Anatomy of an Error: The Case of Loss Reserve Development Error Research

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Abstract: The academic literature on loss reserve errors spans five decades and follows two general themes: accident year reserve errors and calendar year reserve errors. The error metrics have different purposes, and in some research one method may be more appropriate than the other. In recent years, a material error has crept into the academic literature concerning the definition and measurement of loss reserve errors, and that error has found its way into peer-reviewed articles, into working papers found online, and in conference presentations. Our primary goal in this paper is to present a history of the two reserve error metrics and to correct the evolving error before it becomes too deeply embedded into the literature. [Key words: insurance reserve errors, loss development] JEL Classifications: G22, G28

INTRODUCTION

The purpose of this research is to briefly review the literature on property-liability loss reserve error metrics, to distinguish between the two major categories of reserve error measurement, and to clarify a material error that has crept into the academic literature over the last ten years concerning the definition and measurement of loss reserve errors. In our view, this emerging error has been caused at least in part by the propensity of researchers to commingle the two categories of reserve error measurement without distinguishing between the two approaches. Inaccuracies in published academic literature, and especially in peer-reviewed academic literature, tend to be persistent.[3]

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We first review the early work on loss reserve development error calculations and trace their evolution over time. We then address the definitional error that has evolved over the past ten years. After a summary and conclusions section, we include an appendix that illustrates the alternative methods of calculating reserve errors, using data from the Hartford Insurance Group.

ACADEMIC LITERATURE

There are two basic loss reserve error measurement approaches in the academic literature: calendar year development and accident year development. Calendar year development measures the errors in the aggregate loss reserve estimates for all active accident years from time t to some time n years into the future ($t+n$). Accident year development, on the other hand, measures the error for a single accident year from time t to time $t+n$. These two approaches were described in detail five decades ago in two contemporaneous articles: Anderson (1971) and Forbes (1970).

Anderson (1971) defined two loss reserve error measurement approaches:

(1) the *loss reserve difference* [accident year development], which follows loss development of a single specific accident year and is most appropriate when either the variability or the ultimate value of the specific claims for that period is the primary interest, such as for pricing purposes or for research into the impact of specific events; and

(2) the *loss reserve adjustment* [calendar year development], which follows the development of the aggregate unpaid reserves from all accident years at a given point in time forward to some point in the future. This approach is particularly appropriate for solvency studies since changes in the aggregate reserves directly affect policyholders' surplus. Indeed, the one-year-forward and two-year-forward loss reserve adjustments are reported in columns 11 and 12 of the current version of Schedule P of property/casualty statutory filings and represent the short-term effects of aggregate incurred loss development on policyholders' surplus. This approach is also

[3]Subsequent researchers rely in good faith on the imperfect vetting process of peer review, face-to-face interactions at conferences, and in-process research circulated via working papers. While our objective here is to correct the error, we do not malign the good faith efforts of any of the authors mentioned within. Indeed, we understand that even despite the best intents of editors, authors, reviewers, and the general process of building knowledge on the works of previous researchers, errors will inevitably slip in.

commonly encountered in the academic literature on earnings management, albeit over longer time horizons such as five years.

Contemporaneously, Forbes (1970) described two slightly different measures of reserving accuracy:

(3) The *incurred loss development ratio* [accident year development] of the reported incurred loss at the beginning of the development period to the incurred loss at the end of the development period, measured for each policy-accident year in Schedule P; and

(4) The *surplus adjustment ratio* [calendar year development], which is the sum of developed incurred losses for a given set of policy-accident years minus the initial estimate of those same incurred losses, divided by the average surplus available during the evaluation period.

Although Forbes and Anderson are using different terminology, they are describing the same two basic approaches to measuring loss reserve errors: accident year development and calendar year development. The specific calculations to derive the two metrics are presented in the Appendix using the 2014 version of Schedule P from the statutory annual statement, but researchers should be aware that the statement editions used in early studies were materially different. In the 1960s and 1970s, Schedule P was reported on a policy-accident year basis, so each accident year was reported in two separate lines. The first line matched accident year losses to policies written in the prior year and the second line matched accident year losses to policies written in the current year. Salzmann (1967) describes the problems inherent in reporting Schedule P under the policy-accident year basis, and Anderson (1971) describes the steps necessary to convert the policy-accident year Schedule P into the accident year basis. Kist (1988) provides a description of the material changes to the 1989 Schedule P when it changed from the policy-accident year basis to the accident-year basis and expanded the reporting to the ten full accident years that researchers are familiar with today.

