead to accidents being falsely reported as damage incurred while parked

Generally, NCB scales are dictated by marketing considerations and are not statistically justified. However it is possible to use accident histories as a method of adjusting premiums to reduce the distortions caused by the NCB scale. Bonus scales are discussed in more detail in The Future of No Claims Bonus workshop paper included in this year's conference papers.

6.2.1 The future of bonus in the UK

The distinguishing feature of the UK market is that the bonus scale is relatively short. Maximum bonus is achieved in only a few years and the majority of mature drivers in the standard market (around 80%) have maximum bonus. Longer scales and the introduction of excess based scales for younger drivers are potential developments.

The definition of "allowed" and "disallowed" claims are widely perceived by the public as unfair. Nevertheless, bonus is a powerful marketing tool. The popularity of bonus protection demonstrates this. Rating systems based on actual driver experience may be a fairer system. However, NCB has the advantage of simplicity and there would be significant administrative and marketing hurdles to overcome to develop such a system.

Renewal notices are usually used as proof of bonus but this is still a considerable administrative burden on both broker insurers and direct writers. Investigations have shown that the additional costs of checking bonus entitlements are justified because of potential fraud. Market databases may eventually reduce these costs.

7. Technical analysis

7.1 Technical pricing analysis in practice

The role of a typical rating actuary or statistician is to analyse the insurer's experience and develop a basic rating framework in conjunction with underwriters and possibly marketing staff. Inevitably, the analysis involves a degree of judgement based on skill and experience. The analysis should be discussed with the underwriter to identify reasons for unexpected results. The skilled user will also understand the practical implications and limitations of the work undertaken. This should allow identification of areas where there is greatest scope for underwriting flexibility within the rating basis.

The technical rating basis provides a starting point for further analysis and judgement required to make effective pricing decisions. This analysis includes competitive pricing analysis, lapse rates, strategic underwriting objectives and wider market knowledge.

Non-standard risks are priced by underwriters using their experience and judgement. Standard rates are usually used as a benchmark in setting rates. Guideline rules and referral authorities are usually provided to junior underwriters.

To maximise the value of technical analysis it is necessary to combine a clear understanding of its limitations with underwriting knowledge of real world risk factors. This ensures that the pricing structure is justifiable and minimises the risk of misleading conclusions due to flaws that may exist in the data. The approach can also be extended to adjust the technical basis to achieve strategic underwriting objectives and take account of emerging trends.

7.2 Generalised linear modelling (GLM)

The GLM rating approach has rapidly become established as the modern technical pricing approach in the UK market. GLM is a multifactor approach to premium rating under which models based on frequency and average claim amounts by claim type are used to derive technical rates. Adjustments are made for nil claims, large claims, the impact of NCB and inflation as appropriate. The April 1992 Institute paper by Brockman & Wright (JIA 119, III) and the 1994 GISG paper is a useful introduction to the subject.

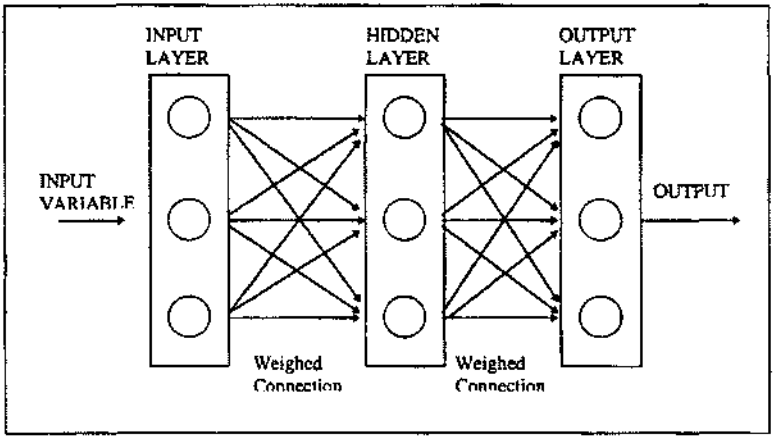
The GLIM statistical package is widely used to carry out GLM analysis. The latest version of GLIM is GLIM4. The main improvement over earlier versions is probably in higher resolution graphics. The RSS package Genstat has some generalised linear modelling capability, but is not as powerful as GLIM. More recently the SAS statistical package has also offered a similar capability in one of its optional modules. Both GLIM and SAS are currently widely used for pricing analysis.

