Lecture 6: Bornhuetter-Ferguson, Cape Cod Techniques; Exposures

AS 8360: Insurance Ratemaking

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Overview

- Additional reserving techniques
  - Bornhuetter-Ferguson
  - Cape Cod
- Criteria for exposure bases
- Exposure aggregation
  - Calendar vs policy year
  - Written, earned, unearned, in-force
- Exposure trend

Additional reserving techniques

Bornhuetter-Ferguson technique: a blend of the chain ladder and expected loss ratio techniques.

In the chain ladder technique, we multiply actual claims by a cumulative claim development factor. In the expected loss ratio technique, the unpaid claim estimate is equal to the difference between a predetermined estimate of expected claims and the actual payments.

also: age-to-∞ factor CDF

The Bornhuetter-Ferguson technique combines the two by splitting ultimate claims into actual reported (or paid) claims and expected unreported (or unpaid) claims. As experience matures, more weight is given to the actual claims and the expected claims become gradually less important.

The following two formulae represent the reported and paid Bornhuetter-Ferguson methods, respectively:

Ultimate Claims = Reported Claims + Unreported Claims =
Reported Claims + (Expected Claims) × (1 – % Reported)

two estimate

Ultimate Claims = Paid Claims + Unpaid Claims =
Paid Claims + (Expected Claims) × (1 – % Paid)

The % Reported and % Paid are the reciprocals of the cumulative claim development factors, and they show how credible actual experience is.

CDF's

Cape Cod technique: another method where unreported claims develop based on expected claims, which are derived using reported (or paid) claims and earned premium.

In contrast with Bornhuetter-Ferguson, the expected claims are derived using a unique loss ratio which is defined as:

Loss Ratio = Total Reported Claims / Total Used Up Premium

The used-up premium represents the percent of premium corresponding to the claims that are expected to be reported through the valuation date.

In both techniques, if details on historical rate level changes are unavailable, unadjusted earned premium data can be used.

Bornhuetter-Ferguson detailed example

Expected Loss Ratio

1 - 1/CDF

Accident Year	Expected Claims	CDF to Ultimate		Percentage		Expected Claims		Claims at 12/31/07		Projected Ultimate Claims Using B-F Method with	
		Reported	Paid	Unreported	Unpaid	Unreported	Unpaid	Reported	Paid	Reported	Paid
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1998	51,430,657	1.000	1.002	0.0%	0.2%	0	102,656	47,742,304	47,644,187	47,742,304	47,746,843
1999	51,408,736	1.000	1.004	0.0%	0.4%	0	204,816	51,185,767	51,000,534	51,185,767	51,205,350
2000	51,680,983	1.001	1.006	0.1%	0.6%	51,629	308,236	54,837,929	54,533,225	54,889,558	54,841,461
2001	54,408,716	1.003	1.011	0.3%	1.1%	162,738	591,984	56,299,562	55,878,421	56,462,300	56,470,405
2002	59,421,665	1.006	1.020	0.6%	2.0%	354,404	1,165,131	58,592,712	57,807,215	58,947,116	58,972,346
2003	56,318,302	1.011	1.040	1.1%	3.8%	612,761	2,166,089	57,565,344	55,930,654	58,178,105	58,096,743
2004	59,646,290	1.023	1.085	2.2%	7.8%	1,341,021	4,672,751	56,976,657	53,774,672	58,317,678	58,447,423
2005	61,174,953	1.051	1.184	4.9%	15.5%	2,968,528	9,506,918	56,786,410	50,644,994	59,754,938	60,151,912
2006	61,926,981	1.110	1.404	9.9%	28.8%	6,136,908	17,819,445	54,641,339	43,606,497	60,778,247	61,425,942
2007	61,864,556	1.292	2.390	22.6%	58.2%	13,981,773	35,979,805	48,853,563	27,229,969	62,835,336	63,209,774
Total	569,281,839					25,609,761	72,517,830	543,481,587	498,050,368	569,091,348	570,568,198

Chain Ladder

Development triangle data

Column Notes:

(2) Developed in Chapter 8, Exhibit II, Sheet 1.

