Multi-Year Policy Pricing

Benjamin R. Newton, FCAS, RPLU

Abstract: Currently, the pro rata method is widely used to price policy extensions and other changes to policy length. However, there are several other methods that an actuary can use in pricing policy-length changes, such as option and forward pricing, or modeling. There is little discussion in the literature about the relative merits of these different methods, leaving the pricing actuary potentially unsure of which method to use in a given situation. This paper seeks to resolve some of that ambiguity by identifying the features of a contract that would indicate the need to select a certain method over others. The goal of this discussion is to provide the pricing actuary with a framework that can be used to select the most appropriate method for the particular contract that is being priced. The paper then provides simple examples of how these methods might be applied in different situations. Finally, it compares the results obtained using the recommended method to the results from the pro rata method, and points out the potential for pricing insufficiencies when the pro rata method is applied universally. These results should encourage the reader to consider pricing techniques aside from the standard pro rata method.

Availability: The @Risk™ workbook used for example purposes is available on the CAS Web Site at http://www.casact.org.

Keywords: Policy extension, pro rata, option, forward, simulation, multi-year, pricing.

1. INTRODUCTION

Policy extensions are likely the most common premium bearing change to a policy. When faced with the task of pricing a policy extension, actuaries will often immediately turn to the pro rata method. For example, one can purchase a physical "Pro Rata Wheel" and there are an abundance of free "Pro Rata Wheel" calculators. This paper will demonstrate that, unfortunately, simply using the pro rata method is often inadequate. In fact, as the paper will show, there is no one method that is sufficient to price all policy extensions. Rather, there are several different pricing methods that are most appropriately used depending on the particulars of the situation. The paper will attempt to guide the pricing actuary through the process of selecting the optimal pricing method by creating a framework detailing which types of policy extensions are most accurately priced by which method and presenting the theory supporting the use of the different methods in these different contexts.

1.1 Research Context

This paper lays out the theoretical underpinnings of pricing policy extensions and provides a framework for selecting the appropriate policy-extension pricing method in a variety of situations. This framework is intended to be used any time a policy duration differs from the standard policy length. Examples of changing policy lengths are six-month policies written on an annual basis, annual policies written on a six-month basis, single-year policies written on a multi-year basis, and multi-year policies written on a single-year basis, among others. For simplicity all of these various changes to policy length will be referred to in this paper as "policy extensions."

A brief review of the literature reveals a variety of methods in use today to price policy extensions, including discounts [7], pro rata [5][6][8], option-based approaches [11], and pricing ranges [3]. The idea that there are different methods that should be used to price policy extensions is not inherently wrong; however, the potential source of confusion for the pricing actuary is that these different sources cannot agree on which methods to use when. Even within a single source, a variety of methods can be found such as ISO rules requiring short-rate return of premium, pro rata extension premium, or a combination of short-rate and pro rata return of premium [5].

1.2 Objective

This goal of this paper is to provide the pricing actuary with a framework for selecting the most appropriate method of pricing policy extensions. This framework is based on the premise that it is policy language that largely determines the appropriate pricing method. It is not the goal of this paper to reinvent the wheel, for that reason the examples will remain simple and the discussion will not address expenses. The paper will not delve into significant detail about the technicalities of pricing policy extensions using any particular method. There are many better sources of information on using those techniques in other financial, actuarial, and mathematical literature.

1.3 Outline

Section 2 presents the four ways to price policy extensions (option, forward, simulation, and pro rata) and discusses when each should be used. Section 3 illustrates the pricing implications of writing each type of endorsement and the potential for variation in loss costs based upon different contractual terms.

2. BACKGROUND AND METHODS

The four methods that can be used to price policy extensions are option, forward, simulation, and pro rata. This section provides a brief overview of each pricing method and identifies which method should be used in which circumstances. For further descriptions of the type of policy provisions that would require each of these methods to be used, please refer to Appendix 1.

2.1 Policy Extension Using Option Pricing

An option is a contract that gives the purchaser the right, but not the obligation, to buy a good at an agreed-upon price in the future. In essence, when an insured purchases an option to renew a policy at a fixed price in the future, they are betting that the price of the option is less than the present value of the expected rate increase.

Option-pricing methodology is appropriate when the insured has the option to accept a guaranteed future price or to decline and receive better terms if market conditions are favorable [11]. See Appendix 1 for an example of policy language that would indicate this.

