# A QUANTIFICATION OF SNADER'S DEDUCTIBLE SAFETY FACTOR

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Abstract

In deductible pricing formulas presented in the CAS Part 9 syllabus, a "safety factor" is mentioned but not fully explained. This paper describes the purpose, scope, concepts, and applications of the safety factor in Workers Compensation deductible programs. A procedure for quantification of this factor is presented using a component approach. The authors also discuss the theory and practice of estimating each component. Further research on the subject is encouraged, and some suggestions are provided for enhancing the body of actuarial knowledge of the safety factor.

## Background to Development of Safety Factor

In Gillam and Snader's study note "Fundamentals of Individual Risk Rating", the actuarial student is introduced to a term Snader originally labeled as the "safety factor". In his deductible premium credit formula (see Exhibit 5), this factor is applied to the loss elimination ratio (LER), which is the ratio of losses eliminated by a deductible to full coverage losses. The study note introduces the safety factor but offers little explanation of what it is. This paper expands the concept of a safety factor and touches upon a full range of ratemaking considerations in doing so.

The authors quantified the safety factor for the pricing of Workers Compensation small deductible coverage only. Even a large inaccuracy in the estimation of the safety factor has relatively little effect on the pricing of small deductible coverage. Nonetheless, we believe our efforts have expanded the body of actuarial knowledge and we wish to share this knowledge with others. In addition, when the concepts described in this paper are applied to large deductibles of $100,000 or more, even small inaccuracies in the safety factor have a significant impact on the pricing of large deductible coverage.

After extensive research and consideration, the authors have concluded that the purpose of Snader's safety factor is to convert the loss elimination ratio of the entire insured population to one appropriate for the population choosing a deductible. The resulting LER is then converted to a premium credit, which reduces the premium that the insured pays by an amount equal to the savings to the insurer resulting from the insured's selection of a deductible. Both the insurer and the insured should consider the selection of a deductible a fair transaction.

If priced correctly, the insureds premium credit should pass on any savings created by the deductible plus a charge for any additional expenses incurred and any additional risk which will arise. For small deductibles, this usually results in vary little change in the combined ratio to premium (this ratio includes provisions for losses, expenses and dividends). The insurer should be indifferent to the choice of a deductible or no deductible. If this is not the case, then the transaction becomes unfair to either the insurer or the insured. If there is a competitive market place, unfair transactions will ultimately not occur (and in ths case, deductible coverage will not be sold or bought).

During our research, other purposes for the safety factor have been proposed. Some have suggested that the safety factor should reflect any increase in general and other acquisition expenses resulting from the choice of the deductible. While the authors agree that any change in expenses should be reflected in the premium credit, we show in the Adjustments to Expense Provisions section that the adjustments apply better to the expense provisions themselves rather than to the LER.

Others have suggested that the safety factor should correct for deficiencies in other rating variables such as the class plan. They suggest that if insureds who choose a deductible have, on average, a better or worse *full coverage* loss ratio than those who don't, then the safety factor should recognize these differences in addition to those that affect the LER. In the Adverse Selection section, the authors will show that we could find no proof that employers who choose a deductible have a full coverage loss ratio different than the general insured population. Even if we had found a difference, we would have recommended introducing a secondary class plan variable (or perhaps a separation of manual rates for popular deductible sizes as in the automobile rating plan) rather than reflecting this difference in the safety factor. The safety factor is applied directly to the LER and we believe the natural purpose of this factor is related only to the LER.

With the purpose and scope of the safety factor in mind, the authors reasoned that the safety factor for Workers Compensation deductible pricing should be quantified as an algebraic relation of components. The formula is presented in Exhibit 1. We identified four components which should affect the LER and therefore be included in the combination: the effect of adverse selection against the insurer, the risk of employer default, the loss of investment income due to delays surrounding the collection and handling of the deductible amount, and finally the risk loading associated with retaining excess rather than ground up losses. We will discuss each of the components in turn. As previously mentioned, the effect of writing deductible policies on the insurer's general and other acquisition expenses should be quantified separately, so we discuss this adjustment in a separate section.

## Summary of Conclusions

1. The authors were unable to discover any prospective criteria which predict when an employer will choose a deductible. Initially, NCCI had little data reported for deductible policies and so an *a priori* approach was sought in order to quantify the effect of adverse selection.

2. After data become available, a reasonable approach to measuring adverse selection is to compare the LER of employers who select a deductible to the LER of all employers. The authors suspect that this type of retrospective analysis will reveal a significant potential for adverse selection. We assumed all employers would reimburse the insurer for all claim amounts below the deductible threshold and measured the risk of default on the deductible amount separately.

3. National average bankruptcy rates for small businesses serve as a simple but reasonable measure of an employer's risk of default.

4. The analyst must measure two types of investment income for safety factor determination. The first compensates the insurer for the time value of money associated with the Workers Compensation deductible reimbursement process. The second is related to the potential change in the desired rate of return due to the employer's choice of deductible coverage.

5. Most likely, ratemaking expense provisions will change with the introduction of deductible coverage. Coding collection and handling expenses as subrogation expenses may capture some of the expense differences in the adverse selection component. The expense provisions in the deductible pricing formula can be adjusted for other types of expense differences.

6. A risk load factor of 4% of full coverage pure premium is reasonable for all small deductible coverages. When related to premium *net* of a deductible, the risk provision always increases as the selected deductible increases.

7. The effects of the individual components of the safety factor are probably not independent of each other. Nonetheless, assuming each component acts on the LER independently makes it easier to develop the (combined) safety factor. This is especially true when limited data is available.

8. Like so many other actuarial endeavors, safety factor analysis needs to continue. The pricing of small deductible coverage may not warrant the necessary expenditure of resources, but *large* deductible coverage involves billions of premium dollars. The cost of more research when compared to the impact on large deductible pricing is justified.

