# Intermediate Reserving Boot Camp: Part 1

Casualty Loss Reserve Seminar
Anaheim, California
September 6th, 2018

## Welcome

- Introductions
  - Instructors
    - Karin Rhoads
    - Brian Clancy
    - Scott Lamb
    - Andrew Somers

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## Agenda

- Session 1
  - Reserving Level-Set
  - Chain Ladder and Mix Changes
  - Tail Strategies
  - Comparison and Look-Forward
- Session 2
  - Recap
  - Berquist-Sherman Adjustments
  - Cape Cod

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## Agenda

### Session 1



## Working Definitions

- Workers Compensation
  – Insurance providing wage replacement and medical benefits to employees injured in course of employment in exchange for right to sue
- Indemnity
  – Compensation for lost wages
- DCC (aka ALAE; Expense)
  – Litigation, defense, and medical cost containment
- Medical
  – Compensation for medical costs



## Working Definitions

- Categories of medical payments
  – Medical Only
    - Medical payments on those claims without any lost time (wage loss) benefit
  – Medical on Indemnity claims
    - Medical payments on those claims which also incurred a lost time (wage loss) benefit
    - Tend to be larger, more complex claims
    - Abbreviate with MPoIC

Appendix

## The Data

- 20 years of data by accident year (AY), development year (or age, DY) and WC coverage
  - – Premium
  - – Paid Loss
  - – Incurred Loss
  - – Reported Claims
  - – Closed Claims
- The chain ladder method is simple enough that you might do it first

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## Chain Ladder Method

Selected CDFs:

| 12-240 | 24-240 | 36-240 | … | 192-240 | 204-240 | 216-240 | 228-240 |
|---|---|---|---|---|---|---|---|
| 2.63 | 1.56 | 1.38 | | 1.03 | 1.02 | 1.01 | 1.01 |

Projected Medical Ultimate ($M) at Age 240:

| AY | 12 | | 24 | | 36 | … | 228 | | 240 | Ult at 240 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1998 | 39 | | 71 | | 82 | | 112 | | 113 | 113 |
| 1999 | 30 | | 57 | | 67 | | 93 | x 1.01= | | 94 |
| 2000 | 30 | | 59 | | 69 | | | | | 96 |
| 2001 | 25 | | 46 | | 54 | | | | | 78 |
| 2002 | 23 | | 42 | | 50 | | | | | 70 |
| … | | | | | | | | | | … |
| 2016 | 158 | | 260 | x 1.56 = | | | | | | 406 |
| 2017 | 168 | x 2.63 = | | | | | | | | 440 |

($M)

| Total Ultimate | Unpaid |
|---|---|
| 3,998 | 852 |

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## Chain Ladder Method

- Summary
  - – Build cumulative triangle of losses, calculate loss development factors, and "square" the triangle
- We have an estimate of our Total Ultimate Loss, but is it right?
- What else should we have looked at?
- In other words:
  - – How can we move to the intermediate level without throwing out our favorite method?

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## Chain Ladder Limitations

- Assumes past development can predict future development
- Assumes stability in:
  - Mix of Claim Types
  - Claim Reporting Patterns
  - Claim Payment Patterns
  - Policy Limits
  - Reinsurance
  - Inflation
- Does not handle projection past the last age in the triangle: need tail methods

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## The Rest of Our Training

- Let's "fix" the chain ladder!
- Session 1
  - **How to handle mix changes in your triangles?**
  - How to handle the tail, even without data?
- Session 2
  - Berquist-Sherman Adjustments for Case Reserve Adequacy changes
  - Bornhuetter-Ferguson to Cape Cod

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## Chain Ladder Method – Mix

- When is mix a problem?
  - Must satisfy two criteria
    1. Your loss development is not homogenous across some variable
    2. The relationships between the levels of the variable are changing
  - When both criteria satisfied, running the chain ladder on an aggregate triangle will produce misleading results
- So, does our medical chain ladder have problems?

