Reserving in Two Steps: Total IBNR = Pure IBNR + IBNER

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Abstract

Motivation. To estimate IBNR, with separate amounts estimated for pure IBNR and for IBNER or development on known claims, using methods similar to traditional triangle methods.

Results. We applied several methods to our sample data set to calculate estimates that ultimately proved to be more accurate than traditional triangle methods.

Conclusions. Estimating the pure IBNR separately from development on known claims is more cumbersome and requires additional data extraction work, but provides additional information needed in order to make optimal business decisions.

Keywords. Pure IBNR, IBNER, development on known claims

1. INTRODUCTION

Standard actuarial methods for reserving generally apply development factors to losses paid-to-date and reported-to-date to calculate an estimate of ultimate losses, which then result in an estimate of total IBNR. In this paper, we look at separately developing estimates for: 1) pure IBNR, and 2) IBNER, (sometimes called "development on known claims").

The separate estimate of the two amounts can be addressed in a number of ways, for example as a part of a claim simulation model (see, for example, Sahasrabuddhe[1]); we chose to apply a method that looks and functions much like traditional loss development methods, based on triangles, but with adjustments to allow for the separate estimates to be calculated.

We define "pure IBNR" to mean the estimate of ultimate losses for claims not yet reported; "IBNER" or "development on known claims" to mean the estimate of ultimate losses for known claims, less currently reported amounts; and "total IBNR" to mean the total of these two amounts.

1.1 Motivation and Rationale

Standard actuarial methods (development factor, Bornhuetter-Ferguson, etc.) are commonly used across a wide variety of circumstances to provide for estimates of total reserves or IBNR. Various methods are commonly used to adjust for changes in development patterns, for example, methods based on the Berquist-Sherman[2] paper.

The methods commonly used combine into one factor/projection the results of two separate processes:

- The development, to their ultimate value, of claims that have already been reported; and
- The emergence of claims that were not previously reported (which then subsequently develop to their ultimate value).

In this paper, we look at various ways to analyze these processes separately rather than a single, combined projection. Our motivation in analyzing reserves this way was twofold:

1. Accuracy of reserve estimate: The method allowed us to observe separately two distinct changes that were occurring in the book being analyzed:
    - A law change affected the late reporting of claims; the result is that patterns were distorted for pure IBNR with no impact on IBNER.
    - A court ruling affected development on the current inventory of claims; a large number of claims across various accident years saw late development that would not reasonably be expected to be repeated in the future.
2. Communication regarding our reserve estimate: Management had their own views on the expected future of development on known claims, and wanted to compare to the assumptions underlying the actuarial analysis; in order to do this, we required separate estimates of the two sources of "total IBNR."

Generally, we see the value in using these methods for situations where there is a change in the claims handling process, which could be due to legal issues (as in our case) or other reasons (for example, changes in claims handling personnel), where the change would be expected to only affect one of the two components of total IBNR, either pure IBNR or IBNER.

Difficulties in using these methods include the following:

- They require a volume of data that is often not available or hasn't previously been extracted.
- They require significantly more data manipulation work than standard methods.

- While we found that nonactuaries might understand results from this model as well as or better than they understood results from standard methods, they struggled even more with the underlying assumptions.

The data shown in this paper is actual data for a single coverage from a single company in a single state. Some scaling and other adjustments were made to obscure the actual data for competitive reasons, but we believe the patterns shown are representative of actual development and therefore representative of a realistic experience set. The data, being short-tailed, was treated as fully developed at 10 years. Obviously the use of these methods for longer-tailed lines (i.e., workers comp) would require significantly different assumptions (i.e., a judgmental tail factor or a larger triangle).

1.2 Outline

Section 2 of this paper covers methods for developing known claims only. Section 3 covers methods for developing Pure IBNR. Section 4 briefly addresses other issues and considerations. The Appendix summarizes and demonstrates some associated calculations.

2. METHODS FOR DEVELOPING KNOWN CLAIMS ONLY

Below we use several different methods to estimate losses associated with known claims only. Note that the methods below use paid losses to arrive at an estimate of ultimate losses on known claims; we could easily use reported losses and similar methods to arrive at a similar result.

2.1 Loss Development Factors in Three Dimensions

While the standard development methods use triangles in two dimensions (normally accident years in rows and evaluation ages in columns; or in the case of Schedule P of the Statutory Annual Statement, evaluation dates in columns), we introduce a third dimension (accident reporting date) to fit the needs of our analysis.

