7.1.1 → Berquist-Sherman Paid Claim development adjustment

→ Overview → As we discussed in Section 6.2, a change in the rate at which claims are settled can distort the age-to-age factors when using the development method. To be specific, an increase in the settlement rate can result in overestimated development factors & a decrease in the settlement rate can result in underestimated development factors. This would lead to overestimated or underestimated ultimate claims estimates, respectively.

→ To account for this, we can apply the Berquist-Sherman paid claims development adjustment, sometimes called the Berquist-Sherman claims settlement rate adjustment. This technique involves adjusting paid claims by interpolating between the historical disposal rates & the most recent disposal rates at each maturity for the same for each AY. After this, the development method can be performed as usual.

→ This technique's main assumption is that increases in the percentage of closed claim counts relative to ultimate claim counts are associated w/ increases in the percentage of total claims paid. In other words, the disposal rates are assumed to be roughly proportional to the total percentage of ultimate claims paid for each maturity.

→ Though this is frequently true, there are exceptions. For example, if a company launched an initiative to prioritize closing large claims before small ones, the percentage of ultimate claims paid could increase w/o the disposal rates changing at all. So, it is important to be aware of any other changes that could impact the claims settlement rate when considering applying the Berquist-Sherman (B-S) adjustment.

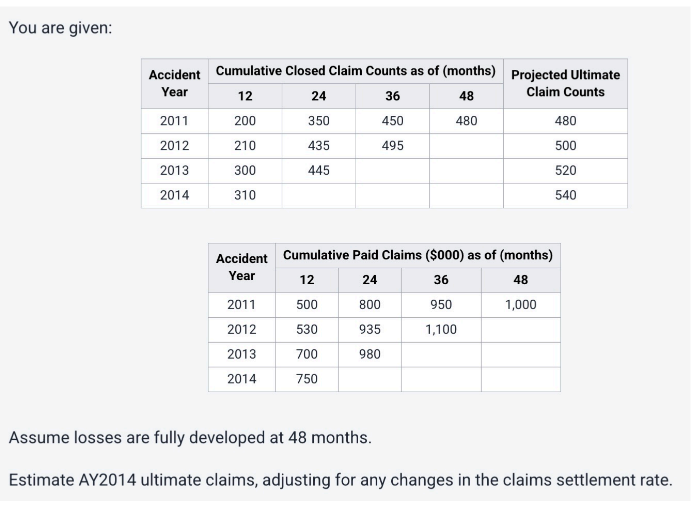
→ Mechanics of the Berquist-Sherman paid claim development adjustment

→ In order to determine whether or not the B-S adjustment is needed, we should have evidence that the settlement rate is actually changing. We can do this by looking at a triangle of the disposal rates. If the disposal rates at each maturity are not consistent between AYs, an adjustment may be appropriate.

→ As a reminder, the disposal rate for a given AY & maturity is calculated by dividing the cumulative closed claim counts by the projected ultimate claim counts. Exam questions often provide the projected ultimate claim counts for each AY to facilitate the calculation of disposal rates. If this information isn't provided, you'll need to first project the ultimate claim counts for each AY using reported data.

→ We'll demonstrate how to apply the B-S paid claims development through an example. Note that the table structure in this example is commonly used in past CAS exam questions.

→ Example →



You are given:

Accident Year	Cumulative Closed Claim Counts as of (months) 12	24	36	48	Projected Ultimate Claim Counts
2011	200	350	450	480	480
2012	210	435	495		500
2013	300	445			520
2014	310				540

Accident Year	Cumulative Paid Claims ($000) as of (months) 12	24	36	48
2011	500	800	950	1,000
2012	530	935	1,100	
2013	700	980		
2014	750			

Assume losses are fully developed at 48 months.

Estimate AY2014 ultimate claims, adjusting for any changes in the claims settlement rate.

→ Evaluate data

→ First, we need to investigate & see if any adjustments are actually needed. We can view the claims settlement rates by creating a disposal rate triangle.

