The CAS *E-Forum*, Summer 2015

The Summer 2015 edition of the CAS *E-Forum* is a cooperative effort between the CAS *E-Forum* Committee and various other CAS committees, task forces, or working parties.

This *E-Forum* contains one ratemaking call paper, a report of the CAS Low Interest Rate Working Party, a special report prepared for the CAS Committee on Health Care Issues and three independent research papers. The ratemaking paper was created in response to a call issued by the CAS Committee on Ratemaking and was presented at the CAS Ratemaking and Product Management Seminar held March 9-11, 2015.

Low Interest Rate Environment Working Party

Christopher G. Gross, *Chairperson*

Jonathan L. Ankney
Waswate Ayana
Andra Ban
Etai Barach
Sandra J. Callanan
Kenneth J. Eiger
Eric J. Gesick
Denis G. Guenthner
Dave Kunka
James M. Maher
Ankit Nanda
William H. Panning
Leonid Rasin
Karen Sonnet, *Staff Liaison*
Lu Sun
Gayna Swart
Samantha M. Taylor
Susan E. Witcraft
Jianwei Xie

Committee on Health Care Issues

Anne Marlene Petrides, *Chairperson*
Glen Alan Leibowitz, *Vice Chairperson*

Christopher T. Andersen
Christian J. Coleianne
Michael L. DeMattei
Stephen R. DiCenso
Veronique Grenon
Melissa S. Holt
Lauren Miranda Inglis
Millie Man Sum Lo
Natasha C. Moore
Timothy C. Mosler
Clista E. Sheker
Megan Elizabeth Taylor
Cheri Widowski, *Staff Liaison*

CAS *E-Forum*, Summer 2015

Table of Contents

For information on submitting a paper to the *E-Forum*, visit http://www.casact.org/pubs/forum/.

A Practical Approach to Variable Selection — A Comparison of Various Techniques

Benjamin Williams
Greg Hansen
Aryeh Baraban
Alessandro Santoni

Abstract: Selecting a useful list of variables for consideration in a predictive model is a critical step in the modeling process and can result in better models. Sifting through and selecting from a long list of candidate variables can be onerous and ineffective, particularly with the increasingly wide variety of external factors now available from third-party providers. This paper explores a variety of variable selection techniques, applied to frequency and severity models of homeowner insurance claims, developed on a dataset with over 350 initial candidate variables. The techniques are evaluated using multiple criteria, including the predictive power of a resulting model (measured using out-of-sample data) and ease of use. A method based on Elastic Net performs well. Random selections perform as well as some more sophisticated methods, for sufficiently long shortlists.

Key Words: variable selection, frequency and severity models, homeowners, Elastic Net regularization

1. INTRODUCTION

Between the data stored by companies and that available from external providers, modelers now have access to hundreds or even thousands of factors. So many factors are available that it is often impractical to consider all of them in a formal predictive modeling context. This situation will only be accentuated in the future, as the number of candidate variables continues to grow. Recognizing which factors to consider in predictive modeling becomes an important problem for which automated approaches are required.

This paper considers this issue in the context of continuous, geo-demographic factors. For each variable selection technique, the long list of factors is reduced to a shortlist, upon which a model is fitted. The techniques are evaluated in terms of various criteria: predictiveness and goodness of fit of the resulting model; ease of set-up and ease of implementation. We do not go into great detail on each of the variable selection methods used, as none of the methods themselves are particularly novel, and such details are available elsewhere.

1.1 Research Context

The area of the science addressed by this paper is Financial and Statistical Methods, Statistical Models and Methods, Predictive Modeling.

1.2 Objective

Variable reduction is an active area of research in insurance modeling, and many papers have been written on the topic. However we consider that the exact question raised here, i.e., how to select, from a (potentially very) long list of factors, a shortlist which will be useful for current predictive modeling techniques, has not received sufficient attention. We make the distinction between this, which we call variable selection, and variable reduction. We consider variable reduction techniques to be those that create "super-factors," small numbers of linear combinations or other functions of the original factors, which may have more predictive power than the original list of factors. An example of what we consider a variable reduction technique is Principal Component Analysis.

The difficulty of fitting models when a large number of variables is available is widely recognized (see for example [1], [2], [4] and [5]). In [1] and [5], the use of a variable clustering technique to reduce a large number of geographic variables into clusters for use in Generalized Linear Models (GLMs) of auto insurance claims experience is discussed. In [2], Principal Component Analysis (PCA) and partial least squares are used to reduce variables on simulated data and the results are compared. [3] and [4] use alternative approaches based on data-mining.

Our analysis seeks to extend these papers by investigating a wide variety of techniques, including some of those discussed in the papers referred to above, and using different methods to compare predictiveness of models.

Our research considers a variety of variable selection techniques applied to a dataset of insurance claims experience, which has previously been randomly divided into training and testing datasets. Each factor selection technique results in a shortlist of factors, which are tested for inclusion in a GLM on the training dataset via an automated approach.

The performance of the resulting models is evaluated in terms of both predictiveness and goodness of fit. The predictiveness is evaluated on the testing data in two ways: 1) ranking Gini coefficients, and 2) comparing selected models via double-lift curves. The techniques are also evaluated in terms of ease of use (including software considerations and processing efficiency). The goodness of fit is ranked by deviance on the testing data.

1.3 Outline

Section 2 discusses in detail the data used, the techniques investigated, and how they were compared. Section 3 provides the results of our analysis. Section 4 gives our conclusions and recommendations for further analysis.

2. A COMPARISON OF VARIABLE SELECTION TECHNIQUES

2.1 Data Used

A dataset of approximately 1.9 million observations corresponding to five years of homeowner claims experience was used in our research. Predictors for each observation included 15 policy-related factors (including typical rating factors such as Age of Dwelling, Policy Tenure, Construction Type, Insurance Score Tier etc.) and over 350 ZIP code or Census Block level geo-demographic variables. This dataset was randomly divided into training and testing datasets on a ratio of 2:1. The geo-demographic variables were anonymized, ordinal, and pre-banded. All variable selection techniques were run and all models fitted on the training dataset, and all comparisons of predictiveness were performed on the testing dataset.

The techniques were analyzed in the context of four different model responses: frequency (number of claims per year of exposure) and severity (average cost per claim) for each of two claim types (water and fire), in order to see if results differed. Due to time constraints, it was not practical to create a shortlist for each method for fire frequency and severity.

2.2 Variable Selection Techniques Considered

The techniques considered belonged to one of three broad types:

1. Modeling methods that, when implemented, create a relevance score which allows the factors to be ranked. A shortlist of length *N* is created by taking the first *N* variables.
2. Variations on stepwise modeling techniques.
3. Random selection of variables, used as a baseline against which to gauge the performance of the more sophisticated techniques.