Subsequent researchers have often referenced the work of Forbes (1970) and Anderson (1971) in their published works. Smith (1980) uses the loss reserve difference measure (accident year development) found in Anderson (1971) to test for earnings management in a sample of insurers. In the appendix to that article, he described the calculation of the loss reserve difference (accident year development) and provided an explicit example using the extant Schedule P Part 2A. In his example, the five-year loss reserve difference for 1973 is the value of the initial estimate of accident year 1973 incurred losses reported as of 12/31/1973 minus the developed estimate of the accident year 1973 incurred losses reported as of 12/31/1977.

The initial estimate of accident year 1973 incurred losses includes the cumulative paid losses as of 12/31/1973 and the unpaid losses (reserves) as of 12/31/1973. Any change in the incurred losses over the subsequent period would be development of the unpaid portion, so the difference in the reserves and the difference in the incurred losses would be the same number. Also, while Smith referred to this as "five year development" because five distinct years are included in the development period calculation (1973, 1974, 1975, 1976, and 1977), subsequent researchers have typically termed this "four year development" because the development period runs from time t (1973) to time t+4 (1977).

Another early researcher who is frequently quoted is Weiss (1985), who defined her reserve error variable as follows (p. 202):

$$\left(\begin{array}{c}\text{Loss Reserve}\\ \text{Error}\end{array}\right)_t = \frac{\left(\begin{array}{c}\text{Originally Reported}\\ \text{Incurred Losses}\end{array}\right)_t - \left(\begin{array}{c}\text{Losses as}\\ \text{Actually Developed}\end{array}\right)_{t+4}}{\left(\begin{array}{c}\text{Originally Reported}\\ \text{Incurred Losses}\end{array}\right)_t} \times 100,$$

Weiss is very precise about the source of her metric. In footnote 4 of her article, she states that her measure is a modification of the metric in Anderson (1971) and that "Smith (1980) also used this variable in his study" (p. 202). The modification she references is to divide the loss reserve difference by the originally reported incurred losses, which then scales the loss reserve error by the original amount to describe a percentage change. Her calculation is also very similar to Forbes's (1970) loss reserve development ratio. As already noted, Smith (1980) gives a specific formula for the loss reserve difference metric, citing Anderson (1971) as the original source. Some academics claim an ambiguity in Weiss's formula as "losses as actually developed" could refer to cumulative paid losses rather than incurred losses. However, a complete reading of the references clears up any controversy. Weiss was using the loss reserve difference metric, and "losses as actually developed" refers to incurred loss development, not losses paid.

Another widely quoted author is Grace (1990), who describes her reserve error metric as follows (p. 37):

> The dependent variable is defined as ERROR = [$\text{Resest}_{i,j}$ − $\text{Resdev}_{i,j+4}$], where
>
> $\text{Resest}_{i,j}$ = accident year estimate at the end of period j of unpaid claims arising from premiums written in period j for insurer i
>
> $\text{Resdev}_{i,j+4}$ = developed claim costs on an accident year basis arising from premiums earned in period j for insurer i.

The only difference between the error metric described in Weiss (1985) and the error metric described in Grace (1990) is the use of incurred losses by Weiss and the use of the unpaid portion of incurred losses by Grace. Since the changes in the incurred losses in subsequent development years stem from changes in the unpaid portion, the change in incurred losses would be the same as the change in loss reserves.[4]

Another seminal article is Kazenski, Feldhaus, and Schneider (1992) (hereafter, KFS), who used data reported in the 10K filings of publicly traded property-liability insurers to measure loss reserve development errors over alternative time horizons. The 10K loss development data is reported in a variation of a calendar-year format, similar to the loss data found in the Canadian version of the statutory annual statement. KFS used the 10K data because unlike the statutory annual statement data from the early 1980s, the 10K data covered ten full development years. KFS had to modify the loss reserve information found in the 10K in order to transform it into accident year data, but the advantage was that they had a longer development period to work with than was provided in the pre-1989 statutory statements. They described the process (and provided an example of the calculation) in an appendix to their article.

In summary, these four early researchers—Smith (1980), Weiss (1985), Grace (1990), and KFS (1992)—all used accident year loss reserve error metrics based on the loss reserve difference method proposed by Anderson (1971). However, in the early 1990s a series of researchers in the accounting field began publishing research into earnings management that used the calendar year approach (again, Anderson (1971) termed this approach the loss reserve adjustment). In this approach, the aggregate loss reserves at time t are re-estimated at time $t + n$ to determine whether the aggregate losses at time t were over-estimated or under-estimated. Some of the more widely cited research from this body of work includes Petroni (1992); Beaver, McNichols, and Nelson (2003); and Gaver and Paterson (2004).