Accident Year	Historical Disposal Rate 12 Months	24 Months	36 Months	48 Months
2011	$200/480 = 0.417$	$350/480 = 0.729$	$450/480 = 0.938$	$480/480 = 1.000$
2012	$210/500 = 0.420$	$435/500 = 0.870$	$495/500 = 0.990$	
2013	$300/520 = 0.577$	$445/520 = 0.856$		
2014	$310/540 = 0.574$			

→ Upon reviewing the disposal rates, there is a noticeable increase in the proportion of ultimate claims closed beginning CY 2013, suggesting an increase in the settlement rate. Given this evidence, an adjustment may be warranted.

→ To perform a B-S adjustment for a change in settlement rate, we start by selecting the disposal rates for each maturity. Since the disposal rates have changed, we will select the most recent ones available, i.e. the disposal rates along the diagonal. One advantage of choosing the latest diagonal as the starting point is that it ensures that the latest diagonal of the adjusted paid claim remains consistent w/ that of the unadjusted paid claim triangle.

For the first maturities, there is technically a column of zeros (for when adjusting downward)

Accident Year	Historical Disposal Rate 12 Months	24 Months	36 Months	48 Months
2011	$200/480 = 0.417$	$350/480 = 0.729$	$450/480 = 0.938$	$480/480 = 1.000$
2012	$210/500 = 0.420$	$435/500 = 0.870$	$495/500 = 0.990$	
2013	$300/520 = 0.577$	$445/520 = 0.856$		
2014	$310/540 = 0.574$			
Selected	0.574	0.856	0.990	1.000

→ Restate paid claims

→ The next step is to restate paid claim amounts using the selected disposal rates.

→ To do this, we can either use linear interpolation or exponential interpolation. Although the source text utilized exponential interpolation, linear interpolation has been used on the past CAS exams. For simplicity & to align w/ the approach used in the past CAS exam, we will begin w/ linear interpolation & discuss the exponential interpolation approach afterward.

→ We can linearly interpolate the paid claim amounts for each year & maturity by relating them to the historical & selected disposal rates. The values we interpolate between depend on whether the selected disposal rate is larger or smaller than the historical disposal rate.

→ If the historical disposal rate is below the selected disposal rate, adjust cumulative paid claims upward, i.e. interpolate between the claims at the current (t) & the next (t+1) maturities.

$$\bigstar(1)\quad \text{Adjusted Paid}_t = \text{Paid}_t + (\text{Paid}_{t+1} - \text{Paid}_t)\left[\frac{\text{Selected DR}_t - \text{Historical DS}_t}{\text{Historical DR}_{t+1} - \text{Historical DS}_t}\right]$$

& if the historical rate is above the selected disposal rate, adjust cumulative paid claims downward, i.e. interpolate between the claims at the previous (t−1) & the current (t) maturities.

$$\bigstar(2)\quad \text{Adjusted Paid}_t = \text{Paid}_t - (\text{Paid}_t - \text{Paid}_{t-1})\left[\frac{\text{Historical DR}_t - \text{Selected DR}_t}{\text{Historical DR}_t - \text{Historical DR}_{t-1}}\right]$$

★ Excel

= Forecast(x, [y₀:y₁], [x₀:x₁])

↳ output is adjusted P_t

⇒ works regardless of adjusting upward or downward (i.e no need for two cases of the formula)

⇒ NEED column of zeros at 0 months for it to work for all cells

point-slope form: line through (x_0, y_0) + (x_1, y_1) at x is

$$y = y_0 + \frac{y_1 - y_0}{x_1 - x_0}(x - x_0)$$

use $(x_0, y_0) = (DR_t, P_t)$ + $(x_1, y_1) =$ either (DR_{t+1}, P_{t+1}) or (DR_{t-1}, P_{t-1})

$y =$ adjusted P_t when $x =$ selected DR_t

→ Notes → As a tip, notice that for the final term in both equations, the numerator, denominator, as well as the difference in paid claims should all be positive.