Prior to testing the variable reduction techniques on the 350+ geo-demographic variables, a Base Model was fitted on the 15 policy-related variables using traditional GLM techniques and assumptions. The techniques were then tested on a residual basis, contemplating the signal already explained by the Base Model. Several were also tested directly on the response variable (frequency or severity), without any consideration of the variables in the Base Model.

The following techniques were considered:

- Classification and Regression Trees (CART): the result of a standard implementation of CART by Salford Systems is a usefulness score, which allows the relevance of the variables to be ranked. This method was tested on both a direct (CARTBase) and residual (CARTRes) basis.

- Elastic Net: a penalized regression technique that uses a combination of two different penalty functions; L^2 (i.e., sum of squares) penalty function similar to the penalty used in Ridge regression and L^1 (i.e., sum of absolute values) penalty function similar to the penalty function used in the Least Absolute Shrinkage and Selecting Operator (LASSO) introduced by Tibshirani in 1996. The use of L^1 penalty function allows variables to enter the model one at the time. Variables that are most important in explaining the signal typically enter the model first followed by less important variables. The ranking of variables was based on the order in which they entered the model. This method was tested on both a direct (ENetBase) and residual (ENetRes) basis.
- AIC Improvement Rank: each factor under consideration is added to the model as a first, second and third degree polynomial. Candidates are ranked according to the AIC improvement of the best-performing polynomial. This method was tested on both a direct (AICRankBase) and residual (AICRankRes) basis.
- Stepwise GLM based on AIC Improvement with Correlated Variables Removed (GLMCorr): similar to AIC Improvement Rank. At each step, every factor under consideration is individually added to the model as a first degree polynomial. The best candidate (as determined by AIC improvement) is added to the model, and all strongly correlated variables are removed from further consideration. For this test, "strongly correlated" was subjectively defined as a correlation coefficient of greater than 0.35. This method was only tested on a residual basis.
- Stepwise Least Squares Regression with Correlated Variables Removed (LSRCorr): similar to the GLMCorr but using Least Squares Regression instead of GLMs to significantly improve processing speed. This method was only tested on a residual basis.
- Variable Clustering (Varclus): a standard implementation of the Varclus procedure in SAS, to create N clusters. The variable from each cluster with the lowest $1 - R^2$ ratio was selected.
- Random List (Rand): a random selection of factors from the list of available factors

2.3 Testing Predictiveness and Goodness of Fit

The factors in each shortlist were tested for inclusion in a GLM on the training dataset. The basics of GLMs are beyond the scope of this paper, see [6] for reference. In order to prevent the modeler's judgment from biasing the results, an automated modeling technique, forward regression using AIC improvement, was used. Starting from the same Base Model discussed above, which contained only policy factors, each factor in the shortlist was considered for inclusion as a first degree polynomial with unknown values grouped with the base level. The regression halted when the addition of no remaining unused factors resulted in an improved model.

Predictiveness of the shortlist provided by each technique was analyzed by testing how well the GLM fitted using the shortlist predicted out-of-sample data. Many methods exist to compare predictiveness of models (see, for example [7] for further discussion). As mentioned previously, we have limited ourselves to two methods: Gini coefficient[1] and Double Lift charts[2].

Goodness of fit of the shortlist provided by each technique was analyzed by ranking the deviance of the GLM fitted using the shortlist when applied to out-of-sample data.

2.4 Other Criteria

While we consider that the most fundamental property of a good variable selection technique is that it provides a shortlist of factors that result in a highly predictive model, other desirable properties are:

- Ease of set-up (in terms of software considerations and setting up the analysis)
- Processing efficiency (i.e., speed)

It should be noted that we did not attempt to undertake an exhaustive survey of all software currently available to carry out a variable selection technique.

---

[1] A Gini Coefficient is calculated from a Gains Curve, which is a plot of cumulative exposure, ordered by fitted values, against cumulative response. The Gini Coefficient is twice the area between the Gains Curve and the 45 degree line. The higher the Gini Coefficient, the more predictive a model.

[2] A Double Lift Chart compares two fitted model results on a given dataset. On the horizontal axis is the percentage difference between the fitted values, divided into bands. On the vertical axes are the average observed and fitted values in each percentage difference segment, and the exposure in each segment. The more predictive of the two models is that which more closely follows the observed values.
See [8] for a more detailed discussion on Gini coefficients and double lift charts.

3. RESULTS AND DISCUSSION

3.1 Testing Predictiveness and Goodness of Fit

In the following tables and graphs, N is the length of the shortlist on which each model was fitted. Most of the shortlists in the main table are of length 50 or 5. These lengths were decided upon by the authors. The few methods that have different length shortlists do so because they reached their stopping conditions prior to identifying 50 candidate variables.

Table 1. Comparison of Gini coefficients

		Water		Fire	
Method	N=	Frequency	Severity	Frequency	Severity
AICRankBase	50	0.2914	0.1413	0.2764	0.1018
AICRankRes	50	0.2869	0.1422	0.2766	0.1273
CARTBase	5	0.2982	0.1409		
CARTBase	50	0.3010	0.1473		
CARTRes	50	0.3043	0.1459		
ENetBase	5	0.2939	0.1394		
ENetBase	50	0.3060	0.1425	0.2806	0.1257
ENetRes	5	0.2999	0.1376		
ENetRes	50	0.3086	0.1475	0.2820	0.1168
GLMCorr	25	0.2997	0.1450		
GLMCorr	5	0.2997	0.1392		
Rand	5	0.2924	0.1390		
Rand	50	0.3079	0.1443	0.2711	0.1585
VarClus	50	0.3020	0.1462	0.2692	0.1521
LSRCorr	50	0.3073	0.1455		
LSRCorr	48				0.1166
LSRCorr	45			0.2781	

