Source of Earnings Analysis for Property-Casualty Insurers

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Abstract

Source of earnings analysis has long been a staple of life insurance policy pricing and profitability monitoring. It has grown in importance with the advent of universal life insurance and of similar contracts with non-guaranteed benefits or charges. SFAS 97 now mandates the use of source of earnings analysis for GAAP reporting of universal life-type contracts.

Source of earnings analysis is equally applicable to several lines of property-casualty insurance, such as workers' compensation and personal automobile insurance. An accident of history has restricted it to life insurance. Source of earnings analysis was first developed for allocating policyholder dividends on participating life insurance policies, and it has since been expanded to other policy forms as well. Casualty actuaries have developed their own ratemaking traditions. Casualty actuaries and life actuaries grow up in separate societies with little interaction, and source of earnings analysis has never been extended to the casualty lines of business.

This paper shows the uses of source of earnings analysis for understanding the factors affecting policy profitability. Source of earnings analysis is not a specific ratemaking "method," like the loss ratio method or the pure premium method. Rather, source of earnings analysis is a reporting structure that reveals the sources of gain and loss on a block of business, highlighting errors in the pricing parameters as well as the sensitivity of profit and loss to various pricing factors, and enabling more accurate selection of new parameters and factors.

This paper develops source of earnings exhibits for casualty insurance, using private passenger automobile insurance policies and retrospectively rated workers' compensation policies as examples. The uncertainty in many casualty insurance pricing factors, such as loss development factors and loss trend factors, make source of earnings analysis particularly important for casualty products.

The paper shows how to use the source of earnings exhibits to better analyze the factors driving insurance results. In particular, the paper divides the variance caused by each earnings factor into an estimation error component, which is within the purvey of the pricing actuary, and a random error component, which results from random fluctuations in loss occurrences, inflation rates, or interest rates.

Some sources of gain or loss, such as persistency patterns and investment earnings, are not always included in casualty ratemaking procedures. A complete source of

earnings analysis incorporates (a) an analysis of expected versus actual experience by each pricing factor and (b) an amortization of initial expense and loss costs by policy year. The initial acquisition expense includes the solicitation costs for not taken business, which can be substantial in large account workers' compensation retrospectively rated policies. These costs are not always considered by pricing actuaries, but they have great effect on ultimate profit margins.

Similarly, movements in the achieved interest rate spread is a major factor in life annuity profitability because of the long duration of these policies and the substantial cash accumulation in these policies. Changes in expected versus actual investment income can have a large effect on workers' compensation profitability as well.

Pricing actuaries sometimes say that their indications are best estimates, and they disclaim responsibility for variances of actual from expected. In truth, analysis of the variances from previous years' predictions is one of the best means of improving next year's predictions. Sources of earnings analysis provides the needed *post mortem* to rigorously measure the variances in each source of earnings factor

Source of Earnings Analysis for Property-Casualty Insurers

Section I: Introduction

This paper illustrates source of earnings analysis for property-casualty insurance. Source of earnings analysis is a staple of life insurance policy pricing and reporting, and it is mandated by NAIC regulations or GAAP statements for participating policies issued by mutual life insurance companies, for universal life policies, and for other policies with non-guaranteed benefits or charges.

We discuss source of earnings analysis for private passenger automobile insurance and workers' compensation insurance ratemaking. Because of the complexity of this topic, we focus on issues that are most germane to pricing actuaries for these two lines. Private passenger automobile insurance ratemaking is well suited to source of earnings analysis, since the volume of business is large and the effects of estimation error and random error can be more easily discerned. In addition, private passenger automobile has high retention rates and different acquisition expense costs for new policies versus renewal policies, making profitability highly sensitive to persistency patterns.

Workers' compensation retrospectively rated policies are somewhat analogous to universal life insurance contracts. In both cases, expected profits stem from the margins in the pricing assumptions. The casualty actuary prices the components of the retrospectively rated policy, such as the insurance charge, even as the life actuary prices the components of the universal life policy. In addition, large account retrospectively rated policies have high not taken rates, various premium payment plans, and considerable investment income, which require actuarial expertise for pricing and design. Measuring profitability by comparison of total premiums with total costs may yield little information that can improve the pricing process. Source of earnings analysis is better suited to identifying the causes of superior and inferior performance.

Structure of this Paper

Section II provides a description of source of earnings analysis as applied to life insurance products, with specific reference to two areas: (i) calculation of policyholder dividends by means of the contribution principle for mutual life insurance companies and (ii) the FAS 97 accounting for universal life-type products.

Section III applies source of earnings analysis to private passenger automobile ratemaking. The general framework is outlined, along with a detailed analysis of trend.

The major themes of this section are the differentiation between estimation error and process error; the handling of credibility; the difference between implicit profit margins and explicit profit margins; and source of earnings analysis for investment income.

Section IV applies source of earnings analysis to workers' compensation ratemaking for retrospectively rated contracts. The major themes of this section are static versus dynamic amortization of deferred policy acquisition costs; the source of earnings exhibits showing charged, expected, and actual results; and interpreting the source of earnings exhibits.

Section V summarizes two fundamental implications of the paper regarding pricing paradigms and the effects of random variations.

Section II: Classical Source of Earnings Analysis

Source of earnings analysis was originally used to determine policyholder dividends for permanent life insurance policies sold by mutual insurance companies. With the advent of interest sensitive policies, source of earnings analysis has been mandated for GAAP financial statements: by SFAS 97 for universal life-type contracts and SFAS 120 for participating policies sold by mutual life insurance companies.

Policyholder Dividends: The contribution principle, which is required both by the NAIC model act on policyholder dividends and by the AAA Standards of Practice, mandates that the amount of divisible surplus used to pay policyholder dividends on any block of business reflect the contribution of that block to company earnings.[1] Although simple and elegant, this principle is difficult to apply rigorously, since it requires the actuary to quantify the long-term contributions to profit from calendar year changes in the pricing assumptions.

Persistency Rates: The major elements affecting long-term profitability are persistency rates (or withdrawal rates), interest earnings, and mortality ratios. Let us consider each of these, since they are all applicable to property-casualty business as well. Suppose the expected withdrawal rates are 10% for the second year of a cohort of permanent life insurance policies, but the actual withdrawal rates are 15%. The payment of surrender charges and the takedown of conservative statutory reserves cause an increase in statutory profits in the second year. However, the smaller block of persisting business generally leads to lower profits in succeeding years, which more than offsets the statutory gain in the second year. Policyholder dividends for that block of business must be reduced. Source of earnings analysis helps quantify the equitable change in the dividend rate.

[1] See particularly Actuarial Standard of Practice #15, *Dividend Determination and Illustration for Participating Individual Life Insurance Policies and Annuity Contracts*, and Actuarial Standard of Practice #24, *Compliance with the NAIC Life Insurance Illustrations Model Regulation.*

For casualty products priced by traditional ratemaking procedures, we use a simpler adjustment in this paper for persistency changes, though the effects on product profitability are great. Solicitation costs on not taken business, as well as high first year acquisition expenses, are amortized over the expected policy lifetimes.[2] If withdrawal rates increase, the amortization period is reduced and profitability declines.

Interest Earnings: Continuing the previous example, suppose that the expected Treasury bill rate was 6% per annum in the second year of a cohort of permanent life policies but the actual Treasury bill rate was 5% per annum. The change in statutory investment earnings during this year may have been nil, since (i) the coupons on existing bonds have not changed, (ii) bonds are valued at amortized cost in statutory statements, and (iii) invested assets are small in the second year of a cohort of permanent policies. The anticipated change in long-term profitability may range widely, depending on the inflation sensitivity and the duration of the liabilities. For a standard guaranteed cost block of traditional whole life business, the expected long-term profitability would drop, necessitating a decrease in policyholder dividends.

The effects of changing interest rates are more complex for casualty products, since both loss payments and asset returns are sensitive to changes in interest rates and inflation rates. A full source of earnings exhibit, showing the effects of variation in loss cost trends side-by-side with the effects of variation in the investment yield is necessary to judge the net effect on product profitability.

Mortality: Variations in mortality ratios highlight the importance of estimation error versus process error. Suppose that the ratio of actual to expected mortality in the second year of a cohort of business is 150%. If the higher than expected mortality reflects random deaths, policyholder dividends paid to the remaining insureds should not be changed. If the higher than expected mortality reflects a poor quality book of business, the policyholder dividends should be reduced.

For casualty lines of business, loss frequency and loss severity are similar to mortality rates in life insurance or morbidity rates in health insurance. Higher than expected loss frequency or loss severity in any calendar year may reflect either random loss occurrences or estimation error of the expected means. The latter possibility necessitates re-examination of the ratemaking procedure.

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[2] "Not taken" business is business that is underwritten and where an insurance offer is make but not accepted. The importance of "not taken" business for determining fixed expense provisions by classification is discussed in S. Feldblum, "Personal Automobile Premiums: An Asset Share Pricing Approach for Property/Casualty Insurance," *Proceedings of the Casualty Actuarial Society*, Volume 83 (1996), pages 190-296.]. The "Personal Auto Premiums" paper shows the assumptions regarding "not taken" business needed to price the policy. This paper shows the methods to test for variance of actual results from the pricing assumptions.

Amortization of the DPAC

GAAP treatment of deferred policy acquisition costs necessitated a wide application of source of earnings exhibits in GAAP statements for universal life-type policies.[3] In statutory statements, deferred policy acquisition costs are expensed when incurred. In GAAP statements for traditional policies, deferred policy acquisition costs are expensed as the premium is earned. For universal life-type policies, there is no set premium, so one can not amortize the DPAC asset in relation to premiums. Instead, SFAS 97 mandates that the DPAC asset be amortized as a proportion of future expected profits.[4]

To illustrate the use of source of earnings analysis in FAS 97 accounting, consider again the example with an unexpected increase in the withdrawal rate from 10% to 15% in the second year of a cohort of policies. If this cohort consists of universal life-type policies, the DPAC asset would be amortized in relation to future expected profits. Suppose that originally the second year profits were expected to be 10% of all future profits. After the withdrawal rate increase, the actual second year profits increase and the future expected profits decrease, leading to a higher ratio and a larger amount of deferred policy acquisition costs amortized in the second year.[5]

Extension to Casualty Products

Source of earnings analysis is applicable to any insurance product whose returns depend on conditions subsequent to the policy pricing. This is true of all property-casualty products, since their returns depend on random loss occurrences as well as on interest rates and inflation rates.

The profitability of private passenger automobile business also depends (in part) on the persistency of the business, particularly for direct writing insurers.[6] The original pricing of products whose profitability depends on persistency can be done by asset share models. The subsequent monitoring of product performance requires dynamic amortization of the deferred policy acquisition costs and is best accomplished by multi-

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[3] The unfortunate term "universal life-type" is not an actuarial malapropism; it is the standard GAAP term for policies with benefits or charges that are not fixed.

[4] The amortization of deferred policy acquisition costs in relation to expected profits rather than in relation to premium earnings makes sense for all policies. However, the AICPA did not wish to change accounting practice for existing policies, so the new rules apply only to universal life-type policies.

[5] This is an oversimplified treatment of FAS 97. For a thorough analysis, along with illustrations of the source of earnings exhibits, see Joseph H. Tan, "Source of Earnings Analysis under FAS 97 Universal Life Accounting", *TSA* XLI (1989), pp. 443-506, and Michael Eckman, "Additional Source of Earnings Analysis under FAS 97," *TSA*, Volume LXII (1990), pages 59-81.

[6] See Stephen P. D'Arcy and Neil A. Doherty, "The Aging Phenomenon and Insurance Prices," *PCAS*, Volume 76 (1989), pages 24-44, and S. Feldblum, "Personal Automobile Premiums: Asset-Share Pricing for Property-Casualty Insurers," PCAS (1996), pages 190-276.

year source of earnings exhibits.

