Ratemaking for Maximum Profitability

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Abstract

The goal of ratemaking methodologies is to estimate the future expected costs for a book of business. Using past experience, including both internal and external data, the actuary attempts to quantify the required premium level to achieve an acceptable profit.

However, if one looks at the rate activity in a market, it is apparent that company actions do not always follow the indications. Surprisingly, such decisions often lead to successful results. It seems that there must be something going on that is invisible to the naked eye? Do indications really mean so little? Or are there other factors, buried in the actuarial judgment of the experienced actuary but difficult to quantify?

It is the premise of this paper that such factors do indeed exist. One such factor is the effect of the rate change on market behavior. In this paper, we will describe one method for quantifying some of this effect. The methodology described will require much research to determine reasonable assumptions before it can used in practice. It is our hope that it will stimulate further discussion, research, and a move toward acceptance of dynamic economic principles in ratemaking.

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Introduction

The goal of ratemaking methodologies is to estimate the future expected costs for a book of business. Using past experience, including both internal and external data, the actuary attempts to quantify the required premium level to achieve an acceptable profit.

However, if one looks at the rate activity in a market, it is apparent that company actions do not always follow the indications. It is not uncommon for a company to leave rates relatively unchanged even with large indicated increases. To the purist, such action seems illogical.

Even more surprising is the fact that such a decision often leads to successful results. It seems that there must be something going on that is invisible to the naked eye? Do indications really mean so little? Or are there other factors, buried in the actuarial judgment of the experienced actuary but difficult to quantify?

It is the premise of this paper that such factors do indeed exist. The great unknown in current actuarial methodologies is a function of the fact that the future book of business is not necessarily the same as the historical one. To the extent that the nature of the book changes, traditional methodologies are inadequate. They are using outdated data, based on policies that no longer figure in future costs.

For very moderate rate changes, this distortion may be minimal. However, large revisions may cause significant changes in the nature of a company's book. This is logical, because a company does not operate in a vacuum. One company's actions can have an effect on the actions of its competitors, and (perhaps more importantly) will have an effect on the behavior of its own policyholders. Will current customers renew? Will new business levels be affected?

Therefore, one major factor in future results is the effect of the rate change on market behavior. In this paper, we will describe one method for quantifying some of this effect. The methodology described will require much research to determine reasonable assumptions before it can be used in practice. It is our hope that it will stimulate further discussion, research, and a move toward acceptance of dynamic economic principles in ratemaking.

Review of Current Methodology

Every actuary knows the basic steps to developing rate indications. In a loss ratio method, premium is adjusted to current rate level, and trended if the exposure base is inflation-sensitive. Accident year losses are developed to ultimate, trended, and adjusted to reflect catastrophe risk. Credibility of the data is considered, and external data is used if necessary. Loss adjustment expenses are loaded by some method (often being treated the same as losses), and underwriting expenses are reflected. Of course, determination of the profit provision is an important, and often controversial, step. The projected loss ratio is then compared to the target loss ratio to determine the indicated rate level change.

Pure premiums methods use a similar procedure, except that projected indicated average premiums are compared to current average premiums to determine the indicated change.

The traditional methodology contains a number of implicit assumptions. Among them are:

- The future book of business will have essentially the same characteristics as the current (or historical) one.
- Rate changes will have no effect on the actions of other companies in the market.
- The indicated rate level change (if taken) will be equal to the change in premium volume.
- Rate changes will have no effect on the company's retention or ability to write new business.
- The profit provision can be determined academically, rather than being dictated by the market.

The assumption concerning profit provisions deserves further comment. The idea of setting a regulated profit provision is a function of the insurance industry's history. For much of the 20th century, competition in the industry was limited. For roughly the first ¾ of the century, bureau rates were not uncommon. In this environment, the filed rate was the same for most (if not all of the market). Therefore, it was impossible for the market to gravitate to a profit level determined by competition. This led to a "public utility" attitude toward regulation. In that environment, a regulated profit provision is not unreasonable – the consumer needs more protection when market power is absent. However, in the current, increasingly competitive market, it makes sense for insurance markets to work like other private industries.

There are many ways that one could attempt to reflect the inadequacies of traditional ratemaking assumptions. This paper will address the profit margin as a tool for reflecting the dynamic nature of the market. By using such statistics as price elasticity, we will quantify, to some extent, the way that economic forces operate on the profit margin. As you will see, such an approach would allow us to have indications that more reasonably reflect the probable future results.