## Adverse Selection

In the context of our paper, *adverse selection* occurs when the Loss Elimination Ratio (LER) predicted from a theoretical loss distribution is higher than the LER emerging from subsequent experience on policies with a deductible.

Why would this ever happen? Since 'losses eliminated' for the insurer means 'losses retained' for the insured, and since the premium credit reflects the *average* amount of losses retained (i.e. is the same for all insureds in the hazard group), risks who anticipate retaining a smaller percentage of loss dollars than predicted will save money by choosing a deductible. The population of deductible policies will probably contain more of these risks than average, and the LER which emerges from the experience of this population will be lower than the LER which the insurer predicted. The insurer, who gave away more premium dollars in deductible credits than it saved from eliminating loss dollars, will most likely experience a loss ratio higher than expected.

An obvious question is: Can a risk predict *a priori* whether it will retain fewer loss dollars than average? And if so, what criteria does it use to make its prediction? One would expect the losses eliminated by a deductible to depend heavily upon the claim frequency; all other things being equal, an insured with higher frequency pays the deductible more often. Another possible criteria is the size of the risk's experience modification (mod).

Since the NCCI Revised Experience Rating Plan is more sensitive to high frequency than high severity, the LER may vary between risks with credit and debit mods. We segregated the insureds in one state who were eligible for NCCI experience rating into those with 'smaller than average' or 'larger than average' claim frequencies, and (separately) those with credit or debit mods. Pretending that a $2,500 deductible applied, we examined their experience over policy years 1986-1988, searching for evidence that adverse selection could occur if the deductible was offered in the coming rating year.

Exhibit 2, (top box) indicates almost no difference in the LER between the 'small' and 'large' claim frequency groups and thus no evidence of adverse selection. On the other hand, Exhibit 2, (lower box) shows that the LER is lower for risks with *debit* mods than for credit mods. This means that 'debit' risks will (at least in this sample) benefit from choosing a deductible.

At first, it seems odd that these risks, which should have higher claim frequency than credit risks, retain a smaller percent of losses than average. However, our data indicated that these higher frequency risks also have a higher claim severity. The volume of losses excess of the deductible thus drives down the LER. It is apparent that selecting criteria for *prospectively* detecting and quantifying adverse selection potential is very difficult, if not impossible, because the researcher must start by second guessing the insured's motivation for selecting a deductible.

An alternative way to measure the effect of adverse selection is to record who did and did not choose a deductible and (retrospectively) calculate the emerged loss elimination ratio for each group. Since Workers Compensation deductible programs are relatively new, a limited quantity of policy year experience reports for deductible risks are available. Nevertheless, NCCI has constructed a 'deductible profile' which contains the LER for risks who chose deductibles of various sizes.

Exhibit 3 compares the LERs for the deductible risks to the LER (at the deductible amount) for all risks in the profiled state. The ratio of the 'deductible risk' LER to the 'all risk' LER is a measure of the safety factor component for adverse selection (actually, the factor component which would have been appropriate for the past period). The ratios in Exhibit 3 are based on a 932 claim sample at fourth report; a much larger sample size and a longer development history would obviously improve the accuracy of this estimation. The exhibit depicts a simple way to compute the safety factor component for adverse selection given that a company can identify policies written with a deductible in the past. When using this method for measuring a safety factor, the analyst assumes that the same criteria for selecting a deductible in the past will be used to decide whether to choose a deductible in the future.

When estimating safety factors empirically, two distortions should be recognized. Many insureds may not report losses which do not exceed the deductible, since they have to pay them anyway. Exhibit 4 shows how using data from these insureds could result in distortion of the factor component for adverse selection. Claims which go unreported are not recorded as losses eliminated (for the insurer), so the LER is underestimated for deductible risks and thus the degree of adverse selection is overstated.

In addition, it is important to know exactly how losses are being reported. For instance, some states have legislated that losses be reported to NCCI *net of* the deductible amount for experience rating purposes. We found that the results were distorted significantly when studying states with net loss reporting laws.

In Workers Compensation deductible programs, the insurer is usually required to pay the full coverage benefit to the injured worker and later collect the deductible amount from the employer. When the employer is unable to reimburse the insurer for losses paid on its behalf, the empirical LER is lower than anticipated. For our adverse selection analysis, we assumed all employers would reimburse the insurer for the deductible amount, because we quantified the impact of the insured's risk of default separately (in the next section). When the deductible profile data is mature enough, an analyst could use empirical LERs to measure both components of the safety factor at once. (A general discussion of interactions among safety factor components appears later in this paper.)

Conclusion:

The safety factor component for adverse selection should be the ratio of the loss elimination ratio for risks who choose deductibles to the loss elimination ratio for all risks in the population. Estimating this value prospectively (i.e. without knowing who is choosing deductibles) requires identifying the insured's criteria for deciding to take a deductible. We found that basing the criteria on prior claim frequency or related information (such as experience modification) did not produce conclusive results. Estimating the adverse selection component retrospectively, based on historical loss elimination patterns for risks who did and did not choose deductibles, provides a reasonable result. While this is currently difficult for NCCI due to a lack of deductible claim data and data reporting requirements, individual carriers may be able to construct more detailed databases to be used for estimation.

## Risk of Employer Default

As we mentioned earlier, deductible programs in this line have an unusual feature. Since claims must be paid in full by the insurer and the deductible amount collected separately from the employer, we must consider the possibility that the employer will default on the deductible. In prospective evaluations of the adverse selection component, we have assumed that the insurer recovers the deductible amount from the insured, and ignored the effect of outright failures in collection. Therefore, our quantification of the safety factor includes an explicit component for the risk of default. Unfortunately, default risk may be difficult to quantify accurately, especially using data not originally collected for that purpose.