→ The table below summarizes adjusted cumulative claim counts.

→ Cells highlighted in orange have a lower historical disposal rate than the selected disposal rate. Therefore, we interpolate paid claims upward using equation (1) from above. For example, the adjusted claims for AY 2011 as of 24 months is

$$800 + (950-800)\left(\frac{0.856 - 0.729}{0.938 - 0.729}\right) = 891.15$$

→ Cells highlighted in blue have a higher historical disposal rate than the selected disposal rate. Therefore, we interpolate paid claims downward using equation (2) from above. For example, the adjusted claims for AY 2012 as of 24 months is

$$935 - (935-530)\left[\frac{0.870 - 0.856}{0.870 - 0.420}\right] = 922.19$$

→ The adjusted claim amounts on the diagonal are the same as the corresponding unadjusted claim amounts b/c they were already stated using the most current claims settlement rates.

Column of zeros at zero months

Accident Year	Adjusted Cumulative Paid Claims ($000) as of (months) 12	24	36	48
2011	651.11	891.15	992	1,000
2012	668.67	922.19	1,100	
2013	696.54	980		
2014	750			

→ After completing the adjustment, we can perform the development method as normal on the adjusted claims to estimate the ultimate claims for AY 2014.

Accident Year	Adjusted Paid Claims Development Factors 12-24 Months	24-36 Months	36-48 Months
2011	$1.37 = 891.15/651.11$	$1.11 = 992/891.15$	$1.01 = 1{,}000/992$
2012	$1.38 = 922.19/668.67$	$1.19 = 1{,}100/922.19$	
2013	$1.41 = 980/696.54$		
Selected	1.38	1.15	1.01

→ The estimated ultimate claims are:

AY 2014 ultimate claims = 750 (1.38) (1.15) (1.01) = 1,202.18

→ Note that w/o making an adjustment for the changing claims settlement rate, we would obtain the following development factors:

Accident Year	Unadjusted Paid Claims Development Factors 12-24 Months	24-36 Months	36-48 Months
2011	$800/500 = 1.60$	$950/800 = 1.19$	$1{,}000/950 = 1.05$
2012	$935/530 = 1.76$	$1{,}100/935 = 1.18$	
2013	$980/700 = 1.40$		
Selected	1.59	1.18	1.05

which would lead us to significantly overestimating ultimate claims:

AY 2014 unadjusted ultimate claims = 750 (1.59) (1.18) (1.05) = 1,481.88

→ In the long run, consistently overestimating ultimate claims could cause an insurance company to keep too much cash in the reserve in order to pay those claims. This means that the insurer has less money to invest & could cause the firm to become unprofitable.

→ Here is a summary of the B-S paid claims development adjustment:

→ 1) Analyze the historical disposal rates. If disposal rates have changed significantly over the years, a B-S paid claims development adjustment is warranted.

→ 2) (Assuming adjustment is appropriate) Restate the cumulative paid claims.

- → a) Select the disposal rates by maturity
- → b) Interpolate between paid claims of consecutive maturities
  - → If historical disposal rate < selected disposal rate, then adjust paid claims upward w/ equation (1)
  - → If historical disposal rate > selected disposal rate, then adjust paid claims downward w/ equation (2)

→ 3) Perform the paid development method

→ Alternative to linear interpolation: Exponential Fits

→ Though linear interpolation is more commonly used on the exam to determine the adjusted paid claims, we may also be asked to do this using two-point exponential fits. In this case, start by obtaining an adjusted cumulative closed claim count triangle by multiplying the estimated ultimates for each AY by the selected disposal rates for each maturity.