The following can be used for a simple analysis of our data using standard triangle techniques (following the form seen in many texts, for example, Chapter 7 of Friedland[3]):

Accident Year	12	24	36	48	60	72	84	96	108	120
2002	12,562,376	25,862,513	28,467,263	29,575,021	30,091,230	30,073,026	30,104,946	30,166,426	30,186,326	30,189,073
2003	14,619,720	25,402,485	27,155,996	27,946,880	28,224,494	28,481,593	28,418,174	28,441,572	28,501,185	
2004	9,959,858	15,436,434	16,398,604	16,682,005	16,808,181	16,817,113	16,830,511	16,833,318		
2005	6,633,610	11,007,035	11,407,596	11,591,573	11,695,406	11,757,884	11,850,579			
2006	6,290,293	9,478,911	10,085,187	10,406,254	10,685,927	10,907,900				
2007	7,336,768	11,828,200	12,709,085	13,100,700	13,429,193					
2008	7,585,085	12,634,480	13,500,587	14,841,451						
2009	10,823,234	20,222,524	23,270,335							
2010	17,829,334	33,345,851								
2011	13,138,447									

Ex hibit 1

For accidents that occurred in 2002, for example, $12,562,376 was paid out in the first 12 months; $25,862,513 was paid in the first 24 months, and so on. Dividing $25,862,513 by $12,562,376 results in a loss development factor (LDF) of 2.059. Cumulative losses at the end of 2003 are 2.059 times the value of those losses at the end of 2002. Applying this same procedure to the rest of the triangle, we get a triangle of LDFs:

Accident Year	12-24	24-36	36-48	48-60	60-72	72-84	84-96	96-108	108-120
2002	2.059	1.101	1.039	1.017	0.999	1.001	1.002	1.001	1.000
2003	1.738	1.069	1.029	1.010	1.009	0.998	1.001	1.002	
2004	1.550	1.062	1.017	1.008	1.001	1.001	1.000		
2005	1.659	1.036	1.016	1.009	1.005	1.008			
2006	1.507	1.064	1.032	1.027	1.021				
2007	1.612	1.074	1.031	1.025					
2008	1.666	1.069	1.099						
2009	1.868	1.151							
2010	1.870								
Simple Average	1.725	1.078	1.038	1.016	1.007	1.002	1.001	1.001	1.000
ATU	1.984	1.150	1.066	1.028	1.011	1.004	1.002	1.001	1.000

Exhibit 2

The last lines give an average LDF for each period and the age to ultimate (ATU), which gives a factor which can be applied to predict ultimate losses for each development period. We use the notation $LDF_{12\text{-}24}$ to denote the development for the period of 12-24 months (here, 1.725).

In order to develop known claims only, significantly more data is required and more data organization needs to occur. Using standard methods allows LDFs to be developed for all historical accident years from a single triangle. To develop only known claims, a separate triangle is needed to develop a factor for each of the historical accident ages.

The following triangle shows development for claims known (reported) during the first 12 months of the accident year:

Accident Year	12	24	36	48	60	72	84	96	108	120
2002	12,562,376	25,118,811	27,554,751	28,588,661	29,100,263	29,085,791	29,116,019	29,165,603	29,182,707	29,185,106
2003	14,619,720	24,788,513	26,468,578	27,179,855	27,438,716	27,693,922	27,641,313	27,657,101	27,691,518	
2004	9,959,858	15,034,728	15,951,729	16,230,914	16,354,359	16,365,200	16,378,598	16,381,406		
2005	6,633,610	10,638,603	11,017,732	11,130,327	11,219,686	11,278,566	11,367,675			
2006	6,290,293	9,240,966	9,818,560	10,102,109	10,388,013	10,609,986				
2007	7,336,768	11,446,700	12,291,777	12,632,077	12,953,176					
2008	7,585,085	12,329,181	13,146,004	14,438,614						
2009	10,823,234	19,605,018	22,511,712							
2010	17,829,334	32,564,625								
2011	13,138,447									

Exhibit 3

This triangle leads to a familiar-looking triangle of LDFs:

Accident Year	12-24	24-36	36-48	48-60	60-72	72-84	84-96	96-108	108-120
2002	2.000	1.097	1.038	1.018	1.000	1.001	1.002	1.001	1.000
2003	1.696	1.068	1.027	1.010	1.009	0.998	1.001	1.001	
2004	1.510	1.061	1.018	1.008	1.001	1.001	1.000		
2005	1.604	1.036	1.010	1.008	1.005	1.008			
2006	1.469	1.063	1.029	1.028	1.021				
2007	1.560	1.074	1.028	1.025					
2008	1.625	1.066	1.098						
2009	1.811	1.148							
2010	1.826								
Average	1.678	1.077	1.035	1.016	1.007	1.002	1.001	1.001	1.000
ATU	1.921	1.145	1.064	1.027	1.011	1.004	1.002	1.001	1.000

Exhibit 4

This triangle would then show a factor of 1.678 for what we label as $LDF_{12\text{-}24}(12)$; that is, the development for the period of 12-24 months on claims known as of 12 months.