To better explain the calculation of reserve development, researchers often included data from the statutory annual statement to illustrate the calculation. This reduced the ambiguity in the description of the data and makes it easier to follow the mechanics of the calculation. However, most researchers do not take the additional step of illustrating the inconsistent results that arise from changes in the individual accident years. That is, an overstatement of aggregate reserves does not mean that each individual accident year was overstated; it simply means that the dollar amount of the

[4]Grace (1990) also references premiums earned and premiums written in her definition. Since the NAIC does not separate losses (estimated or developed) for premiums earned and premiums written, we assume that she used the two phrases interchangeably.

overstated accident years overwhelmed any understatements in other accident years. Aggregate loss reserves may also include restatements of decades-old claims, such as those for asbestos, that are completely unrelated to the development of the claims in the more recent accident years.

It is also important to note that the results of studies using accident year development are not directly comparable to the results of studies using calendar year development. The calendar year development approach includes multiple accident years, all of which are at different stages of development, and the results for a specific accident year can run counter to the results for the other accident years. (See the appendix for further details.) Anderson (1971) explained the differences in his original work and cited some instances where the loss reserve difference (accident year development) would be more appropriate than the loss reserve adjustment (calendar year development). As an example, solvency researchers may be more concerned with aggregate loss reserve development because it directly impacts surplus. The current version of Schedule P Part 2 reports the loss reserve adjustment calculation (calendar year development) for the two most recent development years. Conversely, researchers studying specific economic incidents may be more concerned with examining individual accident years development. For example, Harrington and Danzon (1994) used the accident year development approach to evaluate general liability insurance pricing during the soft market of the early 1980s. Yet in spite of the differences between the two approaches, researchers continue to commingle the results of studies employing accident year development with those employing calendar year development.

AN ERROR CREEPS INTO THE LITERATURE

Grace and Leverty (2006) defined two measures of reserve errors, W error and KFS error, which they attributed to Weiss (1985) and Kazenski, Feldhaus and Schneider (1992), respectively. Grace and Levberty (2012, p. 354) note:.

> In the literature there are two methods for calculating reserve error. The first reserve error, which we call the Weiss (1985) or W error, is the difference between *total* incurred loss for firm i as of a given calendar year t and cumulative developed losses paid in a future calendar year $t+j$.

$$W_{i,t} = Incurred\ Losses_{i,t} - Developed\ Losses\ Paid_{i,t+j}. \quad (1)$$

Subsequent to defining the W error, Grace and Leverty (2012, p. 357) define the KFS error:

> The second reserve error, which we call the Kazenski, Feldhaus, and Schneider (1992) or KFS error, is the difference between *total* incurred losses for firm i as of a given calendar year t and a revised estimate of incurred losses in calendar year $t+j$:
>
> $$KFS_{i,t} = Incurred\ Losses_{i,t} - Incurred\ Losses_{i,t+j}. \quad (2)$$

These definitions were subsequently published in Grace and Leverty (2012) and have found their way into the literature in a number of other peer-reviewed outlets (e.g., Born and Boyer, 2011; Browne, Ju, and Lei, 2012; Kelly, Kleffner, and Li, 2012) and non-peer-reviewed sources.[5] In fact, we count no fewer than ten versions of working papers and dissertations by authors from North America, Europe and Asia that explicitly cite these error definitions. Many of these working papers have been presented at academic conferences and are currently in proceedings that are readily available on the Internet. While working papers do not carry the same gravitas as peer-reviewed, published articles, they are still part of the research landscape and give the appearance of widespread acceptance. The reality is that W error was not employed in any of the studies cited by Grace and Leverty (2012), including Weiss (1985) (as shown above), and the KFS error was not employed by its namesakes (KFS actually used accident year development, not calendar year development). Furthermore, the W error has a known bias towards positive errors, which Grace and Leverty (2012) themselves discuss, making it an inappropriate metric for reserve error studies.

SUMMARY AND CONCLUSIONS

Early researchers such as Forbes (1970) and Anderson (1971) cited specific instances where either calendar year development or accident year development would be the more appropriate reserve error metric. However, even today researchers continue to commingle the conclusions reported in accident-year development research studies and calendar-year development research studies without reference to the differences between the two approaches. Accident year development is more appropriate for

[5]Browne, Ju, and Lei (2012) refer to the "KFS error" in their paper, but the description appears closer to the "W error."

testing the impact of a specific event within a specific accident year and is commonly used to establish pricing accuracy for a specific block of business. Calendar year development is widely used in the literature to measure earnings manipulations without regard to which specific reserves are being manipulated.