Asset share pricing for casualty products is complex, and it is not the intention of this paper to review that topic. Instead, we examine the dynamic amortization of solicitation costs for not taken business in retrospectively rated workers' compensation policies.

Workers' compensation retrospectively rated policies often have premiums that are based on the total exposure but provide insurance coverage only for certain portions of the risk. The cost of the coverage is based on an insurance charge calculation that considers premium bounds, loss limits, the size of the insured, and the class of the insured. The profitability of the book of business depends on implicit margins in the insurance charge and on the investment income from the underwriting cash flows. Source of earnings analysis allows the actuary to monitor the performance of the business in terms of the pricing assumptions.

These two illustrations show the power of source of earnings exhibits to deal with sources of gains and losses that are not adequately reflected in traditional ratemaking and profitability monitoring procedures. However, the primary benefits of source of earnings analysis are applicable to all products. Source of earnings analysis serves as a *post-mortem* of previous reviews, evaluating the accuracy of the various assumptions, and uncovering the causes of poor performance.

Section III: Private Passenger Automobile

The structure of the source of earnings analysis depends on the factors affecting the rates for each line of business. Most life insurance products use a four factor analysis, focusing on withdrawal rates, mortality ratios, interest rates, and expense ratios. For property-casualty products, mortality ratios are replaced by loss assumptions, such as loss development, loss trend, loss frequency, and loss severity assumptions.

There are three levels of the source of earnings analysis.

- The individual factor level shows the application of source of earnings analysis to each earnings factor. For private passenger automobile, we examine loss severity trends in this paper, differentiating between estimation error and process error. For workers' compensation, we examine several earnings factors: non-ratable losses, acquisition costs, and interest earnings.

- The source of earnings exhibits for a single policy or a single policy year combine the earnings factors but without consideration of policy renewals (retention rates). These exhibits are appropriate for blocks of business with low persistency rates, little difference between first year and renewal year loss and expense costs, and low solicitation costs for not taken business. Many independent agency companies ignore persistency rates in their pricing analyses.

- The source of earnings exhibits for a cohort of policies considers both the current policy year and the renewals of existing policies. These are the standard exhibits required for universal life-type policies and for participating policies issued by mutual life insurance companies.

Maintenance expenses are not discussed in this paper. Maintenance expenses are generally stable, and they are more easily analyzed by direct examination than by source of earnings exhibits.

Individual Factor Level: Estimation Error and Process Error

We illustrate the workings of source of earnings analysis with the loss cost trend adjustments used in most casualty rate reviews. For private passenger automobile, which does not use an inflation sensitive exposure base, the trend assumptions are particularly critical for rate adequacy.[7]

Actual insurance results frequently differ from expected results. The source of earnings analysis attributes this variance to the underlying earnings factors (or "sources"). For each factor, there are two potential reasons for the variance: estimation error and process error. Estimation error is the difference between the actuary's forecast and the true expected result. Process error is the difference between the true expected result and the actual realization. These errors emerge over time, starting from the date of the rate review to the final settlement of claims. Estimation error can often be controlled by the pricing actuary, whereas process error is an unavoidable element of actuarial ratemaking.[8]

For the private passenger automobile trend illustration we assume an experience period

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[7] For space limitations, we begin *in medias res*, and we continue rapidly through lines of business and ratemaking procedures of various hues: casualty, life, and financial. In practice, source of earnings analysis is overlaid on the ratemaking method. Ideally, we would use a more structured exposition, beginning with the pricing procedure for each line and working through the implicit assumptions and sources of variance in each section of the rate review.

[8] Actuaries often speak of parameter risk versus process risk (see Robert S. Miccolis, "On the Theory of Increased Limits and Excess of Loss Pricing," *Proceedings of the Casualty Actuarial Society;* Volume 64 (1977) pages 27ff and S. Feldblum, "Risk Loads for Insurers," *Proceedings of the Casualty Actuarial Society*, Volume 77 (1990), pages 160-195). These are similar though not identical concepts. For instance, process variance often causes the historical data to imperfectly reflect expected experience. This process variance causes the actuary to misestimate the parameters of the loss distribution, resulting in parameter risk for prospective ratemaking. However, the estimation error for severity trend in this paper is not affected by the historical experience. The process variance leading to a misestimation of the parameters of the loss distribution remains process variance in this paper.

Some actuaries categorize risk more finely into process risk, parameter risk, and specification risk. This division is most common in discussions of dynamic financial analysis; see, for instance, Gerald S. Kirschner and William C. Scheel, "The Mechanics of a Stochastic Corporate Financial Model," *PCAS* Vol 85 (1998), pages 404-454, or Hodes, Feldblum, and Blumsohn, "Workers' Compensation Reserve Uncertainty," *PCAS* Vol 86 (1999). Both parameter risk and specification risk would be included in estimation error.

of accident year 1999, and a future period of annual policies written in 2001; the loss trend period is 2.5 years (7/1/99 to 1/1/2002). In the rate review, the trend factors estimated from countrywide fast track data are a +7% per annum severity trend and a +1% per annum frequency trend.[9]

There are three sources of potential error.

1. predicting future fast track trends based on historical experience.
2. applying countrywide fast track figures to a particular state.
3. using loss trend estimates to predict the changes in actual losses incurred.

Several months after the policy year has expired, the source of earnings analysis shows that the actual fast track trends were +8% per annum for severity and +2% per annum for frequency. Our fast track estimates, which we used as a proxy for the actual loss trends, were too low. This is estimation error. The quantification of estimation error is independent of the actual frequency and severity changes in the statewide data.

Discrepancies between countrywide trends and statewide trends are not easily discerned. When there is no change in state compensation systems or other structural characteristics, no difference is normally expected. When there is a change in compensation systems or in other structural characteristics (such as the degree of attorney involvement in insurance claims), trend differences can be significant. To simplify the presentation in this paper, we do not analyze countrywide-statewide differences in expected trend.[10]

We examine the average loss severities and loss frequencies in the experience period and in the new policy period. Our initial numbers are estimates, since (i) the figures for the new policy year are immature and (ii) even for the experience period the loss severities may still be uncertain. We won't have actual loss severity and loss frequency figures for the new policy period until all the policies (not just the policy year) have expired and their data have been collected. For the first source of earnings exhibit, we use some actual data and some revised estimates. For the second and subsequent source of earnings exhibits, we have more complete actual data.

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[9] Numerous data sources are available for trend estimates. We assume that the pricing actuary uses countrywide fast track data for estimating trend factor, since this allows a clear demarcation between estimation error and process error. In theory, the same two sources of error exist when one extrapolates future trend factors from historical statewide experience, though it is harder to separate the two.

[10] The 1991 compensation system changes in Massachusetts showed the effect of structural changes on expected loss frequency and loss severity; see Sarah S. Marter and Herbert I. Weisberg, "Medical Expenses and the Massachusetts Automobile Tort Reform Law: First Review of 1989 Bodily Injury Liability Claims," *Journal of Insurance Regulation*, Volume 10, No. 4 (Summer 1992), pages 462-514. On the importance of these regional differences as private passenger automobile "cost drivers," see John B. Conners and Sholom Feldblum, "Personal Automobile: Cost Drivers, Pricing, and Public Policy," *PCAS* Vol 85 (1998), pages 370-403.

Suppose that our new loss severity and loss frequency figures indicate a trend of +5% per annum for severity and +4% per annum for frequency, as shown in Table 1.

Table 1: Estimation Error and Process Error

	Estimated Fast Track	*Actual Fast Track*	*Actual S/W Change*
Loss Severity	+7%	+8%	+5%
Loss Frequency	+1%	+2%	+4%

We under-estimated loss severity by 1% (+7% → +8%), and we underestimated loss frequency by 1% (+1% → +2%). For a 2.5 year trend period, this caused the rates to be inadequate by 4.9% [$((1.08*1.02)/(1.07*1.01))^{2.5}$]. This is the estimation error.

The actual loss severity change was +5% per annum, and the actual loss frequency change was +4% per annum. We do not call this the actual trend, since it may be influenced by random losses — either in the new policy period or in the experience period — or it may be a systematic change in loss filing patterns. Lacking other information, we presume that the actual severity trend is +8% per annum, and the actual frequency trend is +2% per annum. There may have been some unusually large claims in the experience period or a lack of large claims in the new policy period, thereby accounting for the low severity trend. Similar random effects may account for the large change in claim frequency.

If compensation system changes and structural changes are not explicitly considered, they are subsumed under the process risk component of the source of earnings exhibits. For instance, there may have been an influx of nuisance claims in the new policy period which are settled for small amounts. The phenomenon has plagued private passenger automobile insurance for the past twenty years, and it must always be considered when the frequency change is large and the severity change is small.

We group all the possible explanations of the difference between the observed patterns in the state and the "hindsight" trend observed in the fast track data as the process error in the trend estimate. This term is not entirely accurate, since not all of the causes of the observed difference are necessarily a result of process error. The intention is simply that this observed difference is not a result of misestimation of the fast track trend.

As the new policy year develops, and as actual data replaces estimates, the observed loss trends may change. The changes can be substantial until the new policy year is fully earned, followed by minor changes as losses are settled. For a single policy, or a single policy year, the primary value of the source of earnings exhibits lies in the first few years. For analyzing a cohort of business whose profitability depends (in part) on persistency of existing business, the year-by-year source of earnings exhibits are critical.

Extending the Exhibits

To analyze the sensitivity of the profits to trend errors, we convert the estimation and process errors into dollar amounts. Assuming $10 million of annual losses and using the figures above, we begin the source of earnings exhibits:[11]

Table 2: Private Passenger Auto Loss Severity (one year)

Date	Projection		Estimation Error		Process Error		Total
12/02	+7%	$0	+8%	-$250K	+5%	+$750K	+$500K

The figures are simplified for ease of presentation. We assume a 2.5 year trend, so a 1% understatement in the trend causes a loss of $250,000 on a $10 million book of losses, as is true for the estimation error in this illustration.[12] Sometimes estimation error is unavoidable; sometimes estimation error results from poor work and can be mitigated by better pricing techniques. The conscientious actuary examines past estimation errors to check for any biases in the ratemaking procedures.

Process error derives from the uncertainties of worldly activity. The presence of process error is the justification of insurance coverage. Nevertheless, the analysis of process error is critical for two purposes.

1. First, it is critical to the analysis of profitability. The management of an insurance company must know whether variance from expected results was predictable or random. Continuing random variances from expected results may indicate that the line of business is highly unstable. Repeated variances in a particular direction indicate possible biases in the ratemaking or underwriting operations.

2. Second, careful analysis of the process error may indicate that certain structural factors are impinging on the insurance environment. Changes in compensation systems and changes in attorney involvement in insurance claims are examples of such structural factors. This analysis is particularly important when state compensation systems change.

Source of earnings exhibits use a multi-year format, particularly when persistency patterns are included. Suppose that by 12/31/2003, the actual severity increase is

[11] We assume that the trend factors in the private passenger automobile rate filing contain no implicit profit margin; see the discussion below in the text.

[12] For clarity's sake, we use rough numbers. "Book of losses" is not a realistic concept, since the size of the losses depends on the trend factors. In practice, the "gain or loss" is the difference in profits under the two trend assumptions. (When examining variances in persistency rates for a cohort of business, the arithmetic is complex, but it is not conceptually difficult.) As discussed further below in the text, we use nominal losses for the trend figures, and we separately quantify the gain or loss from investment earnings. When an increase in trend stems from higher inflation that is associated with higher interest rates, the loss from trend may be offset in part by a gain from interest; see the discussion below in the text.