So, $LDF_{12\text{-}24}(12) < LDF_{12\text{-}24}$; the difference in the two factors being due to $LDF_{12\text{-}24} = 1.725$ including a provision for late reporting claims, while unreported claims are excluded from $LDF_{12\text{-}24}(12) = 1.678$. Exhibit 4 would then provide a development factor applicable only to known claims at 12 months of age (losses for accident year 2011, for claims known as of 12/31/2011, in the data being analyzed here).

A separate triangle would then be created to include all claims that are reported during the first 24 months of the accident year, as shown in exhibit 5.

Accident Year	12	24	36	48	60	72	84	96	108	120
2002	12,562,376	25,862,513	28,462,819	29,564,219	30,080,258	30,062,055	30,093,974	30,155,455	30,175,354	30,178,101
2003	14,619,720	25,402,485	27,151,706	27,942,495	28,220,109	28,477,208	28,413,789	28,437,186	28,496,799	
2004	9,959,858	15,436,434	16,398,604	16,682,005	16,805,451	16,814,383	16,827,781	16,830,588		
2005	6,633,610	11,007,035	11,407,596	11,591,573	11,695,406	11,757,884	11,850,579			
2006	6,290,293	9,478,911	10,082,599	10,397,520	10,677,194	10,899,167				
2007	7,336,768	11,828,200	12,693,907	13,070,724	13,392,298					
2008	7,585,085	12,634,480	13,499,537	14,839,324						
2009	10,823,234	20,222,524	23,268,025							
2010	17,829,334	33,345,851								
2011	13,138,447									

Exhibit 5

Exhibit 6 shows development factors calculated.

Accident Year	12-24	24-36	36-48	48-60	60-72	72-84	84-96	96-108	108-120
2002	2.059	1.101	1.039	1.017	0.999	1.001	1.002	1.001	1.000
2003	1.738	1.069	1.029	1.010	1.009	0.998	1.001	1.002	
2004	1.550	1.062	1.017	1.007	1.001	1.001	1.000		
2005	1.659	1.036	1.016	1.009	1.005	1.008			
2006	1.507	1.064	1.031	1.027	1.021				
2007	1.612	1.073	1.030	1.025					
2008	1.666	1.068	1.099						
2009	1.868	1.151							
2010	1.870								
Average	1.725	1.078	1.037	1.016	1.007	1.002	1.001	1.001	1.000
ATU	1.983	1.149	1.066	1.027	1.011	1.004	1.002	1.001	1.000

Exhibit 6

Exhibits 5 and 6 would then provide a set of factors: $LDF_{24\text{-}36}(24)$, $LDF_{36\text{-}48}(24)$, $LDF_{48\text{-}60}(24)$, etc.; multiplying these together would then result in $LDF_{24\text{-}ult}(24)$: the factor to develop losses as of 24 months to their ultimate value. Similar to the above, these factors would only apply to a single accident year (accident year 2010 in the analysis this data was pulled from).

Constructing the remaining triangles gives us the rest of the age-to-age LDFs:

Known up to	12-24	24-36	36-48	48-60	60-72	72-84	84-96	96-108	108-120
12	1.678	1.077	1.035	1.016	1.007	1.002	1.001	1.001	1.000
24		1.078	1.037	1.016	1.007	1.002	1.001	1.001	1.000
36			1.037	1.016	1.007	1.002	1.001	1.001	1.000
48				1.016	1.007	1.002	1.001	1.001	1.000
60					1.007	1.002	1.001	1.001	1.000
72						1.002	1.001	1.001	1.000
84							1.001	1.001	1.000
96								1.001	1.000
108									1.000
Simple Average	1.678	1.077	1.037	1.016	1.007	1.002	1.001	1.001	1.000

