An Enhanced On-Level Approach to Calculating Expected Loss Costs

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Abstract.

Virtually every loss reserve analysis where loss and exposure or premium data is available includes an estimate of an expected loss cost to be used in the calculation. Most estimates are either calculated by trending forward historical loss costs or are judgmentally selected. Occasionally, a change in the underlying exposure is reflected, usually in the form of a judgmentally selected factor. The methodology we present is a simple approach to using individual risk experience in generating a series of on-level factors that can reflect changes in mix by year in the development of expected loss costs. In addition, possible enhancements to the method to reflect the incorporation of new exposures over time are included. The result is a series of expected loss costs that better reflect the composition of business in a given accident or policy year, while still including the stability gained by utilizing multiple years of experience.

Keywords. Loss costs, initial expected loss cost, exposure, on-level, trend, Bornhuetter-Ferguson method

1. INTRODUCTION

This paper presents a technique for estimating an initial expected loss cost (IELC) in situations where the underlying mix of business is shifting. The IELC is commonly used to estimate an initial expected loss for use in a Bornhuetter-Ferguson (B-F) method, and the examples in this paper are presented in that context. Of course, an IELC can be used for various other purposes such as prospective funding estimates.

1.1 Research Context

A common approach to developing an IELC is to trend losses and exposures (if applicable) to current levels and use the trended losses to calculate "on-level" loss costs for each policy period. The actuary selects the IELC after examining the historical on-level loss costs.

This traditional approach can be distorted by changes in the mix of business. For example, if a commercial auto carrier elects to non-renew a particular account consisting of a large fleet of autos with particularly high historical loss costs, then the historical loss costs could potentially be misleading when selecting the IELC.

While various approaches to selecting an expected loss cost are referenced in the actuarial literature (e.g., see Chapter 8 of [1]), we are not aware of any that address continual changes in the underlying exposures over time, a situation that occurs quite frequently. This paper will rely on

knowledge of basic reserving methodologies and an understanding of the assumptions used in those methodologies, but it does not rely on any specific papers currently in the actuarial literature.

1.2 Objective

This paper presents a method for selecting the IELC that explicitly adjusts for changes in the mix of business over multiple years. It takes advantage of detailed information available now to insurers through data warehouses and advanced information technology that can enable the actuary to remove much of the judgment typically associated with mix adjustments over multiple years. In developing this approach, trend and new business growth will also be considered. This approach extends the conventional on-leveling approach, so that mix changes as well as trend are contemplated in the on-level calculation.

1.3 Outline

The remainder of the paper proceeds as follows:

Section 2 will briefly review the traditional approach to selecting an IELC. In Section 2.1, we illustrate how the traditional approach can be distorted by changes in the mix of business. In the remainder of Section 2, we will present our method to adjust for the change in mix. Specifically, in Section 2.2 we will illustrate how to adjust for non-renewed business, and in Section 2.3 we will illustrate how to adjust for the addition of new business.

Section 3 will discuss the results of the analysis and possible future enhancements while Section 4 presents the conclusions and main findings of this paper. Finally, references are provided in Section 5.

2. BACKGROUND AND METHODS

Suppose we have the data displayed in Table 1. The "Exposure" in column 1 might be car-years, payroll, or various other exposure bases. The Ultimate Loss amounts and implied loss costs in columns 2 and 3 were previously estimated (e.g. by a chain ladder method) and we want to estimate an IELC for use in a B-F method. In this example we use data organized by policy year, because changes to mix of business are most easily analyzed on a policy year basis.

Table 1: Data for Company XYZ

	(1)	(2)	(3)
Policy Year	**Exposure**	**Ultimate Loss**	**Loss Cost**
	[data]	[derived]	[(2)/(1)]
2005	14,000	56,000	4.00
2006	14,000	57,680	4.12
2007	14,000	59,410	4.24
2008	10,000	48,080	4.81
2009	14,000	54,502	3.89
2010	14,000	56,137	4.01
2011	14,000	38,603	2.76
2012	14,000	39,761	2.84

A typical approach is displayed in Table 2. Using a trend of 3% (based on judgment, analysis, or some external information), we trend all the loss costs to a 2012 level[1]. These trended loss costs, called "on-level" loss costs, are displayed in column 5, and the 2012 IELC is typically selected after considering various averages of the factors.

[1] The trend used here should be understood to be a composite of both the loss and exposure trend and would include benefit level changes if applicable. These trends are often estimated and displayed separately, but we have combined them here for simplicity of discussion.

