7.4.3 → Estimating a trend

→ Overview → After gathering & adjusting the exposure, premium, or loss data, it can be used to estimate trends that reflect changes over time. In this section, we cover methods for determining both premium & loss trends, focusing on selecting a trend that accurately reflects expected future conditions.

→ Calculating trends in insurance data

→ Consider the following example to demonstrate how a trend might be calculated. The table below shows data typically used to estimate premium trends resulting from distributional changes. WP data is used rather than EP data, as it more quickly reflects shifts in distribution.

→ Example →

You are given the following calendar quarter data:

Calendar Quarter	Written Premium at Current Rate Level	Written Exposures
2016Q1	68,409.73	132
2016Q2	69,933.21	134
2016Q3	70,910.48	135
2016Q4	72,977.61	138
2017Q1	74,634.01	140
2017Q2	75,774.76	141
2017Q3	77,435.68	143
2017Q4	78,323.20	144
2018Q1	80,263.03	146
2018Q2	81,959.37	148
2018Q3	83,634.55	150
2018Q4	84,526.43	151

Estimate the calendar quarter average written premium trend.

→ To begin, calculate the average WP for each period by dividing the WP at the CRL by the written exposures.

Calendar Quarter	WP at Current Rate Level	Written Exposures	Avg WP at Current Rate Level
2016Q1	68,409.73	132	68,409.73/132 = 518.26
2016Q2	69,933.21	134	521.89
2016Q3	70,910.48	135	525.26
2016Q4	72,977.61	138	528.82
2017Q1	74,634.01	140	533.10
2017Q2	75,774.76	141	537.41
2017Q3	77,435.68	143	541.51
2017Q4	78,323.20	144	543.91
2018Q1	80,263.03	146	549.75
2018Q2	81,959.37	148	553.78
2018Q3	83,634.55	150	557.56
2018Q4	84,526.43	151	559.78

→ To identify the rate of change, calculate quarterly percentage changes & annual percentage changes in average WP

↳ % Δ one quarter to the next quarter

↳ % Δ one quarter to the following year's same quarter (e.g. 2025 Q1 / 2024 Q1 − 1)

Calendar Quarter	WP at Current Rate Level	Written Exposures	Avg WP at Current Rate Level	Quarterly % Change	Annual % Change
2016Q1	68,409.73	132	518.26		
2016Q2	69,933.21	134	521.89	0.7%	
2016Q3	70,910.48	135	525.26	0.6%	
2016Q4	72,977.61	138	528.82	0.7%	
2017Q1	74,634.01	140	533.10	0.8%	2.9%
2017Q2	75,774.76	141	537.41	0.8%	3.0%
2017Q3	77,435.68	143	541.51	0.8%	3.1%
2017Q4	78,323.20	144	543.91	0.4%	2.9%
2018Q1	80,263.03	146	549.75	1.1%	3.1%
2018Q2	81,959.37	148	553.78	0.7%	3.0%
2018Q3	83,634.55	150	557.56	0.7%	3.0%
2018Q4	84,526.43	151	559.78	0.4%	2.9%

Avg WP @ CRL

2017 Q1 / 2016 Q1 = 533.10 / 518.26 − 1 = 0.0286

→ Given sufficient data, the actuary will often use quarterly avg WP (rather than annual avg WP) to enhance the responsiveness of the statistic.

→ Methods for determining trends

→ There are multiple methods for calculating trends. The choice of method depends on the stability of the data & the type of trend being measured

1) Simple average of percent changes

→ For premium trends, where changes in average premium are relatively stable, a simple arithmetic average of periodic percentage changes often suffices. This approach is straightforward & is commonly used on the exam.

→ For instance:

→ The average quarterly percent change can be estimated as:

$$\frac{0.007 + 0.006 + \cdots + 0.007 + 0.004}{11} = 0.70\%$$

→ The average annual percent change can be estimated as:

$$\frac{0.024 + 0.030 + \cdots + 0.030 + 0.029}{8} = 2.98\%$$

2) Linear & exponential trend fitting

→ For loss trends, where loss data often exhibits volatility, simple averages may be less reliable. In such cases, actuaries use curve fitting methods like linear or exponential regression to determine trends:

→ Linear trend → Assumes a constant increase or decrease per period

→ Exponential trend → Assumes a constant percentage change per period, ideal for data showing compounding effects

→ Both linear & exponential models may be suitable for capturing upward trends. However, when used to measure downward trends, the linear model may eventually project negative values. Since frequency & severity cannot be negative in insurance, this limitation highlights a drawback of linear trend models.