(3) and (4) Developed in Chapter 7, Exhibit I, Sheets 1 and 2.

(5) = [1.00 - (1.00 / (3))].

(6) = [1.00 - (1.00 / (4))].

(7) = [(2) x (5)].

(8) = [(2) x (6)].

(9) and (10) Based on Best's Aggregates & Averages U.S. private passenger automobile experience.

(11) = [(7) + (9)].

(12) = [(8) + (10)].

The technique is in (5)-(8) and (11)-(12).

Accident Year	Claims at 12/31/07		Projected Ultimate Claims Using B-F Method with		Case Outstanding at 12/31/07	Unpaid Claim Estimate at 12/31/07			
						IBNR - Based on B-F Method with		Total - Based on B-F Method with	
	Reported	Paid	Reported	Paid		Reported	Paid	Reported	Paid
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1998	47,742,304	47,644,187	47,742,304	47,746,843	98,117	0	4,539	98,117	102,656
1999	51,185,767	51,000,534	51,185,767	51,205,350	185,233	0	19,583	185,233	204,816
2000	54,837,929	54,533,225	54,889,558	54,841,461	304,704	51,629	3,532	356,333	308,236
2001	56,299,562	55,878,421	56,462,300	56,470,405	421,141	162,738	170,843	583,879	591,984
2002	58,592,712	57,807,215	58,947,116	58,972,346	785,497	354,404	379,634	1,139,901	1,165,131
2003	57,565,344	55,930,654	58,178,105	58,096,743	1,634,690	612,761	531,399	2,247,451	2,166,089
2004	56,976,657	53,774,672	58,317,678	58,447,423	3,201,985	1,341,021	1,470,766	4,543,006	4,672,751
2005	56,786,410	50,644,994	59,754,938	60,151,912	6,141,416	2,968,528	3,365,502	9,109,944	9,506,918
2006	54,641,339	43,606,497	60,778,247	61,425,942	11,034,842	6,136,908	6,784,603	17,171,750	17,819,445
2007	48,853,563	27,229,969	62,835,336	63,209,774	21,623,594	13,981,773	14,356,211	35,605,367	35,979,805
Total	543,481,587	498,050,368	569,091,348	570,568,198	45,431,219	25,609,761	27,086,611	71,040,980	72,517,830

Column Notes:
(2) and (3) Based on Best's Aggregates & Averages U.S. private passenger automobile experience.
(4) and (5) Developed in Exhibit I, Sheet 1.
(6) = [(2) - (3)].
(7) = [(4) - (2)].
(8) = [(5) - (2)].
(9) = [(6) + (7)].
(10) = [(6) + (8)].

Breakdown of Unpaid Claims into Case Outstanding and IBNR.

Cape Cod detailed example

Accident Year	Earned Premium	Age of Accident Year at 12/31/07	Reported Claims at 12/31/07	Reported CDF to Ultimate	% of Ultimate Reported	Used Up Premium	Estimated Claim Ratios
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1998	68,574,209	120	47,742,304	1.000	100.0%	68,574,209	69.6%
1999	68,544,981	108	51,185,767	1.000	100.0%	68,544,981	74.7%
2000	68,907,977	96	54,837,929	1.001	99.9%	68,839,138	79.7%
2001	72,544,955	84	56,299,562	1.003	99.7%	72,327,971	77.8%
2002	79,228,887	72	58,592,712	1.006	99.4%	78,756,349	74.4%
2003	86,643,542	60	57,565,344	1.011	98.9%	85,700,833	67.2%
2004	91,763,523	48	56,976,657	1.023	97.8%	89,700,413	63.5%
2005	94,115,312	36	56,786,410	1.051	95.1%	89,548,346	63.4%
2006	95,272,279	24	54,641,339	1.110	90.1%	85,830,882	63.7%
2007	95,176,240	12	48,853,563	1.292	77.4%	73,665,820	66.3%
Total	820,771,905		543,481,587			781,488,943	69.5%

$\frac{1}{CDF}$

numerator of ratio

denominator of ratio

Column and Line Notes:

(2) Based on Best's Aggregates & Averages U.S. private passenger automobile experience.