Confounding the ambiguity in the published literature is the emergence of citations to the so-called W error and KFS error. Although there are both formal and informal peer-review procedures in place to catch mistakes, sometimes inaccuracies still slip through and become part of the established literature. Once published in peer-reviewed channels or placed on the world wide web as working papers, inaccuracies tend to become ingrained in the collective psyche. When mistakes appear, it is important to rectify them in the peer-reviewed literature so that future researchers do not repeat past mistakes. Unfortunately, an inaccuracy has crept into the long line of research into reserve estimation errors in the property-liability insurance literature. W error, misnamed for the pioneering work of Weiss (1985), and KFS error, misattributed to Kazenski et al. (1992), are two such examples.

The terms W error and KFS error should be struck from the lexicon as they do not represent the actual metrics used in past studies of reserve errors. Our paper is not meant to malign any authors that have used or are currently using "W error" or "KFS error." Current researchers naturally and rightly build on the work of others that have gone before them. Rather, we only seek to correct the mistake that seems to be blossoming before it is entrenched in the literature.

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APPENDIX

The 2014 financial data for the Hartford Insurance Group are used to calculate the various metrics of loss reserve development error. There are four sets of financial data used to illustrate the calculations:

- Excerpted data from Schedule P Part 1 on Incurred Losses and Adjustment Expenses
- Schedule P Part 2 – Incurred Losses
- Schedule P Part 3 – Paid Losses
- 10K Data on Loss Reserves

The statutory data values found in Schedule P are similar to the GAAP-based data values found in the 10K statement, but there are some material differences between statutory and GAAP accounting that lead to small differences in the reported values. Schedule P Part 2 does not include unallocated loss adjustment expenses, although that data is reported in Schedule P Part 1. The 10K data includes both losses and loss adjustment expenses, but Schedule P Parts 2 and 3 include losses and loss and defense containment losses (historically referred to as allocated loss adjustment expenses). There are some other minor data differences between the statutory statements themselves that have to do with loss discounting, and there are other minor GAAP-versus-SAP differences that may appear in certain insurers, but those differences are not material to the examples reported here.

Table 1 shows the loss reserve difference (Anderson, 1971) (accident year development) for accident years 2005 through 2010.[6] The initial estimate of the accident year incurred losses is the left-most value reported in each accident year in Schedule P Part 2 (Figure 2) while the developed incurred losses is the row value four columns to the right of the initial estimate. The initial paid losses for each accident year is the left-most value reported in Schedule P Part 3 (Figure 3). Table 1 shows that the accident year reserves for 2005 through 2009 were initially overstated, while the accident year reserves for 2010 were initially understated. For example, as of 12/31/2005 the accident year 2005 incurred losses were estimated to be $5,672 million, consisting of $2,117 million of paid losses and $3,555 million of unpaid losses. As of 12/31/2009, Hartford had re-estimated that original reserve and it had come down from $3,555 million to $3,043 million, which

[6]Since Schedule P now reports 10 years of development, we can observe several four-year development periods using one year's Schedule P. This is a luxury Anderson (1971) did not have.

meant that they had originally overstated the 2005 accident year losses by $512 million. Those losses had of course continued to develop beyond 2009 and will continue to develop until the last claim is paid out and closed in some distant future.

Table 2 shows the loss reserve adjustment (calendar year development) for the Hartford Group. The aggregate reserves as of 12/31/2010 can be computed by first summing the total cumulative incurred losses (rows 1 through 7 of column 6 of Schedule P Part 2) and then subtracting the total cumulative paid losses as of 12/31/2010 (rows 1 through 7 of column 6 of Schedule P Part 3). The revised estimate of the aggregate reserves can be measured by summing rows 1 through 7 of column 10 of Schedule P Part 2 and subtracting the cumulative paid losses as of 12/31/2010 (rows 1 through 7 of column 6 of Schedule P Part 3). Table 2 shows the results for the individual accident years that made up the cumulative reserves as of 12/31/2010, and we can see that the incurred losses in accident year 2005 continued to be revised downward past the four-year development point reported in Table 1. In fact, the reserves for accident years 2005 through 2009 were overstated, but the incurred losses for 2010 and for all accident years prior to 2005 were understated. The understatements from the prior years and from accident year 2010 were enough to cause the aggregate reserves to be understated, even though the most recent years were overstated.

