Sneak Peek

Reading: Siewert, J.J., "A Model for Reserving Workers Compensation High Deductibles", Casualty Actuarial Society Forum, Summer 1996, pp 217-244.

Synopsis: This dependable paper looks at reserving problems in the context of high deductible programs, particularly when there may be limited data available. It contains several readily testable methods which vary with complexity as well as critical formulas for implementing those methods. This is a reading you'll want to go through quickly at first and then return to periodically to keep the methods fresh.

Contents

Study Tips

- Practice writing out the key formulas and development methods until you have them memorized.
- The direct development method is the hardest — don't forget you're always looking for an explicit excess loss development factor when applying this method.
- Return to these questions periodically to keep them fresh.

Estimated study time: 3 days *(not including subsequent review time)*

BattleTable

Based on past exams, the **main things** you need to know *(in rough order of importance)* are:

- How to **apply Direct Development method** for calculating ultimate claims and IBNR.
- Know the **limited severity relationships** to translate between unlimited, excess and limited layer loss development factors.
- Be able to apply the **loss ratio**, **implied development** and **Bornhuetter-Ferguson** techniques.
- Understand the differences between the empirical **development model** and the **distributional model**.
- Know how to calculate the **service revenue asset**.

Questions are held out from Spring 2019 exam. (Use these to have a fresh exam to practice on later. For links to these questions see Exam Summaries.)

reference	part (a)	part (b)	part (c)	part (d)
E (2018.Spring #2)	**Distributional Model** - compare	**Limited Severities** - discuss		
E (2017.Spring #9)	**Layer Direct Method** - calculate			
E (2016.Spring #9)	**Loss Ratio Method** - calculate	**Direct Method** - calculate	**Compare Methods** - discuss	
E (2015.Spring #6)	**Loss Ratio Method** - calculate	**Implied Method** - calculate	**Direct Method** - discuss	
E (2014.Spring #6)	**Limited Severities** - calculate	**Direct Method** - calculate		
E (2012.Spring #6)	**Limited Severities** - calculate			
E (2011.Spring #6)	**Direct Method** - calculate	**Bornhuetter-Ferguson** - calculate	**Bornhuetter-Ferguson** - discuss	

Full BattleQuiz ***Excel BattleQuiz***

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In Plain English!

A Workers Compensation policy may be "full coverage" or have a high (large) deductible. High deductible plans were introduced in the early 1990s to pass additional risk onto insureds, add pricing flexibility, provide greater incentive for loss control, and give cash flow advantages. However, high deductibles may mean it takes a (long) while for adequate reserving data to develop as initially most claims may be in the deductible layer. Siewert examines several methods for estimating the ultimate loss net of the deductible.

Question: Briefly describe five reasons why the insurance industry introduced high deductible Workers Compensation programs.

Solution:

1. **Pricing Flexibility:** Pass additional risk onto the insureds and make premiums more manageable/tailored in a previously unprofitable line of business.
2. **Taxes:** Reduce premium taxes in some states and lower residual market charges.
3. **Cash Flow Advantages:** The insurer pays all losses and seeks reimbursement for the deductible. This means the insured holds onto their cash for longer.
4. **Loss Control:** Gives insureds an incentive to control losses while still protecting them from large, random losses.
5. **Self-insurance:** Choosing a sufficiently large deductible allows some insureds to effectively self-insure without having to go through demanding state requirements.

Loss Ratio Approach

When a credible development history is unavailable, one way to determine liabilities is by multiplying the estimated full coverage loss ratio by the associated premium for the high deductible policy and then adjusting this to account for per-occurrence and aggregate excess losses. Loss ratios should be available as they would have initially been used to price the workers compensation product. A credible loss development history emerges over time, so the loss ratio approach is likely the best option for immature years in a long-tailed line of business.

The per-occurrence and aggregate excess ratios should reflect state and hazard group differences as well as the size of the workers compensation account and deductible involved. The per-occurrence charge and aggregate charge are calculated using a retrospective rating method from Exam 8 (i.e. not currently on the Exam 7 syllabus).

The **Per-Occurrence Loss Charge** is $P \cdot E \cdot \chi$ and the **Aggregate Loss Charge** is $P \cdot E \cdot (1 - \chi) \cdot \phi$ where P is the premium, E is the expected (full coverage) loss ratio, χ is the per-occurrence charge, and ϕ is the aggregate charge. The per-occurrence charge reflects the portion of a claim which is expected to exceed the deductible, while the aggregate charge reflects the portion of deductible layer losses which may exceed an aggregate deductible if it exists. An exam question would give you the charges while in practice they would be looked up in tables or calculated using methods from Exam 8.