Price Elasticity

Price elasticity is defined as the percentage decline in the units of a good sold for every percentage increase in the price.[1] Let X = price elasticity then,

0 > X > -1 (Price inelastic)

X <= -1 (Price elastic)

(Note that the case where X = -1 is defined as "unitary elastic")[2]

Price elasticity of property casualty insurance probably varies significantly by market (state) and line. For example, the sale of worker's compensation insurance with state mandated rates is much more inelastic than competitively rated reinsurance catastrophe covers.

The Rate Indication Revisited

Traditional ratemaking models make 2 assumptions:

- Rate changes will only impact average premium and not policy counts.
- Profit provisions should be determined in advance.

The common formula is $\frac{(LR+FER)}{(1-VER-P)}-1=IRLC$ (1)

Where LR = Forecast Loss/LAE ratio
FER = Fixed Expense Ratio
VER = Variable Expense Ratio
IRLC = Indicated Rate Level Change.
P = Target Underwriting Profit

In a highly elastic marketplace, this approach can fail for two reasons:

1. Companies may be more concerned with maximizing profit and/or market share than profit margin. Note this is not always the case in insurance because it is so capital intensive. However, while additional volume may require additional capital, it also implies future profits (or losses) in the present value of the renewals. Therefore, an insurance company might reasonably seek to write 10 million at a 3% margin rather than 5 million at a 5% margin. Since traditional formulas determine the profit margin in advance, volume considerations are explicitly ignored.

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[1] Andre Gabor, Pricing: Concepts and Methods for Effective Marketing, University Press, Cambridge, 1977, p. 16
[2] Timothy M. Devinney, Issues in Pricing, Lexington Books, 1988, p. 10

2. Most ratemaking formulas were derived at a time when agency writing was very prevalent, with a large portion of the expenses being variable. However, the increase in direct writers means that fixed expenses are a larger percentage of expenses and must be considered carefully.

   The Internet is an even more interesting example. A policy sold through a company web site would have an even greater percentage of fixed expenses, with virtually all acquisition costs as fixed.

   With a high number of fixed costs, firms could receive significant short-term benefits to the income statement by increasing volume and spreading fixed costs over additional premium.

   Of course, not all fixed expenses are truly fixed. Ultimately, all expenses are variable expenses. This paper will not examine how best to classify expenses as "fixed" or "variable," except to note that this is an increasingly sensitive assumption in the indication process.

   The formula above assumes that the fixed expense ratio will vary with the magnitude of the rate change. Suppose an insurer has a forecast 100% loss/lae ratio, a 10% fixed expense ratio, and a 15% variable expense ratio, with a 3% underwriting profit target. The traditional indicated rate level change is +34.1%.

   This assumes that fixed expenses will fall to 7.5% of premium. However, such a large increase will not likely produce nearly a 34.1% increase in premium. It is very likely that actual premium volume will decline in such an environment. Therefore, the fixed expense ratio assumed by the formula will be far too low. The opposite case can be made with declining rate levels.

   Therefore, this formula assumes that price elasticity = 0.

   The pricing actuary must consider the elasticity of her product in order to make reasonable estimates of the impact of fixed expenses.

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Another common formula used by actuaries is $\frac{(LR)}{(1-FER-VER-P)}-1=IRLC$ (2)

Where LR = Loss/LAE ratio
FER = Fixed Expense Ratio
VER = Variable Expense Ratio
P = Predetermined profit margin
IRLC = Indicated Rate Level Change

This formula assumes that premium remains the same as before, since fixed expenses are the same percentage as premium.

Therefore, Premium before the rate change = Premium after the rate change

Premium after the rate change = (1 + RateChange) x (Avg Premium) x (Policy count after rate change)

Premium before the rate change = (AvgPremium) x (Policy Count before Rate Change)

Since the two expressions above are equal,

Policy count after rate change = Policy Count before Rate Change/(1 + RateChange)

Therefore, percentage change in policies = 1/(1 + RateChange) - 1

Elasticity = Percentage change in policies/Percentage change in Rates

=[1/(1 + RateChange) -1]/RateChange

= -1/(1 + RateChange)

Note that for any rate increase, -1 < Elasticity < 0, so this formula implies more elastic markets than (1). In the example provided, the elasticity is approximately -.7, as a 39% increase by formula (2) would cause a 28% drop in policy counts.

This formula implies that elasticity can never be <= -1, which is not a reasonable conclusion if the insurance market is elastic.

Pricing Theory

There is considerable debate in the economics profession whether any meaningful general theories of pricing can be formulated. Few pricing managers in any business consult economic theory when setting prices.[3] However, it is well known that firms tend to pursue market share as well as profitability.[4]

Customers tend to infer the overall level of price from those items most frequently purchased. This explains why large super stores may tend to have very competitive prices ("loss leaders") for staples such as milk.[5]

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[3] Devinney, p. 337
[4] Devinney, p. 240
[5] Gabor, p. 170

For a multi-line insurer, that may mean pricing lines that are purchased more frequently (auto) differently than those items which are purchased less often (life insurance).