Table 2: IELC calculation

	(1)	(2)	(3)	(4)	(5)	(6)
Policy Year	**Exposure**	**Ultimate Loss**	**Loss Cost**	**Trend**	**On-Level Loss Cost**	**B-F IELC**
	[Table 1 Col (1)]	[Table 1 Col (2)]	[Table 1 Col (3)]	[1.03^n]	[(3)*(4)]	[Selected (5)/(4)]
2005	14,000	56,000	4.00	1.23	4.92	2.85
2006	14,000	57,680	4.12	1.19	4.92	2.93
2007	14,000	59,410	4.24	1.16	4.92	3.02
2008	10,000	48,080	4.81	1.13	5.41	3.11
2009	14,000	54,502	3.89	1.09	4.25	3.20
2010	14,000	56,137	4.01	1.06	4.25	3.30
2011	14,000	38,603	2.76	1.03	2.84	3.40
2012	14,000	39,761	2.84	1.00	2.84	3.50
				Selected	3.50	

In this example we have selected an IELC of 3.50. Other selections would certainly be possible; for example we might select 4.50 (the average of policy years 2005-2011). Typically, actuaries consider various indications (3 year average, 4 year average, etc.) prior to making a selection. We arrive at the B-F IELC's in column (6) by "de-trending" this selection back to each policy year, using the trend factors displayed in column (4).

These factors might appear reasonable. True, the IELCs for 2011 and 2012 are substantially different from what the On-Level Loss Cost would indicate. But these years are immature and we might distrust the Ultimate Loss estimate in column (2) for various reasons. Thus disparity between the On-Level Loss Cost and the B-F IELC for these two years might actually be viewed as an advantage; it gives us more options when making our final selection of Ultimate Loss. Similarly, the B-F IELC is substantially lower than the On-Level Loss Costs for the older policy years; we might accept this because we are unlikely to select the B-F method for these older, relatively mature years.

2.1 Distortions Caused by Change in Mix

We investigate further by analyzing the loss experience at the individual account level. This analysis reveals the history displayed in Table 3. The shaded cells in the table indicate that the account was either non-renewed or new business that had not been written yet.

Table 3: Account-Level Data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Account A			Account B			Account C		
Policy Year	Exposure	Ultimate Loss	Loss Cost	Exposure	Ultimate Loss	Loss Cost	Exposure	Ultimate Loss	Loss Cost
	[data]	[derived]	[(2)/(1)]	[data]	[derived]	[(5)/(4)]	[data]	[derived]	[(8)/(7)]
2005	2,000	$4,000	2.00	4,000	$12,000	3.00			
2006	2,000	$4,120	2.06	4,000	$12,360	3.09			
2007	2,000	$4,244	2.12	4,000	$12,731	3.18			
2008	2,000	$4,371	2.19						
2009	2,000	$4,502	2.25				4,000	$30,000	7.50
2010	2,000	$4,637	2.32				4,000	$30,900	7.73
2011	2,000	$4,776	2.39				4,000	$31,827	7.96
2012	2,000	$4,919	2.46				4,000	$32,782	8.20

Table 3 (Continued)

	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
	Account D			Account E			Account F		
Policy Year	Exposure	Ultimate Loss	Loss Cost	Exposure	Ultimate Loss	Loss Cost	Exposure	Ultimate Loss	Loss Cost
	[data]	[derived]	[(11)/(10)]	[data]	[derived]	[(14)/(13)]	[data]	[derived]	[(17)/(16)]
2005	8,000	$40,000	5.00						
2006	8,000	$41,200	5.15						
2007	8,000	$42,436	5.30						
2008	8,000	$43,709	5.46						
2009				8,000	$20,000	2.50			
2010				8,000	$20,600	2.58			
2011							8,000	$2,000	0.25
2012							8,000	$2,060	0.26

For simplicity, we've assumed each account has a constant loss cost, affected only by a 3% annual trend. However, when examining the loss costs for all accounts combined, the simplicity of this assumption has been hidden by the changing mix of business.

In the subsequent section, we will describe a method to adjust for the change in mix. Specifically, we will show how to calculate "Mix of Business" factors as displayed in columns (5) and (6) of Table 4. The factors in column (5) can be thought of as incremental adjustments for the change in mix within a given policy year. The factors in column (6) are simply the cumulative product of the factors in column (5), beginning at the bottom of the column.