→ For loss data, trends can be analyzed by examining the pure premium, or separately analyzing frequency & severity trends. If separate frequency & severity trends are selected, these selected trends can be combined to a single pure premium trend as follows:

$$(1 + \text{Pure Premium trend}) = (1 + \text{Frequency trend}) \times (1 + \text{Severity trend})$$

→ Notes → On the exam, you will most often be asked to calculate trends using the simple average of percent changes.

→ If given a trend, it will usually be presented as an annual rate of change, although other compounding periods are possible

→ Using historical data for trend selection

→ When determining a trend, the amount of historical data to include depends on the actuary's judgment, balancing both responsiveness & stability

→ In cases of changing conditions, a shorter historical period (e.g. the last 4-8 quarters) may better reflect current trends. Conversely, a longer period helps smooth out seasonal or anomalous fluctuations.

→ Below is a comparison of the exponential fit for avg WP using different data point intervals:

Number of Points	Avg WP Exponential Fit
12 point	2.9%
8 point	2.9%
6 point	2.9%
4 point	2.5%

→ Example →

You are given the following information:

- The annual premium exponential trend fit based on data for the 12 months ending each quarter evaluated through December 31, 2017 is:

Year Ending Calendar Quarter	Avg Earned Premium at Current Rate Level
2015Q1	497.30
2015Q2	499.70
2015Q3	487.00
2015Q4	476.80
2016Q1	469.00
2016Q2	461.20
2016Q3	465.60
2016Q4	469.50
2017Q1	474.80
2017Q2	480.20
2017Q3	483.60
2017Q4	489.50

Renewals begin to ↑ deductible

All policies have ↑ deductible

B/c CY data, includes policies w/ old deductible not affected by old deductible

17 / 8 / 6 / 4

Number of Points	Annual Exponential Trend Fit
12 point	-0.8%
8 point	3.1%
6 point	4.1%
4 point	4.0%

- All policies are annual.
- Proposed rates will be in effect from January 1, 2019 to January 1, 2020.
- Starting with July 1, 2015 renewals, the minimum deductible was increased from $500 to $1,000.

Select the trend to be applied to CY2017 earned premium. Include justification of the premium trend selection.

→ Since the deductible change was implemented starting w/ policies renewing on July 1, 2015, the last possible date a policy could be written w/ the old deductible is June 30, 2016. So, there could be policies w/ the old deductible earning premium as late as June 30, 2018.

→ The trend will be applied to CY2017 EP, so we want to select a trend that is not as affected by the deductible change. However, we also want to include as much data as possible.

→ B/c the 6-point trend avoids most of the influence of the deductible change, & the data point stabilizes at this point, select a trend of 4.1%

⇒ Since all of the trends use at least 4 data points, all will still be impacted by the old deductible. So, we want to choose a value where the impact is minimal & the data has stabilized

→ Seasonality

→ The data for some lines of business can be affected by seasonality. For instance, auto insurance losses due to hail damage may be more likely to occur during spring & summer months. To smooth out the seasonality in the data, it is common to use 12-month rolling data.

→ To smooth out seasonality in monthly data, we will look at periods of 12 months ending each month to find any trend (e.g. the 12 months ending Jan 2018, the 12 months ending Feb 2018, etc.). With quarterly data, we will look at periods of 12 months ending each quarter (e.g. the 12 months ending Q1 2018, the 12 months ending Q2 2018, etc.).

→ Effects of limits on trend

→ When trending loss data that is subject to limits, the effect of these limits on the severity trend should be considered. This is b/c if you apply a severity trend to ground-up losses that have been split by a deductible, there will be a different effective trend rate for the portion of losses above & below the point where losses are split.

→ In a previous subsection, we briefly introduced basic limits ratemaking. Recall that basic limits losses are losses that have been capped at the basic limit, i.e. the limit associated w/ the base rate. Ground-up losses, or losses that are not capped, can be referred to as total limits losses. Then, the difference between total limits losses & basic limits losses is referred to as excess losses. Let's go through an example to see how severity trend affects each of these types of losses.

→ Example →

You are given the following loss information:

Claim Number	Total Limits Loss
1	$15,000
2	$24,000
3	$43,000
4	$19,000
5	$37,000
6	$29,000
7	$51,000
8	$12,000

- Every total limits loss is subject to a 10% severity trend.
- The basic limit is $20,000.

Determine the trends for basic limits losses and for excess losses.