Once it has been determined that the policy language indicates that option-based pricing is appropriate, the actuary can use the following basic formula to price the policy extension. For simplicity, we will assume that the option can only be exercised on the policy expiration date, so that we can use a European call option to price the policy. Using the notation from Hull [4], the value of the option at expiration can be expressed as:

$$\text{Max}(S_T - K, 0) \tag{2.11}$$

Where S_T is the market price of the insurance contract at renewal and K is the guaranteed renewal price. The expected future value of the option at expiration can then be obtained by:

$$E[Max(S_T - K, 0)] = \int_k^\infty (S_T = K) f(x) dx. \tag{2.11}$$

Where $f(x)$ is the probability distribution function of rate change for an insured and $S_T - K$ represents the option value at each rate change. From this formulation it can be observed that the option to renew will expire worthless if the renewal market price S_T is less than the guaranteed price K. Further, if the renewal market price at expiration is greater than K, then the value of the option will be the difference in the market price and guaranteed price K.

This same valuation method can be extended to a multi-period scenario in the event of longer-term renewal guarantees [11].

2.2 Policy Extension Using Forward Pricing

This section will seek to identify which types of contracts should be viewed as a forward contract and will outline the basic formulas necessary to price these contracts. Unlike an option, which is a right to buy or sell without any obligation to do so, a forward contract is both the right and obligation to buy or sell a good at some future time. The important feature of a forward agreement is that the insured and the insurer lock in a price in the future regardless of what the market price might be at the future date. It is appropriate to use forward pricing when the insurer and insured are required to enter into a policy at some point in the future. An example of a forward agreement would be a non-cancelable, automatic policy extension. See Appendix 1 for an example of policy language that would indicate this. If the actuary determines that the policy language indicates that forward pricing should be used, he can price the policy extension as follows.

The value of a forward contract at expiration can be expressed as:

$$S_T - K. \tag{2.20}$$

Where S is the market price of the insurance contract at time T, the renewal date, and K is the guaranteed renewal price. Using the distribution of future changes to policy prices, $f(x)$, the expected future value of the forward contract at expiration can then be expressed as:

$$E\left[S_T - K\right] = \int_{-\infty}^{\infty} \left(S_T - K\right) f\left(x\right) dx. \tag{2.21}$$

As this formula indicates, a key difference between a forward contract and an option is that a forward contract allows for potentially positive and negative outcomes for both parties. However, the seller of an option (in this case the insurer) is the only party able to lose money at the option expiration.

2.3 Policy Extension Using Modeling

Any time that policy extensions result in changes to the claim payment process and not just to the collection of premium, it becomes necessary to model these changes. Changes to the claim payment process can occur through alteration of deductibles, limits, or the effective attachment point. Use of a simulated approach allows for the pricing of any possible type of policy once the claim process and contract are understood. Due to the complexity of contracts and claim processes, it is not possible to present a single model that will address all possibilities. Instead, a simple example is presented in Section 3 to demonstrate the importance of building a model appropriate to the contract and the loss process.

2.4 Policy Extension Pro Rata

No discussion of policy extension is complete without the inclusion of the pro rata method. It is the most popular method of policy extension due to ease of computation. Pro rata policy extensions are appropriate when all loss and other expenses vary proportionately with premium or with changes to loss and expense that directly offset the cost of the option or forward contract. Due to the likelihood of changes to loss or expense over an extension period, it is often not the theoretical pricing considerations that cause an actuary to use the pro rata method, but the result of operational considerations.

The calculation of pro rata premium is relatively straightforward and can be expressed as:

Policy cost total = (Policy cost annual / 365) * (Expiration Date – Inception Date).

With this simple formulation, each additional day of coverage costs $1/365^{th}$ of the cost of a one year policy and a two year policy costs double what a one year policy costs.

2.5 Other Costs of Risk Transfer

It is important to consider all costs of risk transfer when pricing multi-year policies and not just changes in premium and losses. Some potential areas for consideration are policy initiation expense, client retention rates, and capital requirements. These are important considerations when pricing multi-year policies. However, an appropriate treatment is outside the scope of this paper.

3. RESULTS AND DISCUSSION

This section will compare the pricing implied by option, forward, and simulation techniques to the pro rata method. The divergence from the pro rata implied pricing will demonstrate the importance of pricing policy extensions in accordance with the contract terms. In order to make these comparisons using easy-to-follow examples, it will be necessary to make some simplifying assumptions.