We reasoned that the population of risks choosing small deductibles consists primarily of small businesses. Larger employers tend to choose retrospective rating, large deductibles of $100,000 or more, or self-insurance. The preliminary 'deductible profile' underlying Exhibit 3 supports our assumption, indicating that 78% of deductible risks generate earned premium of under

$10,000 each, and 92% generate under $50,000 each. Consulting the 1991 U.S. Statistical Abstract, we found the "death rate" for small businesses (defined there as those employing fewer than 500 people) to be about 9% over the latest three-year period. The death rate for specific industries ranged between 8.5 and 10.5 percent. We selected a 9% risk of default based on this information. Industry sources deemed this a reasonable selection.

Eventually, NCCI may obtain sufficient data on deductible risks to evaluate the adverse selection component retrospectively by comparing emerged LERs to predicted LERs. Individual carriers may be able to implement this type of evaluation now. When this happens, the default risk will be reflected (along with the adverse selection potential) in the "unrealized" portion of the predicted LER, reducing or eliminating the need for a separate component.

Conclusion:
The risk of employer default must be quantified on its own until it becomes reflected in emerged LERs for deductible risks. NCCI data indicates that small deductibles are chosen primarily by small businesses. We conclude, referencing external data on small employers, that 9% is a reasonable selection for this component.

## Investment Income

A significant amount of investment income arises out of a Workers Compensation policy. Most policyholders pay premium within 18 months after the policy effective date, but a large portion of the benefits and expenses are paid much later (some larger policyholders negotiate later premium payments). For the most part, adequate (and not redundant) premium collected and subsequent investment income is greater than the expenses and losses ultimately paid. This investment income partially compensates the insurer's investors for the risk associated with underwriting Workers Compensation. Without investment income, manual rates would need to be higher to compensate for this risk component.

Manual rates, therefore, implicitly include a consideration of investment income. A deductible premium credit is applied to manual premium. If the premium credit only reflects savings in ultimate losses and expenses, then the premium credit reflects the same consideration for investment income as the manual rate.

The authors identified two reasons why the safety factor should include a component for investment income. For Workers Compensation deductible policies, the insurer almost always pays the claim first and is reimbursed later by the employer. This amounts to the insurer giving the employer a loan for the period of time necessary for the reimbursement process to be completed.

The second difference may arise from the employer paying losses under the deductible sooner than the insurer pays losses over the deductible. Large losses are typically settled at a later date than small losses and in Workers Compensation indemnity payments are paid over many years.

On small claims and lump sum settlements, many insurers do not collect the deductible until after the loss is fully paid. In this situation, the adjustment for this second difference is not necessary. For other claims (e.g., indemnity), the claim is paid incrementally over longer periods of time. The premium used to pay for these claims will be supplemented with more investment income than the smaller deducted losses which are paid initially.

For simplicity, we assumed a 90 day collection delay and an interest rate of 6% annually or 1.5% for the reimbursement period. The selected 6% was based on the interest rate for commercial paper at the time of the analysis.

Traditionally, NCCI has used a 2.5% profit and contingency loading which includes an estimate of impact of investment income on ratemaking. The rate of return needed for the investors of an individual insurer varies significantly. In addition, an estimate for ultimate losses and expenses is needed before discounting for investment income can take place. Consequently, the authors excluded any adjustment for investment income differences arising from deducted losses (losses below the deductible) being paid sooner than losses above the deductible.

An individual insurer who knows the amount of investment income needed for its operation and the stream of (payments for deducted losses and all losses separately) may be able to use a duration concept to estimate the differences that arise. If the duration of deducted losses is shorter than the duration of all losses, then the interest rate times the change in duration may be used to estimate an increase in the safety factor.

The reader who is interested in enhancing the mechanics of using the duration concept in this way should refer to papers written by Ferguson[1] and Bustic.[2]

Conclusion:

By design, the weakest part of our analysis is the quantification of the investment income component. Investment income considerations are inextricably linked to desired rates of return. The authors believe rates of return are best determined by the market place and not a rating bureau or regulator.

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[1]Ferguson, R. E., "Duration" PCAS LXX pp 265-288

[2]Bustic, R. P., "The Effect of Inflation on Losses and Premiums for Property-Liability Insurers" Inflation Implications for Property Casualty Insurance, Casualty Actuarial Society Discussion Paper Program, 1981 pp 58-102

## Adjustments to Expense Provisions

The safety factor is intended to account for all phenomena which make the LER emerging from experience on deductible policies smaller than the prospectively predicted LER. In addition to the LER itself, the loss adjustment and general expense provisions (expressed as a percentage of premium) assumed for the insured population in ratemaking may differ for a population of deductible policies. If so, these provisions should be adjusted when used in the Snader deductible credit formula.

Exhibit 5 shows that when Snader's credit formula is used, factors $L_A$ and $L_N$ should be multiplied by A and N, respectively, in the formula to reflect the percent change in expense provisions necessary for deductible pricing. It also suggests one way of defining the adjustment factors empirically.

The analyst must first express each expense provision as a ratio to a suitable independent variable. The choice of these variables will depend on the detail of the data available. For instance, one might expect loss adjustment expense to vary more or less directly with the amount of labor time spent processing claims. If claim transaction data were readily available, using the number of transactions as the independent variable might sufficiently capture the variation in the expense provision between full coverage and deductible policies. Similarly, general expenses are usually defined as initial policy-writing and issuing expenses. Hence, the provision probably varies directly with the *number* of policies written. Whatever variable is chosen for the denominator, the adjustment factor ($L_A$ or $L_N$) will be the ratio of the expense ratio for policies with a deductible to the expense ratio for full coverage policies.

It is difficult for a rating bureau to obtain the detailed transaction data described above. NCCI would have to require a special call for this data in order to estimate the size of the expense adjustments necessary. However, individual companies may be able to use their own detailed claim data to select appropriate variables.