→ First, find the basic limits losses before the severity trend is applied by capping the losses at $20,000. Then find the excess losses as the portion of losses above the basic limit.

Claim Number	Total Limits Loss	Basic Limits Loss	Excess Loss
1	15,000	15,000	0
2	24,000	20,000	4,000
3	43,000	20,000	23,000
4	19,000	19,000	0
5	37,000	20,000	17,000
6	29,000	20,000	9,000
7	51,000	20,000	31,000
8	12,000	12,000	0
Total	**230,000**	**146,000**	**84,000**

→ Next, apply the severity trend of 10% to the total limits losses. Then, find the basic limits losses & excess losses for the trended loss amounts (i.e. repeat the same process as above, just w/ the new trended loss amounts). The results are shown below, along w/ the trends for each amount.

Claim Number	Total Limits Trended Loss	Total Limits Trend	Basic Limits Trended Loss	Basic Limits Trend	Excess Loss Trended Loss	Excess Loss Trend
1	16,500	10.0%	16,500	10.0%	0	N/A
2	26,400	10.0%	20,000	0.0%	6,400	60.0%
3	47,300	10.0%	20,000	0.0%	27,300	18.7%
4	20,900	10.0%	20,000	5.3%	900	N/A
5	40,700	10.0%	20,000	0.0%	20,700	21.8%
6	31,900	10.0%	20,000	0.0%	11,900	32.2%
7	56,100	10.0%	20,000	0.0%	36,100	16.5%
8	13,200	10.0%	13,200	10.0%	0	N/A
Total	**253,000**	**10.0%**	**149,700**	**2.5%**	**103,300**	**23.0%**

→ Therefore, as the table shows, the trend for the basic limits losses is $\frac{149,700}{146,000} - 1 = 2.5\%$.

The trend for excess losses is $\frac{103,300}{84,000} - 1 = 23.0\%$

→ Notice that the trend for basic limit losses is much lower than the trend applied to the total limits losses. On the other hand, the trend for excess losses is much higher. This occurs for two reasons:

→ 1) For losses that are above the basic limit, the entire increase in losses associated w/ these claims is realized in the excess losses trend.

→ 2) For losses that are below but close to the basic limit, the trend pierces the losses into the excess layer, which means there are more losses in that layer

→ In general, for a positive severity trend,

Basic limits trend ≤ Total limits trend ≤ Excess loss trend

On the other hand, if the severity trend is negative, the relationship becomes

Excess loss trend ≤ Total limits trend ≤ Basic limits trend

→ For basic limits ratemaking, the indicated severity trend based on total limits losses should be adjusted before it is applied to basic limits losses. An alternative approach is to use basic limits data when estimating the severity trend.

→ Notice that deductibles have a similar effect to limits on severity trend. The only difference when determining the different effects on trend is that losses are censored below the deductible instead of above the limit. So, we won't cover that effect in more detail.

→ Example →

You are given the following information for accident year 2017:

Claim Number	Ground-up Loss
1	92,300
2	116,000
3	68,500
4	79,200
5	134,100
6	43,000

- Ground-up annual claims have an inflation rate of 20%.

Calculate the annual inflation rate for claims in the layer $50,000 in excess of $75,000 for 2018.

→ First, determine the losses in layer $50,000 in excess of $75,000, which is the portion of any loss between $75,000 & $125,000.

Claim Number	Ground-up Loss	Loss in 50xs75
1	92,300	17,300
2	116,000	41,000
3	68,500	0
4	79,200	4,200
5	134,100	50,000
6	43,000	0
Total	**533,100**	**112,500**

→ Then, trend the ground-up losses using the inflation rate of 20%, & determine the portion of trended losses that are in the layer $50,000 in excess of $75,000.

Claim Number	Trended Loss	Trended Loss in 50xs75
1	110,760	35,760
2	139,200	50,000
3	82,200	7,200
4	95,040	20,040
5	160,920	50,000
6	51,600	0
Total	**639,720**	**163,000**

→ Therefore, the annual inflation rate for claims in the layer $50,000 in excess of $75,000 is

$$\frac{163,000}{112,500} - 1 = 44.9\%$$

ALWAYS: new / old − 1

→ Assignment

→ Q1) (a) ***(2 points)*** Given the following claim information for accident year 2005, calculate the annual inflation rate for claims in the layer $50,000 excess of $100,000 for 2006. Assume a ground-up annual claims inflation rate of 10%. Show all work.