Accident Year	Adjusted Closed Claim Counts as of (months) 12	24	36	48
2011	$480(0.574) = 276$	$480(0.856) = 411$	$480(0.990) = 475$	480
2012	$500(0.574) = 287$	$500(0.856) = 428$	495	
2013	$520(0.574) = 299$	445		
2014	310			

→ Then, to adjust the claim amounts, we will apply the equation $Y = ae^{bX}$ where

→ Y is the adjusted closed claim amount

→ X is the adjusted closed claim count

→ a + b are regression parameters

→ Notes → a + b can be calculated using data, but doing so is quite time-consuming. As such, we expect that if you encounter any problems on this topic, the values of a + b for each AY + maturity will be provided to you. This has been the case for all previous CAS exam problems on this topic. Here are the calculations anyways:

$$\Rightarrow \text{At each maturity } t,\ b = \frac{\ln(\text{claims at } t) - \ln(\text{claims at } t-1)}{[\text{count at } t] - [\text{count at } t-1]} = \frac{\Delta y}{\Delta x}$$

$$\Rightarrow \ln(y) = \ln(a e^{bx}) = \ln(a) + bx \quad \text{slope}$$

$$\ln(y) - bx = \ln(a) \Rightarrow a = \frac{y}{e^{bx}} = \frac{\text{claims at } t}{\exp[b \times \text{count at } t]}$$

recalculate for each AY + maturity combo

→ Also note that since we selected the most recent disposal rate of each maturity, the most recent claim counts for each maturity, i.e. along the diagonal, do not need to be adjusted.

→ Here are parameters a + b in our motivating example above.

Accident Year	Parameter ("a" ; "b") for Two-Point Exponential Fit 12 Months	24 Months	36 Months	48 Months
2011		$(267.18\,;0.00313)$	$(438.40\,;0.00172)$	$(440.13\,;0.00171)$
2012		$(312.02\,;0.00252)$	$(287.81\,;0.00271)$	
2013		$(348.95\,;0.00232)$		

→ To adjust the cumulative paid claims, the a + b parameters used for each period are determined by comparing the historical & adjusted closed claim counts.

→ If the historical claim count is below the adjusted claim count, then adjust paid claims upward, i.e. use a + b at the next maturity.

→ For example, for AY 2011 at 24 months, the historical claim count of 350 is lower than the adjusted claim count of 411. Therefore, we use a = 438.40 & b = 0.00172 (the values at 36 months) when computing the AY 2011 adjusted paid claims at 24 months:

$$438.40\,e^{0.00172 \times 411} = 888.06$$

→ If the historical claim count is above the adjusted claim count, then adjust paid claims downward, i.e. use a + b from the current maturity

→ For example, for AY 2012 at 24 months, the historical claim count of 435 is higher than the adjusted claim count of 428. Therefore, we use a = 312.02 & b = 0.00252 (the values at 24 months) when computing the AY 2012 adjusted paid claims at 24 months:

$$312.02\,e^{0.00252 \times 428} = 918.36$$

→ One thing to note is, that for any AY at the first maturity, we will always use a & b at the second maturity. That is b/c the parameters are not calculated for the first maturity. Take AY 2013 at 12 months as an example. The historical claim count is 300, which exceeds the adjusted claims count of 299. However, there are no parameters calculated for the 12-month maturity. So, use the 24-month parameters for that AY instead.