Alice: "The per-occurrence charge may also be called the **excess ratio** *or* **excess loss pure premium factor**. *The first is applied to the expected losses while the second is applied to the premium."*

By applying this process to each workers compensation account and aggregating the resulting expected excess losses, we get an estimate of the ultimate accident year losses.

Let's see this in practice.

Siewert's Loss Ratio Example

Question: What are three advantages and two disadvantages of using the loss ratio approach to price a high deductible plan?

Solution:

Advantages

1. Useful when there's no data or data is very immature.
2. Initial loss ratio estimates are derived from pricing structure so the method is clearly tied to the product sold.
3. Use of more company (the company's full coverage premium and loss data) and/or industry data gives more credible pool of data.

Disadvantages

1. Ignores actual emerging experience, so is not very useful after several years of development.
2. May not fully reflect the characteristics of the exposures being written.

Implied Development

The data for both full coverage losses and deductible layer losses are more credible than the data for excess losses because not every full coverage loss pierces the excess layer (i.e. a full coverage loss may remain within entirely within the deductible layer if it had been associated with a high deductible policy instead). The **implied development** approach builds on this strength as follows:

1. Develop *full coverage* losses to ultimate.
2. Develop *deductible* losses to ultimate by applying development factors which reflect inflation indexed limits.
3. Determine ultimate excess losses by subtracting the limited ultimate losses from the full coverage ultimate losses.

There are many standard actuarial techniques for developing the full coverage losses. It's important to make sure the full coverage tail factor is consistent with the limited loss tail factor. The limited losses should not be developed further than the unlimited losses, and the development length should be consistent across limits.

Siewert's Implied Development Method

Question: Why is it important to account for inflationary effects when calculating development factors for deductibles?

Solution:

We adjust the deductible by indexing it for inflationary effects so the ratio of deductible to excess losses is approximately constant from year to year.

Example: If inflation is 5% then the percentage of losses over a $200,000 deductible in year 1 is the same as the percentage of losses over a $210,000 deductible in year 2. This allows multiple years of data to be combined in the analysis.

Question: How could you measure the inflationary index?

Solution: The inflationary index could be measured by:

1. Fitting a trend line to the average severities over a long period of time.
2. Use an index, possibly from industry, which reflects annual severity changes.

Question: Briefly describe three advantages and one disadvantage of Siewert's implied development method.

Solution:

Advantages

1. Provides an estimate of excess losses at early maturities, even when no excess losses may actually have emerged at that time.
2. Development factors for limited losses are more stable than those for the unlimited losses.
3. Can estimate revenue collected by applying a loss multiplier to future losses.

Disadvantage

1. It's an implicit method, we'd prefer to have a direct method.

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Direct Development

There is a subtle difference between the implied development and direct development methods. Both methods require loss development factors for the limited (deductible) and full coverage losses. However, the implied method develops both sets of losses to ultimate and takes the difference to get the ultimate excess loss, whereas the **direct development** method calculates excess development factors and then applies them to the **reported** excess losses.

Alice: "Remember, the excess and limited factors applied together should (as close as possible) get you back to the full coverage factors/development."

Several standard techniques exist for calculating excess development factors but there are significant limitations:

Question: Briefly describe two limitations of Siewert's direct development method.

Solution:

Disadvantages

1. Excess factors can be highly leveraged and very volatile.
2. If no excess losses have emerged at a given development stage then it's impossible to get an estimate of the ultimate excess liability.

Siewert's recommended approach to the direct method uses two formulas you should memorize.

Key Formulas (Part 1):

- $R_t^{\text{limited}} = \dfrac{\text{Severity}_t^{\text{limited}}}{\text{Severity}_t^{\text{unlimited}}}$. This is the **ratio of limited to unlimited severity** at time *t*. Often the subscript *t* is dropped in the notation.
- $\text{LDF}_{t-Ult}^{\text{unlimited}} = R_t^{\text{limited}} \cdot \text{LDF}_{t-Ult}^{\text{limited}} + (1 - R_t^{\text{limited}}) \cdot \text{XSLDF}_{t-Ult}^{\text{limited}}$

Rearranging the second equation to solve for the excess loss development factor produces the required LDF for the direct development method.

Siewert's Direct Development Method

Credibility Weighting Techniques/Bornhuetter-Ferguson

Credibility weight actual experience with expected values which are derived from pricing estimates. Requires determination of suitable weights/credibilities.