Many of the additional expenses postulated for deductible policies may be associated with the collection and handling of the reimbursement to the insurer. The additional collection and handling expenses are similar to subrogation expenses, which are netted against losses. If the insurer is able to identify these expenses and code them as subrogation, then the LER for deductible policies would be lower than that for full coverage policies, all other things being equal. The adverse selection component of the safety factor, if calculated in the manner recommended above, would automatically incorporate the effect of the difference in these expenses. However, it is unclear whether a simple change in the definition of subrogation expenses would account for *all* additional expenses associated with writing deductible policies. A combination of re-coding handling expenses and adjusting the expense provisions in the Snader formula may be best.

<u>Conclusion:</u>
According to industry sources, indicated expense provisions for policies with deductibles are

higher than indicated expense provisions for policies without deductibles. To price deductible credits correctly, the analyst needs to estimate the percent change in the loss adjustment and general expense provisions and modify the numerator of the Snader formula to reflect the changes. In addition, coding collection and handling expenses on deductible policies as subrogation expenses may capture some of the expense differences by making the LER lower for deductible policies that incur these additional expenses.

## Adjustment for Increased Risk

In Workers Compensation, small deductibles (usually below $5,000) eliminate many small claims but relatively few loss dollars. Consequently, the average claim size changes little, but without the numerous small claims the variance in severity of a claim increases. This increased variance generates increased risk for the insurer. Stone illustrates this concept in detail[3].

With small deductibles, the increase in risk is small. Therefore, we were motivated to select a procedure which was commonly accepted, and fit data readily available at NCCI. Exhibit 6 shows an application of a procedure which satisfies both criteria.

We chose to adapt a procedure developed by Miccolis[4] because:

1. The Casualty Actuarial Society (CAS) has chosen it to illustrate measurement of risk by size of loss for the Part 9 actuarial student.

2. We were able to easily adapt it to NCCI's excess loss factor (ELF) data.

3. The procedure avoids the need to estimate the moments of the frequency distribution.

Before wading through the detail in Exhibit 6, it is important to understand the nature of the value being estimated. An increase in estimated risk provision decreases the safety factor which decreases the premium credit and increases the remaining premiums paid to the insurer.

The risk provision is stated as a percentage of full coverage pure premium; however, the impact on net pure premium (after premium credit) is more heuristically relevant. Our sensitivity tests indicated a decrease in risk provision (as applied to the LER) as the deductible increases.

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[3]Stone, J.M., "Theory of Capacity and the Insurance of Catastrophe Risks". The Journal of Risk and Insurance, June 1973, Vol XL No. 2

[4]Miccolis, R. S., "On the Theory of Increased Limits and Excess of Loss Pricing", PCAS LXIV, 1977, pp 60-73

However, as a percentage of net pure premium, the risk provision always increases.

Exhibit 7, Page 1 illustrates the sensitivity of the risk load to the size of deductible. As shown, the risk load factor (provision) decreases from 4.4% for a $500 deductible to 4.0% for a $5,000 deductible. However, when related to net pure premium, the increase in risk provision increases from .1% (.031-.030/(1-.031)) to .7% ((.164-.158/(1-.164)). This risk provision as a percentage of net pure premium is the increase in profit and contingencies provision (P&C) for the insurer. The size of the risk provision developed using our procedure is relatively small when compared to the risk provisions developed in the Miccolis paper. This discrepancy is a reflection of differences between the P&C for Workers Compensation versus that for the liability coverage in other lines.

When Miccolis wrote his paper, P&C for most liability lines was 5% for *basic limits* coverage. For Workers Compensation, a 2.5% P&C is common for ***unlimited coverage***. Miccolis calibrated his risk provision by choosing a premium change limit of 5% of basic limits premium. We chose to calibrate our change limit at 5% of unlimited pure premium.

The choice of pure premium change limit is highly subjective. Our reasoning was that if the insurance investor only requires 2.5% of premium plus future investment income to underwrite a Workers Compensation unlimited coverage policy, then 5% of *pure* premium is a reasonable change limit for determination of the risk provision. Exhibit 6 shows how the pure premium change limit is used to develop the lambda, which determines the amount of variance of the pure premium which enters Miccolis' risk loading formula.

Exhibit 7, Page 2 shows that the risk load factor is very sensitive to the choice of pure premium change limit. Since the Miccolis paper shows significantly higher risk loads even at basic limits, the authors suspect that in reality a 2.5% P&C loading is inadequate for Workers Compensation and a higher corresponding pure premium change limit is necessary to provide an adequate risk load.

For completeness, Exhibit 7, Pages 3 and 4 show our method's sensitivity to different loss distributions by state and hazard group. The results are relatively unexciting since the variance in risk load factor is insignificant.

The relatively small impact of the risk provision motivated the choice of a simple, two-parameter loss distribution (Weibull) fitted to readily available excess loss ratios from NCCI's excess loss factor procedure. (For more information on how NCCI develops excess loss factors, please refer to Robin Gillam's paper: "Retrospective Rating: Excess Loss Factors").[5] From prior studies. we knew the Weibull fit reasonably well.

Almost six months after this safety factor analysis, NCCI revised the excess loss factor (ELF)

[5]PCAS LXXIX

distributions. NCCI's ELF analysis would most likely intrigue even the most dedicated loss distribution expert. The change in excess loss ratio was dramatic for large limits, but for small deductibles, the changes were small. If the new NCCI loss distributions were used to develop the safety factor risk provision, the authors suspect that the results would be similar to those found in this paper.

Originally, a numerical analysis (Simpson's Rule) approach using the brute force of the computer was used to estimate moments of the truncated Weibull loss distribution. For the loss distribution zealot, Exhibit 8 shows a more sophisticated development of a closed form for the moments of the distribution after a deductible. This application would probably make little difference in our results for small deductibles.

Since 1989, large deductibles of $100,000 or more have become very popular for Workers Compensation. A risk loading procedure for these policies may justify greater sophistication and precision than shown in this paper.