Table 3 shows the results of the four-year loss reserve development calculations presented in Kazenski, Feldhaus, and Schneider (1992), computed from the data in Figure 4 as reported in The Hartford Group's 10K filing for 2014. The mechanics of the calculation are somewhat convoluted and are described in the appendix to that article, but the loss development patterns match those of the loss reserve difference in Table 1. The magnitude of the individual accident year differences is slightly different because the GAAP-based data includes unallocated loss adjustment expenses, whereas the statutory data from Schedule P Part 2 does not. The approach used in Kazenski et al. (1992) was notable at the time because Schedule P had only recently expanded to include 10 years of development, but this approach is obsolete in the U.S. today. The Canadian statutory statement uses a similar reporting approach, albeit for a shorter development horizon, and the details of that calculation are described in Kelly, Kleffner, and Li (2012).

Table 4 illustrates the bias problem inherent in Grace and Leverty's (2012) W error calculation.[7] Very few lines of business are completely paid out within five years, which means that cumulative paid losses are normally lower than reported incurred losses after only five years of development. Indeed, Kazenski et al. demonstrated that loss development contin-

ued well past five years for aggregate losses, and some lines of business continue to develop for decades. Therefore, W error is normally a positive value indicating overstated initial reserves. Because of the biased nature of the calculation, it is not used in academic research. Table 5 shows the W error calculation on a calendar year basis. The aggregation of the bias is easily seen, as the W error is an order of magnitude higher than the other errors.

Finally, Table 6 shows a summary of the reserve error calculations in the various studies mentioned in this paper. Here we can observe the difference between the W error as calculated by Grace and Leverty (2012) and the actual methodology used by Weiss (1985). Further, while the KFS error of Grace and Leverty (2012) is the same as the calendar year error of Anderson (1971), it is apparent that it is not the error used by KFS (1992).

[7]In this Table, we use the calculation performed by Grace and Leverty (2012) on an accident year basis. Grace and Leverty (2012) subtract paid losses from the initial estimate of incurred losses and then, within a calendar year, aggregate across all accident years.

Figure 1. Excerpt from Hartford Insurance Group Schedule P Part 1 Summary for 2014

Loss Reserve-Related Portions of Schedule P Part 1—Summary

Year in Which Premiums Were Earned and Losses Were Incurred	Losses Unpaid				Defense and Cost Containment Unpaid				Adjusting and Other Unpaid		23 Salvage and Subrogation Anticipated	24 Total Net Losses and Expenses Unpaid
	Case Basis		Bulk + IBNR		Case Basis		Bulk + IBNR					
	13 Direct and Assumed	14 Ceded	15 Direct and Assumed	16 Ceded	17 Direct and Assumed	18 Ceded	19 Direct and Assumed	20 Ceded	21 Direct and Assumed	22 Ceded		
1. Prior…..	2,059,203	308,113	2,740,386	276,772	225,742	96,827	448,168	64,268	102,452	0	753	4,829,971
2. 2005…..	156,743	23,684	148,943	14,595	14,966	2,292	34,768	4,151	8,522	0	376	319,221
3. 2006…..	178,534	14,204	131,998	14,026	16,223	2,058	34,848	2,519	14,798	0	1,869	343,593
4. 2007…..	177,395	9,691	180,853	21,031	15,482	1,306	59,674	6,879	19,590	0	3,566	414,088
5. 2008…..	260,897	25,247	206,424	23,511	20,219	1,558	59,681	4,392	21,609	0	5,668	514,122
6. 2009…..	254,092	11,226	299,043	34,643	23,749	2,664	68,068	7,648	32,485	0	9,951	621,257
7. 2010…..	338,716	20,634	471,076	40,748	33,123	5,153	113,937	9,514	53,304	0	21,700	934,107
8. 2011…..	502,985	42,319	783,608	62,227	53,035	7,886	155,920	14,074	58,269	0	35,834	1,427,312
9. 2012…..	624,874	45,092	1,136,959	100,916	57,513	6,187	283,760	22,440	103,534	0	60,043	2,032,007
10. 2013…..	729,569	70,573	1,604,742	142,037	54,094	3,242	360,901	34,893	148,408	0	85,377	2,646,968
11. 2014……..	1,028,970	69,100	2,432,718	215,234	41,373	1,103	451,262	41,874	297,163	0	171,735	3,924,174
12. Totals	6,311,978	639,883	10,136,749	945,739	555,521	130,275	2,070,986	212,652	860,136	0	396,874	18,006,821