For commodity products, firms tend to use market forces more than cost based pricing. Differentiated products are typically priced on a "cost plus" basis, which is analogous to traditional rate level indications.

The Model

In this section, we introduce an alternative model which can be used for pricing insurance. This type of model could also be used as a benchmark for existing pricing decisions.

The model we will develop in this section is appropriate for a highly elastic book of business. Specifically, we are going to use non-standard auto as our example because this book is not only highly elastic, but also has very different characteristics for new and renewal business.

New business tends to be highly elastic and highly unprofitable, while renewal business tends to be less elastic (but not necessarily inelastic) and highly profitable due to significant improvements in loss and expense ratios (note: this paper only considers improvements in loss ratios).

The elasticity difference is due to the typical marketing distribution of non-standard auto. Typically, new business for non-standard auto is competitively rated against a large number of companies. Renewals may be rated again, depending on agent or consumer preference, but many will be renewed without an additional comparison of rates.

Note that the elasticity of the different types of business leads to different profit assumptions in the marketplace.

A company that followed traditional actuarial pricing models for new and renewal business would be uncompetitive on new business and very competitive on renewal business. While this would maximize profit margins on any particular risk, the overall portfolio of risks would not be as profitable as a price discriminating book. And as an economist would expect, the market is much less competitive for the less elastic part of the book.

The process for building an "ad hoc" model to employ both competitive forces and the difference in new business and renewal profitability will be to calculate the profitability for each increment of proposed rate change. While the "profit maximizing" rate change could be calculated directly, we will maximize income by inspection because this will more easily allow for stochastic simulation.

Inputs

LR = Forecast Loss/LAE ratio
VER = Variable Expense Ratio
NB% = Current New Business Percentage
RB% = Current Renewal Business Percentage (1 – NB%)
FER = Fixed Expense Ratio (at current rates)
RenBet = Renewal Betterment or the expected point differential in loss/lae ratios between new and renewal business
NE = New Business Elasticity (<=0)
RE = Renewal Elasticity (<=0)
CE = Competitive Environment or the percentage change in business given no rate change
AP = Average Premium (at current rates)
CP = Premium at current rates
RC = Proposed rate change

New Business and Renewal Mix

Let's first calculate the revised New Business/Renewal Business mix.

Let AdjPol = Policies adjusted for the competitive environment (assuming no rate change)

Then AdjPol = [CP x (1+CE)]/AP

Let RCNB% = New Business (for a given rate change)

Then RCNB% = ([RC x NE] + 1) x NB%

Similarly, RCRB% = Renewal business (for a given rate change)

and RCRB% = ([RC x RE] + 1) x RB%

Since renewal and new business must combine to equal 100%, these must be adjusted for the new distribution. Therefore,

PropNB% = Proposed New Business
PropRB% = Proposed Renewal Business

PropNB% = (RCNB%)/(RCNB% + RCRB%)
PropRB% = 1 – PropNB%

New Business and Renewal Loss/LAE ratios

One of the features of non-standard auto is a major difference in the loss costs between new and renewal business. This can cause unexpected results for a large rate increase or decrease. A significant rate increase will decrease the ratio of new business to renewals and lower the loss ratio more than the rate change would traditionally suggest. Similarly, a rate decrease can cause the opposite effect. While unprofitable new business may eventually season into a profitable renewal book, the short-term pressures on results can be significant.

Let NBLR = New Business Loss/LAE ratio after the proposed rate change

Note that

LR/(1+RC) = NB% x NBLR + (RB%) x (NBLR – RenBet)

Which simplifies to

NBLR = LR/(1+RC) + (RenBet)(RB%)

And RBLR = Renewal Business Loss/LAE ratio after the proposed rate change

= NBLR – RenBet

Proposed Income Statement

In order to simplify the analysis, we will only examine underwriting income. In our example,

Income = Premiums Earned – Incurred Losses/LAE – Fixed Expenses – Variable Expenses

Let Premiums Earned = EP, then

EP = (RCNB% + RCRB%) x (AdjPol) x (AP) x (1+RC)

Incurred Losses/LAE (IL) can be defined as

IL = EP x [(NBLR)(PropNB%) +(RBLR)(PropRB%)]

Fixed Expenses and Variable Expenses are defined simply as

FE = (FER)(CP)

VE = (VER)(EP)