In the past GLM analysis has been restricted by computing restraints due to memory or processing power. However, a standard modern PC with a 166 Mhz Pentium chip, 128 Mb of RAM and 4 Gb hard disk can perform GLIM runs in a fraction of the time taken by typical PCs in use 5 years ago. The improvement in computer power has led to more detailed routine analysis. Extensions include additional rating factors and increased subdivision of rating factors.

7.3 Potential future tools

7.3.1 Neural networks

Research into Neural Networks started with models of the function of nerve cells in the brain. A neural network consists of a large number of interconnected computing units or neurons. Each unit performs a few simple operations and communicates the result to its neighbouring units. Typically the neurons are organised into layers with each neuron in one layer having a connection to each neuron in the next layer. Each connection has an associated weight. The neuron sums the weighted inputs and applies a (typically non-linear) function to produce an output layer.



The most basic form of neural network is a perceptron. A perceptron has only one layer and a small number of neurons. Perceptrons are used to decide whether an input pattern belongs to one of two classes. The basic form of a three neuron perceptron is

Output = (Input1 x Weight1) + (Input 2 x Weight2) + (Input3 x Weight3) + k

The constant k is referred to as the threshold. The perceptron predicts membership of a class if the calculated output is positive. An iterative learning algorithm is used to calculate the weights. The training process alters the weights when the output of the perceptron incorrectly classifies the input. The perceptron is effectively learning where to draw a line to split the data into two classes.

More complex neural networks are developed by using non-linear functions and multiple layers of interconnecting neurons. The network then consists of an input layer, intermediate hidden layers and an output layer.

In practice, sample data is usually divided into a training set and a test set. The network is calibrated using the training data and validated against the test data. In the calibration process there is a risk that the network may learn patterns that are too specific to its training set thereby limiting its predictive value.

User friendly neural network systems that can be operated on powerful PCs are currently available from a number of suppliers. These systems provide a relatively simple way to model non-linear systems without specialist knowledge.

Advantages

- can model non-linear behaviour
- easy to update as new data becomes available
- capable of handling noisy or incomplete data
- can cope with contradictory examples
- overlaps existing statistical techniques

Disadvantages

- modelling process does not yield explanation of the results
- risk of overfitting
- requires a large volume of data for maximum effectiveness
- requires powerful computer hardware such as a UNIX box to deal with large data volumes

Possible Applications

- project new business conversion rate
- project lapse rate
- forecast the profile of new and renewing business
- investigation of factors affecting claim experience

7.4 Genetic algorithms

A genetic algorithm is an optimisation method based on the theory of Darwinian evolution. It starts with an initial population of solutions to a problem and then produces a new generation of solutions (chromosomes) that are better than the previous ones. Candidate solutions (chromosomes) that contribute towards the solution of a problem are rewarded and solutions that appear unsuccessful are penalised. The underlying principle is survival of the fittest.

Genetic algorithms operate through the following cycle:

Population Creation: The initial population can be generated randomly or an initial solution can be used as a starting point. Each solution is represented as a fixed length string (a succession of bytes) and each string is thought of as a chromosome.

Selection: Members of the initial population are selected to produce new chromosomes or "offspring". The chances of a particular member being selected depends upon the fitness of the member defined by its ability to solve the problem.

Reproduction: New chromosomes are created by a variety of genetic operators such as crossover, replication or mutation. This is analogous to the swapping of genetic material in sexual reproduction. For example, crossover between two chromosomes combines parts of the bit strings representing the parent chromosomes to produce an "offspring" solution. The principle is that the "offspring" will retain the good qualities of its parents and evolve to improve the solution.

Evaluation: The chromosomes resulting from reproduction are evaluated by a fitness function. This assesses the degree to which the new solutions are good at solving the problem and to select solutions for the next stage of breeding. The cycle continues until some stopping criterion is satisfied.

Consider the problem of fitting a fourth order polynomial to some data. A possible solution can be represented as a vector with five elements with each element representing a coefficient of the polynomial. Suppose we define the fitness of possible solutions as the difference between the calculated value of the polynomial and the observed value of the data. The problem is to select coefficients that minimise this fitness function.

The genetic algorithm could start with a random choice of possible coefficient solutions. These will be evaluated and compared to the data. The best solutions will be selected for reproduction. The resulting offspring are evaluated and the process iterates until the population converges on solutions that satisfy the stopping criterion specified by the user.