## Interaction of Components

We have, up to now, followed a "divide and conquer" approach to measuring the safety factor. Without the ability to observe the ultimate loss and expense experience on Workers Comp. deductible programs, we have postulated discrete ways in which populations of deductible risks may differ from the general population and attempted to separately quantify the pricing impact of each. For each component listed in Exhibit 1, the percent of the LER which will not be realized due to its impact is subtracted from unity. Then these complement percentages are multiplied together, with the interest rate component used as a discounting factor, to get the final safety factor -- the percent of the predicted LER that we *do* expect to realize. By combining the components this way algebraically, we are implicitly assuming that they affect the LER independently of one another. Even though we have estimated each in a vacuum, so to speak, in reality there are many opportunities for overlap among the components.

For example, suppose employers who are in financial difficulty feel it is beneficial to them to reduce their premium immediately by choosing a deductible and receiving an up-front credit. In the long run, of course, they will neither gain nor lose because the premium credit, if calculated correctly, is offset by the losses they must pay (below the deductible). However, if the employers become insolvent, they will force the insurer to assume the losses below the deductible, reducing the empirical LER. In this situation, the safety factor component for the risk of default overlaps with the component for adverse selection.

Another example was mentioned previously. Some companies may choose to code collection expenses on deductible polices as subrogation expenses. This will reduce the empirical LER (and thus increase the adverse selection component) because such expenses are netted against losses. We also discussed adjustments to the loss adjustment and general expense provisions in the deductible pricing formula, which reflect the increased expenses associated with writing and administering deductible policies. To the extent that these adjustments account for collection expenses coded as subrogation, the adverse selection safety factor component and the expense provision adjustment factors will overlap as well.

The practical problem is one of determining what loss and expense differences will really show up by reducing the emerged LER (and thus be accounted for by our adverse selection component) for a mature book of business with deductibles, and what components should be adjusted for separately (by applying other reductions to the theoretical LER and introducing expense provision adjustment factors). Because of the dearth of Workers Compensation deductible data, our adverse selection component is currently an educated guess, rather than the ratio of an emerged LER to an expected LER. Considering this, we have accounted for other components of the overall safety factor separately through other studies.

In time, the safety factor may be "consolidated" as the ratio of LERs gets smaller, and the effect of the other components may be reduced. For now, we are considering the effect of adverse selection, the risk of default by the employer, the time value of money due to collection delays, and the charge for assuming addtional risk as independent events and expressing the overall safety factor accordingly as a (discounted) product.

Conclusion:

We have formulated the safety factor implicitly assuming that each component affects the LER independently. In reality, the effects of each component will probably overlap. Specifically, the ratio of the empirical to the predicted LER, designated the "adverse selection" component, will absorb some of the effects of employer bankruptcy and increased expenses on deductible policies as well as strictly defined adverse selection of employers against the insurer. When detailed historical data on deductible populations is available, we will be able to observe the combined effects of adverse selection, delays and expenses associated with collection, defaults by employers, and the increased risk for deductible business. Until then, we must estimate all components of the safety factor separately.

## Beyond this Paper

Our analysis suggests that by far the largest component of the safety factor is the provision for adverse selection. With time, NCCI will measure the component for adverse selection with greater precision for small deductibles.

Recent data indicates that the premium credits for large deductibles are as high as 90% of full coverage standard premium. For large deductibles, the precise measurement of all of these components is more critical. To date, all large deductible programs are filed by individual carriers. The actuaries for these carriers could improve upon the methods described in this paper in several ways:

1. For an individual carrier, frequency of loss (claim count) information is usually readily available. With frequency of loss data, the actuary could introduce more complex statistical methods (e.g. use a frequency of loss distribution which is not Poisson).

2. As noted earlier, with payment streams of both the deducted losses and total losses, individual carriers can measure the change in the safety factor resulting from differences in investment income. The authors suggest that any future researcher exercise caution in this area because:

   a. Workers Compensation is a very long tailed line.
   b. Losses are often discounted both explicitly and implicitly.
   c. Before an adjustment is made for the duration difference of deducted losses and total losses, the researcher needs to measure the degree of discounting already included in the manual rate. This is especially important for large deductibles where losses over the deductible may not arise for many years.

3. The authors were unable to measure the increase in fixed expenses resulting from the introduction of deductibles. An individual carrier may measure the amortized value of both start up costs and on going costs. Industry sources indicate that the additional processing costs associated with deductibles are significant.

4. The authors measured the adverse selection component and the risk of default component separately. By looking at actual (empirical) loss elimination ratios (LER) over a adequate period of time, both components could be measured together.

One state issued a regulation requiring the measurement of all of the components described in this paper. The authors believe that this is an unnecessary restriction on free market pricing. We also regret that our work may have influenced this regulation. Further research as described in this section may help other actuaries cope with this type of regulation which, in our opinion, should not spread to other states and should be rescinded in the state where it is now in effect.

# Development of Safety Factors For Small Deductibles

| | | |
|---|---|---|
| [A] | Component for Adverse Selection | 20.0% |
| [B] | Component for Risk of Employer Default | 9.0% |
| [C] | Component for Loss of Investment Income | 1.5% |
| [D] | Component for Increase in Risk | 4.0% |
| [E] | SAFETY FACTOR<br>= (1−A)(1−B)(1−D)/(1+C) | 0.69 |

# Prospective Estimation of Adverse Selection

## Claim Frequency Criteria

| Frequency Group | Loss Elim Ratio (LER) | LER Rel. to Total |
|---|---|---|
| LESS than Avg | 0.226 | 100% |
| MORE than Avg | 0.225 | 100% |
| All Risks | 0.225 | 100% |

## Experience Mod Criteria

| Mod Range | Loss Elim Ratio (LER) | LER Rel. to Total |
|---|---|---|
| CREDIT (Mod < 1) | 0.367 | 160% |
| DEBIT (Mod >= 1) | 0.198 | 86% |
| All Risks | 0.229 | 100% |

# Empirical Estimation of Adverse Selection

| Deductible | [A] LER for Deductible Risks | [B] LER for All Risks | *[A]/[B] Factor for Adverse Selection* |
|---|---|---|---|
| $500 | 0.151 | 0.220 | *0.686* |
| $1,000 | 0.221 | 0.294 | *0.752* |
| $2,000 | 0.321 | 0.395 | *0.813* |
| $5,000 | 0.510 | 0.575 | *0.887* |

Based on a 932 claim sample valued at fourth report.