Chart 1. Ranking of Methods by Gini Coefficient for Water Frequency Models

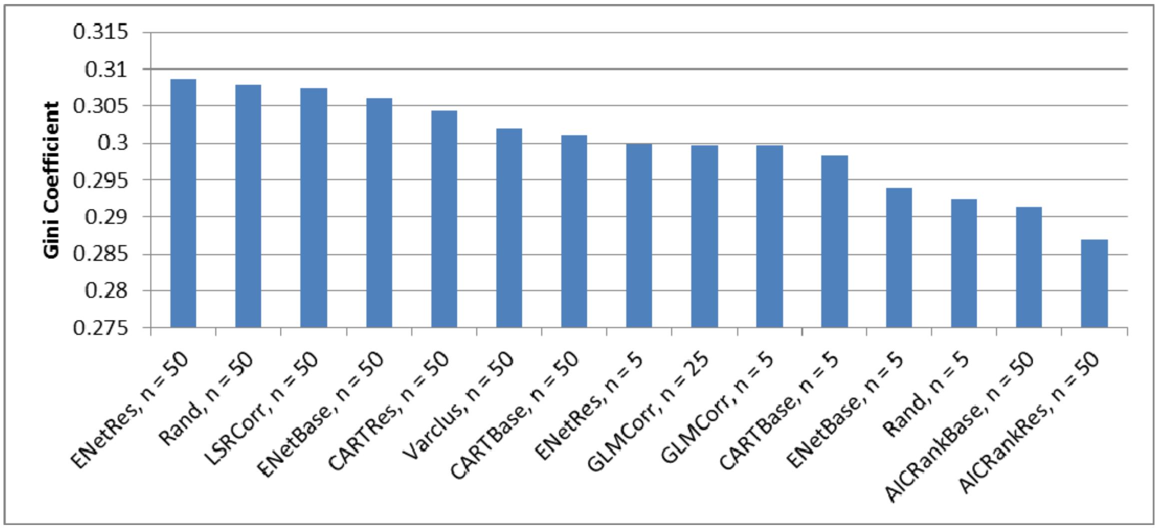


Chart 2. Ranking of Methods by Gini Coefficient for Water Severity Models

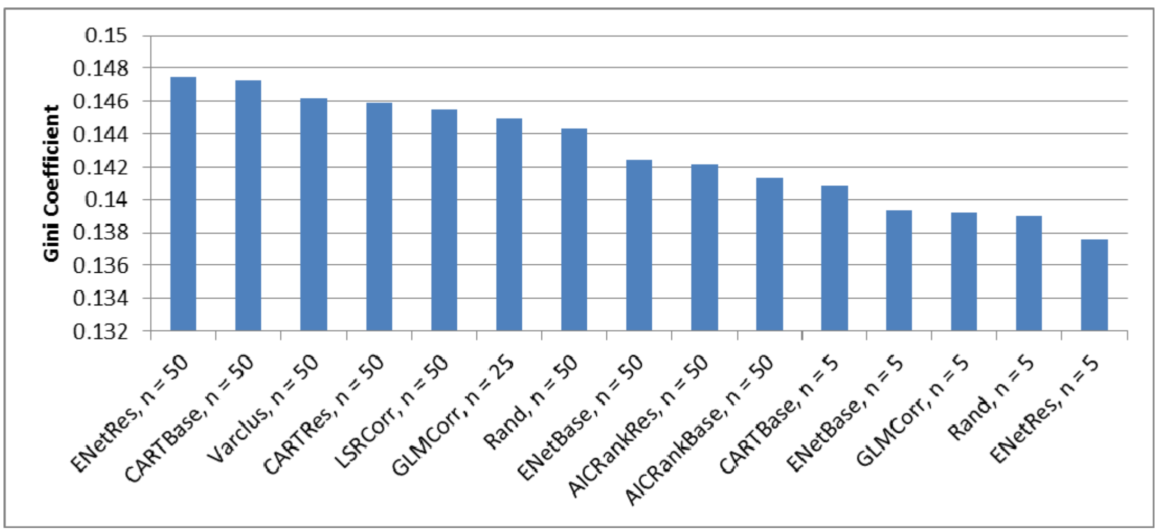


Chart 3. Ranking of Methods by Gini Coefficient for Fire Frequency Models

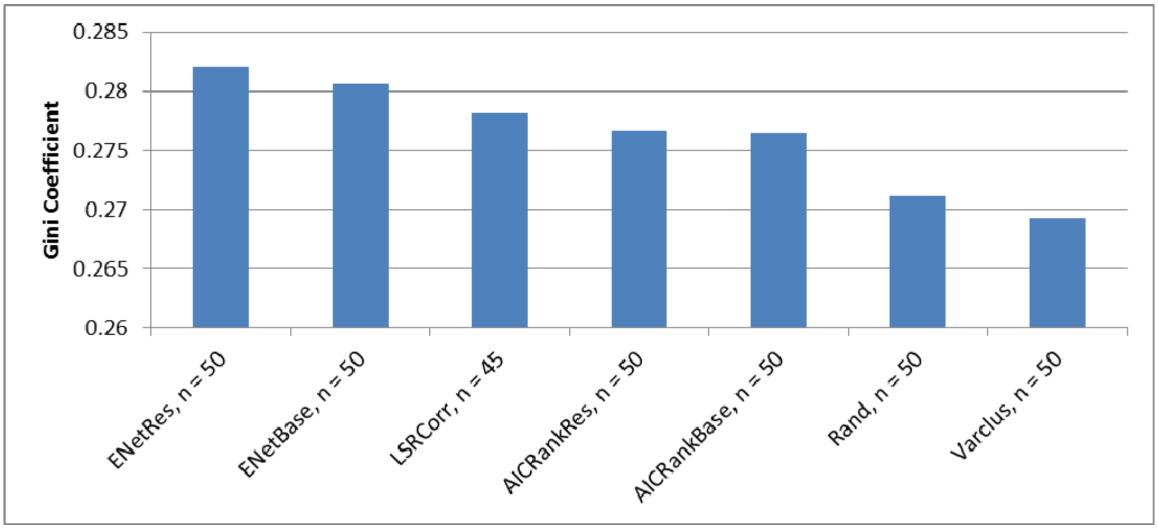
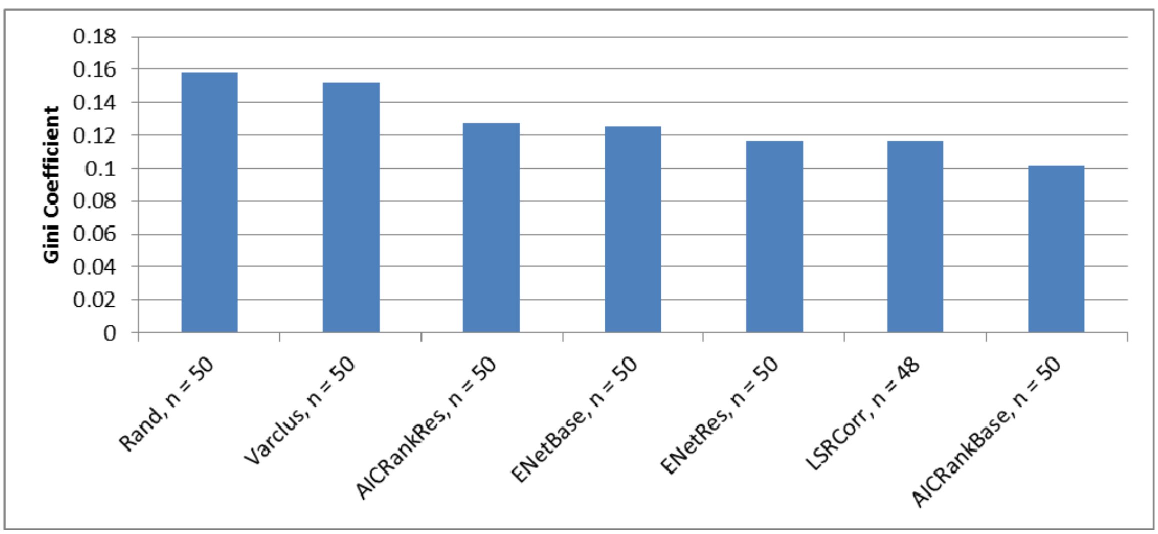