+6%. A second line would be added to the severity trend source of earnings exhibit:

Table 3: Private Passenger Auto Loss Severity (multiple years)

Date	Projection		Estimation Error		Process Error		Total
12/02	+7%	$0	+8%	-$250K	+5%	+$750K	+$500K
12/03	+7%	$0	+8%	-$250K	+6%	+$500K	+$250K

The dollar variances in each column of the table above relates to the current row, not to the entry in the previous row of the same column. The projection column is the original pricing assumption. Since no implicit profit margin is used in the trend assumption, the original "gain or loss" is $0. The projection columns do not change as additional years are added to the table.

The estimation error columns show the difference between the actual trend rate, based on actual fast track data, from the projected trend rate. The "gain or loss" reflects the variance between the actual trend rate and the projected trend rate translated into dollars of gain or loss in the book of business. In this example, the actual fast track trend is 1% per annum greater than the projected trend rate. For a trend period of 2.5 years and a $10 million book of losses, there is a loss of $250,000 from estimation error.

To keep the exposition simple, the actual fast track trend does not change from December 2002 to December 2003 in the example above. December 2002 and December 2003 are the estimation dates; the fast track trend in each row refers to the same period (July 1, 1999 to January 1, 2003). When the first row of the source of earnings exhibit is completed before final fast track data is available (as is true in this example), the estimation error entries often change between the first and second rows.

The process error columns show the difference from the trend rate as indicated by the fast track data and the actual severity change in the company's ratemaking data for that state. Assuming that there are no structural changes that affect loss severity trends in this state, the difference stems either from random loss occurrences in the historical experience period or from random loss occurrences in the policy period. The average severity in both the historical experience period and the policy period may change as the losses mature, so the variance resulting from process error changes as years are added to the source of earnings exhibit.

Revisions stems from both actual (past) data and revised estimates of the future. Consider the first row in Table 3 above. The "projection" column shows the estimated trend for 7/1/99 through 1/1/2003 at the time of the rate analysis. Some of the fast track trend is actual: if the rate analysis is done in the middle of 2000, then the fast track trend for 7/1/99 through 12/31/99 may be actual and the remaining trend is an estimate.

The "estimation error" column shows the expected trend for this same period at a valuation date of December 31, 2002. Most of the trend is now actual data (7/1/99 through perhaps 6/30/2002) while the trend for 7/1/2002 through 12/31/2002 is a revised estimate.

The source of earnings exhibits trace the replacement of prior assumptions by actual data and by revised assumptions. There is no need to wait until "hard data" come in to form the source of earnings exhibits. For instance, if the actual fast track trend is higher than the assumption for the first half of the trend period, we expect that it will be higher than the assumption for the second half of the trend period as well.

Credibility

Credibility is an important component of casualty actuarial pricing procedures. Life insurance pricing does not use credibility adjustments, thereby facilitating a comparison of expected values with actual values. Source of earnings exhibits are more complex when credibility is used in the ratemaking process.

For other components of the pricing procedure, the actual values are known with hindsight after the policy term expires and the experience is mature. For credibility, there is no actual value. The source of earnings analysis does not compare the initial credibility assumption with a subsequent (revised) value. Rather, the credibility value is used to adjust the initial assumptions.

Credibility is used in a variety of places in ratemaking. For illustration, we focus on statewide credibility factors. The credibility factors adjust the past experience to be a better proxy for the true expected losses in the historical experience period.[13]

A numerical illustration should make this clear. For ease of exposition, we use a pure premium ratemaking framework. Suppose that the underlying pure premium during the experience period of accident year 1999 was $500 per car, based on a rate filing effective July 1, 1998, and intended to be in effect for one year. The new policy period is policy year 2001; that is, the anticipated effective date of the current filing is January

[13] Traditionally, statewide credibility factors are applied to the developed and trended experience loss ratios. This might give the impression that credibility is adjusting the development or trend factors or the future expected values. This is not correct. Credibility factors may indeed be applied to trend factors and development factors, and there are several actuarial papers on this subject. The statewide credibility factors, however, adjust the actual experience to be a better proxy of the expected experience in the past.

The discussion here is based on the "greatest accuracy" justification for credibility, not the "limited fluctuation" justification; see Gary G. Venter, "Credibility," in Matthew Rodermund, et al., *Foundations of Casualty Actuarial Science*, Second Edition (New York: Casualty Actuarial Society, 1992), pages 375-483. Venter correctly notes that the theoretical justification for classical credibility is to limit fluctuations in the rates and that the Bayesian-Buhlmann credibility procedure is designed to optimize rate accuracy. Nevertheless, most actuaries conceive of all credibility procedures as improving the accuracy of the rates. In addition, Mahler convincingly argues that even traditional credibility procedures generally improve expected rate accuracy.

1, 2001. Because of administrative problems, no rate changes were effective between July 1, 1998, and January 1, 2001.

The pure premium trend is 10% per annum. The experience pure premium during accident year 1999 is $600. The credibility for the experience pure premium is 50%; that is, the pure premium used in the ratemaking formula is an equal weighting of the trended experience pure premium and the trended underlying pure premium. How should the source of earnings exhibits reflect the 50% credibility factor?

The trend factor is the same for the experience pure premium and the underlying pure premium. The credibility factor tells us that the true expected loss per exposure during accident year 1999 is a 50:50 average of the information we obtain from the accident year 1999 experience and the rates underlying the accident year 1999 writings.

The rates underlying the accident year 1999 writings are $500(1.10)^{0.5}$ = $524.40, since the $500 rates were adequate for the 12 month period from July 1, 1998, through June 30, 1999. The credibility weighted average experience rates are ($600 + $524.40)/2 = $562.20.[14]

On the source of earnings exhibits, this is reflected in the actual loss cost change. The initial trend rate assumption is 10% per annum. The actual trend rate based on hindsight is whatever the trend index reveals after the end of the policy year. The actual loss cost change is the change between $562.20 and the observed pure premium during the policy year.

In sum, the source of earnings analysis accepts the credibility adjustment and tests the loss cost change; it does not test the credibility value itself.[15]

Implicit and Explicit Profit Margins

Actuaries have used both implicit and explicit methods for incorporating profit provisions in the premium rates. For explicit profit margins, best estimate assumptions are used throughout the ratemaking process and a full profit margin is included in the rates. For implicit profit margins, conservative assumptions are used in the ratemaking process and a lower explicit profit margin is included in the rates.

To illustrate the difference, contrast trend factors with discount factors.

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[14] For a more complete discussion, see S. Feldblum, Discussion of "The Complement of Credibility" by Joseph Boor, *PCAS*, Volume 85 (1998), pages 991-1033.

[15] This is not to imply that credibility factors are impervious to empirical testing. On the contrary: Mahler, Howard C. Mahler, "An Example of Credibility and Shifting Risk Parameters," *Proceedings of the Casualty Actuarial Society*, Volume 77 (1990), pages 225-308.give three methods for testing the accuracy of credibility factors. However, Mahler tests the accuracy of the credibility estimator. One can not test the accuracy of a particular credibility factor. That is, there is no variance between the actual credibility and the assumed credibility.

- *Trend Factors:* Suppose that fast track data imply a loss severity trend of +5% per annum. This estimate is uncertain, not only because it is a future projection but also because the fast track data are not completely comparable to the ratemaking data (different companies, different states, accident year versus calendar year, closed claims versus incurred claims, and so forth). We presume that the trend rate is probably between 4% and 7% per annum.

  The explicit profit method would use a +5% trend and a full explicit profit margin. The implicit profit method may use a +6% trend and a somewhat lower profit margin. Many pricing actuaries prefer best estimate assumptions for most factors and explicit profit margins in the rates, although rate filing exigencies often compel them to use lower explicit profit margins offset by conservative assumptions.

- *Discount Factors:* Suppose that losses are discounted to present value at the expected risk-free interest rate in a discounted cash flow pricing model. The estimate of future interest rates, based on an analysis of the current yield curve and of any mean-reverting tendencies in the assumed interest rate paths, is 5% per annum. This estimate is uncertain, because we are projecting a future rate and because our interest rate model may itself be flawed. We presume that the future interest rate will probably be between 4% and 6% per annum.

  The explicit method would use a 5% assumed interest rate with a full explicit profit margin. The implicit method might use a 4% assumed interest rate with a somewhat lower profit margin.[16]

  Similarly, suppose that expected investment yields will average 8% over the future policy period. For running an internal rate of return pricing model or a return on capital pricing model, the actuary may choose a more conservative investment yield and a lower cost of capital.[17]

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[16]The use of an implicit profit margin in the interest rate is not the same as a risk adjustment to the discount rate. For example, Myers and Cohn [1987, op cit] use a CAPM-based risk-adjusted loss discount rate that reflects the covariance of loss returns with market returns, following procedures used by W. Fairley, "Investment Income and Profit Margins in Property-Liability Insurance: Theory and Empirical Results," *The Bell Journal of Economics* 10 (Spring 1979) pages 192-210, and R. Hill, "Profit Regulation in Property-Liability Insurance," *The Bell Journal of Economics*, Vol 10, No. 1 (Spring 1979) pages 172-191. The CAPM-based risk adjustment reflects the true present value of the loss payments, not "conservatism" or an implicit profit margin. See also Butsic [1988, op cit], who uses a risk adjustment to the loss discount rate to estimate the true economic value of the loss reserves.

[17] Some actuaries prefer the use of explicit profit margins to better monitor the adequacy of the rates; other actuaries prefer the use of implicit profit margins to prevent overly aggressive pricing. Rate filing requirements in many states influence the type of profit margin. A state that limits the explicit profit margin to an inadequate return on capital may cause insurers to load implicit profit margins into the pricing factors.

Investment Income

The expected investment income earned on policyholder supplied funds and on the surplus funds supporting the book of business is an essential element in pricing insurance products. For interest sensitive products, life actuaries speak explicitly of the spread between the earned interest rate and the credited interest rate. The source of earnings analysis considers the difference between the spread that is actually achieved and the spread that is assumed in the pricing analysis.

Casualty actuaries use a variety of financial pricing models. Often, a financial model is used to determine a target underwriting profit margin, which is then used in the ratemaking procedure. The analyst using the prescribed underwriting profit margin in the rate review may not have participated in determining the adequacy of that margin and may not even be aware of the interest rate assumptions embedded in that margin.

This complicates the source of earnings analysis, but it does not diminish its importance. Indeed, the source of earnings analysis is all the more necessary, since it reveals the additional gain or loss resulting from actual investment earnings being higher or lower than expected.

For the source of earnings exhibits, we need three figures:

⇒ the investment yield assumed by the pricing actuary during the future pricing period (this is the assumed earned interest rate), or IY_0.
⇒ the credited interest rate (CR), or the investment yield used in the pricing model.
⇒ the actual investment yield achieved during the period that reserves are held by the company, or IY_t. The actual investment yield includes dividends, interest, and rents, as well as capital gains and losses. The cleanest way to format the source of earnings exhibits is to use market yields and to include both realized and unrealized capital gains and losses (see below).

The interest spread is most important for the long-tailed commercial liability lines of business, such as workers' compensation and general liability. We must estimate the invested funds for the block of business at each point in time (IF_t).[18] Most casualty pricing models estimate the amount of invested funds by projecting premium collection patterns, loss payment patterns, and expense payment patterns.[19]

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[18] Life actuaries use the term "account balance" instead of invested funds. In life insurance and annuities, the funds paid by the policyholder belong to the policyholder and may be withdrawn on demand, sometimes with a surrender charge deducted. In casualty products, the funds paid by the policyholder do not legally belong to the policyholder. We use the term invested funds (instead of account balance) to refer to the financial assets used to fund the unearned premium reserves and the loss reserves.

[19] See Ira Robbin. "The Underwriting Profit Provision," CAS Examination Study Note, 1992, pricing algorithm 7; S. Feldblum, "Pricing Insurance Policies: The Internal Rate of Return Model," Second Edition (Casualty Actuarial Society Part 10A Examination Study Note, May 1992); and Howard C. Mahler, "The Myers-Cohn Profit Model: A Practical Application," *PCAS* Vol 85 (1998), pages 689-774.