**Illustration of Distortion in Adverse Selection Component**

| | | Claim # | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | Total |
| A. | Actual Loss Amount | $100 | $200 | $300 | $10,000 | $10,600 |
| B. | Reported to Insurer | | 0 | | $10,000 | $10,000 |
| C. | Actual Losses Eliminated | $100 | $200 | $300 | $500 | $1,100 |
| D. | Reported Losses Eliminated | | 0 | | $500 | $500 |
| E. | Actual Loss Elim. Ratio [C/A] | | | | | .103 |
| F. | Reported Loss Elim. Ratio [D/B] | | | | | .05 |

# ADJUSTMENTS TO EXPENSE PROVISIONS IN PRICING DEDUCTIBLES

If we assume that the loss adjustment expense and general expense provisions in ratemaking change when a policy is written with a deductible, the deductible credit formula should reflect these changes.

The current formula is:

$$D=1-\frac{(1-k\cdot f)\,E+a+n}{E+a+n}$$

where:

| | |
|---|---|
| D = | deductible premium credit |
| k = | loss elimination ratio |
| f = | safety factors |
| E = | permissible loss ratio |
| a = | provision for loss adjustment expense (LAE) for full coverage policies |
| n = | provision for general expense for full coverage policies |

We propose:

$$D=1-\frac{(1-k\cdot f)\,E+a\cdot L_A+n\cdot L_N}{E+a+n}$$

where $L_a$ and $L_n$ are factors reflecting the precent change in expense provisions necessary to process a polic with a deductible. Using the results of a data call, $L_A$ and $L_N$ could be estimated as follows: $L_a$ = (LAE f Deductible Policies/Claim Transactions for Deductible Policies)

$$L_a = \frac{\text{(LAE for Deductible Policies/Claim Transactions for Deductible Policies}}{\text{(LAE for Full Coverage Policies/Claim Transactions for All Policies)}}$$

$$L_a = \frac{\text{(General Expense for Deductible Policies/Number of Policies with Deductible)}}{\text{(General Expense for Full Coverage Policies/Number of Policies)}}$$

The implicit assumption is that LAE is a function of number of claim transactions, while General Expense a funciton of the number of policies.

# EXHIBIT 6
# DEVELOPMENT OF ADJUSTMENT FOR INCREASED RISK FACTOR

From Miccolis*, risk adjusted pure premium is:

$$E[y]+\lambda Var[y]$$

where E[y] is the ground up pure premium and Var [y] is the pure premium variance. If z is the pure premium after a deductible, then risk adjusted deductible pure premium is:

$$E\cdot[z]+\lambda Var\cdot[z]$$

So, the risk adjusted LER is:

$$1-\frac{E\cdot[z]+\lambda Var\cdot[z]}{E[y]+\lambda Var[y]}$$

The unadjusted LER is:

$$1-\frac{E\cdot[z]}{E[y]}$$

So, the safety factor component ($f_r$) for an increase in risk is:

$$f_r=\frac{1-\frac{E\cdot[z]+\lambda Var\cdot[z]}{E[y]+\lambda Var[y]}}{1-\frac{E\cdot[Z]}{E[y]}}$$

Since the standard excess loss factor (ELF) procedure gives us the $\frac{E\cdot[z]}{E[y]}$ , the problem reduces to estimating λ Var [y] and λ Var ·[z]

*" On Theory of Increased Limits and Excess Loss Pricing", PCAS LXIV, 1977, Page 27.

# EXHIBIT 6
# DEVELOPMENT OF ADJUSTMENT FOR INCREASED RISK

If we assume the frequency of loss distribution is Poisson, then Miccolis shows:

$$Var[y] = E[n] \cdot E[g(x)^2]$$

where $E[g(x)^2]$ is the second moment of the severity distribution about the origin, and E[n] is the average frequency. Since we are considering Workers Compensation, we can assume $g(x)=x$ because there is no policy limit on the losses:

$$Var[y] = E[n] \cdot E[x^2] \qquad \text{.................} (2)$$

and similarly

$$Var^*[z] = E[n]\ E^*[w^2] \qquad \text{.................} (3)$$

where w is the severity variable corresponding to z.

If we multiply both ratios in (1) by $\frac{1}{E[N]} / \frac{1}{E[N]}$ and substitute in equations (2) and (3), we have:

$$\frac{1 - \dfrac{E^*[w] + \lambda E^*[w^2]}{E[x] + \lambda E[x^2]}}{1 - \dfrac{E^*[w]}{E[x]}}$$

So, the problem reduces to estimating λ, $E^*[w^2]$ and $E[x^2]$.

Miccolis estimates λ by assuming that the basic limits premium will not change by more than 5% and then solves for λ. An analogous approach for this application is to assume the ground up pure premium should not change by more than P%. The formula for λ would be:

$$(1 + P)E[y] = E[y]\ \lambda\ Var[y]$$

$$\lambda = \frac{P \cdot E[y]}{Var[y]}$$

# EXHIBIT 6
# DEVELOPMENT OF ADJUSTMENT FOR INCREASED RISK

Since we are assuming a Poisson frequency distribution, this changes to:

$$\lambda = \frac{P \cdot E[n]\,E[x]}{E[n]\,E[x^2]} = \frac{P \cdot E[g]}{E[x^2]}$$

Since we have E[x] from the excess loss factor procedure, we can derive a λ if we can obtain the second moment $E[x^2]$.