Maximizing Income

Developing the expressions derived above as a function of rate changes, we find that

Income = EP – IL – FE – VE

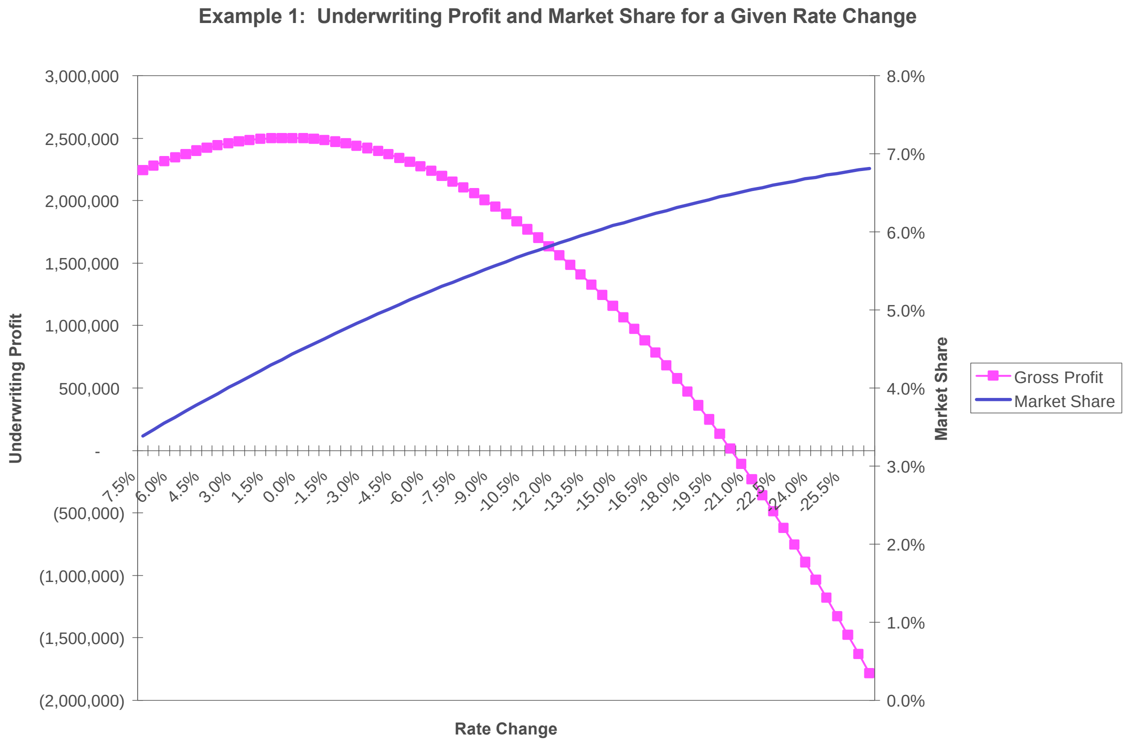
This expression could be differentiated to show that a maximum income exists as a function of the rate change, under the condition that the second derivative is less than zero. Differentiating this expression quickly becomes unwieldy, but we can demonstrate the relationship by a numerical approach. In this approach, we will simply substitute proposed rate changes at small intervals and inspecting the result for the maximum income. Here are three examples:

Example 1 A low forecast loss ratio in a mature state

Assume the following inputs for the model:

LR = 60%
VER = 15%
NB% = 50%
RB% = 50%
FER = 10%
RenBet = 20%
NE = -6
RE = -2
CE = -10%
AP = $1000
CP = 20,000,000

We will also examine "proposed market share" by simply comparing the proposed premium with the market. In this example, assume the company's initial market share is 5%. The traditional indication using (1) is –12.5% with a 5% profit target. Here is a graph of profit and market share versus rate change:



The maximum profit occurs with a +1% rate change, and an underwriting profit of 2.5 million.

The earned premium, originally at 20,000,000, is projected to be at 18,000,000 for the revision with no rate change due to competitor actions.