The source of earnings analysis quantifies the implicit profit margin in the investment yield assumptions and the subsequent unfolding of the actual profit margin. *Each year's* implicit profit margin in the interest rate assumption equals

> *the invested funds times the difference between the future expected investment yield and the investment yield used in pricing, or* $IF_t(IY_0\text{-}CR)$.

The implicit profit margin in the investment yield assumption is the discounted summation of the annual profit margins.[20]

For example, suppose we are performing a source of earnings analysis on a $10 million cohort of workers' compensation business, with average invested funds of $3 million during the policy year, $4 million the next year, and reducing by $1 million a year until all losses are settled.[21] The company expects an investment yield of 8% per annum, and it prices the business assuming an investment yield of 7% per annum, along with a 12% cost of capital to price the business.[22] The implicit profit margin in the investment yield assumption is shown below. The present values are taken to the middle of the initial policy year (year 0).

Table 4: Source of Earnings Analysis for Interest Spread at Policy Inception

Year	Invested Funds	Expected Invest Yield	Credited Interest Rate	Interest Rate Spread	Interest Rate Margin	PV of Margin
0	3,000,000	8%	7%	0.01%	30,000	30,000.00
1	4,000,000	8%	7%	0.01%	40,000	35,714.29
2	3,000,000	8%	7%	0.01%	30,000	23,915.82
3	2,000,000	8%	7%	0.01%	20,000	14,235.60
4	1,000,000	8%	7%	0.01%	10,000	6,355.18
Total						110,220.89

Between initial policy pricing and final settlement of claims, several items may change.

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[20] This formula makes the simplifying assumption that IY_0 is the pricing assumption for all future years; that is, the actuary assumes a constant future investment yield.

[21] This progression of the invested funds reflects a policy year exhibit of casualty insurance contracts. With a pre-paid acquisition expense ratio of 20%, a net premium of $8 million paid in up-front on some policies and with premium payment plans on others, and some losses paid out during the first policy year, the average invested funds are about $3 million. The invested funds generally peak about 12 months after inception of the policy year. During the 12 months following the policy year, the remaining premium is paid in and then the invested funds decline to zero as losses are settled.

[22] The cost of capital is the target return on capital. To keep the arithmetic simple, we ignore federal income taxes in this paper. In practice, one can not run source of earnings exhibits for interest earnings without consideration of federal income taxes, since different investments have different tax rates. For prospective policy pricing, one can avoid this problem by using equivalent risk-free portfolios; see Myers and Cohn [1987, op cit.]. The process error in the source of earnings analysis focuses on the defaults and market value changes of risky investments; the assumption of equivalent risk-free portfolios misses much of the analysis.

1. The actual investment yield may differ from the original assumption, since interest rates shift from year to year.
2. The amount of invested funds may differ from the initial assumption.
3. There may be unexpected capital gains or losses.

The new entries in the source of earnings exhibits are a mix of actual figures and revised estimates. For instance, suppose that investment yields rise to 10% per annum during the initial policy year. Year 0 may show 9.5% as the actual average investment yield, and years 1 through 4 may show 10% as the revised estimated investment yield. Based on the actual premium payment plans taken during the policy year, the estimated invested funds may change for all years. Capital gains and losses generally reflect the actual market value changes of securities.

Table 5: Source of Earnings Analysis for Interest Spread after One Year

	Invested	Investment	Credited	Interest	Interest	Capital	PV of
Year	Funds	Yield	Interest	Spread	Margin	Gain/Loss	Margin
0	$2,500,000	9.5%	7%	2.5%	$62,500	-$50,000	$12,500.00
1	$3,500,000	10%	7%	3.0%	$105,000	$0	$93,750.00
2	$3,000,000	10%	7%	3.0%	$90,000	$0	$71,747.45
3	$2,000,000	10%	7%	3.0%	$60,000	$0	$42,706.81
4	$1,000,000	10%	7%	3.0%	$30,000	$0	$19,065.54
Total							$239,769.81

The source of earnings exhibit at the end of the first policy year provides the profitability information that is critical for proper performance measurement and pricing decisions. Investment yields have increased from 8% from the rate review date to 10% by the end of the policy year. Since most of the increase occurred before assets were bought, the capital loss is small but future increases in coupon payments are large.

Inflation Rates and Interest Rates

The full effects of interest rate changes require a combined analysis of assets and liabilities.[23] If inflation rates rise concomitant with the interest rate rise, the loss severity factor will show corresponding increases. The actual loss ratio for the block of business will exceed the target loss ratio, but this loss will be offset by the rise in the investment yield.[24] Traditional profitability measures of loss ratios and combined ratios can be

[23] For traditional source of earnings analysis applied to life insurance policies and annuity contracts, this statement is obvious. It is only on the property-casualty side that pricing actuaries focus on the liability side. This practice may be appropriate for prospective rating methods that use static procedures. It is misleading for source of earnings exhibits for long-tailed lines of business, whose very purpose is to monitor variances from the pricing assumptions.

[24] Cf Robert P. Butsic, "The Effect of Inflation on Losses and Premiums for Property-Liability Insurers," in *Inflation Implications for Property-Casualty Insurance* (Casualty Actuarial Society 1981 Discussion Paper

misleading. Even the statutory measures of total profitability, such as the investment income allocation procedure in the NAIC's Insurance Expense Exhibit, use portfolio investment yields and may be distorted.

Generally, inflation rates and interest rates do not move in lock-step. The source of earnings exhibits provide a year-by-year analysis of the relative gains and losses from inflation and interest, allowing clearer analysis of the product's contribution to the company's performance.

For instance, if there is a general rise in interest rates and inflation rates (not necessarily equal), the actual loss severity change will be larger than expected, leading to a negative profit variance. The actual investment income will be larger than expected as well, leading to a positive profit variance. The net profit variance shows the combined effects of the changes in the interest and inflation rates. This is particularly important for retrospectively rated workers' compensation policies, since inflation has a leveraged effect on non-ratable losses.

Persistency

For the source of earnings analyses required by SFAS 97 for universal life-type policies, persistency is often the most important earnings factor. This makes sense. The source of earnings factors are mortality, maintenance expenses, interest, and persistency. Mortality rates for standard lives are based on fully credible tables, and the rates change slowly from year to year. Maintenance expense costs are relatively low and stable. Interest earnings come from the spread between earned rates and credited rates. Although the earned rates vary significantly from year to year, many companies try to keep the spreads relatively stable.

Persistency rates can only be roughly estimated by the pricing actuary. Variances of estimated from expected are large, and these variances have strong effects on lifetime profitability of the book of business; see the Tan and Eckman papers referenced above.

Similarly, persistency patterns have a large effect on property-casualty insurance profitability, particularly for direct writers. Admittedly, the effects are not as strong as in permanent life insurance, where first year commission rates may exceed the annual premium. Moreover, in private passenger automobile, the loss factors—such as loss development and loss trend—have larger effects than the corresponding life insurance mortality factors. Nevertheless, persistency is significant, and it should be included in the source of earnings analysis.

Ideally, persistency patterns should be incorporated in the ratemaking process for lines of business with high retention rates and differences between first year and subsequent year loss or expense costs by means of asset share pricing models. The source of

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Program), pages 51-102.

earnings analysis based on an asset share pricing model evaluates the present value of the lifetime profits from a cohort of policies.

For example, if the historical experience used to set the rates has a 90% average persistency rate, and the persistency rate drops to 80% for future business written by the company, the company will show a decline in profitability. The apparent reasons will be higher than expected loss costs and higher than expected expense costs. In truth, expense costs may not have changed and loss costs may be consistent with loss severity indices. Moreover, the full cost of the decline in the persistency rate will not show up until all the old business drops off the company books.

In practice, traditional ratemaking procedures often fail to consider persistency effects. This makes the source of earnings analysis all the more necessary to tease apart the underlying sources of profit or loss.

We illustrate one method in this paper for dealing with the amortization of acquisition expense costs. Traditional property-casualty ratemaking methods combine acquisition expenses with on-going maintenance expenses and treat the sum as either an additive or a multiplicative factor applied to loss costs. This obscures more than it illuminates, and it is not clear why casualty actuaries use these methods.[25] In the illustration here for workers' compensation retrospectively rated business, acquisition costs and solicitation costs on not-taken business are treated separately and amortized over the expected lifetimes of the insurance contracts.

Section IV: Retrospectively Rated Policies

Source of earnings analysis is particularly relevant for retrospectively rated workers' compensation policies. For these policies, the traditional property-casualty accounting framework has severe limitations, which hamper both profitability monitoring and actuarial ratemaking. In this section we apply GAAP (SFAS 97) treatment of universal life-type policies to the corresponding property-casualty policies.

Ideally, actuarial pricing should reflect the underlying economics of the insurance product. Consider first private passenger automobile contracts. In both statutory and GAAP financial statements, earned premium is a revenue, and incurred losses are an expenditure. This is meaningful for profitability monitoring and for ratemaking, since additional earned premium for a block of business signals additional profits and additional incurred losses for a block of business signals decreased profits. Thus, the pricing actuary sets the premium rate (the revenues) based on estimates of the ultimate losses and expenses (the expenditures).

[25] This treatment is peculiar to casualty actuarial practice. Life actuaries treat acquisition costs and maintenance expenses separately. The reason for the difference is a combination of accounting practice and inertia. Note that casualty companies do not amortize deferred acquisition costs over more than one year.

For retrospectively rated policies, additional incurred losses generally lead to additional retrospective premiums, with the net effect depending on the premium sensitivity.[26] A change in losses or in premiums does not by itself signal higher or lower profitability.

Accounting for universal life-type policies reflects the economics of these contracts. When the policyholder pays premiums, the monies belong to the policyholders, not to the life insurance company. The insurance company acts as a mutual fund, investing the policyholder's money and deducting a management fee as well as specified charges for insurance services. In GAAP statements for universal life-type contracts, premiums are a deposit, not a revenue.

One may conceive of the workers' compensation retrospectively rated policy in the same fashion. When the insured pays premiums, the insurance company holds the money to pay losses and to cover the various charges, such as the insurance charge and the basic premium charge. If the losses do not materialize, the insurer returns part of the premium to the insured. If additional losses occur, the insurer collects additional premium from the insured.[27]

In sum, generally accepted accounting principles follow the nature of the contracts. For traditional policies (SFAS 60), premiums are revenues and benefits are expenditures. For universal life-type policies (SFAS 97), revenues are the policy charges plus the investment income earned on the account value. Expenditures are benefit payments in excess of the account value, interest credited to the account value, and expenses paid.

The source of earnings analysis in SFAS 97 highlights the causes of gain or loss during the lifetime of a block of business, allowing actuaries to revise the factors used in policy pricing to accord with emerging experience. We demonstrate below how to apply this source of earnings analysis to retrospectively rated workers' compensation policies.

Retro Policies vs Universal Life

The source of earnings analysis for workers' compensation retrospectively rated policies has two major differences from the corresponding analysis for universal life-type policies.

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[26] See Michael T. S. Teng and Miriam Perkins, "Estimating the Premium Asset on Retrospectively Rated Policies" *Proceedings of the Casualty Actuarial Society*, Volume 83 (1996), pages 611-647, and discussion by S. Feldblum, *Proceedings of the Casualty Actuarial Society*, Volume 84 (1997).

[27] The various charges in a universal life-type policy, such as the mortality charge, the asset management charge, the surrender charge, and the expense charge, are often clearly noted in the policy, particularly if the asset accumulation rate is tied to external investment indices. For the retrospectively rated workers' compensation policy, the pricing actuary sees the individual charges, but the insured may not be aware of the specific components. In addition, because casualty actuaries often avoid an explicit treatment of investment earnings, the investment income earnings factor, as well as the implicit asset management charge, may be nebulous even to the pricing actuary.