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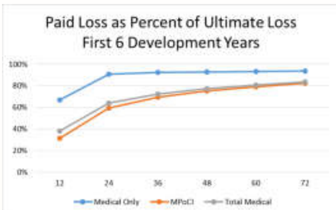
## Chain Ladder Method
## Mix Problems – Criterion 1

- Medical losses are not homogenous




- MPoCI develops very differently from "Medical Only" claims
- "Medical Only" develops less, and faster

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## Chain Ladder Method
## Mix Problems – Criterion 2

- Is something changing between our two types of claims?

| | Age 108-240 CDF |
|---|---|
| Medical Only | 1.06 |
| MPoCI | 1.13 |
| Total | 1.12 |

| | % of Total Paid AY 2005 Age 24 | % of Total Paid AY 2016 Age 24 |
|---|---|---|
| Medical Only | 12% | 35% |
| MPoCI | 88% | 65% |
| Total | 100% | 100% |

- Medical Only has grown substantially compared to the MPoCIs
- **Conclusion:** We should expect some trouble with mix

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## Chain Ladder Method
## After Identifying Mix Problem

- Any ideas for how to handle?
  - Split your triangle by the "mix" variable levels and develop separately
  - Without some recognition of the splitting variable, most other methods will fail
- In our case, split into MPoCI and Medical Only

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## Chain Ladder Method Mix Fixed

| | (A) | (B) | (C) = (B) - (A) |
|---|---|---|---|
| **AY** | **Unpaid** Combined Method | **Unpaid** Separate Method | **Difference** $M |
| | … | | |
| 2014 | 77 | 71 | (6) |
| 2015 | 97 | 87 | (10) |
| 2016 | 146 | 124 | (21) |
| 2017 | 273 | 231 | (42) |
| **Total** | 852 | 767 | (85) |
| **Total Ultimate** | 3,998 | 3,914 | |

- By separating our triangles, we see that the Combined Method overstated Unpaid Loss by $85M (11%)!
- Recent growth in Medical Only, the faster developing segment, drove the over-statement

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## Chain Ladder Method – Mix

- How do I find mix problems?
  - **Outside knowledge:**
    - Underwriting told me they have started selling a lot more policies in NY
  - **Guess and check:**
    - I have a list of variables that seem like they might be important and credible. I will test for differences, build separate triangles and test answers
  - **Statistical clustering:**
    - Feed a dataset with variables attached into a modeling or clustering routine and let it determine significance

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## The Rest of Our Training

- Let's "fix" the chain ladder!
- Session 1
  - ~~How to handle mix changes in your triangle?~~
  - **How to handle the tail, even without data?**
- Session 2
  - Berquist-Sherman Adjustments for Case Reserve Adequacy changes
  - Bornhuetter-Ferguson to Cape Cod

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## Tail Factors

- Our data goes out to age 240 (20 years)
- However, people live 60+ years after injury
- CAS Working Group identified 6 categories
  1. Bondy Methods
  2. Benchmark Data
  3. Curve-Fitting
  4. Remaining Open Counts
  5. Algebraic Methods
  6. Claim-Level Analysis

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## Tail Factors - Bondy

- Methods involve repeating the last AtA factor some number of times
  - $F(n) = AtU\ tail$ and $f(n-1) = last\ link\ ratio$
  - Then, $F(n) = f(n-1)^{\frac{B}{1-B}}$ where $B \in (0,1)$
- Longer tail lines will have larger $B$
- $B$ is an educated selection or least squares fit
  - For least squares, find the $\hat{B}$ to minimize:
    - $\sum_{d=i}^{n}(\log f(d) - \log f(i) x \hat{B}^{d-1})^2$
  - Assume some age $i$ before age $n-1$ is the tail, and see what $\hat{B}$ would minimize the error between the fitted and "true" factors

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## Tail Factors - Bondy

| # Factors in Fit | Error | $\hat{B}$ | Implied Tail Factor |
|---|---|---|---|
| 19 | 6.1E-03 | 0.283 | 1.01 |
| 12 | 3.6E-05 | 0.921 | 1.10 |
| 11 | 3.4E-05 | 0.917 | 1.10 |
| 10 | 3.3E-05 | 0.920 | 1.10 |
| 3 | 1.8E-05 | 0.736 | 1.03 |
| 2 | 1.2E-07 | 1.852 | 0.99 |

- The answer changes depending on our selection for $i$ (# of yrs)
- Using an $i$ that's small or large gives spurious results
- Stable run of estimates around $i \in [9,12]$
- Select $F(n) = 1.10$
- $Total\ Ultimate = \$3.9B\ x\ 1.10 = \$\mathbf{4.3B}$