We have $L = O_t \cdot LDF_t \cdot Z + E(1 - Z)$ where L is the ultimate loss estimate, O_t is the observed loss at time t, LDF_t is the age-to-ultimate development factor, Z is the credibility, and E is the expected ultimate loss.

In the Bornhuetter-Ferguson technique set $Z = \dfrac{1}{LDF_t}$.

Question: Identify three advantages of using a credibility weighted approach to excess loss development.

Solution:

Advantages

1. Uses pricing estimates for years where excess losses have not emerged yet.
2. Places greater weight on the actual excess losses as the losses develop/emerge.
3. Provides more stable estimates over time due to less reliance on highly leveraged or volatile excess loss development factors at early maturities.

Question: Identify a weakness of using a credibility weighted approach to excess loss development.

Solution:

Disadvantages

1. Early actual excess losses are essentially ignored as they have lower weights.

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Development Model

Having formulated the three methods above, Siewert goes on to look at empirically calculating the LDFs needed to apply any of the methods. If the no long-term claims history is available for the deductible program then use the data from a full coverage program and adjust it to reflect the deductible.

Siewert empirically produces loss development factors for several common deductible sizes by first grouping the data according to the deductible size. When aggregating the claims data for a given deductible, de-trend the deductible size by dividing by 1.095 each year to account for the effects of inflation before measuring the deductible layer loss. The 9.5% severity trend was based on an exponential trend line fitted to long-term historical severity data.

The paper recommends developing frequency and severity separately. Siewert looks at counts for full coverage losses rather than worrying about whether a claim emerges over a given deductible. His rationale is larger claims are still reported early — they're just not yet known to be large.

Tail development for the deductible layer losses is modeled with an inverse power curve $y = 1 + a \cdot (t + c)^{-b}$ that was first fitted to the known age-to-age factors for the unlimited loss data. Siewert used the fitted inverse power curve to project ultimate unlimited losses. Since inverse power curves continue indefinitely, Siewert selected a cut-off point of 40 years (for Workers' Compensation policies) by using extended development triangles. After the ultimate age was determined, Siewert fit inverse power curves for each deductible limit being reviewed. This allows the known age-to-age factors for each deductible layer examined to be extended to the ultimate age.

Question: What are two advantages of extending all inverse power curves to the same ultimate age?

Solution:

1. The approach is consistent between deductible layers considered, and
2. It gives uniform decreasing tail factors.

Question: Briefly describe a disadvantage of extending all inverse power curves to the same ultimate age.

Solution: You could be introducing bias by extending to the same maturity — lower limit policies may actually reach ultimate earlier.

Alice: "The next piece of the paper contains some key formulas you'll use repeatedly so make sure you memorize them. You need to be aware of the relationship between full coverage loss development and the limited severity relativities because otherwise you can end up with development factors for the deductible layer which are bigger for small deductibles than large deductibles."

Key Formulas (Part 2):

- $LDF^L = \frac{C}{C_t} \cdot \frac{S}{S_t} \cdot \frac{R^L}{R_t^L}$
- $XSLDF^L = \frac{C}{C_t} \cdot \frac{S}{S_t} \cdot \left(\frac{1 - R^L}{1 - R_t^L}\right)$

where *L* is the deductible limit, *C* is the claim count, *S* is the severity, *R* is the severity relativity, and *t* is the development age. The severity relativity is the ratio of limited to unlimited severity.

That is, for a given fixed deductible, *L*, we can get the limited LDF by multiplying the unlimited LDF by the change in limited severity relativities between the development ages.

The key formulas in part 2 above are used with those *shown in part 1* to express the total loss development consistently in terms of the limited and excess development for a given fixed deductible.

Another form of notation for these formulas is $LDF^L_{t_1-t_2} = LDF^{\text{unlimited}}_{t_1-t_2} \cdot \Delta R^L_{t_1-t_2}$ and $XSLDF^L_{t_1-t_2} = LDF^{\text{unlimited}}_{t_1-t_2} \cdot \Delta(1 - R^L_{t_1-t_2})$. Here, Δ means take the ratio of successive values of R^L or 1 - R^L respectively between development ages t_1 and t_2.

Remember, the formulas *shown in part 1* above demonstrates the unlimited loss development factor is weighted average of the limited and excess development factors using the limited severity relativities as weights.

In Figure 1 (reproduced from the text) below, Siewert shows how the limited severity relativities vary with choice of deductible. The key takeaways are the relativities flatten as the deductible gets larger and as the data matures the relativities approach a fixed value for each deductible.