1. The *insurance charge* takes the place of the *mortality charge*, and *non-ratable losses* takes the place of *policyholder benefits in excess of the account value.*

2. The SFAS 97 amortization of deferred acquisition costs in relation to expected gross profits, with the year-by-year unlocking of assumptions as actual experience emerges, is complex. It may be justified for universal life policies, where the deferred acquisition costs are 50-60% of the total gross profits for many companies.

   For retrospectively rated policies, a simpler amortization procedure is sufficient. However, the amortization schedule should be dynamic, so that the effects of retention rates (i.e., lapse rates) on profits can be monitored.

Evaluation of Results

Pricing for retrospectively rated policies depends on the evaluation of four earnings factors: (a) investment income, (b) non-ratable losses, (c) expense levels, and (d) retention rates.[28]

Standard reports of premiums and losses do *not* show the expected profits on retrospectively rated policies stemming from these earnings factors. Even more important: they do not show the variations in profit caused by changes in each of these four elements. The pricing actuary has trouble seeing if the ratemaking assumptions reflect the future experience on the book of business. This is the crux of the problem that source of earnings analysis rectifies.

If profits are unexpectedly low, we do not know if the cause is (i) higher than anticipated non-ratable losses relative to the insurance charge, (ii) lower than expected investment income relative to the assumptions used in pricing, (iii) excessive expenses, or (iv) higher than anticipated lapse rates or higher than anticipated not-taken rates. This is particularly important for large account retrospectively rated policies, since the profit margins are narrow and variances in any of these factors have significant effects.

Amortization of Deferred Acquisition Costs

The amortization of deferred policy acquisition costs is essential for monitoring universal life profitability for two reasons:

- Deferred acquisition costs are as much as 50% - 60% of gross profits for many

[28] Classical actuarial ratemaking procedures focus on the relationship between the insurance charge and the non-ratable losses. This reflects the history of the Casualty Actuarial Society, whose founding fathers were immersed in the theory of retrospective rating. Even today, casualty actuarial candidates spend months learning the intricacies of Table M construction, one of the relics of early 20th century research, and relatively little time on the marketing, financial, and competitive forces that drive the pricing of insurance policies.

universal life contracts.[29] Generally, these products show large losses in the first one or two policy years. Agents' commissions are high in the initial policy year and sometimes also in the first renewal year. Invested assets from policyholder funds are often zero in the initial policy year and low in the first renewal year.

- Retention rates have great effect on long-term profitability. Statutory accounting, however, distorts the effects, since only the surrender charge (a gain) is shown for the current calendar year. Dynamic amortization of deferred policy acquisition costs reveals the actual effects of retention rates on long-term profitability.

The capitalization and amortization of initial acquisition and issue costs is equally important for the analysis of retrospectively rated policies: First year agents' compensation, initial underwriting costs, loss inspection expenses, and policy issue costs form the bulk of many companies' expenditures for retrospectively rated policies.[30]

For large account retrospectively rated business, "not taken" rates can be high. There are a limited number of large workers' compensation accounts in the country. (The "national accounts" workers' compensation business used as the illustration here are risks with annual premiums in excess of one or two million dollars; the exact cut-off varies.) Each account has a risk manager, who puts the account out to bid to the major workers' compensation carriers every five years or so. Each bid from a competing carrier may have only a 10%-20% chance of being accepted, leading to an 80%-90% not taken rate on this business. The costs of developing the bids often are high.

The costs of "not taken" policies must be included with the acquisition costs of a block of business. Some companies spread these costs over related books of business, thereby artificially lowering the profitability of the related books and raising the perceived profitability of the book being priced. For instance, some companies spread the costs of not taken business over the entire workers' compensation line of business.[31]

To properly price this business and to monitor its profitability, the high acquisition expense costs—*including the cost of "not taken" policies—must be amortized over the* policy lifetimes. It is easy (and tempting) to overestimate persistency rates and to

[29]"Gross profits" are the present value of lifetime profits from the block of business before consideration (including amortization) of prepaid acquisition costs; see SFAS 97.

[30]This is especially true for direct writing companies, which pay large first year commissions and low renewal commissions. The illustrations in this paper assume direct writing of workers' compensation and of personal automobile insurance.

[31] This leads to incorrect pricing and marketing decisions. Sometimes there are valid reasons for this practice, as when a new carrier seeks to break into the large account market. More often this practice stems from the pricing actuary's inability to allocate acquisition costs. Among non-actuaries, one sometimes hears the view that solicitation costs for not taken business should be spread evenly over the company's entire business. Actuarial ratemaking requires that these solicitation costs be charged to the block of business under review; see S. Feldblum, "Personal Auto Premiums: An Asset Share Pricing Approach," *PCAS* 1996.

underestimate not taken rates. Source of earnings analysis with dynamic amortization of policy acquisition costs is an effective tool for more accurately pricing this business.

Static vs Dynamic Amortization

Static amortization schedules, like static depreciation schedules, do not change with the passage of time. The rate of amortization or depreciation may vary from year to year, as with double declining balance depreciation schedules, but the amortization rate is not re-estimated as more information is learned about the business.

For instance, if the average policy in a given cohort is expected to persist five years, then one fifth of a policy's deferred policy acquisition costs are amortized each year (assuming a zero interest rate for amortization). If after two years of experience with this cohort of business, the average policy's lifetime is expected to be different from five years, the amortization schedule is not changed.

Static amortization schedules give distorted measures of profitability if the actual persistency rate or the actual investment yield differs from that assumed during pricing. Dynamic amortization allow for revision of the schedules as actual experience becomes known and as future expectations change.[32]

For example, suppose the actuary prices the business assuming that the excess of first year over renewal acquisition costs is 20% of premium, the average policy lifetime is 8 years, that the not taken rate is 20% for this block of business, and that the solicitation costs for not taken business equals 50% of the excess first year acquisition costs for insured business.[33] For simplicity, we assume an amortization interest rate of 0%.[34]

Amortizing the excess first year acquisition costs plus the solicitation costs for not taken business gives a charge of 2.8% of premium each year. These assumptions are uncertain, though they become known with the passage of time. The not taken rates and the solicitation costs for not taken business are known after the new policies are written, and the average policy lifetime can be estimated more accurately two or three

[32] For the universal life-type policies covered by SFAS 97, the deferred policy acquisition costs are amortized in proportion to future expected gross profits. The amortization schedule must be revised whenever actual experience or future expectations differ from initial assumptions for any of three items: persistency rates, investment yield, and expected or actual gross profits. The amortization of deferred policy acquisition costs in relation to expected gross profits is a complex subject in its own right, and it is not dealt with in this paper.

[33] The not taken rate is the percentage of new business contract discussions that are not consummated by a policy. The figures here are overly optimistic. An average policy lifetime of 9 years means a retention rate of about 89%. Of every 100 policies, 89 are renewals and 11 are new business. With a not taken rate of 20%, there are slightly over 2 contract discussions per 100 insureds that do not result in a policy. In practice, the competition for large account business is intense. For each 10 new policies acquired, the insurer might solicit 30 or 40 accounts.

[34] Using the actual investment yield in the amortization schedule obscures the arithmetic and does not change the conclusion.

years after the expiration of the initial policy year (by projecting from early retention rates).

If estimates are not validated, there is often a temptation to estimate optimistically. Suppose that these figures are revised after the new policies are written, for an average policy lifetime of 5 years and a not taken rate of 60%. The annual acquisition cost charge is revised to

Table 6: Solicitation Costs for Not Taken Business

	Assumptions	
	Initial	*Revised*
A. Premium	$100 million	$100 million
B. Excess acquisition costs	$20 million	$20 million
C. Not taken rate	20%	60%
D. Not taken premium [= A * C/(1-C)]	$25 million	$150 million
E. Not taken acquisition costs	$2.50 million	$15 million
F. Total acquisition costs	$22.5 million	$35 million
G. Average policy lifetime	8 years	5 years
H. Annual amortization	$2.81 million	$7.00 million

Retention rates are essential for monitoring the profitability of workers' compensation retrospectively rated policies. Not only are renewal expense costs much lower than first year expense costs, but renewal loss costs are also lower than first year loss costs. Dynamic amortization of deferred acquisition costs enables the pricing actuary to see the effects of retention rates on long-term profitability.

Supporting Surplus

For universal life policies, source of earnings exhibits do not normally consider invested capital. Before the advent of risk-based capital requirements, this approach was reasonable, at least for GAAP statements. Policy reserves often did not significantly exceed the account balance, deferred policy acquisition costs were amortized, and little surplus was needed to satisfy regulatory requirements. In sum, the capital invested in the block of business was small relative to the funds supplied by policyholders.

For workers' compensation, the opposite is true. Substantial amounts of investors' capital is embedded in the undiscounted loss reserves and in the gross unearned premium reserves. Additional capital is needed to meet the NAIC's risk-based capital requirements or rating agency capital formulas.

Both the explicit and the implicit capital contributions should be considered when initially pricing the block of business. At times, some capital contributions are overlooked, either because the pricing model is faulty or because the actuary is not aware of the

implied equity flows. The source of earnings analysis includes the actual investment income as one source of gain or loss. This investment income applies to both the policyholder supplied funds and to the capital funds.[35]

In addition to the standard life insurance source of earnings exhibits, the allocated surplus amounts and the target returns should be shown on an aggregate basis, so that the source of earnings analysis can be converted to a return on capital basis. This format highlights the variance between expected and actual return on capital, along with the factors that contributed to this variance.[36]

Charged, Expected, and Actual

For the private passenger automobile source of earnings analysis, we showed three stages for the loss severity trend factors:

1. initial (estimated) trend
2. revised (actual) trend
3. actual loss cost change

The change from estimated trend to actual trend is estimation error; the change from actual trend to actual loss cost change is process error. The same three level analysis applies to loss development factors and loss frequency trends, as well as to other components of insurance ratemaking.

Workers' compensation retrospectively rated business loss component differs in two respects.

A. It is difficult to judge the accuracy of our estimates even after the completion of the policy year. For instance, the insurance charge is based on Table M entry ratios and size of loss distributions, as well as standard trend estimates. The policy year experience tells us the actual non-ratable losses; it does not tell us much about the proper insurance charge.
B. There is an explicit charge for the insurance protection in the rate. For private

[35] At a minimum, the cost of the capital funds is the double taxation on these funds; see Myers and Cohn [1987, op cit.]. Some actuaries assume that there are additional costs of holding capital funds, such as the differential earnings rate resulting from the conservatism in many financial portfolios; see R. W. Sturgis "Actuarial Valuation of Property/Casualty Insurance Companies," *Proceedings of the Casualty Actuarial Society*, Volume 68 (1981), pages 146-159 as well as Miccolis's comments in "An Investigation of Methods, Assumptions, and Risk Modeling for the Valuation of Property/Casualty Insurance Companies," *Financial Analysis of Insurance Companies* (CAS 1987 Discussion Paper Program), pages 281-321.

[36] The determination of the needed capital by line of business and of the returns on this capital from the insurer's various operations are discussed in Douglas M. Hodes, Sholom Feldblum, and Gary Blumsohn, "Workers' Compensation Reserve Uncertainty," *Proceedings of the CAS*, Volume 86 (1999), and Douglas M. Hodes, Sholom Feldblum, and Antoine Neghaiwi, "The Financial Modeling of Property-Casualty Insurance Companies," *North American Actuarial Journal*, Volume 3, Number 3 (July 1999), pages 41-69. respectively.

passenger automobile, we set premiums. For retrospectively rated policies, we set charges.