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## Tail Factors - Bondy

- Pros
  - Easy to perform in Excel
  - Similar to curve-fitting concept
- Cons
  - Can fail for complicated patterns
  - Picking a $\hat{B}$ requires judgment, classically
  - Even if you do a least squares fit, $\hat{B}$ can vary a lot depending on the points in the fit
  - Tends to under-predict long-tail lines

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## Tail Factors – Benchmark

- Use Industry data to develop a tail
  - Schedule P
  - National Council on Compensation Insurance (NCCI)
  - Insurance Services Office (ISO)
  - State WC Rating Bureaus
- Pros – Readily available
- Cons – May require adjustment to make it applicable to your book

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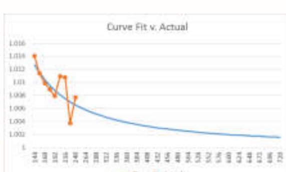
## Tail Factors – Curve-Fitting

- Many different methods
  - One of the most popular is fitting an "Inverse Power Curve"

– Least squares fit, solving for the $\hat{a}$ and $\hat{b}$ that minimize the squared error in the model:




$$\log(\mathrm{f(d)} - 1) = \log(a) + b\ x\ \log(\mathrm{d})$$

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## Tail Factors – Curve-Fitting Inverse Power Curve

| # Factors in Fit | Error | a | b | Implied Tail Factor (to Age 720) | Implied Tail Factor (to convergence) |
|---|---|---|---|---|---|
| 19 | 1.99 | 76.41 | -1.75 | 1.08 | 1.11 |
| 12 | 0.70 | 3.96 | -1.16 | 1.14 | 1.43 |
| 11 | 0.67 | 8.00 | -1.30 | 1.12 | 1.33 |
| 10 | 0.67 | 8.34 | -1.31 | 1.12 | 1.32 |
| 9 | 0.66 | 14.88 | -1.41 | 1.11 | 1.26 |
| 3 | 0.52 | 597133.02 | -3.37 | 1.04 | 1.05 |
| ~~2~~ | ~~7.7E-29~~ | ~~0.00~~ | ~~14.033~~ | ~~1.54E+196~~ | ~~N/A~~ |

– Most tails not close to convergence at 60 years
– Again, issues with using too many or too few points
– Select $F(n) = 1.12$
– $Total\ Ultimate =$
$\$3.9B \ x \ 1.12 =$
$\$\mathbf{4.4B}$

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## Tail Factors – Curve-Fitting Inverse Power Curve

- Pros
  - Easy to perform in Excel
  - Widely known
- Cons
  - Again, you need to figure out how many ages to use
  - Because of the $\log()$, $f(d) \leq 1$ can cause fit issues
  - The curves often don't converge to 1.0 in a reasonable amount of time
- Extensions of this method exist where different distributions are assumed or more parameters are introduced

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## Tail Factors – Curve-Fitting McClenahan and Skurnick

- Fit a curve to each AY to get a tail for each AY
  - $Assume\ e^y = Ar^x$ (or $y = \log(A) + x\log(r)$ )
  - $y = \log(Incremental\ Paid)$, known
  - $x = Development\ Age$, known
  - $r = Decay\ Ratio$, estimated
  - $A = Baseline\ Incremental\ Paid$, estimated
- Log both sides of equation and solve for $\log(r)$, $\log(A)$ with least squares
  - Then $Tail = \frac{1-r}{1-r-r^D}$, $D$ is final dev. age

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## Tail Factors – Curve-Fitting McClenahan and Skurnick

- **Some tweaks to improve results**
  - We fit our curves to only the last 5 years and only on our oldest years
  - Instead of using the tail formula, which assumes the curve is a good fit for all Dev. Ages, we just use the curve for the unpaid portion of the AY and back into the tail
- i.e, $Tail = \frac{Ult\ @\ 240 + r^{20}/(1-r)}{Ult\ @\ 240}$

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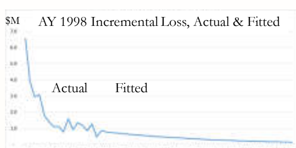
## Tail Factors – Curve-Fitting McClenahan and Skurnick