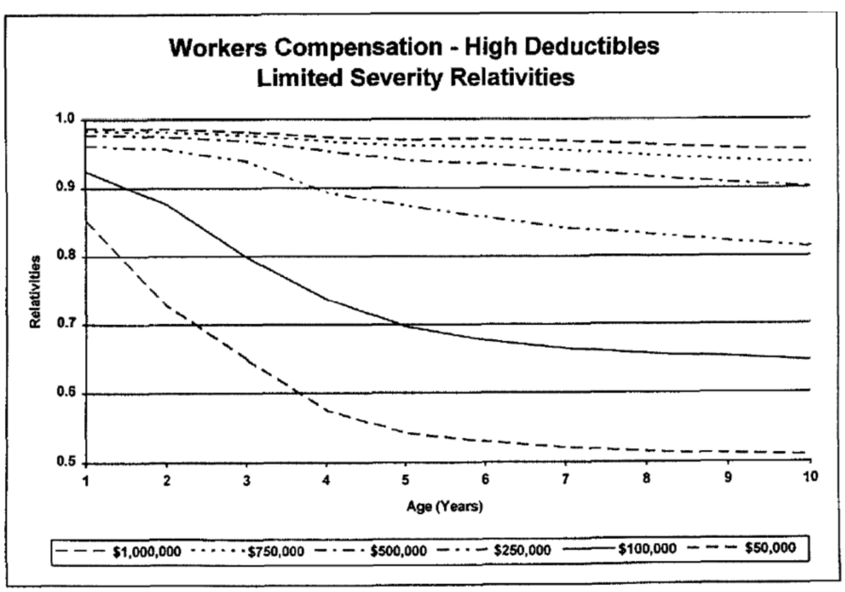

Figure 1

For a more complex way the CAS can test this method let's look at 2017 Question 9

CAS Exam 7 2017, Question 9

Distributional Model

Progressing to a theoretical model through curve fitting is a logical leap given the pleasant formulas derived by Siewert.

Question: Identify two advantages of using a distributional model over the development/empirical approach.

Solution:

1. A distributional model helps tie relativities to severities which means we get consistent loss development factors.
2. It allows for interpolation between limits and years as needed.

Use the following steps to apply the distributional model approach.

1. Select a loss (severity) distribution — Siewert suggests using a Weibull distribution because it's commonly used for Workers' Compensation claims, is familiar to actuaries and easy to work with, plus is reasonably accurate.
2. Parameterize your chosen distributional form; you'll need to produce a set of parameters for each age and at ultimate. Siewert used data for Workers' Compensation policies with a $250,000; he looked at various ways to parameterize such as the Method of Moments and Maximum Likelihood but decided to fit by **minimizing the chi-square statistic** , i.e. minimizing the difference between the actual and expected severity relativities.
3. Calculate the limited and excess severities over time.
4. Use the formulas discussed earlier in this reading to compute the required development factors.

Figure 2 (below) contains Siewert's Table 6 from the source. It shows the observed losses at the ultimate age and at 48 months, plus the results from fitting Weibull distributions to these ages. After fitting, the excess severity relativities are calculated and from there, right at the bottom of the table the fitted limited and excess LDFs are calculated. Siewert made a conscious choice to show the development at 48-months because he assumes there is no claim count development after 36-months. When applying this method at earlier maturities it's important to also account for expected claim count development.

Alice: "You should verify you know how to apply Siewert's formulas by spot-checking some of these figures."

Table 6
Workers Compensation High Deductibles
Actual Versus Fitted Limited/Excess Development Factors (@ 48 Months)
(using a Weibull Loss Distribution)

Ultimate

Limit	Unlimited	$1,000,000	$750,000	$500,000	$250,000	$100,000	$50,000
Observed							
Limited Severity	6,846.4	6,159.2	5,980.4	5,714.4	5,094.8	3,939.6	3,036.5
Relativity	1.0000	0.8996	0.8735	0.8347	0.7442	0.5754	0.4435
Excess Severity	0.0	687.2	866.0	1,132.0	1,751.6	2,906.8	3,809.9
Fitted							
Limited Severity	6,846.4	6,295.2	6,106.5	5,778.7	5,064.4	3,926.7	3,043.8
Relativity	1.0000	0.9195	0.8919	0.8440	0.7397	0.5735	0.4446
Excess Severity	0.0	551.2	739.9	1,067.7	1,782.0	2,919.7	3,802.6