Genetic algorithms are essentially a framework for solving optimisation problems. For example, the fitness function can be expressed as a least square error and the genetic algorithm can be used to find solutions that minimise this function. Genetic algorithms can therefore embrace a wide range of statistical techniques.

Advantages

- extremely flexible and can tackle a wide range of problems
- can handle incomplete data
- provides explanations of decisions reached which is a major advantage over neural networks
- specifying the fitness function requires explicit definition of a good solution which often improves understanding of the problem
- overlaps existing statistical techniques

Disadvantages

- requires powerful hardware and will typically need to be run on a UNIX box
- very little commercially available software
- parameter settings are problem dependent
- extensive experimentation may be required to find a solution; the parameters of the fitness function and the level of mutation and crossover may alter the possibility and speed of convergence

Possible applications

- fitting a curve to claim amounts
- developing a model of claim frequency or severity
- clustering data into homogeneous groups
- developing and testing underwriting acceptance rules
- assessing the value of lifestyle data

7.5 Expert systems

There are a wide variety of expert systems used in business with applications ranging from mortgage underwriting to portfolio management. An expert system attempts to encapsulate the knowledge and expertise of a human into a computer program. The learning process usually involves a series of interviews with a human expert as well as recording observations when the expert is operating. This knowledge is usually recorded by the computer through a series of if statements or rules.

An expert system typically consists of a knowledge base containing rules, a working memory and an inference engine that controls the reasoning process of the system. If the conditions of the rules are satisfied then the rules are applied. The contents of the working memory are updated after the rules have been applied.

Advantages and Disadvantages

- simple and explicit representation of knowledge enabling decisions to be understood and explained
- inability to adapt or learn from changes in their business environment

Possible applications

One Canadian insurer is known to use an expert system to underwrite the majority of its business. Exception risks are returned to human underwriters. This insurer claims that the system has enabled it to significantly reduce overheads. Expert systems are being developed to help assess the expected cost of bodily injury claims. The systems use details about the nature of the injury to project the likely ultimate cost of the claim. The estimates are updated as new information emerges and payments made.

7.6 Cluster analysis

Cluster Analysis refers to a series of techniques that aim to group a set of objects into homogeneous classes. These techniques may also be known as typology, grouping, classification or numerical taxonomy.

Much of the early work in cluster analysis was in natural sciences where techniques were required to allocate plants and animals into classes. The techniques have since been developed in fields such as psychology, zoology, sociology and statistics. In recent years a more rigorous statistical approach has been developed.

The problem is that of categorising n objects, each with a set of p associated variables or characteristics, into k clusters. This categorisation may involve a set of weights for each of the p variables. The number of clusters is usually specified at the outset for simplicity.

Clustering techniques can be classified into 4 main types:

7.6.1 Hierarchical techniques

Hierarchical techniques may be agglomerative (progressively linking the n objects into groups) or divisive (progressively dividing the data into subsets). The objects can be considered as points in p-dimensional space. An agglomerative approach links the two points that are closest together and calculates the centroid of the pair. The approach can then be repeated to combine the next pair of points that are closest together. The routine continues until the required number of clusters is obtained. A divisive approach starts with one group and progressively divides the objects into an increasing number of groups until the required number of clusters is obtained.

7.6.2 Optimisation techniques

Optimisation techniques produce initial clusters by generating k cluster mean points (often the k points mutually furthest apart). The objects are then assigned to the cluster whose centre they are nearest. New cluster centres are then calculated. The next step is to conduct a local search by moving objects into new clusters to test whether there is an improvement in the solution. This process continues until the solution is sufficiently accurate as defined by the user. Unlike hierarchical techniques, this approach allows reallocation of the objects to correct poor initial partitions.

The best known technique of this type is the k-means algorithm. The distance between an object and its assigned cluster is defined as the square root of the sum of squares of the difference between each of the p variables and the mean value of the variable for its assigned cluster. The error of the partition is defined as the sum of the distance between each object and its assigned cluster. A wide range of local searches is performed until the overall error is minimised.

7.6.3 Density techniques

Density techniques search for sectors of the space where the data points are concentrated and separated by areas of low density. The techniques have certain similarities with hierarchical techniques, but classify all objects simultaneously instead of by progressive combination. This technique attempts to overcome the tendency of hierarchical techniques to incorporate objects into existing clusters rather than initiate new groupings.