However, a 1% increase causes a 6% decrease in New Business counts and a 2% decrease in renewal counts. Since New Business and Renewals are each half of the book, the overall counts decrease by 3.5%. Average premium increases by 1%. Therefore, the proposed earned premium (000's) is:

Current Premium	20,000
Competitive Env	-10%
Premium if No Rate Change	18,000
Policy Counts Change	-4.00%
Average Premium Change	1.00%
Premium if +1% Change	17,453

The forecast loss/alae ratio is 60%. Renewal business is projected to be 20 points better than new business. Using the formulas derived above,

NBLR = .60/1.01 + (.20)(.50) = .6941

And RBLR = .6941 - .20 = .4941

The slight increase will readjust the renewal and new business percentages. Using the formulas above, we get:

PropNB% = .4896
PropRB% = .5104

This implies that IL = 10,331,640

Since FE = (.10)(20,000,000) = 2,000,000 and VE = (.15)(17,452,800) = 2,617,920

So Income = 17,452,800 – 10,331,640 – 2,000,000 – 2,617,920 = 2,503,240

A firm may decide to trade short-term profits for additional market share and lower rates further. “Market share” can be considered a measure of long term profitability. In the example above, initial market share was 5%. Assuming that the overall market is neither growing nor decreasing, the new market share will simply be the change in premium times the initial market share. In this example, premium changes by –12.7% which decreases market share to 4.4%.

Example 2 A high forecast loss ratio in a new state with high fixed expenses

Assume the following inputs for the model:

LR = 80%
VER = 15%
NB% = 80%
RB% = 20%
FER = 35%
RenBet = 20%
NE = -6
RE = -2
CE = -10%
AP = $1000
CP = 3,000,000

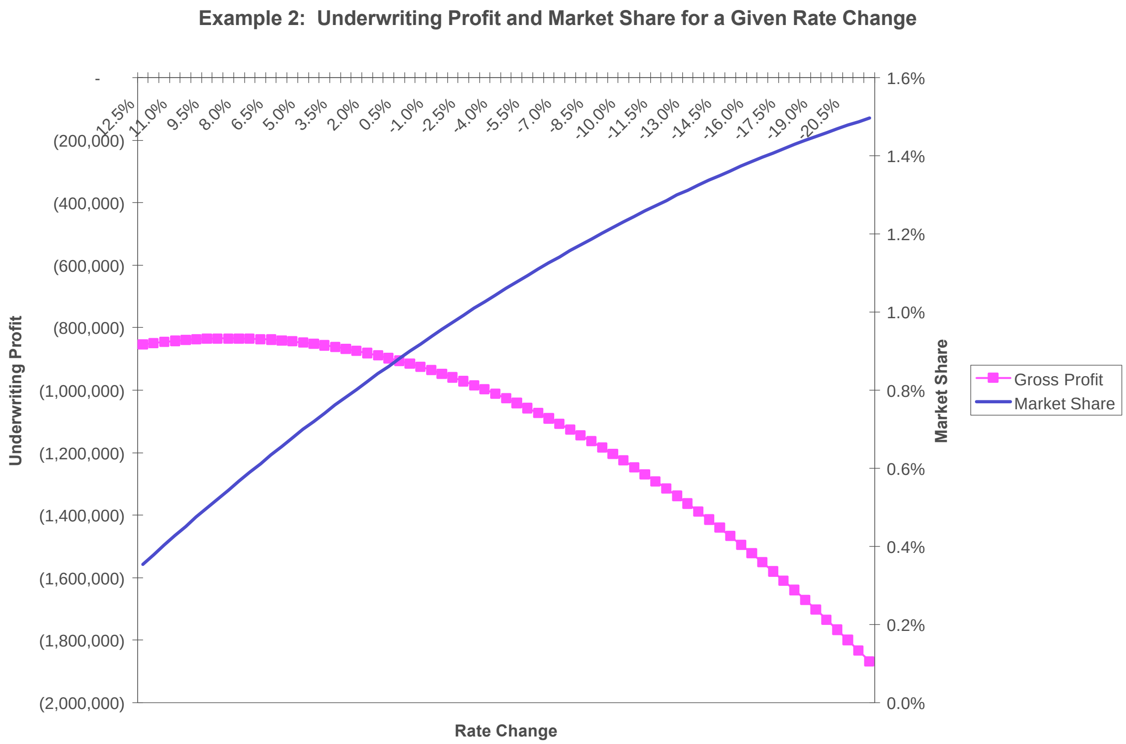
Initial Market Share = 1.0%

Assume this is a new state which is performing poorly. This has happened for two reasons:

- The loss ratio is above expectations
- The premium volume is well below expectations, which has caused the fixed expense ratio to be extremely high

In this case, "fixed expenses" are projected to remain high on an absolute basis over the next rate revision. This may be due to advertising contracts, leases, or other long-term commitments, but we can assume that they will not be eliminated.

The traditional formula would indicate an increase of +44%. However, the profit maximizing increase is just 8.5%. Note that in this case the maximum profit is actually a loss of 834K. However, given the fixed expenses, this is the best that can be projected.