Chart 4. Ranking of Methods by Gini Coefficient for Fire Severity Models

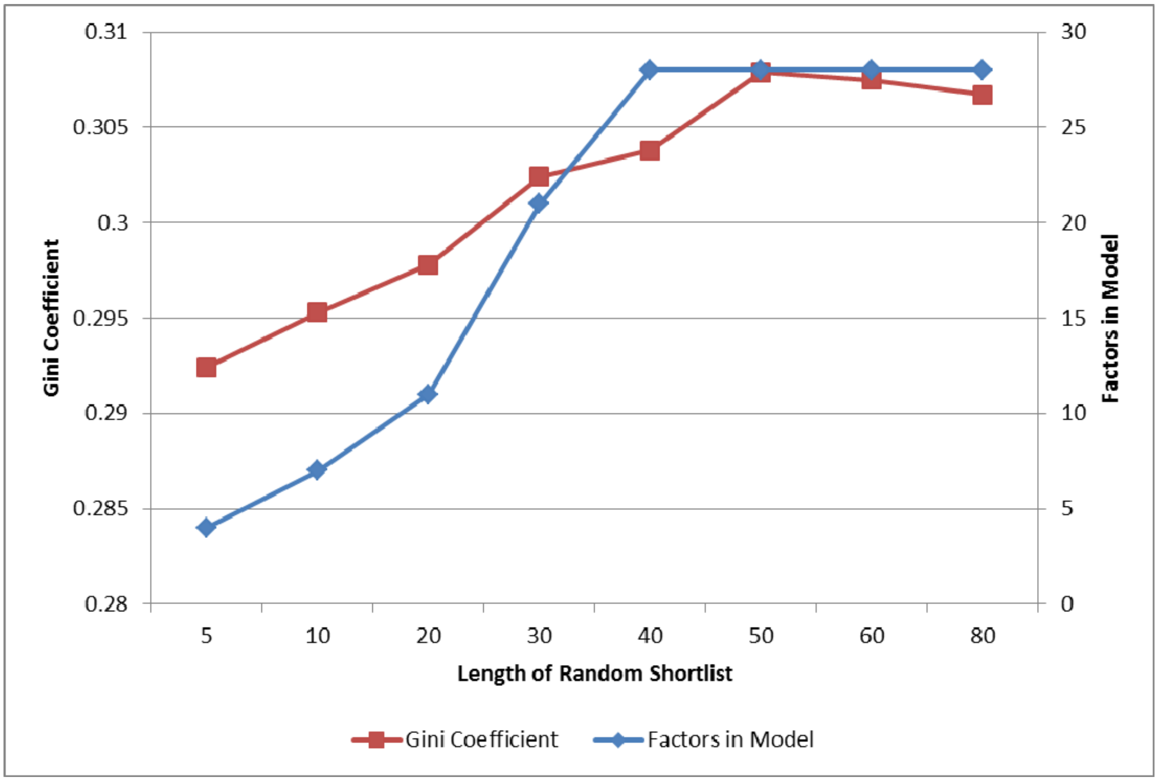


In the absence of an easy-to-apply theory of the distribution of Gini coefficients, it is not clear if any of the methods have performed significantly better than the others. However, we do make the following observations:

1. ENetRes N = 50 achieved the best results on both Water and Fire Frequency and Water Severity
2. ENetBase N = 50, VarClus and the different LSRCorr shortlists performed well.
3. Where the same method was used to generate two shortlists, the model fitted on the longer shortlist was, in most cases, more predictive.
4. A Random shortlist performed as well as many more sophisticated methods on the same length shortlist, for sufficiently long shortlists.
5. The results for Fire Severity are very different from the other models, in terms of ranking of methods and range of Gini coefficients. We believe that this is because of the comparatively small number of Fire claims in the modeling data.

Observations 3 and 4 inspired us to repeat our tests on random shortlists of different lengths. It should be noted here that random shortlists are nested, in the sense that our random shortlist of 10 included our random shortlist of 5, as well as 5 additional randomly-selected factors. The results led to an interesting conclusion, as displayed in Chart 5 below. This chart compares, for various sets of random shortlists (on the horizontal axis), the number of factors retained in the GLM (the right vertical axis) and the Gini coefficient (the left vertical axis). As the shortlists get longer, the number of factors retained in the model by the automated modeling technique plateaus (at about N = 40), while the Gini coefficient continues to improve.

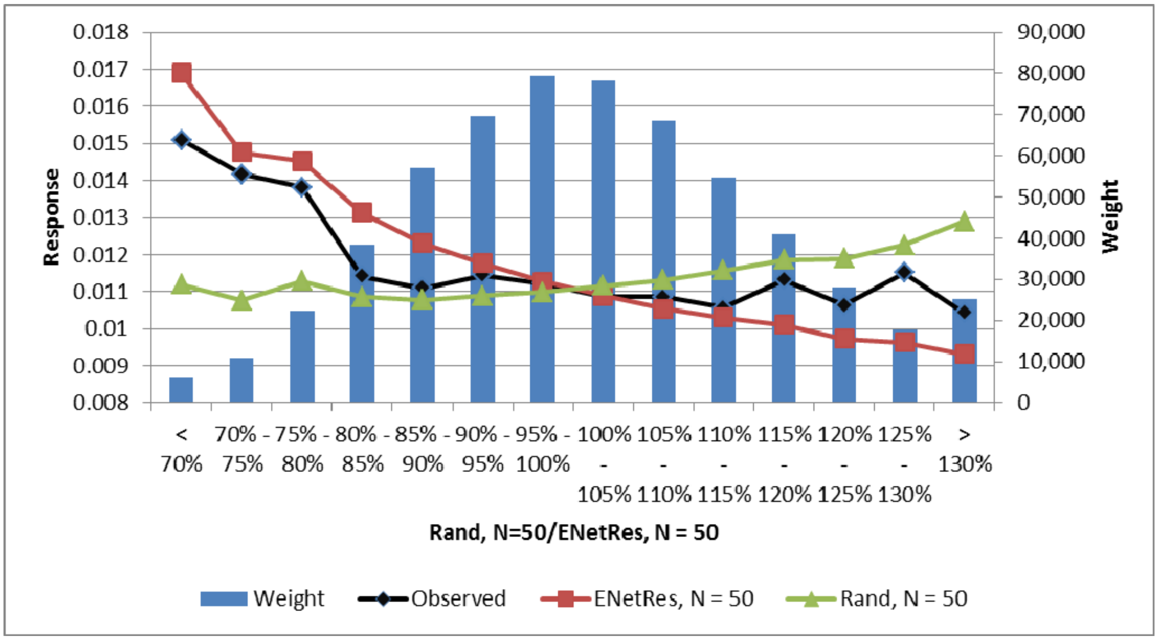
Chart 5. Number of factors in Water Frequency model and Gini coefficient for random shortlists of different lengths



We interpret this as follows. The longer the list of variables the automated modeling technique can choose from, the greater the chances that it will settle on a "best", or at least a "reasonable" predictive set. In the limiting case, the shortlist would include all available factors, and the automated modeling technique would produce the best possible model. This is also related to the structure of correlations among the different factors. We return to this point in Section 4.