7.6.4 Clumping techniques

Clumping varies from the techniques described earlier in that an object does not necessarily have to be allocated to a single cluster. Clumping effectively allows clusters to overlap by allowing an object to be allocated to more than one category.

Advantages

- rigorous underlying statistical theory
- software commercially available
- easy to represent the results visually
- can model non-linear behaviour

Disadvantages

- can require powerful hardware such as a UNIX box depending on the clustering algorithm used
- cannot handle noisy or incomplete data
- correct matching of the clustering algorithm to the application is essential for success
- difficult to validate results

Possible applications

Cluster Analysis has been successfully used in the production of commercially available geodemographic software. The data consisted of 73 variables (such as census statistics, electoral rolls and credit activity) associated with each postcode and was grouped into 52 types. The techniques can be used to analyse the allocation of car models and postcodes into rating groups.

7.7 Data mining

Data Mining is the search for useful new patterns of knowledge in large databases. It is sometimes referred to as Knowledge Discovery in Databases (KDD). It combines techniques and expertise from diverse fields of research including statistics, machine learning, visualisation, expert systems and artificial intelligence. The two main areas of data mining are supervised learning or classification and unsupervised learning or clustering. Concepts are deduced from a sample through a process of induction or inductive learning. Added value results from the identification of concepts that apply generally.

7.7.1 Classification

For classification tasks the data mining system is given a database of cases divided into specified classes. The data mining system produces class descriptions. For example, descriptions of "high risk" or "low risk" drivers may be produced from a database of individual motor policies. The descriptions are of the form "If driver is 40 to 50 years old, married with children and has an open driving policy then high risk".

Sometimes, the system does not return the class description explicitly (for example neural networks). In this case the system returns a model that can be used to classify new data, but which cannot be articulated as a set of rules. Classification techniques include decision tree induction, rule induction, genetic algorithms and neural networks.

Decision tree induction methods produce data partitions in the form of a tree classifying the whole data set. At each branch of the tree, the data is partitioned according to the values of a particular attribute or field. One of the criticisms of decision trees is that there is no backtracking on the decision to split on a particular field. This means that the decision made at the root of the tree affects the whole classification. Clearly the quality of the partitions is critical to the classification accuracy and validity of the decision tree.

Rule induction methods produce rules that classify all or part of the database. Rules are potentially more powerful than decision trees as they overcome the drawbacks of tree methods and present the knowledge in a form easy to understand and implement.

Genetic algorithms and neural networks can perform rule induction by searching for rules of the form "IF ... AND ... AND...THEN ..." which maximise a function of the number of records explained by the rule and the accuracy (the percentage of correctly classified records) of the rule.

7.7.2 Clustering

For clustering tasks, the system is given a set of records with no class descriptions. The aim is to develop a classification for each record. Once the class for each case is established, a class description can also be found in a compact form.

As research in data mining develops, these techniques are starting to provide an alternative to the numerical clustering techniques described earlier. There is considerable overlap between cluster analysis, genetic algorithms and data mining.

Advantages

- designed to cope with very large amounts of data
- can handle incomplete and noisy data
- techniques are non-parametric thereby avoiding a priori assumptions
- can complement statistical analysis
- some techniques provide knowledge in an easily understandable form which can be incorporated into business procedures
- commercial software solutions for data mining are now available

Disadvantages

- heavily reliant on data quality
- significant data manipulation may be required to make the data accessible to data mining algorithms
- some techniques do not provide explanations of the knowledge extracted

Possible applications

- detecting patterns of fraudulent and excessive claims
- characterising high risk customers
- characterising customers likely to lapse
- modelling direct mail responses to improve targeting
- characterising claim and lapse experience according to lifestyle factors

7.8 Spatial analysis

Spatial Analysis is a method of assessing trends in continuous data. The method was originally developed in the restoration of images obtained from satellites. The underlying assumption is that physically close areas are likely to have similar properties, for example colour in image restoration. In insurance, this may be taken to mean that policyholders of similar age, or properties in neighbouring geographical areas, will be similar risks.

When dealing with continuous data, normal practice is to group the data before analysis because of computing constraints. This is true of factors such as policyholder age and postcode data. This can generate artificial results. Spatial analysis allows statistical analysis that takes explicit account of the underlying continuity of the data.