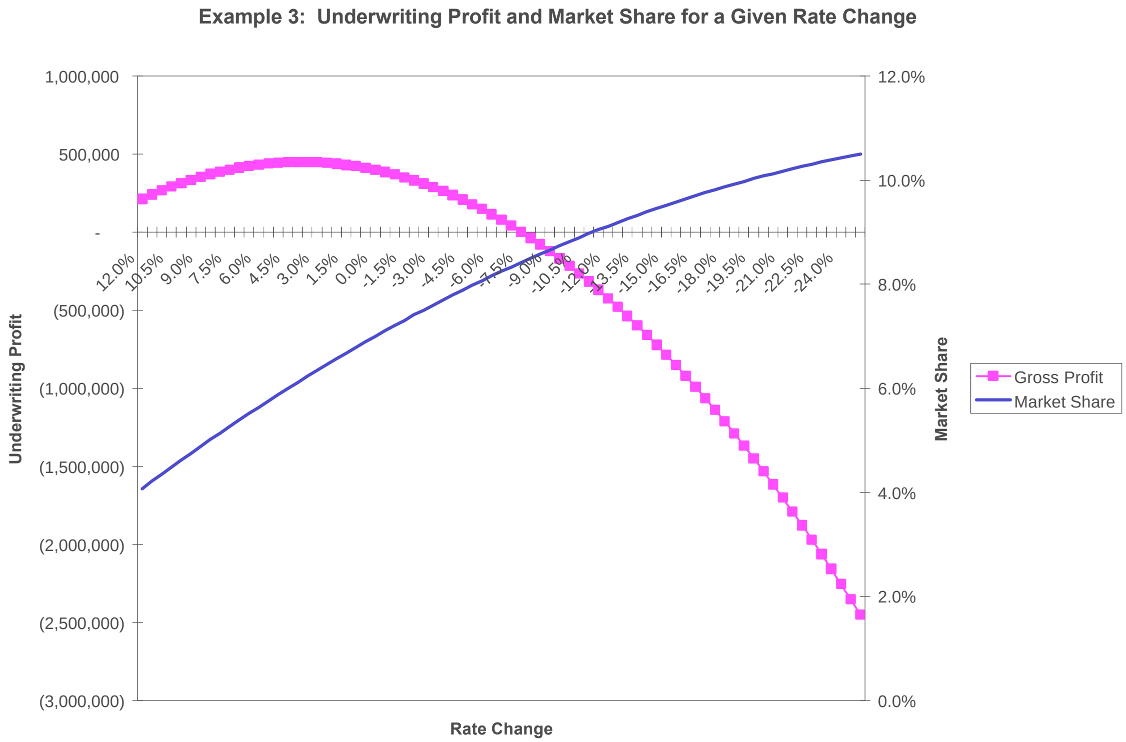
Example 3 A moderate loss ratio in a mature state with high fixed expenses and low variable expenses

Assume the following inputs for the model:

LR = 71%
VER = 7.5%
NB% = 50%
RB% = 50%
FER = 17.5%
RenBet = 20%
NE = -6
RE = -2
CE = 0%
AP = $1000
CP = 10,000,000

Initial Market Share = 7.0%

In this example, the traditional model indicates an increase of +1.1%. This is not a dramatically different result than the +4.0% increase that the “profit maximizing” model produces.



Using the traditional formula in this case would cause a decline in underwriting income of only (25K) and gain in premium of 1484K. Therefore, one should probably look closely at market share in such a situation.