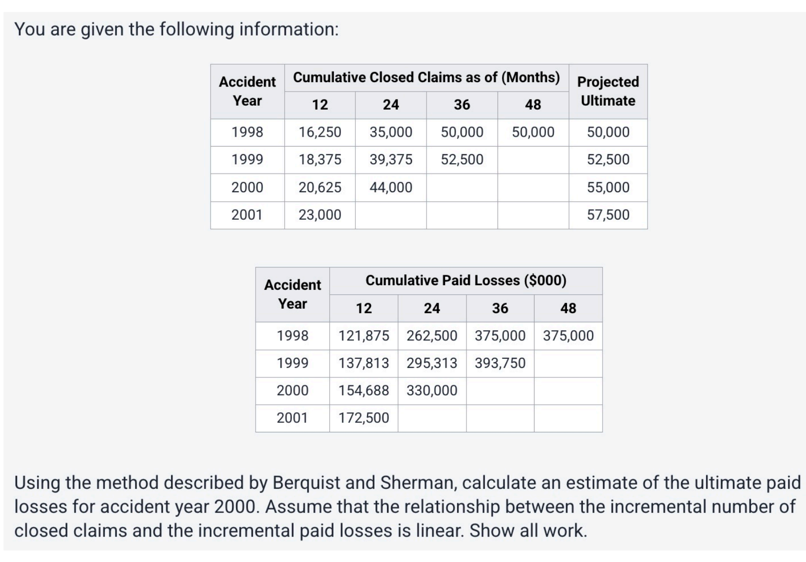
$$348.95\,e^{0.00232 \times 299} = 697.60$$

→ Note → Since the claim counts are adjusted using the selected disposal rates, equivalently, we can also compare the historical & selected disposal rates. In that case, the comparison process is identical to the comparison we performed for the linear interpolation approach above.

→ The complete adjusted paid claims triangle is given below.

Accident Year	Adjusted Cumulative Paid Claims ($000) as of (months) 12	24	36	48
2011	$267.18e^{0.00313\times276} = 633.56$	$438.40e^{0.00172\times411} = 888.06$	$440.13e^{0.00171\times475.2} = 991.83$	1,000
2012	$312.02e^{0.00252\times287} = 643.70$	$312.02e^{0.00252\times428} = 918.36$	1,100	
2013	$348.95e^{0.00232\times299} = 697.60$	980		
2014	750			

→ Example →



You are given the following information:

Accident Year	Cumulative Closed Claims as of (Months) 12	24	36	48	Projected Ultimate
1998	16,250	35,000	50,000	50,000	50,000
1999	18,375	39,375	52,500		52,500
2000	20,625	44,000			55,000
2001	23,000				57,500

Accident Year	Cumulative Paid Losses ($000) 12	24	36	48
1998	121,875	262,500	375,000	375,000
1999	137,813	295,313	393,750	
2000	154,688	330,000		
2001	172,500			

Using the method described by Berquist and Sherman, calculate an estimate of the ultimate paid losses for accident year 2000. Assume that the relationship between the incremental number of closed claims and the incremental paid losses is linear. Show all work.

→ The question does not suggest that there have been any changes in the environment or allow us to show that the data needs to be adjusted in any way. However, since we're given paid claims data & told to use "the method described by Berquist & Sherman", we can assume that the data will need to be adjusted for a change in the settlement rate.

→ We can start by creating a disposal rate triangle & selecting the disposal rates along the diagonal. B/c AY 2000 is already 24 months old, we can skip over the 12-month column. Claims appear to be fully developed by 36 months, so we can skip over the 48-month column.

Accident Year	Disposal Rates 24 Months	36 Months
1998	$35{,}000/50{,}000 = 0.700$	$50{,}000/50{,}000 = 1.000$
1999	$39{,}375/52{,}500 = 0.750$	$52{,}500/52{,}500 = 1.000$
2000	$44{,}000/55{,}000 = 0.800$	
Selected	0.800	1.000

→ We can see from these disposal rates that there is speed on increasing claims settlement rate. In fact, the disposal rate increases each year. As a result, the selected disposal rate is always at least as large as the historical disposal rate for each AY & maturity. So, we don't need to worry about which direction to interpolate & can just apply equation (1) to each cell:

$$\text{Adjusted Paid}_t = \text{Paid}_t + (\text{Paid}_{t+1} - \text{Paid}_t)\left[\frac{\text{Selected DR}_t - \text{Historical DS}_t}{\text{Historical DR}_{t+1} - \text{Historical DS}_t}\right]$$

Accident Year	Adjusted Paid Claims ($000) 24 Months	36 Months
1998	$262{,}500 + (375{,}000 - 262{,}500)\left(\frac{0.800 - 0.700}{1.000 - 0.700}\right) = 300{,}000$	375,000
1999	$295{,}313 + (393{,}750 - 295{,}313)\left(\frac{0.800 - 0.750}{1.000 - 0.750}\right) = 315{,}000$	393,750
2000	330,000	

→ Calculate & select the development factor for the adjusted paid claims, focusing only on the 24-to-36 month period. For AYs 1998 & 1999, divide the adjusted paid claims at 36 months by the adjusted paid claims at 24 months.