Claim	Ground-up Loss
1	$75,000
2	$100,000
3	$125,000
4	$150,000

(b) ***(1.25 points)*** How would you expect the inflation rate in the layer $50,000 excess of $100,000 to differ from the inflation rate for claims limited to $100,000. Explain two reasons for the difference between the inflation rates.

→ a)

	A	B	C	D	E	F	G
1							
2		Layer	$50,000	excess of	$100,000		
3		Inflation rate	10%				
4							
5		Claim	Ground-up Loss	Loss in 50 xs 100			
6		1	$75,000	$0	=IF(C6>E2,MIN(C6-E2,C2),0)		
7		2	$100,000	$0			
8		3	$125,000	$25,000			
9		4	$150,000	$50,000			
10		Total	$450,000	$75,000			
11							
12		Claim	Trended Ground-up Loss	Loss in 50 xs 100			
13		1	$82,500	$0			
14		2	$110,000	$10,000			
15		3	$137,500	$37,500			
16		4	$165,000	$50,000			
17		Total	$495,000	$97,500			
18							
19			50k excess of 100k trend=	30%	=D17/D10-1		
20							
21							
22							

→ b) We would expect the trend in the excess layer to be greater than in the limited layer b/c:

→ 1) For losses already in the excess layer, inflation impacts only the portion of the loss in the excess layer. The basic limit portion does not change

→ 2) For losses near the basic limit, inflation causes the losses to pierce the increased limits layer, resulting in increased frequency of increased limits losses

⇒ Q2) An actuary is calculating a rate change to be effective July 1, 2021. Given the following:

- Policies are written on an annual basis.
- Rates are expected to be in effect for one year.
- The actuary selects a single frequency trend rate and a single severity trend rate.
- The frequency trend is calculated using the quarterly data given below, which needs to be adjusted for seasonal variation.

Calendar Quarter	Earned Exposures	Closed Claim Counts	Frequency
2017Q1	10,000	580	0.0580
2017Q2	10,000	645	0.0645
2017Q3	10,000	720	0.0720
2017Q4	10,000	656	0.0656
2018Q1	10,000	595	0.0595
2018Q2	10,000	671	0.0671
2018Q3	10,000	732	0.0732
2018Q4	10,000	668	0.0668
2019Q1	10,000	612	0.0612
2019Q2	10,000	695	0.0695
2019Q3	10,000	753	0.0753
2019Q4	10,000	680	0.0680

The annual severity exponential trend fit based on data for the 12 months ending each quarter evaluated through December 31, 2019 is:

Number of Points	Severity Exponential Fit
20	-1.20%
16	-1.15%
12	0.50%
8	2.28%
6	2.17%
4	2.30%

Select the annual trend to be applied to AY2017 losses. Include justification of the severity trend selection.

→ We start by selecting the frequency trend. We're told that the data used to compute the frequency trend is adjusted for seasonal variation.

Year Ending Calendar Quarter	4Q Moving Earned Exposures	4Q Moving Closed Claim Counts	4Q Moving Frequency	Annual % Change
2017Q4	40,000	2,601	0.0650	-
2018Q1	40,000	2,616	0.0654	-
2018Q2	40,000	2,642	0.0661	-
2018Q3	40,000	2,654	0.0664	-
2018Q4	40,000	2,666	0.0667	2.50%
2019Q1	40,000	2,683	0.0671	2.56%
2019Q2	40,000	2,707	0.0677	2.46%
2019Q3	40,000	2,728	0.0682	2.79%
2019Q4	40,000	2,740	0.0685	2.78%

2668/40000 / 2601/40000 − 1

Average: 2.62%

⇒ Take an average of the annual % changes to get a selected frequency trend of 2.62%

→ There are several valid choices for selecting the severity trend. Typically, when trend rates are stable, we'll want to select the fit that includes as much data as possible. However, we can see from the given exponential fits that this is not the case. The 20 point & 16 point fits (which include data starting from 2016 Q1 & 2015 Q4, respectively) produce a negative severity trend, whereas the trend becomes positive & appears to stabilize in the fits that use more recent data. Since we have no reason to expect this to change in the future, the most sensible choice is to select the 8 point, 6 point, or 4 point exponential trend, or an average of the three.

→ We'll select the 8 point severity trend of 2.28%. This selection uses the most data while still being recent enough to reflect the period after the severity trend stabilized.

⇒ So, the annual loss trend (pure premium trend) is

Loss trend Yr = (1 + 0.0262)(1 + 0.0228) − 1

↓ = 4.96%