Table 4: IELC Calculation Using Mix of Business Adjustment Factors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Policy Year	**Exposure**	**Ultimate Loss**	**Loss Cost**	**Trend**	**Mix Of Business Factor**	**Mix Of Business Factor (Cum.)**	**On-Level Loss Cost**	**B-F IELC**
	[Table 1 Col (1)]	[Table 1 Col (2)]	[Table 1 Col (3)]	$[1.03^n]$	[derived] (see subsequent discussion)	Cumulative Product of (5)	[(3)*(4)*(6)]	[(Selected (7)/ ((6)*(4))]
2005	14,000	$56,000	4.00	1.23	1.000	0.577	2.84	4.00
2006	14,000	$57,680	4.12	1.19	1.000	0.577	2.84	4.12
2007	14,000	$59,410	4.24	1.16	**1.100**	0.577	2.84	4.24
2008	10,000	$48,080	4.81	1.13	**0.786**	0.525	2.84	4.81
2009	14,000	$54,502	3.89	1.09	1.000	0.668	2.84	3.89
2010	14,000	$56,137	4.01	1.06	**0.668**	0.668	2.84	4.01
2011	14,000	$38,603	2.76	1.03	1.000	1.000	2.84	2.76
2012	14,000	$39,761	2.84	1.00	1.000	1.000	2.84	2.84
						Selected	2.84	

We see that this method produces an On-Level Loss Cost of 2.84 for each year. This makes sense since after adjusting for trend and the change in mix, we should be left only with Accounts A, C, and F in 2012 which, combined, has a loss cost of 2.84. Moreover, the B-F IELCs in column (8) turn out to be exactly equal to the loss costs in column (3) because of the assumptions underlying our simplified example. In practice, the factors in column (7) will not be identical and the selected loss cost (2.84 in Table 4) will need to be estimated in the normal way by considering various averages. As a result, in practice column (8) will not be identical to column (3).

2.2 Adjusting for Non-Renewed Accounts

To show how these Mix of Business on-level factors are developed we begin with the first policy year affected by a mix change, 2008. Table 5 demonstrates how to calculate the Mix of Business factor that would be applied to the 2007 results to adjust for the non-renewal of Account B in 2008. To calculate the Mix of Business factor, first estimate an on-level loss cost for the total book as shown in columns (1) through (5) in Table 5. In this case, we have chosen 4.37 based on the results appearing in column (5). In practice, the values in column (5) will vary and our selection (indicated by the letter (A)) will be an estimate, perhaps a 3-year average.

In columns (6)-(10) we carry out the same procedure, except that Account B is excluded from the history. This yields an on-level loss cost of 4.81.

The Mix of Business factor is equal to (B)/(A), i.e. the percentage change in loss cost resulting from the non-renewal of account B. Thus, by non-renewing Account B, the underlying experience would have worsened resulting in an increase in the average loss cost of about 10%.

Table 5: Mix of Business Factor for Policy Year 2007

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(10)
	Total Company XYZ					XYZ Excluding Account B			
Policy Year	Exp.	Ultimate Loss	Loss Cost	Trend	On-Level Loss Cost	Exp.	Ultimate Loss	Loss Cost	On-Level Loss Cost
	[Table 1 Col (1)]	[Table 1 Col (2)]	[Table 1 Col (3)]	[1.03^n]	[(3)*(4)]	[(1)-Table 3 Col (4)]	[(2)-Table 3 Col (5)]	[(7)/(6)]	[(8)*(4)]
2005	14,000	56,000	4.00	1.093	4.37	10,000	44,000	4.40	4.81
2006	14,000	57,680	4.12	1.061	4.37	10,000	45,320	4.53	4.81
2007	14,000	59,410	4.24	1.030	4.37	10,000	46,680	4.67	4.81
	Selected 2008 Loss Cost (A)				4.37			**(B)**	4.81
								(B)/(A) Mix of Business Factor	1.100

The calculated value of 1.100 is included in Table 4, column (5) as the mix of business factor for 2007. As we will see, because the mix of business factor is cumulatively applied it affects not only Policy Year 2007 but also all prior Policy Years. One may wonder why a change in mix occurring in 2008 should lead to an adjustment factor for 2007. This is because the Mix of Business Factor is used to adjust Policy Year 2007 loss costs for the change in mix occurring in 2008.

The calculation shown in Table 5 is not unusual and is typically performed when a factor causing an underlying shift in loss experience occurs. In reality, changes like this occur in almost all years, not just one year. Also, usually one must contend with both the non-renewal of accounts and the writing of new accounts.

2.3 Adjusting for New Accounts

In the example given in Table 3, three things happen in policy year 2009: Accounts C and E are added and Account D is non-renewed. To adjust for the new account, we must somehow develop an estimate of its expected loss cost. If historical data is available, the actuary can analyze this information and use it to develop prospective estimates. This scenario is illustrated in Table 6,

where the historical data (including exposure and ultimate loss) has been added for accounts C, E and F. The data is displayed in the shaded area of the table, in italic font as a reminder that company XYZ did not actually write the business during those policy years. The exposure and ultimate loss amounts are also not included in the company totals for the older policy years. This assumption could be trued up as experience for that account becomes more credible.