Exhibit 7

As previously stated, we assumed that losses are closed at 10 years (i.e., $LDF_{120\text{-ult}} = 1.000 = LDF_{120\text{-ult}}(x)$ for all values of x), giving the table below for age-to-ultimate LDFs:

Known up to	12-ult	24-ult	36-ult	48-ult	60-ult	72-ult	84-ult	96-ult	108-ult
12	1.921	1.145	1.064	1.027	1.011	1.004	1.002	1.001	1.000
24		1.149	1.066	1.027	1.011	1.004	1.002	1.001	1.000
36			1.066	1.028	1.011	1.004	1.002	1.001	1.000
48				1.028	1.011	1.004	1.002	1.001	1.000
60					1.011	1.004	1.002	1.001	1.000
72						1.004	1.002	1.001	1.000
84							1.002	1.001	1.000
96								1.001	1.000
108									1.000

Exhibit 8

These factors can be compared to the factors obtained from the standard loss triangle:

Accident Year	12	24	36	48	60	72	84	96	108
ATA	1.725	1.078	1.038	1.016	1.007	1.002	1.001	1.001	1.000
ATU	1.984	1.150	1.066	1.028	1.011	1.004	1.002	1.001	1.000

Exhibit 9

Contrasting Exhibits 8 and 9 shows that factors after 24 months are not significantly different for the data we used; this is a result of the fast-reporting data for the line we analyzed and wouldn't be expected to be true for many commercial lines, which would have significantly more late reporting.

As stated in the introduction, this analysis is much more cumbersome than a traditional analysis, and the previous exhibits show the issue: A traditional analysis has one loss triangle and (n – 1) LDFs, where n is the number of years of development (in this case, 10). A three-dimensional analysis has (n-1) triangles and $n*(n-1)/2$ LDFs (in this case, 45), created by constructing separate triangles for each stage of development. LDFs are chosen as normal, using simple or weighted averages similar to those used for standard methods, and actuarial judgment comes into play if those averages are not judged to be representative of future expected development.

This process is repeated for claims reported within the first 12 months, 24 months, 36 months, and so on. The result is a triangle of LDFs which gives a separate LDF for each accident year and stage of development.

There are significant limitations with using this method:

- Adding segmentations to the data can result in lower credibility.
- The large number of LDFs that must be selected increases the amount of judgment

necessary.

- Overall, the method requires significantly more data and data organization effort than standard methods.

2.2 Derivative Methods

The above LDF method is very analogous to the traditional development method, simply adjusted to allow analysis of known claims only. Other common methods could be derived using the same data that was used above and would be analogous to other methods commonly used by actuaries.

We constructed, based on Exhibit 3, a triangle of incremental losses for claims reported within the first 12 months of the accident year:

Accident Year	Exposures	12	24	36	48	60	72	84	96	108	120
2002	50,645	12,562,376	12,556,435	2,435,940	1,033,909	511,602	(14,472)	30,228	49,584	17,104	2,399
2003	68,274	14,619,720	10,168,792	1,680,065	711,278	258,861	255,206	(52,609)	15,788	34,416	
2004	55,783	9,959,858	5,074,869	917,001	279,185	123,445	10,842	13,398	2,808		
2005	44,724	6,633,610	4,004,993	379,129	112,595	89,358	58,881	89,109			
2006	42,487	6,290,293	2,950,673	577,594	283,549	285,903	221,973				
2007	44,220	7,336,768	4,109,932	845,077	340,300	321,099					
2008	47,790	7,585,085	4,744,096	816,823	1,292,610						
2009	45,849	10,823,234	8,781,784	2,906,694							
2010	44,112	17,829,334	14,735,291								
2011	29,189	13,138,447									

Exhibit 10

Then we computed incremental paid loss per exposure for each year:

Accident Year	Exposures	12	24	36	48	60	72	84	96	108	120
2002	50,645	248.05	247.93	48.10	20.41	10.10	(0.29)	0.60	0.98	0.34	0.05
2003	68,274	214.13	148.94	24.61	10.42	3.79	3.74	(0.77)	0.23	0.50	
2004	55,783	178.54	90.97	16.44	5.00	2.21	0.19	0.24	0.05		
2005	44,724	148.32	89.55	8.48	2.52	2.00	1.32	1.99			
2006	42,487	148.05	69.45	13.59	6.67	6.73	5.22				
2007	44,220	165.92	92.94	19.11	7.70	7.26					
2008	47,790	158.72	99.27	17.09	27.05						
2009	45,849	236.06	191.54	63.40							
2010	44,112	404.19	334.05								
2011	29,189	450.12									
Simple Average		235.21	151.63	26.35	11.40	5.35	2.04	0.51	0.42	0.42	0.05

Exhibit 11

The factors from Exhibit 11 can then be applied to the exposures for the 2011 accident year (12 months of age) to calculate a provision for the 2011 development. We would estimate 2011 development to be

29,189*(151.63 + 26.35 + 11.40 + 5.35 + 2.04 + 0.51 + 0.42 + 0.05) = $5,784,189.