Accident Year	Adjusted Paid Claim Development Factors 24 to 36 Months
1998	$375{,}000/300{,}000 = 1.25$
1999	$393{,}750/315{,}000 = 1.25$
Selected	1.25

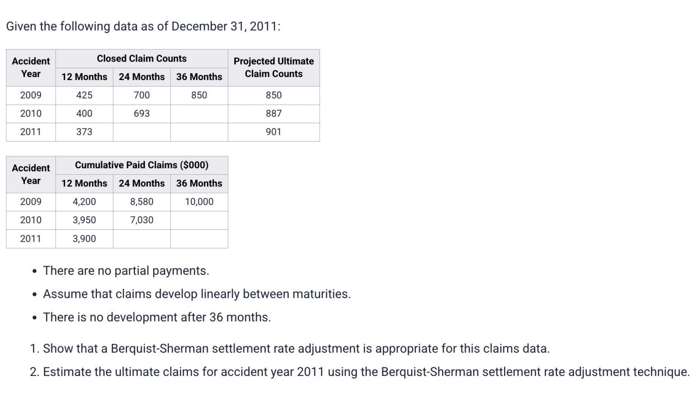
→ Use the selected factor to calculate the ultimate claims for AY 2000:

AY 2000 ultimate claims = 330,000 (1.25) (1,000) = $412,500,000

→ Notes → This problem was relatively brief since we only needed to calculate a few adjusted paid claims & development factors. Estimating the ultimate claims for AY 2001 would have taken longer, as it's only at 12 months of maturity.

→ Assignment

→ Q1)



Given the following data as of December 31, 2011:

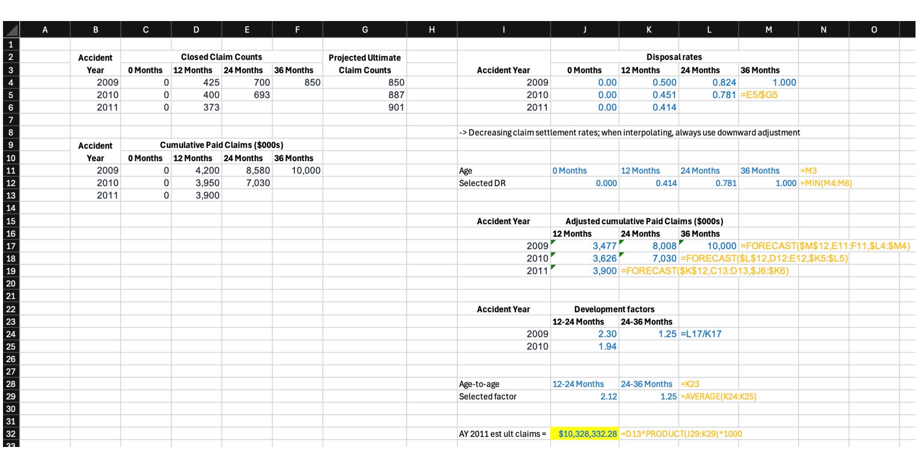
Accident Year	Closed Claim Counts 12 Months	24 Months	36 Months	Projected Ultimate Claim Counts
2009	425	700	850	850
2010	400	693		887
2011	373			901

Accident Year	Cumulative Paid Claims ($000) 12 Months	24 Months	36 Months
2009	4,200	8,580	10,000
2010	3,950	7,030	
2011	3,900		

- There are no partial payments.
- Assume that claims develop linearly between maturities.
- There is no development after 36 months.