For policy extensions that can be priced as an option or forward contact, we will use the following assumptions:

1) Rate per exposure for all insureds is expected to increase on average 5% per annum.
2) Rate change for individual insureds is uniformly distributed from -5% to +15%.
3) Exposures are identical in both periods.
4) Premium for the first policy year is $100.
5) The discount rate is 10%.

For policy extensions that result in changes to contract terms, frequency, and severity assumptions will be made. Frequency will be assumed to be binomial and severity will be assumed to be lognormal. The assumption of distributions will enable concrete examples and demonstrate the importance of applying a model when appropriate and are not meant to imply that these assumptions are appropriate in all circumstances.

3.1 Policy Extension Using Option Pricing

The cost of issuing a renewal option is determined by the present value of the option at expiration. Using Equation 2.11 and the assumptions laid out in Section 3 above, we can calculate the value of an option with the guaranteed renewal price of $100 in one year as:

$$E[\text{Max}(S_T - K, 0)] = \int_{100}^{100*1.15} (x - 100) * (1/20)dx \quad (3.12)$$

$$E[\text{Max}(S_T - 100, 0)] = 5.625 \quad (3.13)$$

$$\text{Present Value } E[\text{Max}(S_T - 100, 0)] = 5.625 / (1+i)^t \quad (3.14)$$

$$\text{Present Value } E[\text{Max}(S_T - 100, 0)] = 5.1136 \quad (3.14)$$

Here, the value of the option is greater than zero and the appropriate premium charges for a two-year contract would be as follows:

Price year 1 + Price year 2 + value of option = 100 + 100 + $5.11 = $205.11. Here the price of the year 1 contract is known, the price of the second year is guaranteed to be $100 and the value of the option the insurer sells to the insured is $5.11. Comparing this to the pro rata method, we see that a pro rata extended policy would generate $200 over two years or $100 per year, resulting in a potentially inadequate price.

Not accounting for the value of the option and using pro rata pricing may be acceptable if it strengthens customer relationships, reduces transaction costs, or provides some other benefit to the insurer to offset the decreased premium collection. However, with any potential upside the downside must be considered as well. One potentially significant risk is that option exercise is correlated between insureds and with a hard insurance market. Hard insurance markets are in turn associated with financial distress among insurance companies. Thus, it is easy to imagine a situation in which many policyholders might choose to exercise the guaranteed renewal option simultaneously and at a time of inadequate pricing.

3.2 Policy Extension Using Forward Pricing

The price of a forward contract is calculated from the present value of the forward contract at expiration. Using Equation 2.21 and the assumptions laid out in Section 3 above, we can calculate the value of a forward contract with the guaranteed renewal price of $100 in one year as:

$$E[Max(S_T - K,0)] = \int_{100*95}^{100*1.15} (x-100)*\left(1/20\right)dx \tag{3.21}$$

$$E[Max(S_T - K,0)] = 5 \tag{3.22}$$

$$\text{Present Value } E[\text{Max}(S_T - K,0)] = 5/(1+i)^t \tag{3.23}$$

$$\text{Present Value } E[\text{Max}(\text{S}_\text{T} - k,0)] = 4.5455 \tag{3.24}$$

Here, the value of the forward contract is greater than zero and the appropriate premium charges for a two-year contract would be:

Price year 1 + Price year 2 + value of forward = $100 + $100 + $4.55 = $204.55.

Here the price of the year 1 contract is known, the price of the second year is guaranteed to be $100, and the value of the forward contract the insurer sells to the insured is $4.55. In this case the value of the forward contract is greater than zero and less than the value of the option contract. At the same strike price, the absolute value of a forward contract will always be between the absolute value of the option contract and zero. Once again, when comparing the forward contract to pro rata extension the pro rata policy generates an inadequate price. The pro rata pricing may be acceptable if other benefits to the insurer exist. Potential benefits mirror those outlined in Section 3.1. However, forward contracts, unlike option contracts, will always be executed at expiration. Thus, the exercise of the forward contract will not be more highly correlated with periods of economic distress for the insurer, but the risk will still exist. The insured will exercise the contract regardless of the underwriting cycle, which should make cash flows more predictable. However, the insurer will not have the ability to quickly increase profitability through rate increases after a period of inadequate pricing.