(3) Age of accident year in (1) at December 31, 2007.

(4) Based on Best's Aggregates & Averages U.S. private passenger automobile experience.

(5) Developed in Chapter 7, Exhibit I, Sheet 1.

(6) = [1.00 / (5)].

(7) = [(2) x (6)].

(8) = [(4) / (7)].

$1 - \frac{1}{CDF}$

Accident Year	Earned Premium	Expected Claim Ratio	Estimated Expected Claims	Reported CDF to Ultimate	Percentage Unreported	Expected Unreported Claims	Reported Claims at 12/31/07	Projected Ultimate Claims
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1998	68,574,209	69.5%	47,689,504	1.000	0.0%	0	47,742,304	47,742,304
1999	68,544,981	69.5%	47,669,177	1.000	0.0%	0	51,185,767	51,185,767
2000	68,907,977	69.5%	47,921,621	1.001	0.1%	47,874	54,837,929	54,885,803
2001	72,544,955	69.5%	50,450,934	1.003	0.3%	150,900	56,299,562	56,450,462
2002	79,228,887	69.5%	55,099,233	1.006	0.6%	328,624	58,592,712	58,921,336
2003	86,643,542	69.5%	60,255,708	1.011	1.1%	655,601	57,565,344	58,220,945
2004	91,763,523	69.5%	63,816,367	1.023	2.2%	1,434,777	56,976,657	58,411,434
2005	94,115,312	69.5%	65,451,904	1.051	4.9%	3,176,068	56,786,410	59,962,478
2006	95,272,279	69.5%	66,256,509	1.110	9.9%	6,565,960	54,641,339	61,207,299
2007	95,176,240	69.5%	66,189,720	1.292	22.6%	14,959,286	48,853,563	63,812,849
Total	820,771,905		570,800,677			27,319,090	543,481,587	570,800,677

Development triangle

Column Notes:

(2) Based on Best's Aggregates & Averages U.S. private passenger automobile experience.

(3) Based on total weighted estimated claim ratios developed in Exhibit I, Sheet 1.

(4) = [(2) x (3)].

(5) Developed in Chapter 7, Exhibit I, Sheet 1.

(6) = [1.00 - (1.00 / (5))].

(7) = [(4) x (6)].

(8) Based on Best's Aggregates & Averages U.S. private passenger automobile experience.

(9) = [(7) + (8)].

Accident Year	Claims at 12/31/07 Reported	Paid	Projected Ultimate Claims	Case Outstanding at 12/31/07	Unpaid Claim Estimate Based on Cape Cod Method IBNR	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1998	47,742,304	47,644,187	47,742,304	98,117	0	98,117
1999	51,185,767	51,000,534	51,185,767	185,233	0	185,233
2000	54,837,929	54,533,225	54,885,803	304,704	47,874	352,578
2001	56,299,562	55,878,421	56,450,462	421,141	150,900	572,041
2002	58,592,712	57,807,215	58,921,336	785,497	328,624	1,114,121
2003	57,565,344	55,930,654	58,220,945	1,634,690	655,601	2,290,291
2004	56,976,657	53,774,672	58,411,434	3,201,985	1,434,777	4,636,762
2005	56,786,410	50,644,994	59,962,478	6,141,416	3,176,068	9,317,484
2006	54,641,339	43,606,497	61,207,299	11,034,842	6,565,960	17,600,802
2007	48,853,563	27,229,969	63,812,849	21,623,594	14,959,286	36,582,880
Total	543,481,587	498,050,368	570,800,677	45,431,219	27,319,090	72,750,309

Column Notes:

(2) and (3) Based on Best's Aggregates & Averages U.S. private passenger automobile experience.

(4) Developed in Exhibit I, Sheet 2.

(5) = [(2) - (3)].

(6) = [(4) - (2)].

(7) = [(5) + (6)].