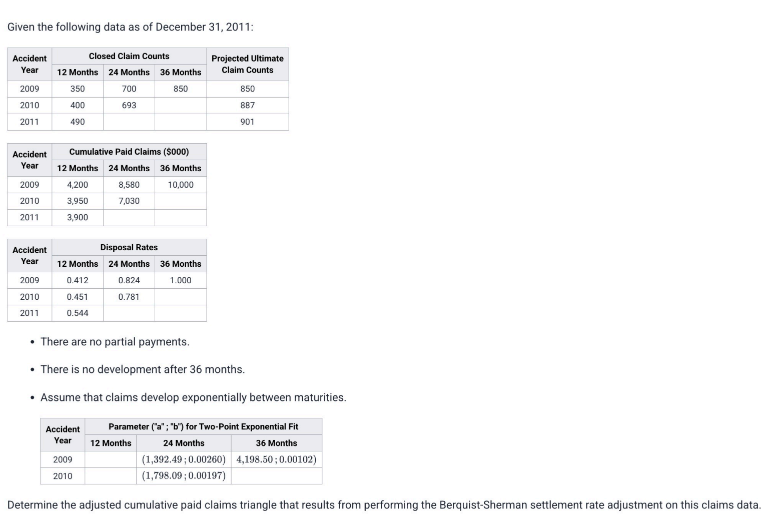
1. Show that a Berquist-Sherman settlement rate adjustment is appropriate for this claims data.
2. Estimate the ultimate claims for accident year 2011 using the Berquist-Sherman settlement rate adjustment technique.

→



	B	C	D	E	F	G	I	J	K	L	M	N
2	Accident		Closed Claim Counts			Projected Ultimate			Disposal rates			
3	Year	0 Months	12 Months	24 Months	36 Months	Claim Counts	Accident Year	0 Months	12 Months	24 Months	36 Months	
4	2009	0	425	700	850	850	2009	0.00	0.500	0.824	1.000	
5	2010	0	400	693		887	2010	0.00	0.451	0.781	=E5/$G5	
6	2011	0	373			901	2011	0.00	0.414			
8							-> Decreasing claim settlement rates; when interpolating, always use downward adjustment					
9	Accident		Cumulative Paid Claims ($000s)									
10	Year	0 Months	12 Months	24 Months	36 Months							
11	2009	0	4,200	8,580	10,000		Age	0 Months	12 Months	24 Months	36 Months	=M3
12	2010	0	3,950	7,030			Selected DR	0.000	0.414	0.781	1.000	=MIN(M4:M6)
13	2011	0	3,900									
15							Accident Year	Adjusted cumulative Paid Claims ($000s)				
16								12 Months	24 Months	36 Months		
17							2009	3,477	8,008	10,000	=FORECAST(M12,E11:F11,$L4:$M4)	
18							2010	3,626	7,030	=FORECAST(L12,D12:E12,$K5:$L5)		
19							2011	3,900	=FORECAST(K12,C13:D13,$J6:$K6)			
22							Accident Year	Development factors				
23								12-24 Months	24-36 Months			
24							2009	2.30	1.25	=L17/K17		
25							2010	1.94				
28							Age-to-age	12-24 Months	24-36 Months	=K23		
29							Selected factor	2.12	1.25	=AVERAGE(K24:K25)		
32							AY 2011 est ult claims =	$10,328,332.28	=D13*PRODUCT(J29:K29)*1000			

→ Q2)



Given the following data as of December 31, 2011:

Accident Year	Closed Claim Counts 12 Months	24 Months	36 Months	Projected Ultimate Claim Counts
2009	350	700	850	850
2010	400	693		887
2011	490			901

Accident Year	Cumulative Paid Claims ($000) 12 Months	24 Months	36 Months
2009	4,200	8,580	10,000
2010	3,950	7,030	
2011	3,900		