Adding development to the known loss of $13,138,447 gives a total of $18,922,635 ultimate loss on known claims in 2011.

Like in the prior calculation, the triangle above would only be useful for an accident year developed to 12 months (2011 in our example), and separate triangles would be necessary for each accident year (i.e., for each age).

2.3 Using a Mathematical Function Representing Development

In addition to these methods which rely on triangles, we used a "development curve" as another method to calculate the development on known claims. The general idea was to calculate a function that could be applied to losses at any stage of development to estimate an ultimate value for those claims. We calculated a development factor $f(a-b,b)$ by taking the ratio of (X) / (Y) where:

X = the total amount paid for all claims within "b" months of occurrence

Y = the total amount paid for all claims within "a" months of occurrence

X and Y are taken from all claims which are reported by age "a" and which reach at least age "b" before the evaluation date (12/31/2011 in our data). Put another way, the LDF f(22-23,23) is a function that calculates development on claims that occurred more than 23 months before the evaluation date, by comparing their value as of 22 months after occurrence with their value as of 23 months after occurrence; using only claims that are reported within 22 months of their occurrence.

The key point that is underlined above is that each LDF is calculated using a different set of claims. Therefore, X and Y will change each time the month being evaluated changes. This concept is illustrated in Exhibit 12. $X1$ and $Y1$ are calculated using all claims which are at least 23 months old and are known within 22 months of occurrence. $X2$ and $Y2$ are calculated using all claims which are at least 24 months old and are known within 23 months of occurrence. Thus, there are two values for "Paid within 23 months", depending on what factor is being calculated and the claims that the factor will be applied to.

Known at 23 months	Total Paid Loss		Known at 24 months	Total Paid Loss
Paid within 23 months (X_1)	139,341,717		Paid within 24 months (X_2)	138,213,757
Paid within 22 months (Y_1)	138,180,265		Paid within 23 months (Y_2)	137,320,270
LDF:	1.008		LDF:	1.007

Exhibit 12

We calculated the development during each month in order to derive a factor for that month of development. For example, for development during month 23, the factor would be calculated using all of the claims in the database that are at least 23 months old and are known within 22 months. Paid loss through 23 months ($139,341,717) is divided by paid loss through 22 months ($138,180,265) to get:

$f(22\text{-}23, 23) = 1.008$

In practice, it might make sense to use only claims from the most recent years or to weight the claims in order to give more credibility to the most recent years. We used all of the claims in our (10-year) database equally.

These factors could be applied to accident year using the average accident date (actual or assumed), or even to individual claims in order to develop ultimate claim amounts. In the appendix, we used an assumed average accident date of June 30, and applied the appropriate factor to each accident year.

3. METHODS FOR DEVELOPING PURE IBNR

Having developed an estimate of development on known claims, we turn to methods to calculate the remaining reserve, pure IBNR.

3.1 Exposure-Based Method

We again construct a set of historical triangles and compare the results to the associated exposures to come to a reserve estimate, in a manner similar to what we did in Section 2.2. In this case, the triangle represents the pure IBNR losses, for losses reported after a particular accident year age.

Exhibit 13 shows the development to ultimate of losses that are unreported at accident year age

12 months. The 743,702 in Exhibit 13 can be calculated by subtracting the corresponding amounts in Exhibit 1 and Exhibit 3: 743,702 = 25,862,531 – 25,118,811. Other numbers in the exhibit are calculated similarly.

Accident Year	Exposures	12	24	36	48	60	72	84	96	108	120
2002	50,645	-	743,702	912,511	986,360	990,967	987,236	988,927	1,000,823	1,003,619	1,003,967
2003	68,274	-	613,972	687,418	767,025	785,778	787,671	776,861	784,471	809,667	
2004	55,783	-	401,706	446,875	451,092	453,822	451,913	451,913	451,913		
2005	44,724	-	368,431	389,864	461,246	475,721	479,317	482,903			
2006	42,487	-	237,945	266,627	304,144	297,915	297,915				
2007	44,220	-	381,500	417,308	468,623	476,017					
2008	47,790	-	305,299	354,583	402,836						
2009	45,849	-	617,506	758,623							
2010	44,112	-	781,226								
2011	29,289	-									

<u>Exhibit 13</u>

We then create an incremental triangle from that in Exhibit 14. The sum of the entirety of the Accident Year 2002 row in Exhibit 14 is equal to the last value in the same row of Exhibit 13.