Figure 2. Hartford Insurance Group Schedule P Part 2 Summary for 2014

Schedule P Part 2—Summary												
Years in Which Losses Were Incurred	INCURRED NET LOSSES AND DEFENSE AND COST CONTAINMENT EXPENSES REPORTED AT YEAR END ($000 OMITTED)										DEVELOP-MENT	
	1	2	3	4	5	6	7	8	9	10	11	12
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	One Year	Two Year
1. Prior…..	10,488,561	10,949,303	11,051,819	10,975,725	11,115,764	11,244,956	11,467,072	11,395,491	11,472,278	11,749,473	277,196	353,982
2. 2005……..	5,671,683	5,562,708	5,328,081	5,204,848	5,159,537	5,061,846	5,049,716	5,048,233	5,039,145	5,030,492	–8,653	–17,741
3. 2006……..	xxx	5,964,939	5,831,873	5,675,590	5,461,980	5,336,413	5,285,866	5,272,553	5,201,423	5,202,246	823	–70,306
4. 2007……..	xxx	xxx	6,296,108	6,255,414	6,149,678	5,988,834	5,917,433	5,893,315	5,825,072	5,831,946	6,873	–61,369
5. 2008……..	xxx	xxx	xxx	6,393,498	6,368,313	6,361,929	6,332,452	6,321,753	6,283,238	6,269,547	–13,691	–52,206
6. 2009……..	xxx	xxx	xxx	xxx	6,055,599	6,025,151	6,002,002	5,971,832	5,961,932	5,967,579	5,647	–4,254
7. 2010……..	xxx	xxx	xxx	xxx	xxx	6,213,687	6,450,835	6,453,904	6,511,114	6,488,102	–23,012	34,198
8. 2011……..	xxx	xxx	xxx	xxx	xxx	xxx	6,856,270	6,907,357	7,052,832	7,048,676	–4,157	141,319
9. 2012……..	xxx	xxx	xxx	xxx	xxx	xxx	xxx	6,687,425	6,709,827	6,705,815	–4,012	18,390
10. 2013…..	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	6,078,252	5,988,198	–90,055	xxx
11. 2014…..	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	6,028,276	xxx	xxx
									12. Totals		146,960	342,013

Figure 3. Hartford Insurance Group Schedule P Part 3 Summary for 2014

Schedule P Part 3—Summary

Years in Which Losses Were Incurred	CUMULATIVE PAID NET LOSSES AND DEFENSE AND COST CONTAINMENT EXPENSES REPORTED AT YEAR END ($000 OMITTED)										11 Number of Claims Closed With Loss Payment	12 Number of Claims Closed Without Loss Payment
	1 2005	2 2006	3 2007	4 2008	5 2009	6 2010	7 2011	8 2012	9 2013	10 2014		
1. Prior……..	0	1,785,905	3,169,190	4,114,326	4,752,740	5,331,619	5,756,332	6,162,951	6,484,327	6,852,961	xxx	xxx
2. 2005……..	2,116,723	3,095,268	3,672,488	4,062,834	4,294,540	4,426,191	4,537,613	4,614,800	4,665,327	4,696,907	xxx	xxx
3. 2006……..	xxx	2,034,771	3,207,756	3,789,127	4,190,478	4,440,175	4,595,717	4,708,308	4,791,180	4,851,208	xxx	xxx
4. 2007……..	xxx	xxx	2,252,396	3,563,540	4,223,852	4,671,087	4,993,271	5,204,191	5,324,439	5,413,546	xxx	xxx
5. 2008……..	xxx	xxx	xxx	2,567,524	3,955,589	4,642,900	5,121,694	5,429,959	5,616,639	5,746,522	xxx	xxx
6. 2009……..	xxx	xxx	xxx	xxx	2,434,853	3,705,338	4,383,934	4,852,815	5,151,249	5,344,484	xxx	xxx
7. 2010……..	xxx	xxx	xxx	xxx	xxx	2,608,371	4,017,078	4,759,991	5,264,666	5,563,605	xxx	xxx
8. 2011……..	xxx	xxx	xxx	xxx	xxx	xxx	2,843,515	4,324,380	5,105,234	5,629,265	xxx	xxx
9. 2012……..	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2,535,387	3,996,807	4,719,839	xxx	xxx
10. 2013……..	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2,261,831	3,432,468	xxx	xxx
11. 2014……..	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2,360,197	xxx	xxx

Figure 4. Loss Reserve Re-estimates from the FY 2014 10-K for Hartford Group ($ millions)