In summary, the only values not supplied by the ELF procedure are the second moments of the ground up severity and the excess of deductible severity. If we can derive these then this is a workable procedure.

## DERIVATION OF SAFETY FACTOR COMPONENT FOR INCREASED RISK
### Sensitivity to Deductible Size

| STATE | Empirical Avg. Cost Per Case | Weibull Parameters C | Weibull Parameters Tau | Premium Change Interval | Deductible | E(X) | Estimated Moments E(X^2) | Estimated Moments E(W) | Estimated Moments E(W^2) | Lambda | Risk Adj. LER | Unadj. LER | Risk Load Factor |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | 6,955 | 0.2021500 | 0.2656596 | 5% | $500 | 6,943 | 2,511,980,445 | 6,724 | 2,505,148,262 | 1.382E−07 | 0.030 | 0.031 | 0.044 |
| | | | | 5% | $1,000 | 6,943 | 2,511,980,445 | 6,569 | 2,498,494,505 | 1.382E−07 | 0.052 | 0.054 | 0.043 |
| | | | | 5% | $1,500 | 6,943 | 2,511,980,445 | 6,438 | 2,491,983,004 | 1.382E−07 | 0.070 | 0.073 | 0.042 |
| | | | | 5% | $2,000 | 6,943 | 2,511,980,445 | 6,323 | 2,485,594,098 | 1.382E−07 | 0.086 | 0.089 | 0.042 |
| | | | | 5% | $2,500 | 6,943 | 2,511,980,445 | 6,219 | 2,479,314,574 | 1.382E−07 | 0.100 | 0.104 | 0.042 |
| | | | | 5% | $5,000 | 6,943 | 2,511,980,445 | 5,801 | 2,449,274,926 | 1.382E−07 | 0.158 | 0.164 | 0.040 |

These estimates pertain to all hazard groups combined.

DERIVATION OF SAFETY FACTOR
COMPONENT FOR INCREASED RISK

## Sensitivity by Pure Premium Change Limit

| Premium Change Limit | Lambda | Risk Adj. LER | Unadj. LER | Risk Load Factor |
|---|---|---|---|---|
| **0%** | 0.0E+00 | 0.089 | 0.089 | **0.000** |
| **1%** | 2.8E-08 | 0.089 | 0.089 | **0.009** |
| **2%** | 5.5E-08 | 0.088 | 0.089 | **0.017** |
| **3%** | 8.3E-08 | 0.087 | 0.089 | **0.026** |
| **4%** | 1.1E-07 | 0.086 | 0.089 | **0.034** |
| **5%** | 1.4E-07 | 0.086 | 0.089 | **0.042** |
| **6%** | 1.7E-07 | 0.085 | 0.089 | **0.050** |
| **7%** | 1.9E-07 | 0.084 | 0.089 | **0.058** |
| **8%** | 2.2E-07 | 0.083 | 0.089 | **0.065** |
| **9%** | 2.5E-07 | 0.083 | 0.089 | **0.073** |
| **10%** | 2.8E-07 | 0.082 | 0.089 | **0.080** |
| **11%** | 3.0E-07 | 0.081 | 0.089 | **0.087** |
| **12%** | 3.3E-07 | 0.081 | 0.089 | **0.095** |
| **13%** | 3.6E-07 | 0.080 | 0.089 | **0.102** |
| **14%** | 3.9E-07 | 0.080 | 0.089 | **0.108** |
| **15%** | 4.1E-07 | 0.079 | 0.089 | **0.115** |
| **16%** | 4.4E-07 | 0.078 | 0.089 | **0.122** |
| **17%** | 4.7E-07 | 0.078 | 0.089 | **0.128** |
| **18%** | 5.0E-07 | 0.077 | 0.089 | **0.135** |
| **19%** | 5.3E-07 | 0.077 | 0.089 | **0.141** |
| **20%** | 5.5E-07 | 0.076 | 0.089 | **0.147** |
| **21%** | 5.8E-07 | 0.076 | 0.089 | **0.153** |
| **22%** | 6.1E-07 | 0.075 | 0.089 | **0.159** |
| **23%** | 6.4E-07 | 0.075 | 0.089 | **0.165** |
| **24%** | 6.6E-07 | 0.074 | 0.089 | **0.171** |
| **25%** | 6.9E-07 | 0.074 | 0.089 | **0.176** |
| **26%** | 7.2E-07 | 0.073 | 0.089 | **0.182** |
| **27%** | 7.5E-07 | 0.073 | 0.089 | **0.188** |
| **28%** | 7.7E-07 | 0.072 | 0.089 | **0.193** |
| **29%** | 8.0E-07 | 0.072 | 0.089 | **0.198** |
| **30%** | 8.3E-07 | 0.071 | 0.089 | **0.204** |
| **31%** | 8.6E-07 | 0.071 | 0.089 | **0.209** |
| **32%** | 8.8E-07 | 0.070 | 0.089 | **0.214** |
| **33%** | 9.1E-07 | 0.070 | 0.089 | **0.219** |
| **34%** | 9.4E-07 | 0.069 | 0.089 | **0.224** |
| **35%** | 9.7E-07 | 0.069 | 0.089 | **0.229** |
| **36%** | 9.9E-07 | 0.068 | 0.089 | **0.234** |
| **37%** | 1.0E-06 | 0.068 | 0.089 | **0.238** |
| **38%** | 1.1E-06 | 0.068 | 0.089 | **0.243** |
| **39%** | 1.1E-06 | 0.067 | 0.089 | **0.248** |
| **40%** | 1.1E-06 | 0.067 | 0.089 | **0.252** |