Accordingly, the source of earnings exhibits reflect the ratemaking procedure. For each "earnings source" in the reporting and evaluation structure, there are three values:

1. the amount charged in the pricing analysis,
2. the expected amount at policy inception, and
3. the actual (realized) amount.[37]

Suppose that a policy is issued on January 1, 2001, with an insurance charge (including the excess loss charge) of $500,000, and with expected non-ratable losses of $450,000.[38] At policy inception, the initial report would show

Table 7A: Workers' Compensation Charged, Expected, Actual

Date	Insurance Charge	Expected Non-ratable losses	Expected Gain	Actual Non-ratable losses	Variance	Actual Gain
1/2001	$500,000	$450,000	+$50,000	---	---	---

Suppose that on December 31, 2001, at the expiration of the policy, the estimated non-ratable losses (including all actuarial bulk reserves) is $470,000. The "variance" is –$20,000, and the "actual gain" is +$30,000. The report would show the following entries for 12/2001:

[37] This structure is analogous to the source of earnings structure for universal life-type policies. For example, non-ratable losses in retrospectively rated policies (that is, the losses which are paid by the insurer and are not reimbursed by the employer), are the analogue of "benefits in excess of account value released" in universal life policies. The insurance charge (including the excess loss charge) in retrospectively rated policies is the analogue of the mortality charge in universal life policies.

[38] The insurance charge, along with the excess loss charge, is amount actually used in pricing the policy. Some actuaries use an insurance charge equal to the expected non-ratable losses, and they include a separate (explicit) profit provision. Other actuaries use conservative factors for the insurance charge and the excess loss charge. The charges in the plan minus the expected non-ratable losses is an implicit profit margin in this earnings factor.

Both methods are common in the property-casualty insurance industry. Life insurance pricing generally uses the latter method, with implicit profit provisions in the mortality and interest factors, and sometimes also in the expense and withdrawal factors. That is, life insurance pricing uses conservative mortality tables as well as a spread between the earned interest rate and the credited interest rate.

We adopt the latter pricing model for the exhibits in this paper. A company that uses the former pricing model, with no "spreads" in the pricing components but with an explicit profit margin, would show zeroes in the initial profit for each source. This does not affect the analysis of gain and loss by source.

In the exhibits, we show all profit margins, gains, and losses as dollar amounts. In pricing the policies, many of these items – such as the insurance charge – are shown as percentages of standard earned premium. This does not affect the analysis in the paper.

Table 7B: Workers' Compensation Charged, Expected, Actual

Date	Insurance Charge	Expected Non-ratable losses	Expected Gain	Actual Non-ratable losses	Variance	Actual Gain
12/2001	$500,000	$450,000	+$50,000	$470,000	–$20,000	+$30,000

The source of earnings exhibits allow the actuary to evaluate the accuracy of the pricing components, providing a better assessment of the pricing procedure. The perception of profitability at expiration of the policy year influences future rates. Multi-year source of earnings exhibits illustrate the effects of claim development, investment yield changes, and persistency changes on the profitability of the book of business. For instance, if actual non-ratable losses increase to $515,000 by December 31, 2002, the report would show

Table 7C: Workers' Compensation Charged, Expected, Actual

Date	Insurance Charge	Expected Non-ratable losses	Expected Gain	Actual Non-ratable losses	Variance	Actual Gain
1/2001	$500,000	$450,000	+$50,000	---	---	---
12/2001	$500,000	$450,000	+$50,000	$470,000	–$20,000	+$30,000
⋮	⋮	⋮	⋮	⋮	⋮	⋮
12/2002	$500,000	$500,000	+$50,000	$515,000	–$65,000	–$15,000

The illustration above assumes that the non—ratable losses expected when initially pricing the policy are less than the insurance charge. In practice, various relationships may be used. The discussions above of the loss severity trend factor and the investment earnings factor imply that

1. when explicit profit margins are used, the initial variance between the expected amount and the factor used in pricing is zero, and
2. when implicit profit margins are used, the expected amount is less than the factor used in pricing.

Insurance Charge

The situation is more complex with the insurance charge. The insurance charge is stated in nominal dollar terms, not in present value terms. A zero dollar initial variance is actually an implied profit margin, since the insurance charge is collected before the excess losses are paid. Retrospectively rated policies can be priced in one of several ways:

1. Present values of losses may be used for determining the insurance charge. Although this method may seem natural, it is not commonly used, since the maximum and minimum premiums are in nominal dollar terms.
2. Ultimate values of losses are used, but the insurance charge is reduced for the expected investment income on the excess losses. This is the method implicitly used in some bureau plans. The insurance charge is stated as a percentage of standard premium, which may have a profit factor that takes into account expected investment income. The resultant insurance charge may be less than the expected (nominal) excess losses. The implicit assumptions are that (a) the profit margin in the standard premium truly takes into account all investment income and (b) the loss payment pattern for excess losses has an average payment date similar to that for all losses. Both assumptions are dubious; in particular, excess losses have slower payment patterns, leading to implicit profit margins in the insurance charge.
3. The insurance charge is based on ultimate losses, and a separate investment income factor is calculated based on all insurance cash flows (both ratable and non—ratable losses), which reduces the basic premium charge.[39]

For simplicity, this example assumes a single policy written on January 1, 2001. Actual reports would be for blocks of policies, such as all large account business written by a particular sales office in policy year 2001. Since non-ratable losses have great random fluctuation, a report showing variances is meaningful only on a block of business basis. The subsequent examples are for a block of policy year 2001 business.

Expenses

Expenses are divided into two components:

1. Underwriting and acquisition expenses, including solicitation costs for not-taken business
2. Policy maintenance expenses, including loss adjustment expenses

The effects of acquisition and underwriting expenses on profitability depends on expected versus actual not taken rates and renewal rates. To reflect traditional source of earnings analysis, we group these under the "persistency" factor. The effects of other expenses on profitability depends on the efficiency of company operations and of loss department procedures as well as on the litigiousness of the claim filing population.

Combining the Earnings Factors

[39] There are endless variations in pricing retrospectively rated policies. For instance, when pricing wide swing plans for large accounts that wish to avoid paying expense fees to the insurance company, the insurer may use ultimate losses to calculate the insurance charge, add a large loss conversion factor, and have no other expense charges. Pricing practices that are intended to conceal the actuary's expectations hamper source of earnings analyses as well.

The complete source of earnings exhibits show the variances by earnings factor. The first row in the table shows the contribution to profitability from each factor in the pricing assumptions. Subsequent rows show the variance resulting from actual data and revised estimates. (The term "variance" is used here in the accounting sense, meaning the difference between expected and actual.)

Table 8: SOE Analysis for Retro Policies ($000)

Valuation Date	Non-ratable Losses	Interest Earned	Persistency	Maintenance Expenses	Explicit Profit	Total Profit
1/1/2001	$2,000	$2,500	-$1,500	$750	$1,250	$5,000
12/31/2001	$1,400	$3,400	-$2,500	$750	$1,100	$4,150
12/31/2002	$2,100	$3,600	-$2,900	$750	$1,100	$4,650

Pricing Assumptions

At January 1, 2001, the inception of the policy year, the figures show the (implicit and explicit) profits margin embedded in the pricing assumptions. Most of the expected profit is built into the pricing components. The pricing actuary has set insurance charges that exceed the expected non-ratable losses by $2 million. In addition, the company expects about a one year float on insurance funds (between premium collection and loss payment) for which the policyholders are not given full credit. Specifically, the actual investment income is expected to exceed the investment income assumed in pricing by $2,500,000.

The company expects actual maintenance expenses (including loss adjustment expenses) to be $750,000 below the amount assumed in pricing. In addition, the company builds in an explicit profit component of $1,250,000 for this book of business.[40]

The company expects to lose money from high solicitation costs on not taken business. Much of this money is recouped from acquisition expense charges in the basic premium. The amount that is not recouped is a negative implicit profit margin of $1,500,000. It is hard to persuade policyholders that they should reimburse the costs of soliciting other business, so it is difficult to explicitly charge for this cost in the premium.

Underwriting

The first row shows the pricing assumptions at the beginning of the policy year. Rarely are all pricing assumptions realized in the policies actually sold. The second row shows

[40] The company wishes to show the low profit margin to policyholders, not the full implicit plus explicit profit margin. For many books of large account business, the explicit profit margin is zero. The company shows the policyholder a pricing analysis with no apparent profit. The company expects to earn profits on the book of business from the conservative pricing assumptions. Some companies even show negative profit margins to their consumers, at times even professing that they are losing money simply to retain a valued account.

the revised earnings factors at the end of the policy year. The variances from initially expected profits stem from two causes: (a) the charges actually embedded in the policy components may differ from those originally anticipated by the actuary and (b) fluctuations in losses or shifts in the financial environment may affect the costs actually incurred by the company.

The changes from underwriting are as follows. Interest rates have risen and the marketplace has softened, but the company underwriters have adhered closely to the actuarial pricing recommendations. The rising interest rates led to a revised estimate of excess losses, since an anticipated rise in inflation has a leveraged effect on higher layers of loss. This reduces the implicit profit from non-ratable losses by $600,000. A few insureds were given premium credits, reducing the explicit profit margin by $150,000. Because of the soft market, not-taken rates increased, leading to a additional $1 million loss from unfulfilled solicitation costs. Interest rates rose before the company received the policy premiums or invested them, leading to an additional $900,000 implicit profit from the interest spread.[41]

Much of the first year revisions stem from underwriting changes in the policy proposal. Thus, revisions in the profit from non-ratable losses stem from changes in the insurance charge in the policy, and revisions in the profit from acquisition expenses stem from unexpected not taken rates.

Actual Experience

Subsequent revisions stem primarily from unanticipated changes in the financial environment, the insurance marketplace, or from random loss occurrences. For instance, the 12/31/2002 row shows an increase in the expected profits from non-ratable losses. By December 31, 2002, all policies have run their course, and there have been fewer large losses than expected. This may be a result of stringent underwriting or of random loss fluctuations.[42]

The December 31, 2002, figures are actual figures in part and estimates in part. For instance, the investment yield in 2001 and 2002 is known; the effect of acquisition costs on policy profitability still depends on future persistency rates.

The source of earnings exhibits are updated until most of the losses have been settled or until subsequent changes in estimated earnings are not material. For the first few years, the changes can be significant, particularly for earnings from non-ratable losses, interest, and persistency.

[41] The pricing actuary must take care to reflect the higher interest rate, and the potentially higher inflation rates, in the insurance charge. If this is not done, the implicit profit margin from non-ratable losses may be overstated.

[42] Most years show somewhat fewer large losses than average; a few years show significantly more large losses than average. The skewed distribution of claim sizes leads to source of earnings gains or losses on different books of business.

Non-ratable losses: Projection of ultimate losses has always been the actuary's task. When pricing retrospectively rated contracts, however, some actuaries rely on published industry figures, as contained in Table M data from rating bureaus. Individual company data are sometimes considered insufficiently credible for revising Table M figures, and the needed adjustments for inflation and for changes in the size of loss distribution are considered complex. In fact, Table M charges should be reviewed periodically to ensure their adequacy. The source of earnings analysis provides a hindsight view of insurance charge adequacy that can be invaluable for the pricing actuary. The challenge for the pricing actuary is to determine from the emerging experience how much of the variance stems from estimation error and how much stems from process error.

Interest: The earnings from interest on retrospectively rated contracts depend on several factors: the investment yield actually received, the investment yield used to price the policy, the payment dates for losses, and the collection dates for premiums. Large accounts often seek cash flow plans to retain more of the investment income for themselves, and their plans may be individually tailored for the insured. For these large accounts, the pricing actuary may have to determine the expected earnings from interest on a plan by plan basis.

As noted above, some of the expected investment earnings may be incorporated in the insurance charge. For instance, the insurance charge may be expressed as a percentage of standard premium, and the standard premium may be adjusted for expected investment income. The source of earnings analysis follows the pricing analysis; it does not dictate it. However, the pricing actuary should be aware of the implicit profit margins in each earnings factor in order to properly monitor profitability.