Accident Year	Exposures	12	24	36	48	60	72	84	96	108	120
2002	50,645	-	743,702	168,810	73,849	4,607	(3,731)	1,691	11,896	2,795	349
2003	68,274	-	613,972	73,446	79,607	18,753	1,893	(10,811)	7,610	25,196	
2004	55,783	-	401,706	45,169	4,216	2,730	(1,909)	-	-		
2005	44,724	-	368,431	21,433	71,382	14,475	3,596	3,586			
2006	42,487	-	237,945	28,682	37,517	(6,230)	-				
2007	44,220	-	381,500	35,807	51,315	7,394					
2008	47,790	-	305,299	49,284	48,253						
2009	45,849	-	617,506	141,116							
2010	44,112	-	781,226								
2011	29,189	-									

<u>Exhibit 14</u>

We then calculate the ratio of the values in the triangle of Exhibit 14 to the exposures, to create the triangle in Exhibit 15. The 14.68 in Exhibit 15 would represent $14.68, per exposure, of pure IBNR paid during the period from 12 months to 24 months, for claims unreported as of 12 months of age, for accident year 2002. The 3.33 would represent $3.33, per exposure, of pure IBNR paid during the period from 24 months to 36 months, for claims unreported as of 12 months of age, for accident year 2002. We would call attention to the fact that both of those numbers, and the entire triangle, are for claims unreported as of 12 months of accident year developement.

Accident Year	Exposures	12	24	36	48	60	72	84	96	108	120
2002	50,645	-	14.68	3.33	1.46	0.09	(0.07)	0.03	0.23	0.06	0.01
2003	68,274	-	8.99	1.08	1.17	0.27	0.03	(0.16)	0.11	0.37	
2004	55,783	-	7.20	0.81	0.08	0.05	(0.03)	-	-		
2005	44,724	-	8.24	0.48	1.60	0.32	0.08	0.08			
2006	42,487	-	5.60	0.68	0.88	(0.15)	-				
2007	44,220	-	8.63	0.81	1.16	0.17					
2008	47,790	-	6.39	1.03	1.01						
2009	45,849	-	13.47	3.08							
2010	44,112	-	17.71								
2011	29,189	-									
Simple Average		-	10.10	1.41	1.05	0.13	0.00	(0.01)	0.12	0.21	0.01

Exhibit 15

This is, to some extent, the complement to the method outlined in section 2.2. The two methods work functionally much the same and use the same exposure base.

Using this triangle, we would estimate

$$29{,}189*(10.10+1.41+1.05+0.13+0.00-0.01+0.12+0.21+0.01) = \$379{,}815$$

of pure IBNR for accident year 2011. Similar to the methods outlined earlier, this triangle is only appropriate for calculating the pure IBNR for the accident year age 12 months (2011). Separate triangles would again be necessary for each accident year.

3.2 Frequency / Severity

Exposures can also be used to estimate the number of unreported claims. Exhibit 16 shows a triangle of claim counts for claims that were not reported in the first 12 months. Exhibit 16 is constructed the same as Exhibit 14, simply substituting reported claim counts for paid losses.

Accident Year	Exposures	12	24	36	48	60	72	84	96	108	120
2002	50,645		252	7	3	0	1	0	0	0	0
2003	68,274		215	10	1	0	0	0	0	0	
2004	55,783		117	3	0	6	0	0	2		
2005	44,724		100	1	0	0	0	1			
2006	42,487		78	3	4	1	0				
2007	44,220		106	3	2	2					
2008	47,790		96	5	1						
2009	45,849		137	6							
2010	44,112		145								
2011	29,189										

Exhibit 16

These claims counts are then divided by the exposures and those factors are used to estimate the ultimate number of unreported claims for any year.