- **Our Tail based on AY 1998 is below**

| | |
|---|---|
| AY | 1998 |
| Age (D) | 20 |
| r | 0.96 |
| A ($M) | 1.93 |
| Ult @ 240 ($M) | 113.2 |
| Tail after 240 ($M) | 19.3 |
| Final Ultimate ($M) | 132.5 |
| Implied Tail | 1.17 |

  - Select $F(n) = 1.17$
  - $Total\ Ultimate = \$3.9B\ x\ 1.17 = \mathbf{\$4.6B}$

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## Tail Factors – Curve-Fitting McClenahan and Skurnick

- Pros
  - Works well for old AYs with stable decay
  - Can be tweaked with more parameters for better fit
- Cons
  - Need to figure out how many ages to use to fit
  - Decay ratios can be variable and cause fit problems; r > 1 is possible
  - Ideal to have a number of older years to fit to
  - Fits involving early development ages can be very unstable from AY to AY

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## Tail Factors – Open Counts

- General Procedure is:
  1. Estimate an average incremental cost per open count for each future calendar period
  2. Estimate the number of claims remaining open in the same future periods
  3. Multiply the two together to get the tail
- Steps 1 and 2 can be estimated in several different ways
  – Age-to-age development factors
  – Curve-fitting or more complex modeling
  – Mortality rates and escalation rates

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## Tail Factors – Open Counts

- Projected Open Claims – AtA Dev. Factors
  – Create these factors the same way you would with losses and LDFs, just using open claims

| AY | 12-24 | 24-36 | 36-48 | . . . | 204-216 | 216-228 | 228-240 |
|---|---|---|---|---|---|---|---|
| 1998 | 0.473 | 0.606 | 0.557 | | 0.900 | 0.889 | 0.875 |
| 1999 | 0.507 | 0.606 | 0.557 | | 0.900 | 0.889 | |
| 2000 | 0.541 | 0.568 | 0.557 | | 0.900 | | |
| 2001 | 0.556 | 0.594 | 0.502 | | | | |
| 2002 | 0.558 | 0.577 | 0.502 | | | | |
| | | . . . | | | | | |
| 2015 | 0.535 | 0.616 | | | | | |
| 2016 | 0.535 | | | | | | |

- Fit a logarithmic curve and use those values to project opens to ultimate

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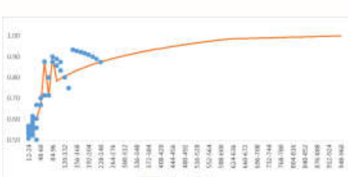
## Tail Factors – Open Counts



– Check that curve looks reasonable
– Check that ultimate opens look reasonable*
– Square your triangle

*Ultimate Opens should be zero or close to it!

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## Tail Factors – Open Counts

- Next step – we need average incremental paid per prior open claims:
  1. Get the actual averages by AY, DY
  2. Model and project to square the average incremental triangle
     a. Select a least squares lognormal fit with AY and DY as variables

$$\log(Increm.Pd.) = a\,x\,AY + b\,x\,DY + c$$

     b. More complex models are possible

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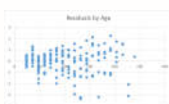
## Tail Factors – Open Counts

- Model check
  – Look at residuals $\hat{e} = (y - \hat{y})$ by model variables
  – The standardized residuals below appear unbiased but may have non-constant variance


- Fixing the model is beyond our scope, but one could look into other variables, smoothing splines, transformations, etc.

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## Tail Factors – Open Counts

| AY | Implied Tail Factor (Age 240 to Age 720) |
|---|---|
| 2009 | 1.18 |
| 2010 | 1.15 |
| 2011 | 1.16 |
| 2012 | 1.17 |
| 2013 | 1.17 |
| 2014 | 1.16 |
| 2015 | 1.15 |
| 2016 | 1.15 |
| 2017 | 1.15 |
| All Year-Weighted | 1.17 |
| 2011-2017 Weighted | 1.16 |

- Multiplying projected incrementals by projected open counts tells us unpaids after age 240 for each AY, so we can get a tail for each AY – or pick an average
  – Select $F(n) = 1.17$
  – $Total\ Ultimate =$ $\$3.9B\ x\ 1.17 =$ $\mathbf{\$4.6B}$

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## Tail Factors – Open Counts

- Pros
  - Methods can use anything from Excel to statistical software
  - Open count projection is easy with enough data, and good techniques exist for fitting incremental paid averages
  - Works well even with a long tail
- Cons
  - May still need to force convergence for open counts
  - Large lump sum payments may throw off fits
- Cross-validation and other procedures can be used to improve method results