Table 6: Account-Level Data*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Account A			Account B			Account C		
Policy Year	Exposure	Ultimate Loss	Loss Cost	Exposure	Ultimate Loss	Loss Cost	Exposure	Ultimate Loss	Loss Cost
	[data]	[derived]	[(2)/(1)]	[data]	[derived]	[(5)/(4)]	[data]	[derived]	[(8)/(7)]
2005	2,000	$4,000	2.00	4,000	$12,000	3.00	*4,000*	*$26,655*	*6.66*
2006	2,000	$4,120	2.06	4,000	$12,360	3.09	*4,000*	*$27,454*	*6.86*
2007	2,000	$4,244	2.12	4,000	$12,731	3.18	*4,000*	*$28,278*	*7.07*
2008	2,000	$4,371	2.19				*4,000*	*$29,126*	*7.28*
2009	2,000	$4,502	2.25				4,000	$30,000	7.50
2010	2,000	$4,637	2.32				4,000	$30,900	7.73
2011	2,000	$4,776	2.39				4,000	$31,827	7.96
2012	2,000	$4,919	2.46				4,000	$32,782	8.20

	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
	Account D			Account E			Account F		
Policy Year	Exposure	Ultimate Loss	Loss Cost	Exposure	Ultimate Loss	Loss Cost	Exposure	Ultimate Loss	Loss Cost
	[data]	[derived]	[(11)/(10)]	[data]	[derived]	[(14)/(13)]	[data]	[derived]	[(17)/(16)]
2005	8,000	$40,000	5.00	*8,000*	*$17,770*	*2.22*	*8,000*	*$1,675*	*0.21*
2006	8,000	$41,200	5.15	*8,000*	*$18,303*	*2.29*	*8,000*	*$1,725*	*0.22*
2007	8,000	$42,436	5.30	*8,000*	*$18,852*	*2.36*	*8,000*	*$1,777*	*0.22*
2008	8,000	$43,709	5.46	*8,000*	*$19,417*	*2.43*	*8,000*	*$1,830*	*0.23*
2009				8,000	$20,000	2.50	*8,000*	*$1,885*	*0.24*
2010				8,000	$20,600	2.58	*8,000*	*$1,942*	*0.24*
2011							8,000	$2,000	0.25
2012							8,000	$2,060	0.26

* Shaded areas represent historical estimates received from the account.

Table 7 illustrates how to compute the Mix of Business factor for policy year 2008. At the beginning of the year, the entire book of business is written except for Account B which was non renewed that year (note that "the entire book of business except for Account B" is equivalent to saying "Accounts A and D"). In policy year 2009, Account D is non-renewed while Accounts C and

E are newly written. Thus, in columns (1)-(5) we consider the total book excluding B, and in columns (6)-(10) we consider the "ongoing business", i.e. Accounts A, C and E. The rest of the procedure is identical to Table 5.

Table 7: Mix of Business Factor for Policy Year 2008

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(10)
	XYZ Excl. Acc't B					Accounts A, C and E			
Policy Year	Exp.	Ultimate Loss	Loss Cost	Trend	On-Level Loss Cost	Exp.	Ultimate Loss	Loss Cost	On-Level Loss Cost
	[Table 5 Col (6)]	[Table 5 Col (7)]	[Table 5 Col (8)]	[1.03^n]	[(3)*(4)]	[Table 6 Cols (1)+(7)+(13)]	Table 6 Cols (2)+(8)+(14)]	[(7)/(6)]	[(8)*(4)]
2005	10,000	44,000	4.40	1.126	4.95	14,000	48,424	3.46	3.89
2006	10,000	45,320	4.53	1.093	4.95	14,000	49,877	3.56	3.89
2007	10,000	46,680	4.67	1.061	4.95	14,000	51,373	3.67	3.89
2008	10,000	48,080	4.81	1.030	4.95	14,000	52,915	3.78	3.89
		Selected 2009 Loss Cost (A)			4.95			**(B)**	3.89
								(B)/(A) Mix of Business Factor	0.786

Continuing with our example, there is no change to the mix of business in policy year 2010, so the Mix of Business Factor for 2009 is 1.000. However, in 2011 Account E is non-renewed and Account F is added. Therefore, we follow the procedure illustrated in Table 8.