3.3 Policy Extension Using Monte Carlo Simulation

Pricing a policy extension that changes the limits, deductible, or the effective attachment point should be based upon the present value of future cash flows and often requires a simulation to model. An expeditious way to tackle this problem is through the use of common modeling software or simplified equations, like those that were used for option and forward contract pricing in Sections 3.1 and 3.2. Here, a straightforward model using @Risk™ was built to demonstrate the importance of modeling simple situations.

The policy extension that we will model involves the extension of a single aggregate limit, after a claim has been reported in the first year and will be referred to as an aggregate extension endorsement. To price this extension, the model will assume:

A claim reported in the first year.

65% chance reported claim will become an incurred loss.

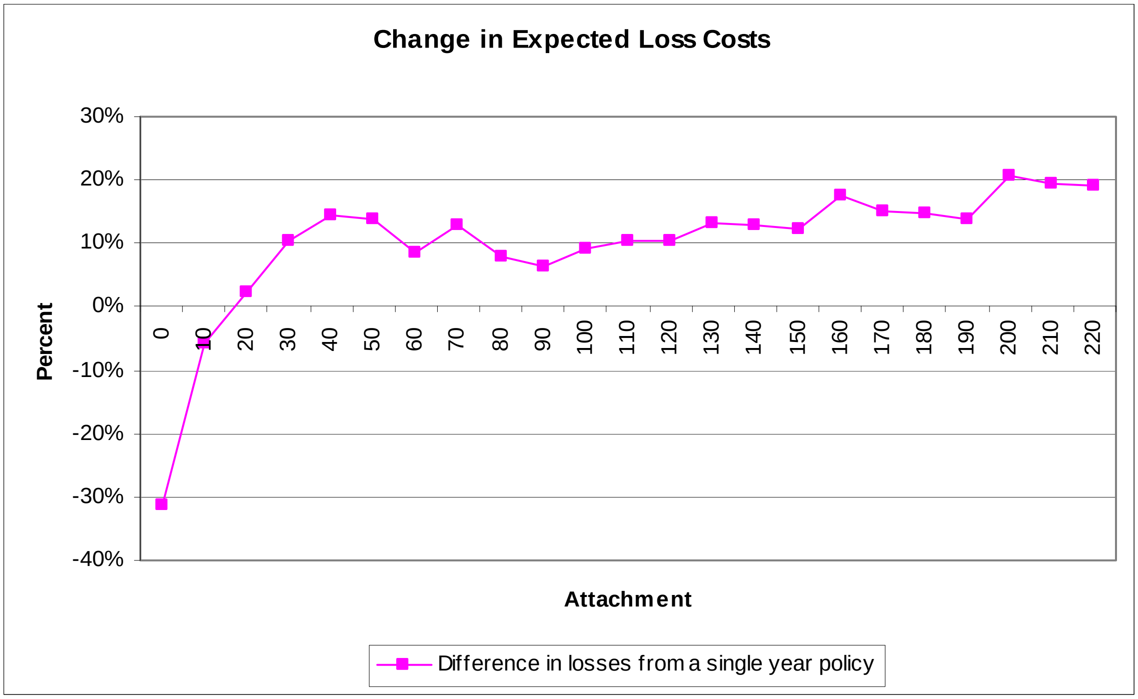
Probability of a claim in the second year will be 2%.

Claim size in year 1 and 2 is log-normally distributed with a mean of $31.2 million and a median of $8 million.

The occurrence of claims and the size of claims will be assumed to be independent.

Graph 1 compares the percentage difference in loss costs for a new limit of liability to the extension of the aggregate limit of liability for the entire tower. It is seen in Graph 1 that expected loss costs for the lowest $20 million in coverage decrease relative to a fresh limit of liability, while exposure for all layers higher on the tower increases.

Graph 1.



Primary carriers are incentivized to pursue this endorsement because of the high-severity and low-frequency nature of claims. With the aggregate extension endorsement the primary carrier is offering less coverage, while carriers higher up the tower, with less pricing control, essentially drop down to a lower attachment point in response to an unrelated second claim. The excess carriers' acceptance of this increased exposure is due to the perception of decreased risk and a weak negotiating position. The model suggests that a pro rata premium charge for this policy extension overcharges for the primary and undercharges for the excess limits.