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## Tail Factors – Algebraic

- Equalizing the Paid and Incurred Tails
  - Requires existing tail estimate for the Paid or Incurred Triangle and backing into the other estimate
  - May create too much dependence between Paid and Incurred Chain Ladder methods
  - **Better:** Derive a Paid Tail factor and then multiply it by an Incurred/Paid ratio

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## Tail Factors – Algebraic

- NCCI Method
  - Estimates each AY's incurred development after 20 years based on development on all prior AYs in the same CY times a growth factor
  - Pros: Well known: it's used by the NCCI!
  - Cons: Need adequate prior year data, and estimating incurreds is subject to distortion by case reserves on large claims or changing case adequacy

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## Tail Factors – Claim Level

- Review very old years when there are only a few claims left open
- Method 1: Review the potential retention on the remaining open claims
  - Produces only an upper bound (bad for WC)
  - Does not work well for more recent years
- Method 2: Have an expert review the remaining open claims
  - Will produce a tail factor, but again, it won't work well for more recent years

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## Comparison of Paid Tails

($B)

| | Bondy | Inverse Power Curve | McClenahan/Skurnick | Open Counts |
|---|---|---|---|---|
| Selected Tail | 1.10 | 1.12 | 1.17 | 1.17 |
| Ultimate @ 240 | $3.9 | $3.9 | $3.9 | $3.9 |
| Ultimate @ 720 | $4.3 | $4.4 | $4.6 | $4.6 |

- Difference in tails amounts to $300M
- **Caution:** Development of **incurred** loss to age 240 also results in an estimate of $4.6B
  - Unless we expect incurred LDFs < 1 after age 240, our paid tail should probably be at least as big as 1.17

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## Conclusion

- In this session, we learned
  - Some Workers Compensation basics
  - How to find and handle mix changes in your data
  - Several pitfalls and solutions for determining a "tail", even without data
- In Session 2, we will discuss
  - How to find and handle changes in claim reporting patterns
  - Bornhuetter-Ferguson to Cape Cod: What to do when you don't want losses-to-date to impact your unpaid loss estimates

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# Questions and Discussion

## Appendix

- Working Definitions
- Chain Ladder Method Details

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## Working Definitions

- Policy
  - Document detailing the terms and conditions of a contract of insurance
  - Terms specify indemnification or reimbursement
- Premium
  - Amount paid to insurer for promise by the insurer to perform under the terms and conditions of a policy

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## Working Definitions

- Claim
  - Formal request or demand to an insurance company asking for a payment on behalf of insured
  - Coverage based on the terms and conditions of the insurance policy
  - Counted as claim by insurer once deemed to be significant event with payment likely; otherwise incident

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## Working Definitions

- Loss
  - Amount of claim for which the insurance company is responsible
- Case Reserve
  - Amount of claim reported but not yet paid
  - Claim assigned a value by a claims adjuster or by formula based on current information (aka Statistical Reserve)
- Ultimate Loss
  - The amount for which we think a claim, or all claims in aggregate, will eventually settle

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## Working Definitions

- Case Incurred (aka Reported Incurred; Incurred Loss)
  - Total amount of claim reported
  - Paid plus Case Reserve
- IBNR (aka incurred but not reported)
  - Ultimate Loss minus Case Incurred
  - Amount of Loss beyond the Current Case Incurred we expect to eventually incur and pay
- Unpaid Loss
  - IBNR + Case Reserve
  - Ultimate Loss – Paid Loss

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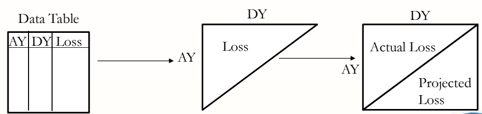
## Chain Ladder Method

- Take your table(s) of data and turn them into triangles
- AY on y-axis, DY on x-axis, losses are on cumulative basis

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## Chain Ladder Method

Total Paid Medical Losses ($M)

| AY | 12 | 24 | 36 | … | 228 | 240 |
|---|---|---|---|---|---|---|
| 1998 | 39 | 71 | 82 | | 112 | 113 |
| 1999 | 30 | 57 | 67 | | 93 | |
| 2000 | 30 | 59 | 69 | | | |
| 2001 | 25 | 46 | 54 | | | |
| 2002 | 23 | 42 | 50 | | | |
| … | | | | | | |
| 2016 | 158 | 260 | | | | |
| 2017 | 168 | | | | | |