Table 8: Mix of Business Factor for Policy Year 2010

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(10)
	Ongoing Business in 2010: Accounts A, C & E					**Ongoing Business in 2011: Accounts A, C & F**			
Policy Year	**Exp.**	**Ultimate Loss**	**Loss Cost**	**Trend**	**On-Level Loss Cost**	**Exp.**	**Ultimate Loss**	**Loss Cost**	**On-Level Loss Cost**
	[Table 6 Cols (1)+(7)+(13)]	Table 6 Cols (2)+(8)+(14)]	[(2)/(1)]	[1.03^n]	[(3)*(4)]	[Table 6 Cols (1)+(7)+(16)]	Table 6 Cols (2)+(8)+(17)]	[(7)/(6)]	[(8)*(4)]
2005	14,000	48,424	3.46	1.194	4.13	14,000	32,330	2.31	2.76
2006	14,000	49,877	3.56	1.159	4.13	14,000	33,299	2.38	2.76
2007	14,000	51,373	3.67	1.126	4.13	14,000	34,298	2.45	2.76
2008	14,000	52,915	3.78	1.093	4.13	14,000	35,327	2.52	2.76
2009	14,000	54,502	3.89	1.061	4.13	14,000	36,387	2.60	2.76
2010	14,000	56,137	4.01	1.030	4.13	14,000	37,479	2.68	2.76
		Selected 2011 Loss Cost (A)			4.13			**(B)**	2.76
								(B)/(A) Mix of Business Factor	0.668

Using the Mix of Business Factors calculated above, we can calculate columns (5) and (6) of Table 4. Column (5) simply assigns the Mix of Business factors to the appropriate year. A factor 1.000 is used for years in which there is no mix change in the next subsequent year. The factors Column (6) are cumulative Mix of Business Factors and adjust for mix changes in all subsequent years.

3. RESULTS AND DISCUSSION

The above procedure is conceptually simple and easy to implement. Of course, if all the information and ultimate losses by account were determined separately, the exercise above could be conducted without the need to calculate on-level factors. In fact, if we are able to estimate credible loss costs for each account (say, by using benchmark loss costs available from an industry source), then the above procedure can essentially be bypassed. The account-level loss costs can be applied to the exposure for each account to develop ultimate losses by account, and these ultimate losses can be added together to produce an ultimate loss indication for the entire book. This indication could then be used as an initial expected loss for the B-F method.

In practice, benchmark loss costs are not always available or not reflective of the business the actuary is reviewing. Also it's possible that recalculating an ultimate loss cost, every year for every account making up the book may be impractical. In that instance, carrying out the exercises shown

in Tables 5, 7 and 8 only once for each, in the year the change actually takes place might be an acceptable solution. Effectively, each mix of business factor, once calculated, would be "fixed" (similar to the way benefit level adjustments are treated for workers compensation), and an adjustment for the change in mix in the latest year would be the only one necessary. Of course, this would not reflect the fact that the implicit Mix of Business factors may change over time as the ultimate loss estimates by account change in subsequent valuations, but, unless subsequent information provides persuasive evidence that an adjustment is warranted it is not unreasonable to treat the adjustment as fixed.

In essence, the calculation of the Mix of Business factor requires the calculation of two prospective loss costs: one which includes the business prior to the change in mix and one which includes the subsequent business. The use of historical account-level data is one way to develop these estimates. However, if historical data is not available (particularly for new accounts, as displayed in the shaded cells of Table 6) one could develop the prospective estimates using other techniques. For example, one might initially assume that the new account will experience an ultimate loss cost equal to that of another account with similar characteristics, or that new business loss ratios are a multiple of that of the existing business.

Finally, we note that whereas the above examples were carried out on a policy year basis, many reserving analyses are conducted on an accident year basis. In most cases, organizing the data by policy year will prove to be the most natural approach when the mix of business is changing, since these changes will typically occur at policy expiration. If the results must be presented on an accident year basis (e.g., in the statutory annual statement), one may convert the results from policy year to accident year. Ultimately, the approach taken will depend upon the granularity of the available data, the specific details of the book of business under consideration, and the actuary's judgment.

4. CONCLUSIONS

We believe the above approach is a natural and intuitive way to adjust the traditional IELC calculation to reflect a changing mix of business. With the availability of detailed historical data at policy level, this approach enables the actuary to take advantage of this accessible information to better reflect normal changes that impact loss experience over time. This produces more accurate expected loss costs over time, and eliminates much of the "judgment" the actuary typically applies to reflect these underlying changes.

5. REFERENCES

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Abbreviations and notations
B-F, Bornhuetter-Ferguson
IELC, Initial Expected Loss Cost

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