Persistency: For large account retrospectively rated business, the solicitation costs for not taken business and the persistency of newly acquired business have large effects on overall profitability.[43] The source of earnings analysis ensures that pricing actuaries incorporate their effects in the ratemaking formulas.

[43] The full effects of interest rate changes and persistency changes take several years to play out. Some pricing actuaries disclaim responsibility for interest rate changes, not taken rates, and persistency rates, since traditional casualty actuarial ratemaking procedures do not deal with these items. The common disclaimer is that "the actual investment yield is the responsibility of the Investment Department; we simply use the projections that they provide us." Similarly one hears that "the actual persistency rate, or the actual not taken rate, is the responsibility of the Marketing Department or of the sales force; we simply use the projections that they provide us." This retort is disingenuous. The source of earnings analysis does not bring investment policy or marketing philosophy under the purview of the actuary. Nevertheless, just as the reserving actuary does not rely solely on the claims department's loss estimates, the pricing actuary can not rely solely on others' estimates for the basic input parameters.

Section V: Conclusions

Two themes run through this paper. One theme underlies the workers' compensation illustration and the other theme underlies the private passenger automobile example. Neither theme is new; both have been expressed in other forms by life actuaries, accountants, and statisticians. When seen from the perspective of source of earnings analysis, however, they imply a major revision of casualty actuarial pricing. We summarize the two themes below and their implications for practicing actuaries.

Pricing Paradigms

A premium-loss pricing paradigm currently dominates casualty actuarial ratemaking. The actuary determines policy premiums to cover expected losses and expenses.

With the policy revolution of the 1980's, life actuaries moved to a credit-charge paradigm. The new interest-sensitive policies were unbundled into various components. The actuary determines explicit charges and credits for the policy components, which may be rearranged into full policies to meet customer needs.

The credit-charge pricing paradigm is extremely flexible, and it is increasingly being used for large account commercial lines ratemaking. The account purchases a customized policy with a variety of specialized components: sublines, deductibles, premium payment plans, retrospective rating, loss engineering services, claims handling services, excess coverage, and so forth.

The actuary prices the components, which are assembled by the underwriter into the policy. For instance, the actuary determines the appropriate insurance charge for a set of plan parameters, or the appropriate interest credit for a given plan type and premium payment pattern. Source of earnings analysis enables the actuary to monitor the adequacy of the charges and credits.

The shift from a premium-loss pricing paradigm to a credit-charge pricing paradigm brought "universal" contracts to the life insurance industry. We may conceive of universal policies as (in effect) retrospectively rated contracts where the premium adjustment depends on the investment yield achieved, not on the loss experience.[44]

By unbundling the policy into its components, the casualty actuary can offer universal policies for lines with long term claim payments, such as workers' compensation. The actuary sets the investment spread; the actual premium for the coverage varies with the investment income realized. Such policies would be particularly attractive to large

[44] There are differences, of course. Universal policies allow more management discretion in setting the credited interest rate; workers' compensation retrospectively rated policies have contractually determined premium adjustments. Universal contracts depends on the insurer's investment yield or on an external interest index; retrospectively rated policies depend on the individual insured's loss experience.

accounts seeking aggressive investment returns. Pricing for unbundled policy components is directly tied to source of earnings analysis.

Random Variations

Actuaries often attribute differences between expected and actual results to random loss fluctuations, to unforeseeable changes in inflation, or to unanticipated market pressures on underwriters and agents. The work pressures on actuaries are so great, and the potential causes of adverse results are so diverse, that many pricing actuaries never examine the variances in past results. In short , some actuaries believe that their time is too valuable to be spent re-examining their past analyses.

In truth, efficient examination of past results is a requisite for accurate prospective pricing. The source of earnings exhibits enable the actuary to quantify the contribution of each earnings factor to overall changes in profitability and to differentiate between estimation errors and process errors within the earnings factors. This "policy post-mortem" may reveal biases in earnings factors or unstable pricing procedures.

Ratemaking is prospective; we price next year's business, not last year's business. The pricing actuary succeeds by peering into the future, not by looking back.

Yet our ratemaking procedures are not infallible. Often our methods are defective and our predictions are erroneous. Ever afraid of looking back, we try to outrun the errors.

We can not outrun our errors. If we never look back, we never know the causes of our errors. We never learn if a variance of actual from expected results from random loss fluctuations or from poor ratemaking assumptions.

Appendix: Implementation Issues

Source of earnings analysis is not a theoretical exercise intended for pure actuaries and academic journals. In life insurance pricing, source of earnings analysis is part of the practicing actuary's repertoire. Similarly, this paper is written for the practicing casualty actuary.

The source of earnings procedures described here are foreign to most casualty actuaries, and they require data that is not always kept by casualty insurers. This latter characteristic is true for many new actuarial procedures.

Imagine a large, multi-line foreign insurer writing long-tailed commercial lines of business. The insurer keeps loss data only by calendar year, and it sets loss reserves by claim adjusters' estimates. The insurer notices that its reserves seem to be perpetually inadequate, and it hires a North American casualty actuary to analyze the problem and to recommend a solution.

The actuary informs the insurer that the required analysis is straightforward and asks to see the company's accident year loss triangles. The company's management is confused; they say that they don't keep accident year data. The actuary requests policy year or report year data, but only calendar year aggregate data are available.

> *Well*, says the actuary, *we must form accident year loss triangles by line of business, as well as by subline, by state, and by type of policy.* The management of the company agrees.

Any practicing actuary can supply the denouement of this tale. The actuary spends months trying to create the necessary triangles, with (ostensibly) full support of the insurer's management, but the efforts come to naught. Revising company data systems is an staggering undertaking. Certain data are simply not available; in some lines of business, the accident date may not even be coded in the electronic claim files. Other bottlenecks are human. No-one has the time or the persistence for this task.

Most reserving actuaries can not conceive of an insurer writing long-tailed lines of business without keeping accurate accident year experience for reserve estimation. Yet the effort to first create an accident year reporting system is enormous. Unless the insurer already appreciates the importance of accident year loss triangles, the insurer is unlikely to expend the effort to create the system.

In the real world, the situation is worse. Practicing actuaries are busy, busier than Alice's White Rabbit. These busy actuaries are forever computing things, crunching numbers, forming endless exhibits. There is never time to review previous work, since current tasks are always pressing.

All too often, the busy actuaries are busily computing numbers which never get used, numbers which do not accurately reflect the values that they purport to measure. The busy actuaries do not realize this, because they are always too busy to evaluate the accuracy of their work.

Time and again, we have looked at the work of some of our colleagues—pricing actuaries, reserving actuaries, and valuation actuaries—and pointed out fundamental errors that negated the value of their efforts. At first there is disbelief, then denial: could it be that months of work were wasted? Eventually comes grudging acceptance, perhaps hastened by the authors' reputations in the actuarial community. Finally the actuaries run off to correct the procedures; they works evenings and weekends to get the project completed on time.

This is the actuary's destiny: the incessant computation of complex exhibits that bewilder the audience and sometimes entrap even the actuary, so that when errors creep in and lead the results astray, no one can distinguish right from wrong.

Source of earnings analysis is crucial to good actuarial work. Source of earnings analysis asks whether the assumptions are borne out by actual results. Some assumptions, like trend factors, development factors, credibility factors, seem trivial. The practicing actuary says: "How can one get these factors wrong?" The practicing actuary shakes his head in disbelief and walks away. But the authors have seen months of highly sophisticated work on trend factors, development factors, and credibility factors that led to erroneous results, unbeknownst to the busy actuaries. Source of earnings analysis enables the practicing actuary to examine the accuracy of the efforts.

Other assumptions are more elusive. The pricing actuary's rate indications rely on investment income assumptions, persistency patterns, acquisition cost assumptions, and loss discount rates. Sometimes the assumptions are explicitly worked into the underwriting profit margin or the underwriting expense ratio; sometimes the assumptions are implicit in the actuary's target loss ratio or target combined ratio. Year after year these assumptions are repeated in the rate reviews. Perhaps the assumptions are supported by extensive "actuarial research," which is all too often a combination of intensive number crunching and sloppy statistics. Rarely—if ever—does the actuary examine the validity of the assumptions.[45]

[45] Sometimes the results are humorous. (i) Casualty actuaries have produced a plethora of financial pricing models, many of which are at odds with financial theory. With no way of checking their validity, rate makers use these models over and over again. (ii) Auto pricing actuaries are among the busiest actuaries there are, churning out rate indications in state after state, repeating the cycle year after year. Yet the incessant churning often misses the true cost drivers of auto insurance losses; see John B. Conners and S. Feldblum, "Personal Automobile Insurance: Cost Drivers, Pricing, and Public Policy," *Proceedings of the CAS*, Volume 85 (1998), pages 370-404.for a re-examination of why costs are higher or lower in different areas. Similarly, source of earnings analysis forces the actuary to rethink the

The practicing actuary may complain that it is difficult to implement the source of earnings analysis for a particular factor, such as the interest earnings factor or the persistency factor. What the actuary is saying is that it is hard to determine whether the factors being used are correct. Let us rephrase this: if it is hard to determine whether the factors are correct, then it is quite possible that the factors are not correct. If the factors are not correct, then not only has the actuary wasted much time computing these factors, but the actuary has wasted even more time performing the analyses that rely on these factors. Source of earnings analysis is not an impediment to productivity; it is crucial to making the busy hours become productive hours.

Data Availability

One of the most common complaints about source of earnings analysis is that the data are not available. This complaint is made about many new techniques, with one difference for source of earnings analysis: the data that are needed for source of earnings analysis are the data that are crucial for policy pricing.

Consider the discussion of workers' compensation retrospectively rated policies in this paper. Almost invariably the pricing actuary says:

> *We don't have the data needed for the analysis of expenses. We don't keep track of our not taken rates, we don't quantify the solicitation costs for the not taken business, we don't separately evaluate the first year acquisition costs, and we don't keep records of policy persistency.*

We wonder: *If you don't know your expenses, how do you price the business?*

The pricing actuary adds:

> *We don't have the data needed for the analysis of the interest factor. We know when the losses are paid, on average, but we don't have a good handle on the premium collection pattern. We have incurred loss retros and paid loss retros, and we have all sorts of premium payment patterns; we don't know when the average premium comes in either for the aggregate book of business or for particular groups of policies. We don't know when the expenses are paid; all we have are IEE aggregate figures by calendar year. We have estimates of new money rates, but we don't know how much we actually earn on a given book of investments. We simply don't have the data to quantify the amount of interest we actually earn.*

We wonder: *If you don't know your interest earnings, how do you price the business?*

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assumptions used in the rate reviews.

The answer to our questions is straightforward: *We price the business as well as we can, using estimates and guesses when we don't have data.*

If an assumption is not material, then it can be ignored in the source of earnings exhibits just as it is treated glibly in the pricing analysis. A good example is maintenance expenses, which we ignored in this paper.

If an assumption is central to the pricing analysis, such as the acquisition expense assumption or the interest earnings assumption, then it can not be ignored in the source of earnings analysis. But it can not be ignored in the original pricing analysis either. The source of earnings analysis tells the actuary the work that must be done. It is amusing to watch pricing actuaries credibility weight loss development link ratios that are computed to three decimal places even while they are oblivious of the acquisition expenses or the interest earnings on their book of business.

Estimation Error and Process Error

For forty years, actuaries have debated the issues of process risk, parameter risk, and specification risk. Some of our readers complain that the risk categorization in the paper is not refined enough. Others complain that one can not easily separate the errors into the categories in the paper.

We do not wish to intrude on this debate. We have discussed these issues in other papers, and there is no gain from repetition here.