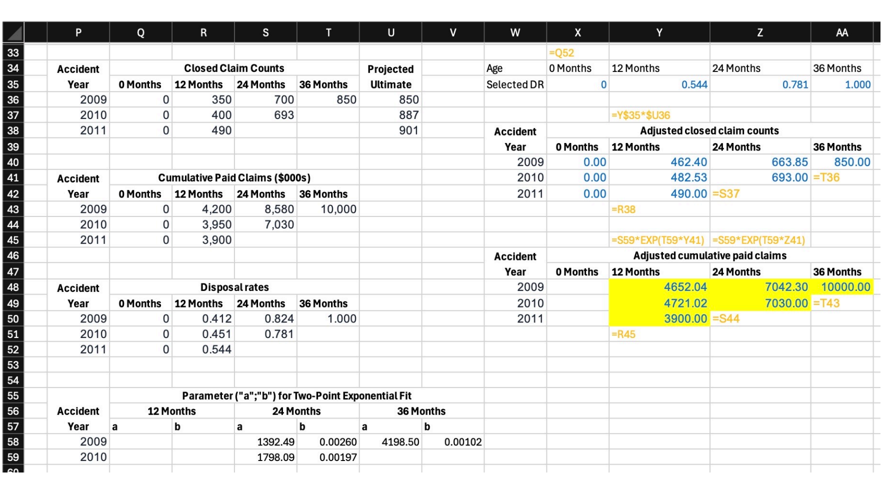
Accident Year	Disposal Rates 12 Months	24 Months	36 Months
2009	0.412	0.824	1.000
2010	0.451	0.781	
2011	0.544		

- There are no partial payments.
- There is no development after 36 months.
- Assume that claims develop exponentially between maturities.

Accident Year	Parameter ("a" ; "b") for Two-Point Exponential Fit 12 Months	24 Months	36 Months
2009		$(1{,}392.49\,;0.00260)$	$4{,}198.50\,;0.00102)$
2010		$(1{,}798.09\,;0.00197)$	

Determine the adjusted cumulative paid claims triangle that results from performing the Berquist-Sherman settlement rate adjustment on this claims data.

→



	P	Q	R	S	T	U	V	W	X	Y	Z	AA
33									=Q52			
34	Accident		Closed Claim Counts			Projected		Age	0 Months	12 Months	24 Months	36 Months
35	Year	0 Months	12 Months	24 Months	36 Months	Ultimate		Selected DR	0	0.544	0.781	1.000
36	2009	0	350	700	850	850						
37	2010	0	400	693		887				=Y$35*$U36		
38	2011	0	490			901		Accident		Adjusted closed claim counts		
39								Year	0 Months	12 Months	24 Months	36 Months
40								2009	0.00	462.40	663.85	850.00
41	Accident		Cumulative Paid Claims ($000s)					2010	0.00	482.53	693.00	=T36
42	Year	0 Months	12 Months	24 Months	36 Months			2011	0.00	490.00	=S37	
43	2009	0	4,200	8,580	10,000					=R38		
44	2010	0	3,950	7,030								
45	2011	0	3,900							=S59*EXP(T59*Y41)	=S59*EXP(T59*Z41)	
46								Accident		Adjusted cumulative paid claims		
47								Year	0 Months	12 Months	24 Months	36 Months
48	Accident		Disposal rates					2009		4652.04	7042.30	10000.00
49	Year	0 Months	12 Months	24 Months	36 Months			2010		4721.02	7030.00	=T43
50	2009	0	0.412	0.824	1.000			2011		3900.00	=S44	
51	2010	0	0.451	0.781						=R45		
52	2011	0	0.544									
55			Parameter ("a";"b") for Two-Point Exponential Fit									
56	Accident	12 Months		24 Months		36 Months						
57	Year	a	b	a	b	a	b					
58	2009			1392.49	0.00260	4198.50	0.00102					
59	2010			1798.09	0.00197							