# The Mix Effect: What is it and how do I estimate it?

As an actuarial analyst dealing largely with insurance premium pricing, a big proportion of my work deals with adjusting prices (duh) for certain segments of the book and analysing the impacts of these adjustments on a portfolio level. Also, there is the part of communicating all the model assumptions, calculations and logic back to the stakeholders.

This article will focus mainly on the analysis of impacts to portfolio performance, and how to do it right. Although we will tackle the issue through the lens of the actuarial profession, the metrics used can be easily converted, logic easily applied to other quantitative fields.

Before delving into the details, let’s just go ahead and assume that the performance of a book is measured by the loss ratio, which is calculated as:

Now, note (for you actuaries out there) that we have defined a very general form of the loss ratio here and different insurers will lean towards different variations of this depending on the business requirements. If you have never heard of this term before, just know that a loss ratio of 100% would mean that every dollar an insurer earns from its customers is being used to pay out claims, and insurers all aim to keep this number as low as possible while keeping the interests of its policyholders as its priority.

So, what does this have to do with premium pricing? At the simplest level, a quick look at the loss ratio formula coupled with some knowledge of high school algebra would reveal that an increase in prices would lead a direct increase in written premiums (income) for the insurer, causing a decrease in the loss ratio and ultimately better performance. Right? Well, not quite. As we will discover in the sections to come, there are some nuances and details to be considered when assessing the impacts of these price increases (or decreases).

## Setting the Scene

Let us visit a fictional insurer Foo Ltd to walk through the issue step by step. Foo Ltd’s portfolio can be categorised into 5 main policyholder segments:

|  |  |  |  |
| --- | --- | --- | --- |
| **Segment** | **Sales Premiums** | **Claims Incurred** | **Loss Ratio** |
| A | $200,000 | $100,000 | 50% |
| B | $50,000 | $40,000 | 80% |
| C | $500,000 | $200,000 | 40% |
| D | $1,000,000 | $800,000 | 80% |
| E | $2,000 | $8,000 | 400% |
| **Total** | **$1,752,000** | **$1,148,000** | **66%** |

Like any other insurer, some customer segments within Foo Ltd’s book perform better than others, and pricing is one of the levers an insurer can pull in order to improve loss ratios.

Say we are working on a project to bring down the company’s overall 66% loss ratio by targeting segment D with price adjustments.

After some actuarial judgement calls, we decide to increase the premiums for customers in segment D by 20%. How will this change in price impact the overall portfolio performance? Note that although there is a theoretically “correct” answer, we cannot expect to realistically calculate this figure in the same way that we can only infer the true mean of a population from statistical tests.

## Naïve Method

Assuming we just take everything at face value, a 20% increase in premiums will bring our sales premiums for segment D from $1,000,000 to $1,200,000. Segment D will then have a new loss ratio of ~67%, and the Foo Ltd’s portfolio will be performing at an overall loss ratio of ~59%, which equates to an approximate 7% absolute (or 11.4% relative) decrease! This can be checked for reasonableness with these quick steps:

1. A 20% increase on Segment D premiums will cause the segment’s loss ratio to decrease from an initial 80% to 67%, an approximate 13% absolute decrease
2. Segment D’s premiums account for ~57% of Foo Ltd’s premiums
3. We can expect the overall effect on the portfolio to be: The effect of the change in loss ratio for Segment D weighted by the premiums, which is 13% \* 57%
4. This gives us approximately 7%, which is what we initially calculated. This serves as a quick and useful check to make sure that your calculations are correct

Is 7% correct? Definitely not. It is, however, a reasonable estimate for the impact of this price adjustment given the data provided. Can we do better? We definitely can.

## What’s wrong with the Naïve Method?

Well nothing really, but let’s pause for a moment to go through the 2 things that were implicitly assumed when we came to the conclusion that a 7% decrease in loss ratio was a reasonable estimate.

* Firstly, we assumed that claims incurred by policyholders in segment D will not change after the premium increases have taken place
* Secondly, and more importantly, we also assumed that the 20% price increase had no effect on segment D policyholders’ demand for the product. In economic terms, we have assumed that the *price elasticity of demand* of the product in relation to segment D customers is 0.

While these assumptions may be reasonable (and true even) depending on the nature of the business and the particular insurer’s book, this is rarely the case. If we want to relax these assumptions, it would be wise to adjust our initial 7% loss ratio decrease by some amount to represent a more realistic and probable view of what the impacts really are. This “amount” is also known as the mix effect.

## The Mix Effect

What then, is this magical number? Could we simply add an arbitrary 2% to our initial 7% to say that the portfolio loss ratio can be expected to decrease by 9% in total from the price adjustments? We definitely can, and I have to stress that there is no one correct method of going about this. An experienced actuary that has been dealing with an insurer for the past 30 years could very well have a good idea of what the mix effects may look like for different segments and premium adjustments at the back of his head. I for one, have neither the experience nor the guts to conjure up an estimate like this and will have to rely on some good old logic and algebra. Don’t get me wrong, there are still some assumptions to be made and reliance on actuarial judgement, but a lot less than just declaring that: “2% is the mix effect”.

Let’s rewind to before the price change and simplify our portfolio. Since we only care about segment D customers, we can view Foo Ltd’s book as:

|  |  |  |  |
| --- | --- | --- | --- |
| **Segment** | **Sales Premiums** | **Claims Incurred** | **Loss Ratio** |
| D | $1,000,000 | $800,000 | 80% |
| ROTB | $752,000 | $348,000 | 46% |
| **Total** | **$1,752,000** | **$1,148,000** | **66%** |

Here, ROTB simply stands for “Rest of the book” and consists of every other customer segment other than segment D. Like before, a 20% price increase for segment D will amount to an approximate 11.4% premium increase for the portfolio, (20% \* 1,00,000 / 1,752,000) and ultimately an 11.4% (11.4% \* 66% equates to 7% like before) decrease in loss ratio.

Let’s term this the “Rate change effect” as this is a direct result of the higher premiums. However, from earlier discussions, we know that although this is true, it isn’t the whole truth. The complete picture would look more like:

Now comes the time to replace assumption 2 from before with a more realistic one, an elasticity measure. I won’t go through the full explanation of elasticity and you can read up on it here, but essentially, elasticity is a number that describes the sensitivity of consumers to price changes. Put simply, if a product is said to have an elasticity of 1, then a 1% price increase can expect to see a drop of 1% in quantity demanded for the same product.

Let’s assume now that segment D has an elasticity measure such that a 20% price increase will result in Foo Ltd losing 50% worth of premiums in customers. The new weights after this expected loss in customers can be calculated as follows:

Notice that there has been a shift in the mix of customers, and ROTB has a higher weight now compared to before.

Now, if we compare this with the initial loss ratio of 66%, we see that the shift in mix causes a decrease in loss ratio by 6%, because ROTB segment had a lower loss ratio of 46% to begin with and since it now carries more weight in the portfolio, the average loss ratio has converged closer to it.

Now that we have somewhat quantified what this shift in the mix has on Foo Ltd’s loss ratio, we can simply plug the figures back into our initial formula:

Which gives us an estimated portfolio loss ratio of 53% after the price increase instead of the earlier estimate of 59%. This seems a lot more reasonable than before and is probably a more realistic representation of the premium impacts. Again, this is just one of the ways to estimate the mix effect of a premium adjustment but maintains a good balance of tractability and accuracy. Note that, depending on the risk appetite of the insurer, some form of conservatism could be introduced into this calculation to give a more pessimistic view of the impacts if required.

Remember, what George Box tells us: “All models are wrong, but some are useful.”