But the central idea of the paper bears repeating. Mere identification of the variances of actual from expected is not sufficient. We must determine (as best we can) the cause of the variance. If the cause is process error, such as random loss fluctuations or random stock market movements, then there is little that the actuary can do to avoid the error. But if the error stems from other causes, whether estimation error or "parameter risk" or "specification risk," then the pricing actuary should attempt to correct the errors, minimize the errors, or ensure that they do not repeat themselves.

In sum, we do not try to specify which items are estimation error and which are process error. The pricing actuary performing the rate analysis is better equipped to classify the errors than we are, since the classification depends on the type of rate analysis and the line of business. The objective is as stated above: to separate the errors which stem from random fluctuations from the errors which are attributable (at least in part) to the estimation procedures.

Investment Income

The earnings factor causes problems for many practicing actuaries. The criticism generally takes the following form:

The source of earnings analysis presupposes some sort of investment income assumption in the rate analysis. But that is not how we develop rate indications. We price to a target combined ratio, or a target underwriting profit provision. This target is not chosen by the pricing actuary doing the rate review. It is set by the chief actuary (or by company management) after reviewing the recommendations of the research actuary (or the research department). The research actuary uses an internal rate of return pricing model, or a Myers-Cohn discounted cash flow model, or a Butsic risk-adjusted loss discount model, to determine the target combined ratio. Even in these models, there is no simple interest assumption: we have the internal rate of return, or the Myers-Cohn CAPM adjusted discount rate, or Butsic's risk adjusted rate. Our pricing procedure does not fit into the source of earnings mold.

This criticism is dismaying. It has been twenty years since actuaries first began using financial pricing models for casualty insurance products. The parameters of these models—such as the assumed investment yield, the risk adjustment, the surplus assumptions, the assumed equity flows—greatly affect the final premium rate. Yet many actuaries who are expert in other pricing issues still can't figure out what their pricing model says. They can tell you the effect of a one point increase in the assumed trend factor, but they can't tell you the effect of a one point increase in the assumed discount factor.

Once again, source of earnings analysis is part of the solution. The source of earnings analysis asks two questions:

1. How much investment income does the pricing model assume the company will receive?

2. How much investment income does the company actually receive?

Some pricing models explicitly consider the investment income of the company stemming from the insurance operations; examples are the internal rate of return pricing model. Other pricing models focus on loss discount rates instead of on investment income rates. Examples are the Myers-Cohn discounted cash flow model and Butsic's risk-adjusted loss reserves discount model.[46]

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[46] For summaries of these pricing models, see Myers, Stewart and Richard Cohn, "A Discounted Cash Flow Approach to Property-Liability Insurance Rate Regulation," in J. David Cummins and Scott E. Harrington (eds.), *Fair Rate of Return in Property-Liability Insurance* (Boston: Kluwer*Nijhoff Publishing, 1987), pages 55-78; Butsic, Robert P., "Determining the Proper Interest Rate for Loss Reserve Discounting: An Economic Approach," *Evaluating Insurance Company Liabilities* (CAS 1988 Discussion Paper Program), pages 147-188; Robert P. Butsic and Stuart Lerwick, "An Illustrated Guide to the Use of the Risk-Compensated Discounted Cash Flow Method," *Casualty Actuarial Society Forum* (Spring 1990), pages 303-347; S. Feldblum, "Pricing Insurance Policies: The Internal Rate of Return Model," Second Edition (CAS Part 10A Examination Study Note, May 1992); Ira Robbin, "The Underwriting Profit Provision," *Casualty Actuarial Society Part VI Study Note* (1992).

In fact, both of the latter two models assume investment earnings at a risk-free rate. The risk adjustment to the loss reserves discount rate serves to compensate the insurer for its underwriting risk. In the source of earnings exhibits, the assumed interest earnings are the interest earnings at the current risk-free rate.

Insurance Charges

Retrospectively rated workers' compensation policies seem the ideal candidates for source of earnings analysis, because the actuary sets charges for each component separately. There is a basic premium charge for underwriting expenses, a loss conversion charge for loss adjustment expenses, a tax charge for premium taxes and state assessments, and an insurance charge for the cost of non-ratable losses. The source of earnings exhibits would compare the charges in the policy with the actual costs incurred by the insurer.

Once again, investment income is the problem. Casualty actuaries have generated numerous models for pricing retrospectively rated contracts. Yet the models are built on a nominal loss foundation. The current "Table M" formulas use nominal loss values, not the present values of the losses.

The nominal loss models are used because the loss limits and the premium limitations are expressed in nominal dollars. The rationale for ignoring investment income in the pricing formula is that the insurance charge is a factor applied to the standard premium. The underwriting profit provision in the standard premium takes into account the expected investment income.

This rationale is applicable only when the insurance charge is indeed based on a standard premium, as is true for the NCCI retrospective rating plan. It is not applicable when companies separately combine an insurance charge with other expenses for their large account business.

Even when an NCCI type plan is used, the rationale assumes that the cash flow patterns are the same for prospectively priced business as for retrospectively priced business. This is rarely the case, and the difference can be substantial.

Many large companies judgmentally reduce the final premiums for expected investment income. Alternatively, these companies judgmentally reduce the component charges for expected investment income.

Actuarial Rates and Market Prices

Some readers have commented that the actuarial indications are not the problem. The problem is that the sales force or the underwriters cut the prices below the indications, either to meet peer company competition or to retain valued customers.

The source of earnings analysis explicitly incorporates such price adjustments. Most commonly, a market decision to revise the charged price is shown as an adjustment to the explicit profit provision in the rates. For instance, if the actuary's indications assume a profit, after incorporation of investment income, equal to 8% of premium, and the underwriter grants a 10% premium reduction, then the revised explicit profit provision is a negative 2%.

The standard critique of this source of earnings analysis is that price cutting is not done arbitrarily. The 10% rate reduction may have been offered to retain market share, to keep a customer, or to keep down fixed expense costs. The source of earnings analysis does not tell us if the 10% rate reduction is justified.

It has been emphasized throughout this paper that both pricing and profitability measurement must be done using "lifetime" methods. Ideally, policy pricing is done by asset share analysis that considers deferred policy acquisition costs, changes in loss costs over time, and policy persistency rates. Similarly, source of earnings analysis should incorporate a persistency factor, and it should examine the cohort of policies from original inception.

This does not mean that we can examine policy profitability only after the policies have been in existence for several years. On the contrary: source of earnings analysis enables us to examine long-term profitability reasonably quickly, since we can examine the extent to which original pricing assumptions have been validated by experience.

This is an introductory paper, and we have not attempted to show source of earnings exhibits for a cohort of policies, using assumed and actual persistency rates. These source of earnings exhibits are meaningful only if the pricing analysis explicitly incorporates persistency factors. If the pricing analysis is deficient, then the source of earnings analysis will be deficient as well.

Classification Rates

One reviewer of this paper has commented (paraphrasing):

> *The paper deals with statewide rate indications. But we don't actually price based on the statewide rate indications. We use classification relativities and territorial relativities in private passenger automobile; we use partial pure premiums by classification to develop rates in workers' compensation.*

This is correct. The first draft of our paper included a section on classification ratemaking. We excluded that section because several other actuaries have already dealt with this topic in well-thought out analyses. These actuaries include Glenn Meyers, Roger Hayne, and Howard Mahler.

We do not dismiss the work of these actuaries; their analysis is good, and it complements the source of earnings exhibits. However, source of earnings analysis has value to company management, in addition to its value for the pricing actuary. Company management is concerned with variances from planned results on an aggregate basis, such as line of business or state within line of business; source of earnings analysis deals directly with this issue.

Combined Effects

One reviewer (Ruy Cardoso) commented upon the potential non-linear effects. This is a much debated issue in traditional life insurance source of earnings analysis. We skipped over this issue because of its complexity. We discuss the problem here for those practicing actuaries who seek to implement source of earnings analysis at their companies.

We illustrate the problem with an example. Suppose that the developed and trended losses are $100 million. The source of earnings analysis shows that the loss development factor should have been 10% higher and the loss trend factor should have been 10% higher. A rote application of the procedure discussed in this paper would show a (negative) gain of –$10 million from development and a similar –$10 million from trend. In truth, the total variance is –$21 million, not –$20 million. When there are multiple non-linear factors in the ratemaking formula, the problems becomes more complex.

This problem is a technical one, not a conceptual one. Actuaries use three types of solutions:

1. *Assign the linear component of the variance to the individual factors, and assign the non-linear components to a general "combined" bucket.* This solution is easy, but it is unsatisfying to many actuaries.

2. *Determine the order of application of the ratemaking factors, and determine the variances by the order of application.* At first glance, this solution seems ideal. In truth, this solution is arbitrary, since there is no inherent "order" to the calculations. For example, do we trend the developed losses or do we develop the trended losses? Most actuaries choose the former because that is the order in most elementary ratemaking texts. But the latter is mathematically identical to the former, and it has as much intuitive rationale as the former does. (Cf. C. F. Cook, "Trend and Loss Development Factors," *PCAS*, Volume 57 (1970), pages 1-14.)

3. *Spread the non-linear components over the individual factors on a formula basis.* This method is the most sophisticated, but it is the most complex.

In sum, the mathematics is not as simple as one might infer from the text of this paper.

When the total variance is small, the non-linear components (or the "second order" components) are small enough that they do not affect the study. When the total variance is large, one of the above procedures should be used for the non-linear components.

Loss Drivers

One reviewer, an experienced and astute pricing actuary for private passenger automobile insurance (John Conners) has pointed out several areas where further analysis would be useful. We paraphrase one of this comments below, though Mr Conners wrote this not as a critique but as an additional subject to be treated:

> *You discuss trend for private passenger automobile. Trend factors we can deal with; that's not the problem for the pricing actuary. Our problems lie with loss development and with weather induced losses.*
>
> *Most pricing actuaries use accident year data with incurred loss chain ladder development factors. They rarely supplement their analyses with paid loss development or with examination of frequency and severity. Moreover, they often use countrywide development factors for individual states.*
>
> *Numerous factors affect these results. Estimates of ultimate losses may be distorted by internal company changes, such as changes in case reserving philosophy, as well as by external changes, such as changes in attorney involvement in auto liability claims.*
>
> *Weather related losses are a significant concern for auto pricing actuaries. Changes in weather conditions—a cold winter versus a mild winter—can affect auto liability losses. It is difficult to examine historical data and project future expected losses when weather has a large and sometimes unpredictable effect.*

Mr Conners is correct, though our paraphrase is a bit misleading. Mr Conners did not intend this as a critique of source of earnings analysis, as we pointed out above. He is saying that the traditional private passenger automobile ratemaking techniques are not optimal, since they ignore some important factors that are crucial to estimating rate needs. These problems are not picked up by source of earnings analysis.

We fully agree. Perhaps this is a happenstance of actuarial education. Philipp Stern's seminal paper on private passenger automobile ratemaking has been read and studied by actuarial students for 30 years, and subsequent papers begin with his framework. Stern uses aggregate incurred loss chain ladder development; Stern does not discuss the effects of weather. Had Stern used paid loss development, or had he examined frequency and severity separately, or had he analyzed the effects of weather, our standard private passenger automobile ratemaking techniques might be different.

This is true for all aspects of actuarial practice. We tend to think of our procedures are the "natural" method of determining our results, when in fact they are the arbitrary results of a choice made 50 years ago and never changed. Actuarial students often seek meaning in the different credibility procedures and standards used in different lines of business and areas of practice. Sometimes the only "meaning" is a rating bureau review done half a century ago, whose procedure has been repeated year after year by a continent of actuaries.

Even more surprising are the differences between casualty and life actuarial sciences. Two separate actuarial societies developed separate techniques for analyzing the same problems. Credibility theory was nurtured among casualty actuaries and has only rarely been applied in life actuarial sciences, despite its obvious applications. Similarly, source of earnings analysis developed among life actuaries, and this paper is its first application to casualty lines of business.