	12/31 2004	12/31 2005	12/31 2006	12/31 2007	12/31 2008	12/31 2009	12/31 2010	12/31 2011	12/31 2012	12/31 2013	12/31 2014
Liabilities for unpaid losses and loss adjustment expenses net of reinsurance	16,191	16,863	17,604	18,231	18,347	18,210	17,948	18,517	18,689	18,676	18,765
Cumulative paid losses and loss expenses											
One year later	3,594	3,702	3,727	3,703	3,771	3,882	4,037	4,216	4,274	4,072	
Two years later	6,035	6,122	5,980	5,980	6,273	6,401	6,664	6,897	7,019		
Three years later	7,825	7,755	7,544	7,752	8,074	8,241	8,503	8,875			
Four years later	9,045	8,889	8,833	9,048	9,411	9,538	9,928				
Five years later	9,928	9,903	9,778	10,061	10,395	10,649					
Six years later	10,798	10,674	10,564	10,845	11,303						
Seven years later	11,448	11,334	11,216	11,612							
Eight years later	12,023	11,895	11,883								
Nine years later	12,526	12,493									
Ten years later	13,088										
Reserve Re-estimated as of:											
One year later	16,439	17,159	17,652	18,005	18,161	18,014	18,315	18,513	18,881	18,904	
Two years later	16,838	17,347	17,475	17,858	18,004	18,136	18,275	18,686	19,207		
Three years later	17,240	17,318	17,441	17,700	18,139	18,093	18,299	19,013			
Four years later	17,344	17,497	17,439	17,866	18,120	18,056	18,629				
Five years later	17,570	17,613	17,676	17,848	18,092	18,408					
Six years later	17,777	17,895	17,673	17,857	18,437						
Seven years later	18,064	17,899	17,749	18,215							
Eight years later	18,062	18,045	18,097								
Nine years later	18,214	18,390									
Ten years later	18,565										
Deficiency (redundancy), net	2,374	1,527	493	–16	90	198	681	496	518	228	

Table 1. Loss Reserve Difference (Accident Year Development) for Hartford Insurance Group for Accident Years 2005–2010 as of 12/31/2014 (000s omitted)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Accident Year	Initial Estimate Date	Re-Estimation Date	Initial Estimate of Incurred Losses	Developed Estimate of Incurred Losses	Cumulative Paid Losses on Initial Estimate Date	Initial Estimate of Unpaid Losses (4)–(6)	Developed Estimated of Unpaid Losses (5)–(6)	Reserve Error (7)–(8)	Direction of Error
2005	12/31/2005	12/31/2009	$5,671,683	$5,159,537	$2,116,723	$3,554,960	$3,042,814	–$512,146	Overstated
2006	12/31/2006	12/31/2010	$5,964,939	$5,336,413	$2,034,771	$3,930,168	$3,301,642	–$628,526	Overstated
2007	12/31/2007	12/31/2011	$6,296,108	$5,917,433	$2,252,396	$4,043,712	$3,665,037	–$378,675	Overstated
2008	12/31/2008	12/31/2012	$6,393,498	$6,321,753	$2,567,524	$3,825,974	$3,754,229	–$71,745	Overstated
2009	12/31/2009	12/31/2013	$6,055,599	$5,961,932	$2,434,853	$3,620,746	$3,527,079	–$93,667	Overstated
2010	12/31/2010	12/31/2014	$6,213,687	$6,488,102	$2,608,371	$3,605,316	$3,879,731	$274,415	Understated

Table 2. Calendar Year Loss Development Calculation Example for Hartford Insurance Group from 12/31/2010 to 12/31/2014 (000s omitted)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Accident Year	Incurred as of 12/31/2010	After X Years of Development	Incurred as of 12/31/2014	After X Years of Development	Cumulative Paid Losses as of 12/31/2014	Estimated Unpaid Reserves as of 12/31/2010 (2)–(6)	Re-Estimate of Unpaid Reserves as of 12/31/2014 (4)–(6)	Reserve Estimation Error (7)–(8)	Direction of Error
Prior	$11,244,956	Unknown	$11,749,473	Unknown	$5,331,619	$5,913,337	$6,417,854	–$504,517	Understated
2005	$5,061,846	5	$5,030,492	9	$4,426,191	$635,655	$604,301	$31,354	Overstated
2006	$5,336,413	4	$5,202,246	8	$4,440,175	$896,238	$762,071	$134,167	Overstated
2007	$5,988,834	3	$5,831,946	7	$4,671,087	$1,317,747	$1,160,859	$156,888	Overstated
2008	$6,361,929	2	$6,269,547	6	$4,642,900	$1,719,029	$1,626,647	$92,382	Overstated
2009	$6,025,151	1	$5,967,579	5	$3,705,338	$2,319,813	$2,262,241	$57,572	Overstated
2010	$6,213,687	0	$6,488,102	4	$2,608,371	$3,605,316	$3,879,731	–$274,415	Understated
Total	$46,232,816		$46,539,385		$29,825,681	$16,407,135	$16,713,704	–$306,569	Understated