3.3 Discussion of Results

This paper explores three different methods for pricing policy extensions: option, forward, and modeling. Although modeling and option pricing methods had been used previously by Wacek [11] and Berens [1] to confront aspects of policy extensions, in this paper, these pricing methods were brought together and combined with forward contracts to create a coherent framework. This paper further demonstrates that option, forward, and simulation methods often produce pricing recommendations that stand in sharp contrast to the standard pro rata method of policy extension.

By using these three basic techniques, or a combination of the techniques, an actuary can appropriately price any change to policy length.

4. CONCLUSIONS

Several different methods are available for pricing policy extensions and selecting the appropriate method from among these is essential. In this paper, I have provided some guidance to the pricing actuary regarding when to use option, forward, and modeling methods. As we have seen, option pricing should be used whenever the insured has the option to accept a guaranteed future price or to decline and receive better terms if market conditions are favorable. This paper demonstrates that if the policy language implies that option-based pricing is most appropriate, but the pro rata method is used instead, the result can be a pricing insufficiency. By contrast, forward pricing should be used when the policy language implies that the insurer and insured are required to enter into a policy at some point in the future. I have shown that using the pro rata method in cases that clearly warrant forward pricing can over- or under-price the policy extension, though not as severely as in the case when option pricing is required. Both option and forward pricing methods are specific cases of the generalized modeled result and can simplify the process of estimating the cost of the policy extension. If, on the other hand, the policy extension results in changes to the claim payment process, then these simple pricing methods will be inadequate. In these cases, I suggest that the actuary create a model to determine the appropriate price for the policy extension. A simple example of a model is presented herein and is also compared to pricing using the pro rata method. While the exact results will vary depending on the situation, in the simple modeled example given, we discover yet another case in which the pro rata method suggests an inaccurate price.

Overall, this paper has explored some of the different methods by which policy extensions might be priced. I have also provided several examples in which applying the pro rata method to policy extensions is inappropriate, and results in a potential erosion of the insurer's financial stability. It is the hope of this author that actuaries will be able to use the information provided here to select the most appropriate method for pricing any policy extension that they encounter.

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APPENDIX 1

Part 1: Contract Language

The examples below are meant to provide a guide as to where to look in the policy for changes that can affect how to price changes to policy length. It is not a comprehensive list, but instead a starting point for a closer examination of the complex policy language that we work with everyday.

Declarations

Policy length can be changed from the standard policy length. For example, if a policy is normally six months long, the declarations page can change the policy length to one year.

Limits can be defined as per claim, per policy period (aggregate), or some other alternative.

Deductibles can be defined as per claim, per policy period (aggregate), or some other alternative.

Premium can be fixed at policy inception or auditable based upon exposure. Premium can be paid in advance for the entire policy period or paid periodically.

Premium earning can specify that premium is fully earned at inception of the policy period, earned uniformly over the policy period, and subject to a variety of other conditions.

Cancellation provisions can vary from non-cancelable to fully cancelable. Upon policy cancelation, premium can be returned to the policy holder on a pro rata basis, a short-rate basis, or another contractually specified basis.

Definitions

Limits can be defined as per claim, per policy period (aggregate), or some other alternative.

Deductibles can be defined as per claim, per policy period (aggregate), or some other alternative.

Endorsements

Endorsements can alter any or all provisions in a policy form.

Part 2: Policy Examples

The examples below are meant to provide a guide as to how to price a stylized policy. It is not a comprehensive list or a definitive pricing manual, but instead a starting point for thinking about how the claims process interacts with policy language to determine expected changes to loss costs as policy periods change.

Option Example

Rate Guarantee

XYZ insurance company agrees to renew policy number 12345678 effective from 1/1/2010 to 12/31/2010 for an additional one-year term at a premium of $1,000 per auto.

Policy Provisions

Initial policy term: 1/1/2010 to 12/31/2010.

Premium: $1,000 per auto.

Cancellation: Cancelable at any time with a pro rata return of premium.

Limits: Each policy period has separate limits.

Deductible: Each policy period has separate deductibles

Why is this rate guarantee an option?

The insured has a right, but not an obligation to purchase the second year policy at a predetermined price, which is the definition of an option. For simplicity, the policy provisions were set up to be identical, but this is not a necessary condition for the second policy period to include an imbedded option.