$AY\ 2002\ 24\ to\ 36\ LDF\ =\frac{50}{42}=1.18$

- In this method, we calculate loss development factors (LDFs) and project to ultimate
- $Age\ to\ Age\ (AtA)\ LDF\ =\frac{Cumul.\ Loss\ @\ Age+12}{Cumul.\ Loss\ @\ Age}$

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## Chain Ladder Method

Age to Age Factors for Medical Losses

| AY | 12-24 | 24-36 | … | 192-204 | 204-216 | 216-228 | 228-240 |
|---|---|---|---|---|---|---|---|
| 1998 | 1.81 | 1.15 | | 1.01 | 1.01 | 1.00 | 1.01 |
| 1999 | 1.87 | 1.18 | | 1.01 | 1.01 | 1.00 | |
| 2000 | 1.94 | 1.17 | | 1.01 | 1.01 | | |
| 2001 | 1.84 | 1.17 | | 1.01 | | | |
| 2002 | 1.86 | 1.18 | | | | | |
| … | | | | | | | |
| 2016 | 1.65 | | | | | | |
| 2017 | | | | | | | |

Select 3-year average, so 192-204 LDF = 1.01

- Select a column-wise average of LDFs as your Selected LDF for that age
- Average can be 1-year, 2-year, all-yea weighted, etc.

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## Chain Ladder Method

Selected LDFs:

| 12-24 | 24-36 | 36-48 | … | 192-204 | 204-216 | 216-228 | 228-240 |
|---|---|---|---|---|---|---|---|
| 1.69 | 1.13 | 1.07 | | 1.01 | 1.01 | 1.00 | 1.01 |

- Cumulative development factors (age-to-ultimate, CDFs) take each age in the triangle to "ultimate", or to the last age in the triangle
- They are formed by successively multiplying together LDFs
  - $(192\text{-}204)_{LDF}$ x $(204\text{-}216)_{LDF}$ x $(216\text{-}228)_{LDF}$ x $(228\text{-}240)_{LDF}$ = $(192\text{-}240)_{CDF}$ =
  - 1.01 x 1.01 x 1.00 x 1.01 = 1.03

## Chain Ladder Method

Selected CDFs:

| 12-240 | 24-240 | 36-240 | … | 192-240 | 204-240 | 216-240 | 228-240 |
|---|---|---|---|---|---|---|---|
| 2.63 | 1.56 | 1.38 | | 1.03 | 1.02 | 1.01 | 1.01 |

- CDFs are applied to the latest diagonal to get the ultimate loss projection at age 240
  - AY 2017 @ age 12 = 168M
  - Multiply by our $(12\text{-}240)_{CDF}$ = 2.63
  - $AY\ Ultimate\ Loss\ (@\ 240)\ =\ 168M\ x\ 2.63\ =\ 440M$
- Follow this procedure for each AY on the latest diagonal of cumulative loss

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## Chain Ladder Method

Selected CDFs:

| 12-240 | 24-240 | 36-240 | … | 192-240 | 204-240 | 216-240 | 228-240 |
|---|---|---|---|---|---|---|---|
| 2.63 | 1.56 | 1.38 | | 1.03 | 1.02 | 1.01 | 1.01 |

Projected Medical Ultimate ($M) at Age 240:

| AY | 12 | 24 | 36 | … | 228 | 240 | Ult at 240 |
|---|---|---|---|---|---|---|---|
| 1998 | 39 | 71 | 82 | | 112 | 113 | 113 |
| 1999 | 30 | 57 | 67 | | 93 x 1.01= | | 94 |
| 2000 | 30 | 59 | 69 | | | | 96 |
| 2001 | 25 | 46 | 54 | | | | 78 |
| 2002 | 23 | 42 | 50 | | | | 70 |
| … | | | | | | | … |
| 2016 | 158 | 260 x 1.56 = | | | | | 406 |
| 2017 | 168 x 2.63 = | | | | | | 440 |

($M)

| Total Ultimate | Unpaid |
|---|---|
| 3,998 | 852 |

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