Accident Year	Exposures	12	24	36	48	60	72	84	96	108	120
2002	50,645		0.00498	0.00014	0.00006	-	0.00002	-	-	-	-
2003	68,274		0.00425	0.00020	0.00002	-	-	-	-	-	
2004	55,783		0.00231	0.00006	-	0.00012	-	-	0.00004		
2005	44,724		0.00197	0.00002	-	-	-	0.00002			
2006	42,487		0.00154	0.00006	0.00008	0.00002	-				
2007	44,220		0.00209	0.00006	0.00004	0.00004					
2008	47,790		0.00190	0.00010	0.00002						
2009	45,849		0.00271	0.00012							
2010	44,112		0.00286								
2011	29,189										
Simple Average			0.00273	0.00009	0.00003	0.00003	0.00000	0.00000	0.00001	-	-

Exhibit 17

We estimate 29,189*(0.00273+0.00009+0.00003+0.00003+0.00001) = 85 additional claims to be reported for accident year 2011.

To estimate an ultimate value for the additional claims, we need to multiply by the average ultimate paid per claim. We looked at a variety of claim statistics to arrive at an estimate of $5,790. Overall, this value was mostly based on the average paid per claim for older (closed or nearly closed) accident years, plus application of appropriate trend. We also considered the recent closed claim statistics and applied some actuarial judgment.

It's worth noting that looking at closed claim statistics and closed accident years was deemed appropriate based on our knowledge of our line of business that we were reviewing, and would not necessarily be applicable to all lines. We specifically considered that the claims we are estimating are claims that have a significant lag between occurrence and report date, and therefore might have different characteristics or be a different mix from those taken by looking at an entire accident year (i.e., when we look at older accident years to arrive at an average ultimate paid per claim). The specific characteristics of our line (limits, historical experience, low-severity/high-frequency) made us comfortable that this would not significantly skew our results. For other lines, it could be worth looking at the difference in severity between early-reported claims and late-reported claims and considering whether an adjustment should be made to the average ultimate paid per claim.

The results of 85 additional claims and average severity of $5,790 gives an expected pure IBNR of $491,818 for accident year 2011.

4. OTHER ISSUES AND CONSIDERATIONS

An additional benefit of our work is that the methods can be more precise and intuitive for interpolating full-year development patterns into quarterly or monthly results. In particular, the comparison to the results shown in Part 3 of the Statutory Quarterly Statement (which splits the development during the quarter into newly reported claims versus development on known) can be accomplished using the assumptions in our model.

Our methods also allow for additional explanation to management of the underlying reasons for development – for example, while unexpected development on known claims might point to an issue of claims handling/reserving, a deviation in the number of previously unreported claims from the expected number would be less likely to be the result of claims handling practices (in the specific case of the state/line of business used in our analysis, it was the result of a specific law change).

Tail factors can be added, and would generally use the same actuarial judgment as traditional methods. In our case, the development past ten years was so small as to be meaningless, but this would not be the case for many lines.

The creation of the triangles necessary for our method was heavily dependent on the use of report date, which adds an additional level of data validation – whether the report date is recorded correctly and consistently in the data systems.

Claim simulation models (for example, as used by Sahasrabuddhe) can also be used to calculate pure IBNR separate from development on known, and could be incorporated as part of the analysis, for example, comparing the results from Section 2 above to the results from a simulation model and making a judgmental selection; and similarly for Section 3. However, we found that the triangle methods we used were sufficient for our needs and did not see a reason to add a simulation.

5. CONCLUSIONS

The methods presented rely largely on the same techniques that are part of the basic actuarial toolkit, but extend them in a direction that can allow the separate review of the two components of total IBNR. As such, they allowed us to differentiate the two for reporting to management in a way that would be directly correlated with the way management was looking at the line of business. Further, the underlying assumptions developed can be used to project future development of the two components of IBNR, which can aid in understanding the source of future development and the reason for deviation from expectations.

Appendix – Supporting Calculation

Using standard methods, the projected ultimate loss for all accident years is $216,433,377. This loss includes development on known claims and IBNR.

Accident Year	Paid Loss as of 12/31/2011	Paid LDF	Standard Method Projected Ultimate
2002	30,189,073	1.000	30,189,073
2003	28,501,185	1.000	28,503,779
2004	16,833,318	1.001	16,858,046
2005	11,850,579	1.002	11,879,982
2006	10,907,900	1.004	10,955,509
2007	13,429,193	1.011	13,582,626
2008	14,841,451	1.028	15,250,843
2009	23,270,335	1.066	24,812,067
2010	33,345,851	1.150	38,338,040
2011	13,138,447	1.984	26,063,411
Total	196,307,331		216,433,377

Exhibit A

Section 2 explored methods that only develop on known claims. Using methods from section 2.1, the projected ultimate loss is $215,488,589. Using exposure methods from section 2.2, the projected ultimate loss is $206,032,673. Using the function method obtained in section 2.3, projected ultimate loss is $211,934,390.