Forward Example

Automatic Policy Extension

XYZ insurance company and ACME Car Driving LLC agree to an automatic extension of policy number 12345678 effective from 1/1/2010 to 12/31/2010 for an additional one-year term at a premium of $1,000 per auto.

Policy Provisions

Initial policy term: 1/1/2010 to 12/31/2010.

Automatic extension period: 1/1/2011 to 12/31/2011.

Premium: $1,000 per auto.

Cancellation: Non-cancelable by either the insurer or the insured, except in cases of insurer downgrade below an AM Best "A" rating.

Limits: Each policy period has separate limits.

Deductible: Each policy period has separate deductibles.

Why is the automatic extension a forward contract?

The insured has a right and obligation to purchase the second year policy at a predetermined price. Neither party can cancel the contract. The second year of the policy has losses that will interact with the limits and deductible in a manner similar to any single year policy.

A practical concern with this type of forward contract, that might argue for treating as an option is the collectability of premium for the renewal period. One way of addressing this issue is to price the expected future premium in a manner consistent with other types of counter party risk.

Modeled Example

Policy Extension Post Claim

In consideration of the additional premium of $100,000, it is agreed that the policy period 1/1/2009 to 1/1/2010 is deleted and replaced by 1/1/2009 to 1/1/2011.

This extension of the policy period shall not increase the insurer's maximum aggregate limit of liability for loss under the policy. All the other terms and conditions of the policy remain unchanged.

Policy Provisions

Initial policy term: 1/1/2009 to 1/1/2010.

Premium: $1,000 per doctor.

Cancellation: Premium for extension fully earned immediately. Non-cancelable.

Limits: Policy period and extension share limits.

Deductible: Policy period and extension have separate deductibles.

Why is a model required to price an extension after a claim?

In this instance, a tower of insurance exists, a claim has been reported and the size of the claim is unknown. Consequently, it is unclear how much of the aggregate limit on the policy or any underlying policy limits will be impaired. In effect, the limit and attachment point for the second year period are unknown at the time the endorsement is written and must be estimated by simulation techniques and expert input.

Pro Rata Example

Uniform Exposure to Loss and no Lag before Inception

A workers compensation policy was written from 1/1/2009 to 1/1/2010 and a policy extension from 1/1/2010 to 1/1/2011.

Policy Provisions

Policy Term: 1/1/2009 to 1/2/2010.

Premium: Per dollar of audited payroll.

Cancellation: Cancelable.

Limits: Statutorily unlimited.

Deductible: Per claim.

Why can a policy be priced using the pro rata method?

In this instance, the limits are unlimited and the deductible is per claim. So each day has the same expected loss. Premiums are auditable, which automatically adjusts for any deviations from the constant force of claims over the year. If no change has occurred to the expected loss per dollar of audited payroll, then it would be appropriate to use the same rates for the second one-year period. In essence the second-year period has all the same characteristics as the first year and should be priced the same. It is difficult to find real-world cases where all the factors align to support pro rata policy extensions. Pro rata extensions are rarely theoretically correct, but are likely to continue to be used regularly due to their simplicity for insurers, insureds, and regulators.

Disclaimer

Any examples in this article are for illustrative purposes only and any similarity to actual individuals, entities, places or situations is unintentional and purely coincidental. This material is not intended to establish any standards of care, to serve as legal advice appropriate for any particular factual situations, or to provide an acknowledgement that any given factual situation is covered under any CNA insurance policy. Please remember that only the relevant insurance policy can provide the actual terms, coverages, amounts, conditions and exclusions for an insured.

Supplementary Material

On the CAS Web Site, the @Risk™ worksheet will be available for those who have access to

@Risk™ and without the @Risk™ formulas to those without access to the software.

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Biography of the Author

Benjamin R. Newton is an actuarial director at CNA Insurance in New York City. He began his career at CNA Insurance, where he has spent time reserving, pricing and underwriting various professional liability lines. Benjamin graduated from The University of Illinois with a BA in Economics and a BS in Mathematics, and is currently pursuing an MBA from Columbia University. He is a Fellow of the CAS and a Registered Professional Liability Underwriter and has volunteered with the CAS since attaining his FCAS. He may be contacted at BenjaminRNewton@gmail.com for discussion of this work or to obtain copies of bibliographical items listed as available on the Internet.