Weibull Parameters Scale = 180.0 Shape = .2326
Mean = 6,846.4 Coefficient of Variation = 10.07

48 Months

Limit	Unlimited	$1,000,000	$750,000	$500,000	$250,000	$100,000	$50,000
Observed							
Limited Severity	5,530.2	5,346.6	5,288.5	5,182.3	4,824.0	3,807.5	2,937.1
Relativity	1.0000	0.9668	0.9563	0.9371	0.8723	0.6885	0.5311
Limited LDF	1.2380	1.1520	1.1308	1.1027	1.0561	1.0347	1.0338
Excess Severity	0.0	183.6	241.7	347.9	706.2	1,722.7	2,593.1
Excess LDF	-	3.7429	3.5830	3.2538	2.4803	1.6874	1.4692
Fitted							
Limited Severity	5,530.2	5,380.5	5,301.4	5,142.5	4,722.4	3,894.0	3,144.1
Relativity	1.0000	0.9729	0.9586	0.9299	0.8539	0.7041	0.5685
Limited LDF	1.2380	1.1700	1.1519	1.1237	1.0724	1.0084	0.9681
Excess Severity	0.0	149.7	228.8	387.7	807.8	1,636.2	2,386.1
Excess LDF	-	3.6820	3.2338	2.7539	2.2060	1.7844	1.5936

Weibull Parameters Scale = 305.7 Shape = .2625
Mean = 5,530.2 Coefficient of Variation = 7.35

Figure 2: Table 6 from the Siewert paper

Lastly, Siewert concludes this section by showing how the expected loss development can be partitioned into deductible layer and excess layer development. The expected development is given by $1-\frac{1}{LDF_t}=\frac{R_t^L\cdot(LDF_t^L-1)+(1-R_t^L)\cdot(XSLDF_t^L-1)}{R_t^L\cdot LDF_t^L+(1-R_t^L)\cdot XSLDF_t^L}$. Although complicated looking, the denominator is just the unlimited LDF so we get the desired partition.

An example of this using the data from Figure 2/Table 6 above is shown graphically below in Figure 3 (Siewert's Chart 5). Notice as the development age increases, the portion of expected development above the deductible becomes larger.

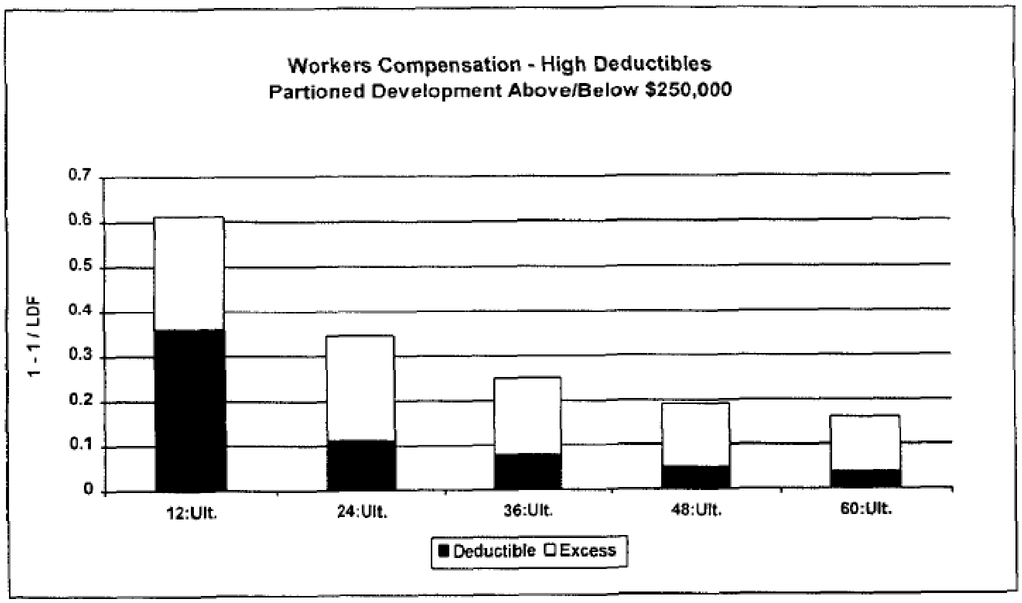

Figure 3: Chart 5 from the Siewert paper

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Other Elements

Aggregate Limits

An aggregate loss limit places an upper bound on the amount the deductible payments made by the insured. Without an aggregate limit, insured face potentially unlimited loss as each new claim adds a deductible layer exposure.