Table 3. Accident Year Loss Development Using 10K Data Conversion Found in Kazenski, Feldhaus, and Schneider (1992) ($ millions)

(1) Accident Year	(2) Aggregate Reserves Estimate as of 12/31 of Current Year	(3) Prior Year Reserve Estimate as of 12/31 of Current Year	(4) Prior Year Cumulative Paid Losses as of Current Year	(5) Aggregate Reserve Re-Estimated Four Years Later	(6) Prior Year Aggregate Reserve Re-Estimated Five Years Later	(7) Accident Year Initial Reserve (2)–(3)+(4)	(8) Accident Year Initial Reserve Re-Estimated Four Years Later (5)–(6)+(4)	(9) Reserve Error (7)–(8)	(10) Direction of Error
2005	$16,863	$16,439	$3,594	$17,497	$17,570	$4,018	$3,521	$497	Overstated
2006	$17,604	$17,159	$3,702	$17,439	$17,613	$4,147	$3,528	$619	Overstated
2007	$18,231	$17,652	$3,727	$17,866	$17,676	$4,306	$3,917	$389	Overstated
2008	$18,347	$18,005	$3,703	$18,120	$17,848	$4,045	$3,975	$70	Overstated
2009	$18,210	$18,161	$3,771	$18,056	$18,092	$3,820	$3,735	$85	Overstated
2010	$17,948	$18,014	$3,882	$18,629	$18,408	$3,816	$4,103	-$287	Understated

Table 4. Calculation of Accident Year W Error Metric Proposed by Grace and Leverty (2012) (000s omitted)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Accident Year	Initial Estimate Date	Re-Estimation Date	Initial Estimate of Incurred Losses	Cumulative Paid Claims as of AY+4	W Error (4)–(5)	Direction of Error	Developed Estimate of Incurred Losses	Cumulative Paid to Initial Incurred Ratio (5) / (4)	Cumulative Paid to Developed Incurred Ratio (5) / (8)
2005	12/31/2005	12/31/2009	$5,671,683	$4,294,540	$1,377,143	Overstated	$5,159,537	76%	83%
2006	12/31/2006	12/31/2010	$5,964,939	$4,440,175	$1,524,764	Overstated	$5,336,413	74%	83%
2007	12/31/2007	12/31/2011	$6,296,108	$4,993,271	$1,302,837	Overstated	$5,917,433	79%	84%
2008	12/31/2008	12/31/2012	$6,393,498	$5,429,959	$963,539	Overstated	$6,321,753	85%	86%
2009	12/31/2009	12/31/2013	$6,055,599	$5,151,249	$904,350	Overstated	$5,961,932	85%	86%
2010	12/31/2010	12/31/2014	$6,213,687	$5,563,605	$650,082	Overstated	$6,488,102	90%	86%

Table 5. Calendar Year W Error Metric
Proposed by Grace and Leverty (2012) (000s omitted)

(1)	(2)	(3)	(4)
Accident Year	Incurred as of 12/31/2010	Cumulative Paid Claims as of 12/31/2014	Calendar Year W Error
Prior	$11,244,956	$6,852,961	$4,391,995
2005	$5,061,846	$4,696,907	$364,939
2006	$5,336,413	$4,851,208	$485,205
2007	$5,988,834	$5,413,546	$575,288
2008	$6,361,929	$5,746,522	$615,407
2009	$6,025,151	$5,344,484	$680,667
2010	$6,213,687	$5,563,605	$650,082
Total	$46,232,816	$38,469,233	$7,763,583

Table 6. Summary of Reserve Error Calculations (000s omitted)

Reserve Error Description	Reserve Error	Calculation Source	Studies
Accident year reserve error calculation for 2010	–$274,415	Table 1, Column (9)	Anderson (1971), Smith (1980), Weiss (1985), Grace (1990), KFS (1992)
4-year calendar year reserve error calculation for 2010	–$306,569	Table 2, Column (9)	Anderson (1971), Grace (1990), Petroni (1992)
"W error" (4 year development)	$7,763,583	Table 5, Column (4)	Grace and Leverty (2012)
"KFS error" (4 year development)	–$306,569	Table 1, Column (9)	Grace and Leverty (2012)