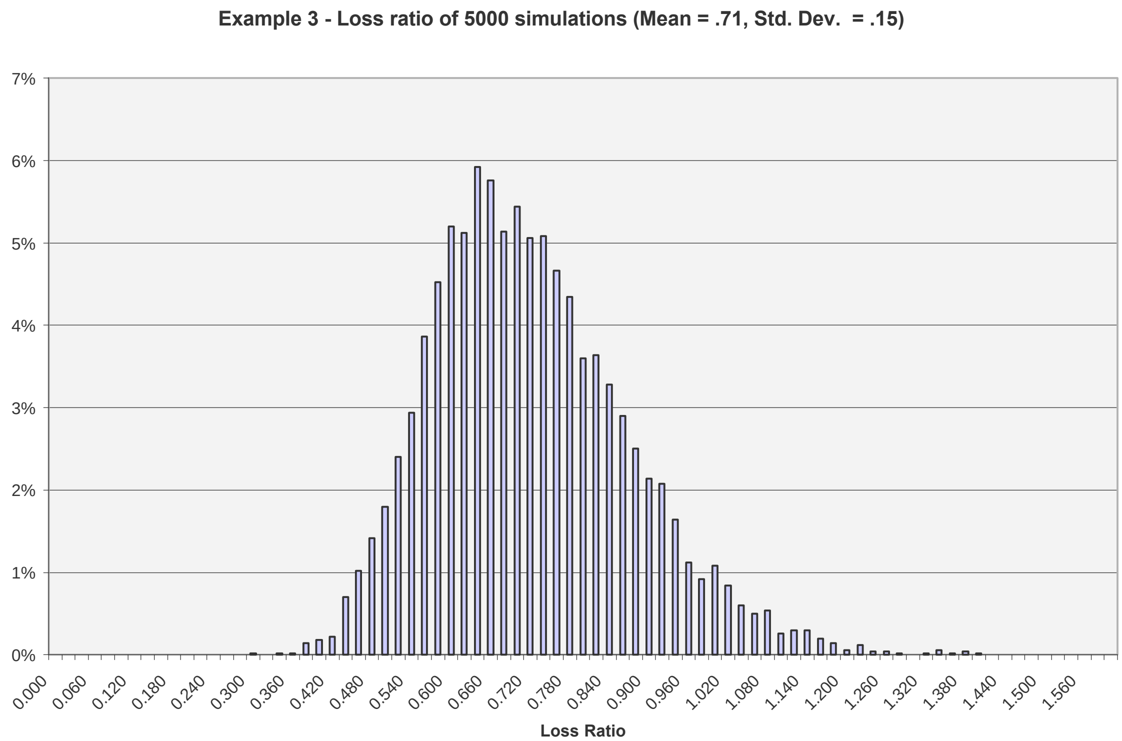
Introducing Simulation

How does the “profit maximizing” model respond to differences in expectations from the traditional model?

5000 simulations of results were run of Example 3, with distributions substituted for the loss ratio, new business elasticity, and renewal elasticity.

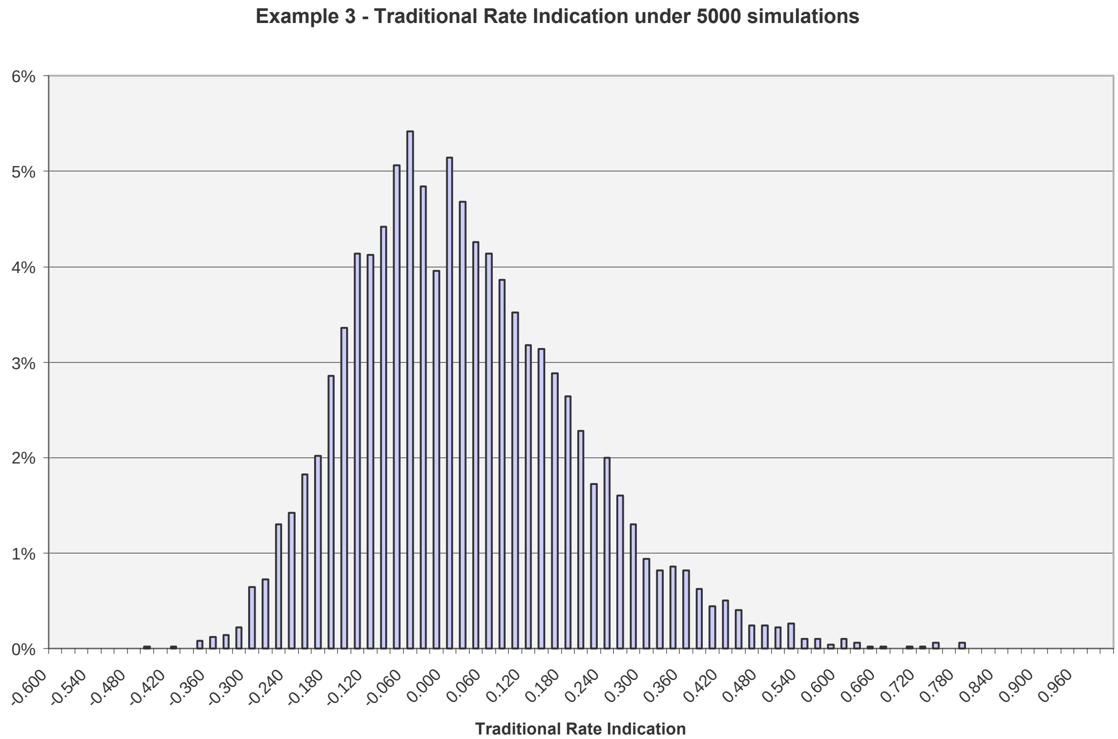
The most sensitive variable in a rate indication is the forecast loss ratio.
We replaced the loss ratio pick in the example above of 71% with a lognormal distribution with a mean of .71 and a standard deviation of .15. We also truncated the result to a minimum of 0.