Criteria for exposure bases

An *exposure* is the basic unit that measures a policy's exposure to loss, and thus serves as the basis for calculating premium.

Criteria for exposure bases:

- Proportional to expected loss: the factor with the most direct relationship to it.
- Practical: easy and cheap to obtain and verify.
- Historical precedence: change is costly.

Which satisfies the above?

- Personal automobile: car year vs. annual mileage.
- Homeowners: house year vs. insurance coverage.
- Workers compensation: payroll vs. hours worked.

Line of business	Typical exposure bases
Personal automobile	Earned car year
Homeowners	Earned house year
Workers compensation	Payroll
Commercial General Liability	Sales revenue, Payroll, Square footage, Number of units
Commercial Business Property	Amount of insurance coverage
Medical malpractice	Number of physician years
Professional liability	Number of professionals (e.g. lawyers or accountants)
Personal articles floater	Value of item

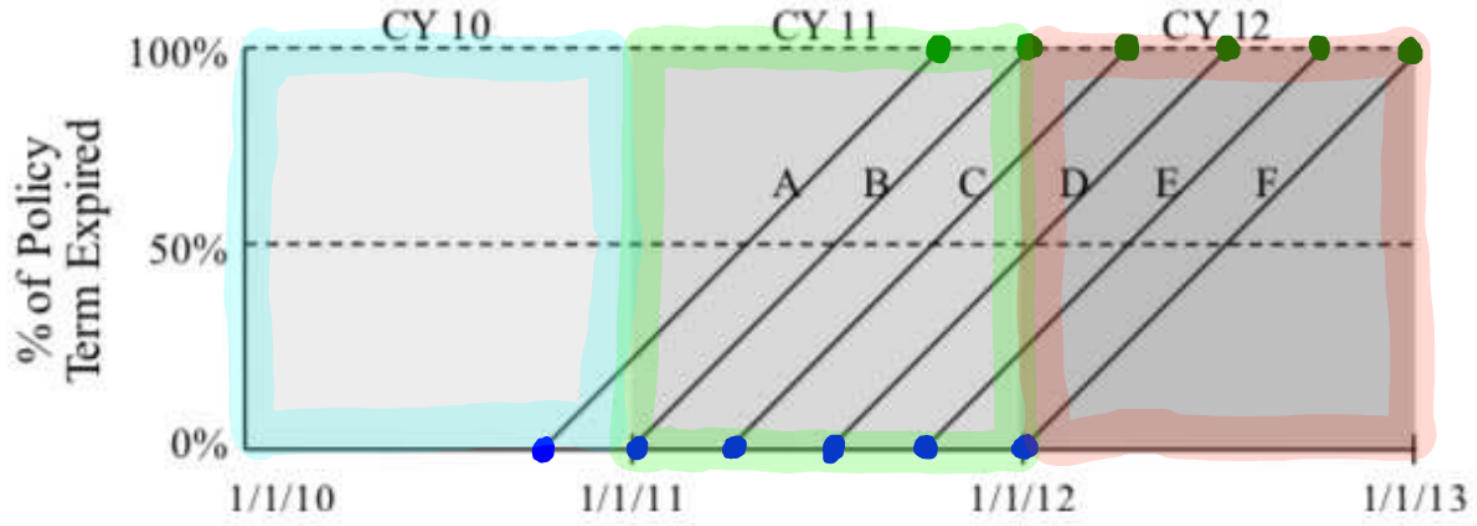
Exposure aggregation

In regards to aggregating exposures, there are only two methods applicable: *calendar year* and *policy year.*