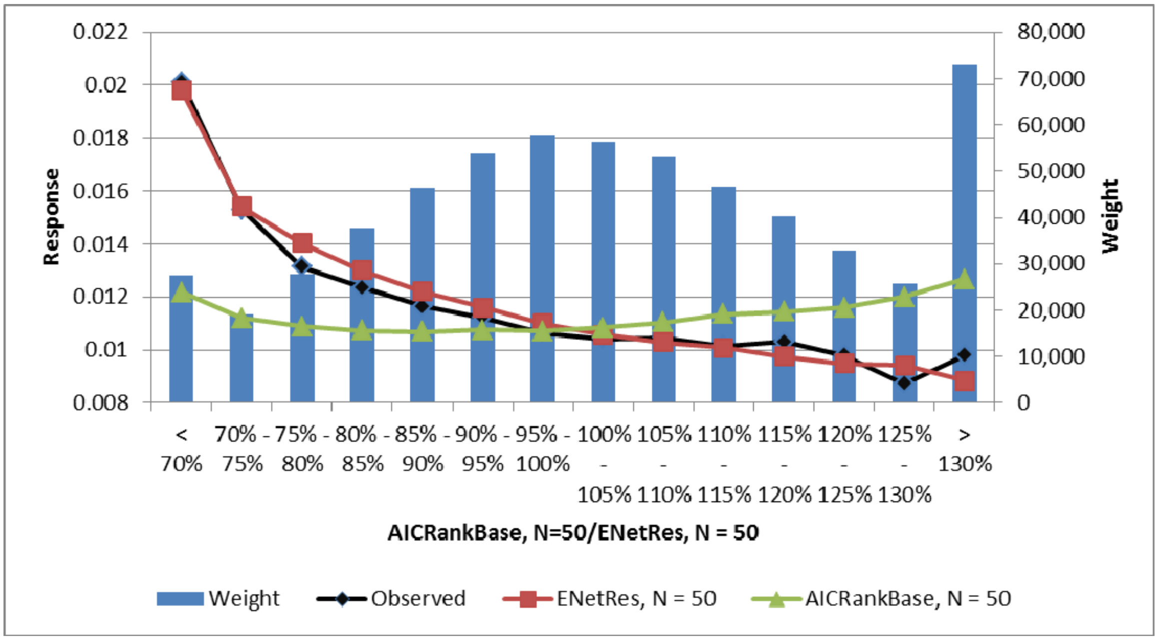
As noted above, a Gini coefficient is only one criterion for judging predictiveness of models. We now consider the double lift chart, to see if it allows us any additional insights.

Chart 6. Double Lift Chart ENetRes, N = 50 vs. Rand, N = 50, Water Frequency



In Chart 6, the two best performing methods in terms of Gini coefficient ranking for Water Frequency are compared. For ratio bands containing the majority of exposure, including 90%-115%, the observed response is closer to ENetRes, N = 50 than to Rand, N = 50, and we conclude that ENetRes, N = 50 is more predictive than Rand, N = 50. This agrees with the Gini coefficient ranking. However, we do note that in some well-populated ratio bands, for example 80%-90% and 115%-120%, the observed response is closer to Rand, N = 50 than to ENetRes, N = 50. It could be argued that ENetRes, N = 50 performs better where the models are not very different, but there is not much difference between the models where the differences between them are more pronounced (i.e., outside the ratio bands 90%-110%). On this basis, we do not consider this a strong victory for ENetRes, N = 50. This may reflect the small difference in Gini coefficient for these two methods.

Chart 7. Double Lift Chart ENetRes, N = 50 vs. AICRankBase, N = 50, Water Frequency



In Chart 7, the best and one of the poorest performing methods in terms of Gini coefficient ranking for Water Frequency are compared. In no ratio band does AICRankBase, N = 50 perform better than ENetRes, N = 50, and in most ratio bands it performs much worse. This appears to confirm the Gini coefficient ranking.

The analysis of other double lift charts tended to confirm the Gini coefficient ranking.

We now evaluate the methods in terms of goodness of fit of the resulting models.

Table 2. Model deviance

		Water		Fire	
Method	N=	Frequency	Severity	Frequency	Severity
AICRankBase	50	59,587	7,559	14,251	3,738
AICRankRes	50	59,634	7,562	14,251	3,712
CARTBase	5	59,495	7,571		
CARTBase	50	59,279	7,627		
CARTRes	50	59,234	7,641		
ENetBase	5	59,541	7,581		
ENetBase	50	59,362	7,655	14,237	3,715
ENetRes	5	59,466	7,589		
ENetRes	50	59,145	7,632	14,230	3,749
GLMCorr	25	59,374	7,544		
GLMCorr	5	59,457	7,577		
Rand	5	59,564	7,577		
Rand	50	59,345	7,648	14,259	3,735
VarClus	50	59,350	7,648	14,260	3,733
LSRCorr	50	59,233	7,656		
LSRCorr	48				3,703
LSRCorr	45			14,238	