## DERIVATION OF SAFETY FACTOR COMPONENT FOR INCREASED RISK

### Sensitivity by State

| STATE | Empirical Avg. Cost Per Case | Weibull Parameters C | Weibull Parameters Tau | Premium Change Interval | E(X) | Estimated Moments E(W) | Estimated Moments E(X^2) | Estimated Moments E(W^2) | Lambda | Risk Adj. LER | Unadj. LER | Risk Load Factor |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 4,596 | 0.2387330 | 0.2605908 | 5% | 4,590 | 4,062 | 1,203,384,423 | 1,186,243,716 | 1.907E−07 | 0.110 | 0.115 | 0.042 |
| B | 6,955 | 0.2021500 | 0.2656596 | 5% | 6,943 | 6,323 | 2,511,980,445 | 2,485,594,098 | 1.382E−07 | 0.086 | 0.089 | 0.042 |
| C | 5,523 | 0.1775510 | 0.2827846 | 5% | 5,519 | 4,888 | 1,189,164,847 | 1,168,541,085 | 2.321E−07 | 0.110 | 0.114 | 0.040 |
| D | 5,950 | 0.1782700 | 0.2805318 | 5% | 5,946 | 5,306 | 1,430,240,994 | 1,407,922,994 | 2.079E−07 | 0.103 | 0.108 | 0.041 |
| E | 2,937 | 0.2851050 | 0.2549202 | 5% | 2,933 | 2,498 | 547,504,533 | 536,804,401 | 2.679E−07 | 0.142 | 0.148 | 0.041 |
| F | 4,926 | 0.2176940 | 0.2672368 | 5% | 4,921 | 4,360 | 1,225,438,234 | 1,207,049,834 | 2.008E−07 | 0.109 | 0.114 | 0.041 |

These estimates correspond to a $2,000 deductible and all hazard groups combined.

## DERIVATION OF SAFETY FACTOR COMPONENT FOR INCREASED RISK

### Sensitivity by Hazard Group (State B)

| HAZARD GROUP | Empirical Avg. Cost Per Case | Weibull Parameters C | Weibull Parameters Tau | Premium Change Interval | Estimated Moments E(X) | Estimated Moments E(W) | Estimated Moments E(X ^ 2) | Estimated Moments E(W ^ 2) | Lambda | Risk Adj. LER | Unadj. LER | Risk Load Factor |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| One | 4,634 | 0.2452000 | 0.2580030 | 5% | 4,628 | 4,106 | 1,284,448,448 | 1,267,139,951 | 1.801E−07 | 0.108 | 0.113 | 0.042 |
| Two | 5,340 | 0.2365110 | 0.2579591 | 5% | 5,331 | 4,785 | 1,706,814,459 | 1,686,733,388 | 1.562E−07 | 0.098 | 0.102 | 0.042 |
| Three | 8,749 | 0.1691290 | 0.2757319 | 5% | 8,734 | 8,035 | 3,342,857,979 | 3,309,460,210 | 1.306E−07 | 0.077 | 0.080 | 0.042 |
| Four | 10,486 | 0.1658540 | 0.2731551 | 5% | 10,456 | 9,730 | 5,012,087,033 | 4,971,791,563 | 1.043E−07 | 0.066 | 0.069 | 0.042 |
| All | 6,955 | 0.2021500 | 0.2656596 | 5% | 6,943 | 6,323 | 2,511,980,445 | 2,485,594,098 | 1.382E−07 | 0.086 | 0.089 | 0.042 |

These estimates correspond to a $2,000 deductible.

# EXHIBIT 8
## Weibull Severity Distribution

For domain: x > 0, and parameters: c > 0, tau > 0,

$$F_X(x) = 1 - e^{-cx^{\tau}}$$

Moments (before deductible):

$$E[X^n] = \int_0^{\infty} x^n f_X(x)\,dx = c^{-\frac{n}{\tau}}\Gamma(1+\frac{1}{\tau})$$

If: W = {X - d for X > d, 0 otherwise} is the payment after a deductible.

$$F_W(x) = Pr[X-d<x] = Pr[X<x+d] = F_X(x+d)$$

$$f_W(x) = \frac{d}{dw}[F_W(x)] = f_X(x+d)$$

Moments (after deductible):

$$E[W] = \int_0^{\infty} w f_w(w)\,dw = \int_d^{\infty}(x-d)\,f_X(x)\,dx$$

$$= \int_d^{\infty} x f_X(x)\,dx - d\int_d^{\infty} f_X(x)\,dx$$

With a substitution: u = cx$^{tau}$, this simplifies to

$$c^{-\frac{1}{\tau}}\Gamma(1+\frac{1}{\tau})\,[1 - Pr(G<cd^{\tau})] - d[1 - F_X(d)]$$

where G is a gamma random variable with parameters:

$$\alpha = 1+\frac{1}{\tau}, \quad \beta = 1$$

$$F_G(x) = \frac{1}{\Gamma(\alpha)}\int_0^{\frac{x}{\beta}} t^{\alpha-1}e^{-t}\,dt$$

$$E[W^2] = \int_0^\infty w^2 f_W(w)\,dw = \int_d^\infty (x-d)^2 f_X(x)\,dx$$

Expand this quadratic to obtain:

$$\int_d^\infty x^2 f_X(x)\,dx \;-\; 2d\int_d^\infty x f_X(x)\,dx \;+\; d^2\int_d^\infty f_X(x)\,dx$$

Use substitutions to reduce to:

$$c^{-\frac{2}{\tau}}\Gamma\left(1+\frac{2}{\tau}\right)\left[1-Pr(H<cd^\tau)\right] \;-\; 2dc^{-\frac{1}{\tau}}\Gamma\left(1+\frac{1}{\tau}\right)\left[1-Pr(G<cd^\tau)\right]$$
$$+\; d^2\left[1-F_X(d)\right]$$

where H is a gamma random variable with parameters:

$$\alpha = 1+\frac{2}{\tau}, \qquad \beta = 1$$