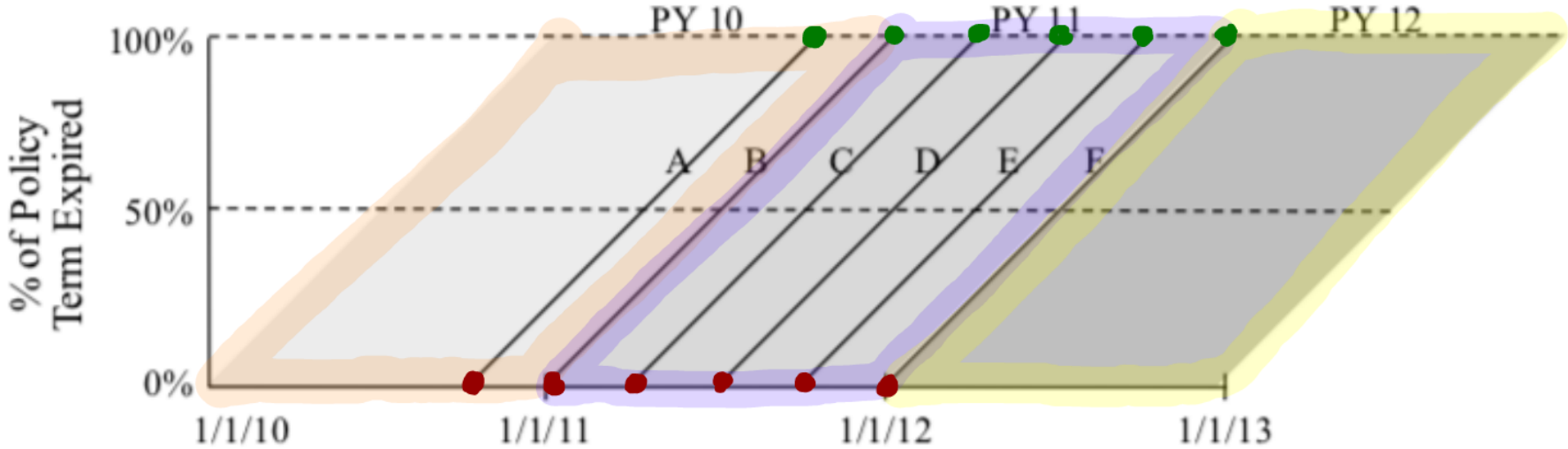
Consider the following example:

Policy	Effective Date	Expiration Date	Exposure
A	10/01/10	09/30/11	1.00
B	01/01/11	12/31/11	1.00
C	04/01/11	03/31/12	1.00
D	07/01/11	06/30/12	1.00
E	10/01/11	09/30/12	1.00
F	01/01/12	12/31/12	1.00

Calendar year considers all exposures during the year without regard to the date of policy issuance. Graphically, it looks as follows:



Policy year considers all exposures on policies with effective dates during the year. It can be represented as:



A disadvantage of the policy year aggregation method is that it takes twice as much time to close.

We can further compute the written, earned, unearned, and in-force exposures for each aggregation method:

Written exposures:

	CY method	PY method
2010	1	1
2011	4	4
2012	1	1

Earned exposures:

	CY method	PY method
2010	$0.25 \cdot 1$	1
2011	$0.75 \cdot 1 + 1 +$	4
2012	$0.75 \cdot 1 + 0.5 \cdot 1 + 0.25 \cdot 1$	1

$0.25 \cdot 1 + 0.5 \cdot 1 + 0.75 \cdot 1 + 1$

Recall that Unearned = Written – Earned.

Unearned exposures:

	CY method	PY method
2010	0.75	0
2011	0.75	0
2012	-1.5	0

In-force exposures:

	CY method	PY method
01/01/11	2	2
06/15/11	3	3
01/01/12	4	4

If individual policy data is not available or not feasible to use, assume policies are issued uniformly during the reference period, or at the midpoint.

Exposure trend

Exposure bases for some lines of business are sensitive to inflation or other time-related influences. Payroll or sales revenue are such examples.

In that case, projecting exposure units into the future requires that the trend be estimated and taken into account when using such data.

Example

Given the following information for an insurance company that writes 24-month term policies:

Exposure unit = car-year

Policy group	Effective date	Expiration date	No of vehicles	# of exp
A	1/1/10	12/31/11	50	100
B	7/1/10	6/30/12	100	200

All policies within each group have the same effective date.