Chart 8. Ranking of Methods by Deviance for Water Frequency Models

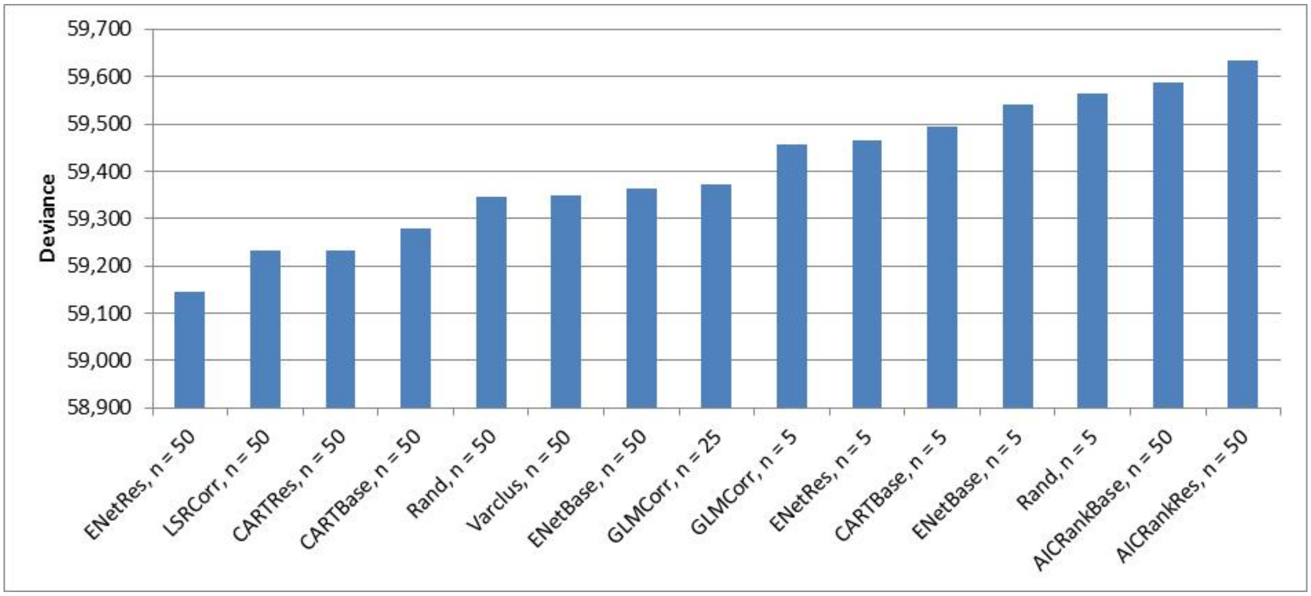


Chart 9. Ranking of Methods by Deviance for Water Severity Models

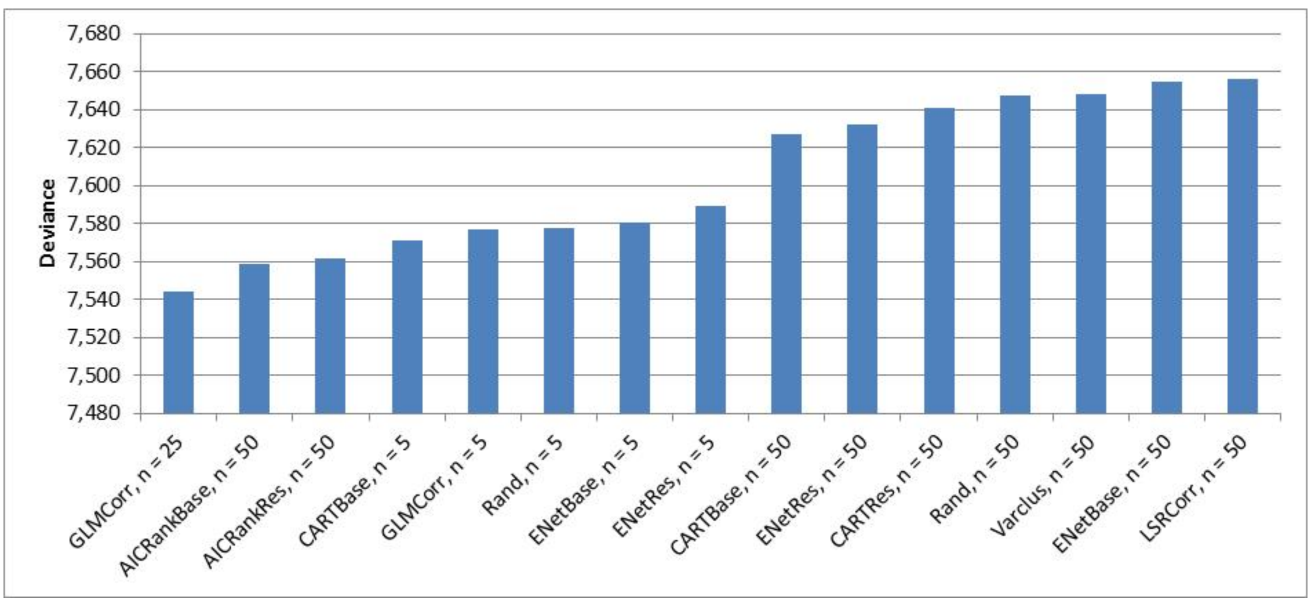


Chart 10. Ranking of Methods by Deviance for Fire Frequency Models

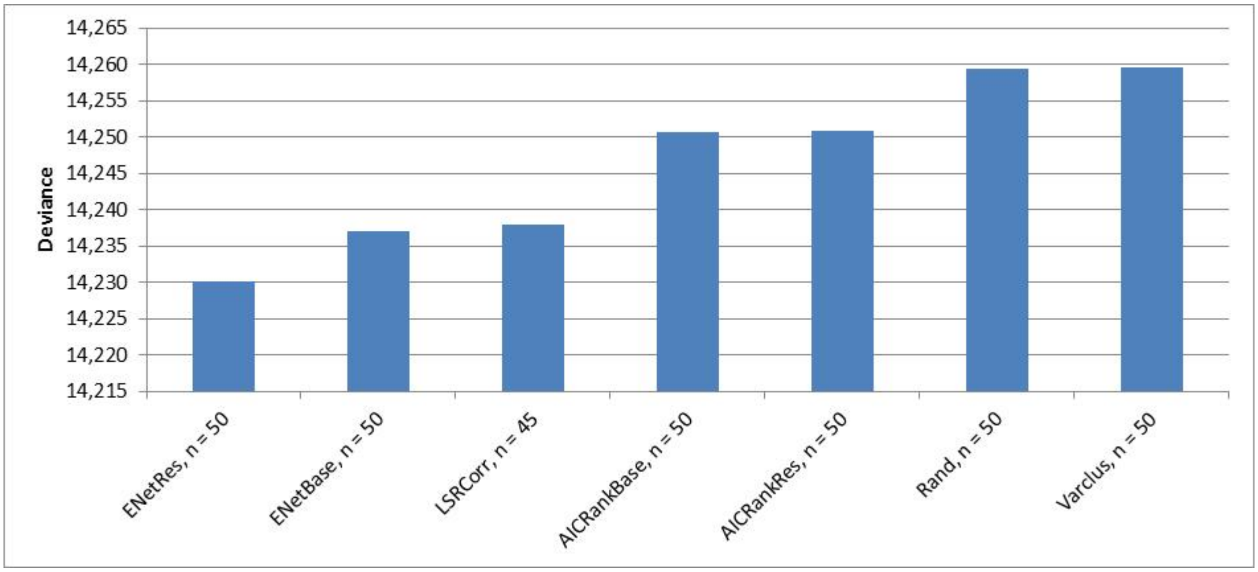
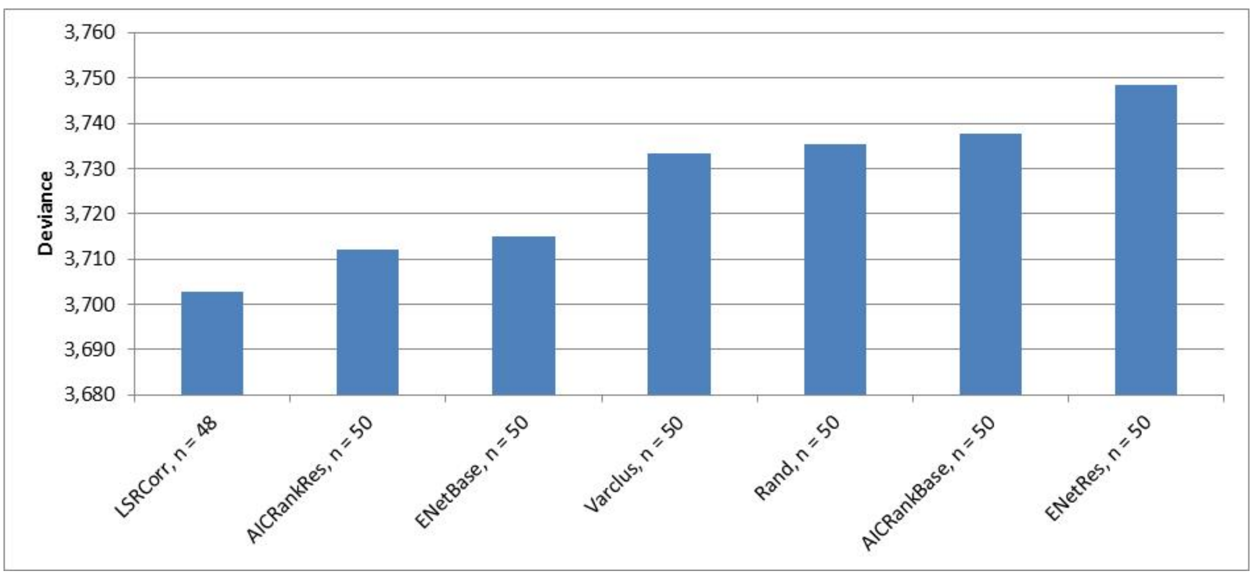