Alice: "It's important to recall a fact from Exam 8: The per-occurrence limit is applied first and then the aggregate limit. So given a loss which exceeds the per-occurrence limit, the part of the loss which is excess of the per-occurrence limit is used to price/develop the per-occurrence limit while the deductible layer part of the loss is then used separately to price/develop the aggregate limit."

Key Points:

- Per-occurrence limits usually have a more significant impact to the insurer's losses than aggregate limits
- Aggregate excess data is generally sparse so not very credible — it takes a lot to exhaust the aggregate deductible.
- Siewert recommends using a collective risk model as determining these development factors is complicated. Such a model extends the earlier work above by incorporating a claim frequency distribution like the Poisson.
- Loss development for losses in excess of the aggregate limit decreases more quickly for small deductibles than large ones because it's easier to get above the aggregate limit and the later development is mostly excess of the deductible, i.e. not covered by the aggregate.
- Larger aggregate limits are more leveraged because it takes longer to get above the aggregate limit.
- There is usually a lot of volatility in the estimated excess of aggregate limits LDFs; a Bornhuetter-Ferguson approach is recommended to smooth out the estimate of ultimate liability by placing less weight on immature years.

Alice: "Siewert doesn't go into any practical details/examples of applying the collective risk model approach so I think you're okay knowing the key points above."

Table M Approach

Another approach Siewert uses for determining IBNR estimates for aggregate excess of loss uses tools from the NCCI for determining insurance charges in retrospective rating.

The IBNR is determined by subtracting insurance charges at different maturities. The NCCI ICRLL procedure adjusted the expected losses to reflect the aggregate deductible. The presence of the aggregate deductible stabilizes the losses the insurer is responsible for, so the expected losses are generally adjusted upwards as a larger volume of claims typically has more stable experience. By increasing the expected losses for a per-occurrence limit, we can use a less dispersed loss ratio distribution and a smaller insurance charge. To adjust expected losses to reflect loss limits multiply the expected losses by $\dfrac{1+0.8\chi}{1-\chi}$ where χ is the excess ratio, $\chi = \dfrac{E[A]-E[A_D]}{E[A]}$. Here, $E[A]$ is the expected unlimited losses and $E[A_D]$ is the expected losses limited by the per-occurrence deductible.

Question: Identify one advantage and one disadvantage of using the NCCI's ICRLL approach to determining expected development factors for losses excess of an aggregate limit.

Solution:

Advantage: More practical than collective risk modelling.

Disadvantage: Accuracy depends on using the right insurance charge table.

Alice: "This is really Exam 8 material so it's unlikely the CAS could ask you to calculate anything more involved that applying the method given the appropriate insurance charges. Let's see how we can do that."

Applying the Table M approach to estimating IBNR

Service Revenue

While a high deductible aims to give the insured more control over their losses, the insurer adjusts all claims regardless of whether or not each claim is ultimate above the deductible. Service revenue is an asset associated with handling (servicing) claims under a high deductible program. It covers the insurer's expenses associated with handling (the portion of) claims which are within the deductible layer. Without a charge for handling these claims, the insurer would (assuming zero credit risk) be out of pocket for any costs associated with adjusting a deductible layer claim because the insured only reimburses for the deductible layer loss, not the associated expenses as well.

A factor called the **loss multiplier** is applied to the deductible losses (limited by any applicable aggregate deductible) to cover the expenses which vary with the deductible layer losses. The resulting additional cash flow is called the **service revenue**. Service revenue is usually collected as losses are paid but can be collected also when losses are incurred.

Calculating the Service Revenue Asset:

1. Determine ultimate deductible losses for each account — *this is only taking into account the per-occurrence deductible.*
2. Subtract ultimate losses excess of aggregate limits from ultimate deductible losses — *now we've accounted for any applicable aggregate deductible.*
3. Apply loss multiplier to the difference to get ultimate recoveries — *this calculates the ultimate service revenue for handling deductible layer claims*
4. Subtract known recoveries from estimated ultimate recoveries and sum over all accounts — *lastly adjust for any service revenue payments already made by the insured to get the service revenue asset.*

Alice: "Let's see this in practice!"

Calculating the Service Revenue Asset

Allocated Claim Expense

In a high deductible program either the insurer manages allocated claim expenses itself or it is considered loss and subject to the program limits. Siewert notes you should make sure you combine your data appropriately. The extra precision gained by developing loss expense separately to losses is likely not worth the effort.

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Full BattleQuiz ***Excel BattleQuiz*** *Excel Files*

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