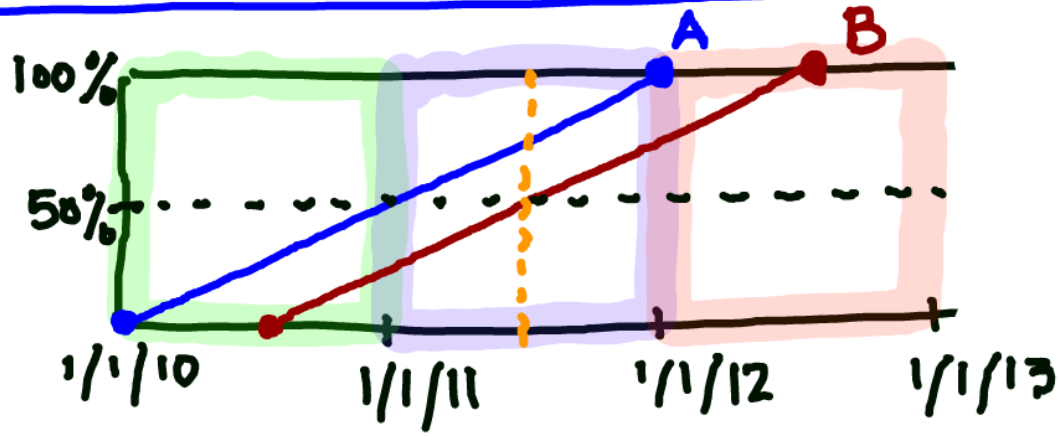
(i) Calculate the earned car-years for CY 2011.

(ii) Calculate the earned car-years for PY 2010 evaluated as of 12/31/10 and as of 12/31/11.

(iii) Assume group B cancels on 1/1/11. Calculate the PY 2010 written car-years evaluated as of 12/31/10 and as of 12/31/11 for group B.

(iv) Assume group B cancels on 7/1/11. Calculate the CY 2010 and CY 2011 written car-years for group B.

(i)

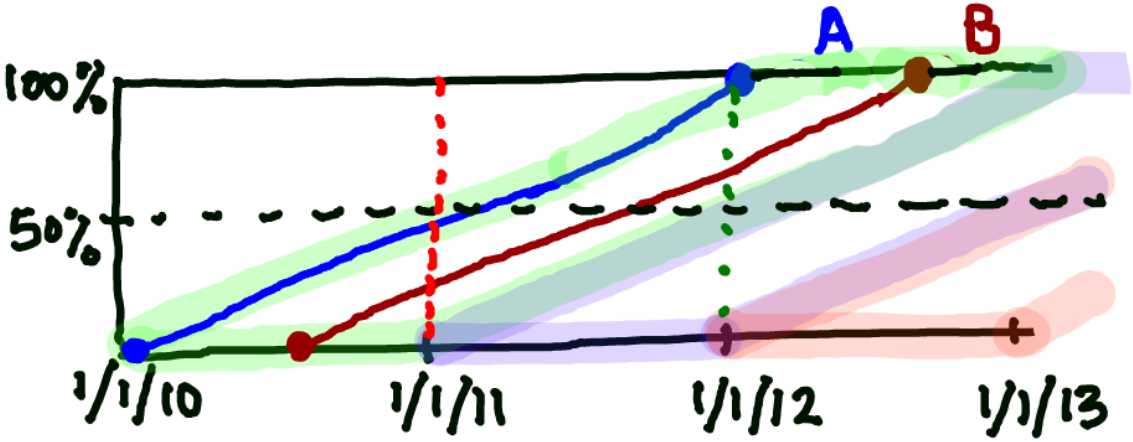


CY 2011

$50\% \cdot 100 + 50\% \cdot 200$

$= 150$

(ii)



PY 2010

12/31/10: $50\% \cdot 100 + 25\% \cdot 200$

$= 100$

12/31/11: $100\% \cdot 100 + 75\% \cdot 200$

$= 250$

(iii)

PY 2010

Group B written exp.

12/31/10: 200

12/31/11: $25\% \cdot 200 = 50$

(iv) Group B written exp.

CY 2010: 200

CY 2011: $-50\%\ 200 = -100$