Chart 11. Ranking of Methods by Deviance for Fire Severity Models



While the range of deviances produced by the best and worst-performing methods in each case is not large, we make the following observations based on the above results:

1. When generated by the same method, longer shortlists produced lower deviances. We are not surprised by this result.
2. ENetRes N = 50 achieved the best results on both Water and Fire Frequency.
3. LSRCorr and GLMCorr also performed well.

In general, evaluating models based on either goodness of fit or predictiveness produced similar conclusions.

3.2 Other Criteria

Judging methods on ease of setting up and processing speed can be difficult, as users are typically restricted by the software and hardware available to them, and a given piece of software or better hardware could greatly simplify the set-up, or improve the speed. However we do think that it is important to give some indication of the amount of time required to set up and process each type of method. In each case, we assume the availability of a user with a level of expertise sufficient to implement the process - in practice, an important consideration. We have not conducted a survey of limitations here (e.g., that R requires all calculations to be done in memory, therefore limiting the size of the dataset studied).

Table 3 summarizes the software we used to perform each method, along with our assessment of its ease of implementation and processing speed.

Table 3. Comparison of methods by implementation and speed

Method	Software Used	Complexity to Set-Up	Processing Speed
AICRank	Emblem	Easy	Average
CART	CART	Easy	Fast
ENetBase	R	Average	Fast
GLMCorr	SAS	Easy	Slow
LSRCorr	SAS	Easy	Fast
Rand	-	Trivial	None required
VarClus	SAS	Easy	Fast

In the above table, Slow means over 8 hours, Average means 2-8 hours, and Fast means less than 2 hours. We leave these ranges deliberately wide as they are strongly dependent on the hardware used, as well as the software.

4. CONCLUSIONS AND FURTHER RESEARCH OPPORTUNITIES

Given that Elastic Net on Residuals performed consistently well across most of our tests, we consider it to be a strong candidate for situations similar to those studied here (i.e., personal lines frequency and severity, with a large number of ordinal rating factors). Other strong candidates in these situations are ENetBase, GLMCorr and LSRCorr. We also note that GLMCorr and LSRCorr may be preferred to methods involving Elastic Net, because of its comparative ease of implementation.

Given that this paper is experimental in nature and our experiments were limited to frequency and severity models of two homeowner perils, we do not consider that we are able to draw strong conclusions about what methods would be most suitable in any given situation. Drawing such conclusions would require the analysis of similar tests to those carried out here on many different datasets. We believe that it would be illustrative to observe how results vary for datasets of different sizes (we recall the observation made earlier that results for Fire Severity were very different than those for other models, and our belief that this is related to the limited number of data points). Analyzing a broader range of factors (for example categorical factors, and not just geo-demographic factors) could also provide interesting results. We consider these to be useful further lines of research.

We were surprised by the performance of random shortlists, which are the simplest to implement. We do note that conclusions reached depend on the length of the shortlist. On a very long shortlist, (N=50), a random list performed, in most cases, almost as well as any of the other methods tested. On a very short shortlist (N=5), a random shortlist did not perform as well as other methods with the same length shortlist. We ran tests for various lengths of shortlists, and saw that the number of factors included in the model by the automated modeling technique tended to plateau (see chart 5.) These two observations on random shortlists lead us to conclude that, assuming the availability of computing power able to fit models on shortlists in a reasonable amount of time, another viable approach is to randomly introduce candidate variables to a model until the number of significant factors plateaus.

Of course, the analysis of shortlists of varying lengths need not be restricted to the "random" method. The random method required a shortlist of about 50 variables for Water Frequency before the Gini Coefficient plateaued (see chart 5.) A more efficient method might plateau at the same (or higher) level of predictiveness with a much shorter shortlist. Future research could evaluate variable reduction methods based on their efficiency in addition to predictiveness and goodness of fit.

The performance of random shortlists also led us to consider the conditions under which a random shortlist will perform as well as other methods. We believe that this depends on the underlying data, in particular the lift provided by each factor, and the correlations between all factors. This can be illustrated with the following mental experiment: In an extreme case in which all factors are perfectly correlated, a random list of any length will work as well as any other technique. Consider, on the other hand, the opposite extreme of a dataset with hundreds of uncorrelated factors, only one of which provides any lift at all. In this case, most of the variable selection techniques discussed within this paper would successfully find the "needle in the haystack", whereas a random shortlist would only find it by chance. We consider that investigating the relationship between predictiveness of factors, correlations, and the usefulness of random shortlists is a worthwhile line of future research.

Because most of these techniques are relatively easy to develop and quick to execute, we see no reason why they could not be used in conjunction with each other. For example, consider the following hybrid process:

1. Fit a base model, using traditional techniques on a subset of factors believed to be relevant.
2. Employ ENetRes to narrow the complete list of candidate factors down to a more manageable shortlist.
3. Incorporate the shortlist of factors into the model, exploring traditional techniques such as splines, interactions, and spatial smoothing.
4. Employ LSRCorr, residual to the model developed in step 3, to seek out any additional factors that may have been missed in Step 2.

The extra step of re-scanning the remaining factors with a new selection method should further reduce the risk inherent in any automated selection process. We propose a refinement of this approach as another potential area for future research.