The variance was selected judgmentally, but a review of the histogram of the results shows a reasonable approximation of results for a line not subject to significant catastrophe losses:

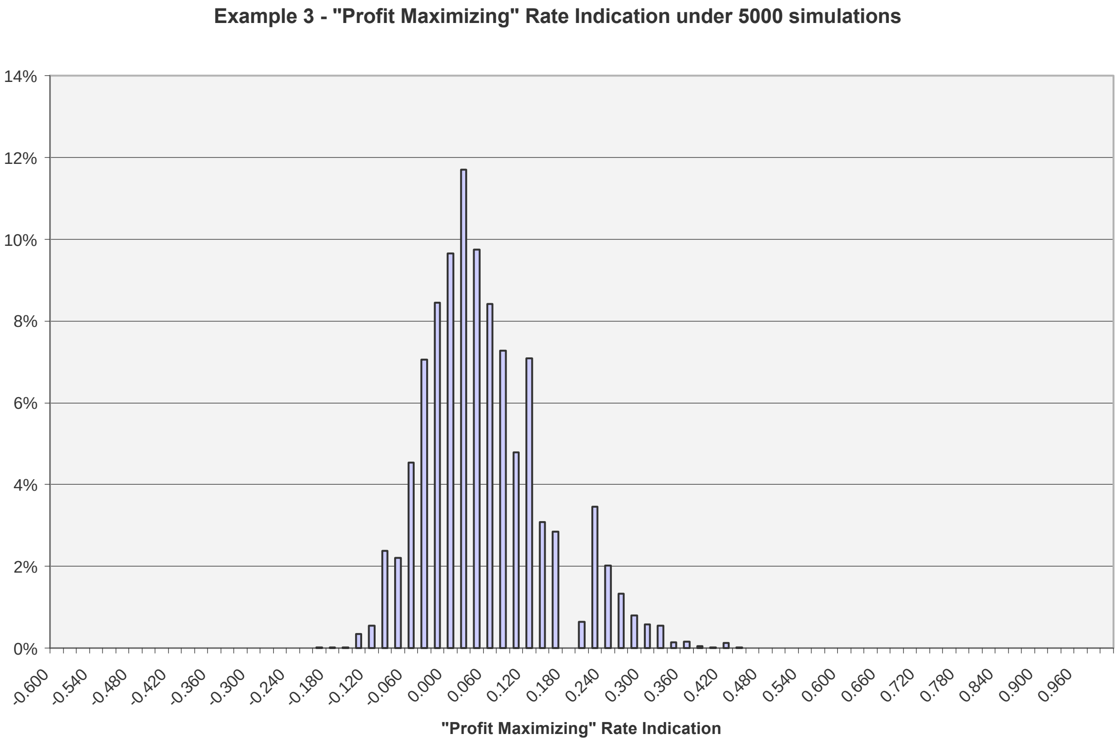


Ideally, empirical studies would determine the elasticity of the product. Also, the elasticity would be expected to change somewhat over the range of rate increases. For example, the elasticity of a 10% rate increase would probably be different than a 1% increase. However, we have not changed our elasticities in this example.

Not surprisingly, “traditional indications” correlate closely with the loss ratio, since elasticities do not impact the result of this formula:



The "profit maximizing" indications, shown below, provide an interesting contrast to the traditional indications:



Note that the shape of the distribution is remarkably different from the traditional indication. The standard deviation of the results from the traditional indication is .171 versus .092 from the "profit maximizing" model.

Conclusion

There are many assumptions in our examples that can be refined and improved. For example, price elasticity is not constant for all indications – as a result our results would be less accurate for extreme rate indications. The emphasis of the paper is on a method of thinking about rate indications in a dynamic market. As we have shown, traditional methodologies do not adequately account for the effect rate changes have on retention and other economic factors.

We hope that our paper will lead to further research. For the model to be usable in the real world, empirical studies will need to develop reasonable assumptions for price elasticity functions, distributions of new versus renewal business, and other model inputs. There are also several simplifying assumptions which would need to be refined.

This proposed approach is only a first step, but we are convinced that it is a step in the right direction. Companies that are able to reflect market forces in their rate analysis can gain a competitive advantage. A ratemaking approach that considers price elasticity to maximize profit would be a useful tool by itself, but could be even more valuable as a component of dynamic financial analysis.

As stated in our introduction, these types of concerns are reflected indirectly every time an actuary chooses not to propose the indicated rate level. With this approach, an insurance company has a better chance of measuring the effect of such decisions, creating a rate structure that balances profit and market concerns.