When allocating postcodes to rating districts, a common objective is to avoid sharp discontinuities in premium rates between neighbouring postcodes. This is probably of more importance in motor insurance than buildings insurance where significant variations in the risk of subsidence can occur over a small geographical area.

The problem of ensuring that neighbouring postcodes have similar rates has proved extremely difficult to formalise. Many insurance companies have tackled this by using mapping software to plot the planned premium rates. The map is visually examined to identify unexpected discontinuities between neighbouring postcodes. Spatial Analysis is a rigorous mathematical approach to this problem.

A solution for policyholder age has been developed using GLIM by fitting a polynomial. Care must be taken in fitting the polynomial to produce a sufficiently smooth function particularly at extremities where there is likely to be little exposure. Cubic splines can be used to smooth the curve and stabilise it at its extremities. Splines are functions that can be fitted between each pair of points to produce a continuous curve.

In practice the steps are as follows:

- fit a GLIM model including all factors
- standardise the data using the GLIM estimates to remove the effect of other factors
- produce a one way standardised age table and fit a cubic spline to it
- use the cubic spline to standardise the original data to remove the age effect
- refit the standardised data in GLIM for factors other than age
- produce a one way standardised age table and compare to the spline estimates
- iterate until the age estimates stabilise

Assessing risk as a function of the postcode is more complex because it is probably also dependent on neighbouring postcodes thereby requiring a two dimensional function.

A number of approaches have been developed. Taylor (1989) suggests the use of a two dimensional spline on a plane linked to a map of the geographical region. Boskov and Verrall (1994) suggest using a Bayesian prior distribution for the spatial factors and applying an assumed conditional distribution for each area given its neighbours. Simulation methods are used to estimate a Bayesian posterior distribution for the geographic effect.
Spatial Analysis can be used to analyse variation in continuous data and is particularly useful where modelled effect varies relatively smoothly rather than in a lumpy manner.

Advantages

- modelling single continuous variables within GLIM is straightforward
- eliminates manual smoothing

Disadvantages

- can add significantly to run times
- fitting cubic splines can be labour intensive
- in allocating a postcode to a rating district several factors are relevant in addition to the geographical location and these are difficult to incorporate formally in practice
- both approaches for tackling two dimensional data require extremely powerful hardware and may not be practical for reviewing a large number of postcodes

Possible applications

- smoothing of claim frequency and severity by policyholder age
- smoothing of claim frequency and severity by the age of a vehicle
- allocation of postcodes into rating groups
- analysis of regional theft variations

8. References

Analysis of 1994 Motor DTI Returns,
ABI Statistical Bulletin (1995)

A Statistical Approach to Motor Rating
Brockman & Wright (JIA 119, III)

Cluster Analysis
Brian Everitt (1974)
Heinemann

Computer Systems that Learn
Weiss and Kulikowski (1991)
Morgan Kaufman

General Insurance Statistics: Sources of premium income 1990 - 1994
ABI statistical bulletin (October 1995)

Intelligent Systems for Finance and Business
Suran Goonatilake and Philip Treleaven (1995)
John Wiley and Sons

Premium Rating by Geographic Area using Spatial Models
Boskov and Verrall (1994)
ASTIN Bulletin Volume 24

Pricing in the London Market
Sanders, Grealy, Hitchcox, Magnusson, Manjrekar,
Ross, Shepley & Waters GISG(1995)

Slippery Road Ahead, UK Private Motor Insurance
Steven Bird (1995)
Merrill Lynch, Pierce, Fenner & Smith, Inc.

Statistical Premium Rating Working Party
GISG (1994)

Use of Spline Functions for Premium Rating by Geographic Area
Taylor GC (1989)
ASTIN Bulletin Volume 19

Appendix A
Historic frequency and average claim amounts

Year	Claim frequency		Average claim amount	
	Comprehensive	Non comprehensive	Comprehensive	Non comprehensive
1984	20.8	13.0	505	387
1985	21.9	13.5	532	404
1986	23.3	13.7	565	450
1987	23.7	14.0	595	505
1988	23.6	14.1	658	571
1989	23.2	14.6	734	633
1990	24.6	15.6	816	737
1991	24.4	16.4	883	828
1992	22.6	15.6	952	980
1993	23.3	14.2	911	1091
1994	21.4	13.2	969	1248

Source: Analysis of 1994 Motor DTI Returns: ABI Statistical Bulletin (1995)