Accident Year	Paid Loss as of 12/31/2011	Development on Known 3-D Projection	Exposure Projection	Function Projection
2002	30,189,073	30,189,073	30,189,073	30,189,073
2003	28,501,185	28,503,751	28,504,888	28,501,185
2004	16,833,318	16,857,055	16,871,657	16,842,083
2005	11,850,579	11,878,854	11,905,273	11,868,251
2006	10,907,900	10,954,452	10,981,252	10,928,589
2007	13,429,193	13,581,572	13,595,637	13,560,877
2008	14,841,451	15,249,371	15,282,623	15,201,215
2009	23,270,335	24,786,385	24,261,461	24,752,435
2010	33,345,851	38,247,339	35,518,174	38,565,430
2011	13,138,447	25,240,739	18,922,635	21,525,254
Total	196,307,331	215,488,589	206,032,673	211,934,390

Exhibit B

Pure IBNR was calculated the using two methods developed in section 3. The exposure method of section 3.1 projects pure IBNR of $626,372. The claim count method of section 3.2 projects a total pure IBNR of $593,139. This method uses the estimated value of $5,790 paid per claim, which was derived separately.

Accident Year	Paid Loss as of 12/31/2011	Pure IBNR Exposure IBNR	Claim Count IBNR
2002	30,189,073		
2003	28,501,185		
2004	16,833,318		
2005	11,850,579		3,095
2006	10,907,900		4,315
2007	13,429,193		5,502
2008	14,841,451	6,198	14,078
2009	23,270,335	35,056	22,387
2010	33,345,851	205,303	44,997
2011	13,138,447	379,815	498,765
Total	196,307,331	626,372	593,139

Exhibit C

Combining estimates for development on known claims and pure IBNR should result in a number close to the standard projection. The following chart shows all projections, along with a minimum and maximum total projection. The range of ($206,259,851, $216,689,071) contains the point estimate that was obtained by the standard method ($216,433,377), but suggests amounts substantially less than that are likely. As the purpose of this paper is to be illustrative rather than to calculate an actual reserve to recommend to management, we used simplifications like taking straight averages rather than exercising actuarial judgment in selecting LDFs; however, the fact that these exhibits suggest an amount lower than the traditional methods was consistent with our final results and recommendation to management.

		Development on Known			Pure IBNR		Total	
Accident Year	Paid Loss as of 12/31/2011	3-D Projection	Exposure Projection	Function Projection	Exposure IBNR	Claim Count IBNR	Minimum Projection	Maximum Projection
2002	30,189,073	30,189,073	30,189,073	30,189,073			30,189,073	30,189,073
2003	28,501,185	28,503,751	28,504,888	28,501,185			28,501,185	28,504,888
2004	16,833,318	16,857,055	16,871,657	16,842,083			16,842,083	16,871,657
2005	11,850,579	11,878,854	11,905,273	11,868,251		3,095	11,871,345	11,908,368
2006	10,907,900	10,954,452	10,981,252	10,928,589		4,315	10,932,904	10,985,567
2007	13,429,193	13,581,572	13,595,637	13,560,877		5,502	13,566,379	13,601,139
2008	14,841,451	15,249,371	15,282,623	15,201,215	6,198	14,078	15,207,413	15,296,701
2009	23,270,335	24,786,385	24,261,461	24,752,435	35,056	22,387	24,283,849	24,821,441
2010	33,345,851	38,247,339	35,518,174	38,565,430	205,303	44,997	35,563,171	38,770,733
2011	13,138,447	25,240,739	18,922,635	21,525,254	379,815	498,765	19,302,450	25,739,504
Total	196,307,331	215,488,589	206,032,673	211,934,390	626,372	593,139	206,259,851	216,689,071

Exhibit D

Postscript: Writing this in August 2013, with 18 months of hindsight, it's interesting to note that the current actuary's comparable estimate as of June 30, 2013 for accident year 2011 is $20.4 million, well below the estimate from traditional methods and within the range (albeit at the low end) of results from our proposed methods. While this isn't necessarily a solid validation of our results, it provides some basis to believe that the methods did, in this case, increase our accuracy.

5. REFERENCES

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