Finally, we feel it is important to distinguish between automated *variable selection* and automated *modeling*. While we used an automated modeling process for the purposes of this research (see section 2.3), we propose that, in practice, such methods should only be used to complement to more traditional modeling techniques. For example, in our research, we were able to significantly improve the predictiveness of models fitted using an automated process through the addition of interaction terms and spatial smoothing of residuals. The use of automated variable selection should allow the modeler more time to refine and improve the models while reducing the risk of altogether missing an important factor.

Acknowledgments

The authors would like to thank Claudine Modlin and Christopher Allard for their involvement in the research, Will Frierson and Mohamad Hindawi for implementing CART and Elastic Net respectively, and Westfield Insurance Company and Explore Information Services for providing the data upon which the research in this paper is based.

5. REFERENCES

[1.] Maitra, Saikat, and Jun Yan, "Principle Component Analysis and Partial Least Squares: Two Dimension Reduction Techniques for Regression," Casualty Actuarial Society *2008 Discussion Paper Program,* http://www.casact.org/pubs/dpp/dpp08/08dpp76.pdf

[2.] Sanche, Robert, and Kevin Lonergan, "Variable Reduction for Predictive Modeling with Clustering" Casualty Actuarial Society *Forum*, Winter 2006, http://casualtyactuarialsociety.net/pubs/forum/06wforum/06w93.pdf

[3.] Kolyshkina, Dr. Inna, Sylvia Wong, and Steven Lim, "Enhancing Generalised Linear Models with Data Mining," Casualty Actuarial Society *2004 Discussion Paper Program*, http://www.casact.org/pubs/dpp/dpp04/04dpp279.pdf.

[4.] Guo, Lijia, Ph.D., "Applying Data Mining Techniques in Property/Casualty Insurance", Casualty Actuarial Society *Forum,* Winter 2003, http://www.casact.org/pubs/forum/03wforum/03wf001.pdf.

[5.] Nelson, Brian D., "Variable Reduction for Modeling using PROC VARCLUS, in Statistics, Data Analysis, and Data Mining," *Proceedings of the Twenty-Sixth Annual SAS® Users Group International Conference,* 2001*,* http://www2.sas.com/proceedings/sugi26/p261-26.pdf

[6.] Anderson, Duncan, Sholom Feldblum, Claudine Modlin, Doris Schirmacher, Ernesto Schirmacher, Neeza Thandi "A Practitioner's Guide to Generalized Linear Models, Third Edition, February 2007, http://www.casact.org/pubs/dpp/dpp04/04dpp1.pdf.

[7.] Frees, Edward W., Glenn Meyers, A. David Cummings, "Predictive Modeling of Multi-Peril Homeowners Insurance," *Variance* 6:1, 2012, http://www.variancejournal.org/issues/06-01/11.pdf.

[8.] Tevet, David, "Exploring Model Lift: Is Your Model Worth Implementing?" *Actuarial Review*, Volume 40, Number 2, May 2013, http://www.casact.org/newsletter/index.cfm?fa=viewart&id=6540.

Abbreviations and Notations

The following abbreviations are used in referring to the different variable selection techniques considered:

AICRankBase: AIC Improvement Rank on Response

AICRankRes: AIC Improvement Rank on Residual

CARTBase: CART on Response

CARTRes: CART on Residuals

ENetBase: Elastic Net on Response

ENetRes: Elastic Net on Residuals

GLMCorr: Stepwise GLM based on AICC Improvement with Correlated Variables Removed

LSRCorr: Stepwise Least Squares Regression with Correlated Variables Removed

Rand: Random List

Varclus: Variable Clustering

BIOGRAPHIES OF THE AUTHORS

Benjamin Williams is a consultant in the New York office of Towers Watson. He is a specialist in predictive modeling and applications to Property and Casualty pricing. He has a master´s degree in mathematics from the Instituto Politécnico Nacional in Mexico and a master´s degree in physics from the University of Canterbury in New Zealand.

Greg Hansen leads the Actuarial Research team at Westfield Insurance Company. He is primarily responsible for developing and enhancing pricing and underwriting models for both commercial and personal lines. He has a degree in Mathematics from Oberlin College. He is a Fellow of the CAS and Member of the American Academy of Actuaries. Mr. Hansen has presented at several industry events on the topic of predictive modeling.

Aryeh Baraban works in the New York office of Towers Watson. He is involved with pricing and reserving work for both personal and commercial lines of business. He holds a bachelor's degree in Mathematics from Yale University and a master's degree from The Johns Hopkins University. He volunteers with The Actuarial Foundation.

Alessandro Santoni is the leader of the Mergers and Acquisitions for Property and Casualty in the Americas and is the Director of Towers Watson's Property and Casualty practice in New York. His main areas of expertise include the review of claims reserves for insurance and reinsurance companies, setting of rates for personal lines and capital modeling. He has worked with clients in Europe, U.S. and the Middle East.

Low Interest Rate Environment Issues Faced by Property-Casualty Insurance Companies (2015)

A Report of the CAS Low Interest Rate Environment Working Party

Jonathan L. Ankney
Waswate Ayana
Andra Ban
Etai Barach
Sandra J. Callanan
Kenneth J. Eiger
Eric J. Gesick
Christopher G. Gross (Chair)
Denis G. Guenthner
Dave Kunka
James M. Maher
Ankit Nanda
William H. Panning
Leonid Rasin
Karen Sonnet (CAS Staff)
Lu Sun
Gayna Swart
Samantha M. Taylor
Susan E. Witcraft
Jianwei Xie

Abstract: The Low Interest Rate Environment Working Party explored issues related to the current environment of historically low levels of interest rates with the purpose of uncovering and communicating potential problems before they occur. There are challenges posed to the property-casualty industry from this new environment, both with regard to income statements (reduced investment income if rates stay low, as well as with the strength of balance sheets) and the market value of fixed income assets, which will drop if rates return to more normal levels. The working party addresses questions related to insurance pricing policy, investment strategy, risks to solvency, use of debt, and long-term impacts, among other issues.

Keywords: interest rates, inflation sensitivity, balance sheets, duration matching

EXECUTIVE SUMMARY

In 2012-2013 the Low Interest Rate Environment Working Party (LIREWP) of the Casualty Actuarial Society (CAS) researched how the new environment of historically low interest rates may impact the property-casualty (P&C) insurance sector. The working party's exploration of the topic led to the following five conclusions:

1. The low interest rate environment puts pressure on sector profitability. However, the industry's response through improved pricing and realigned investment strategies, along with the short term nature of policies, has minimized issues with company solvency solely due to the sustained period of low interest rates.
2. The low interest rate environment creates challenges and risks for the sector should rates suddenly increase. If interest rates were to return suddenly to the higher historical levels, many companies could be negatively impacted by reduced market values of assets coupled with higher expected claim costs.
3. Most P&C insurance liabilities are affected to at least a degree by general inflation. Duration matching approaches that only reflect expected payouts, but not inflation sensitivity, could

prove inadequate to manage interest rate risk, depending on the degree of correlation between interest rates and inflation (i.e., *effective* duration of liabilities could be close to zero, leaving a highly leveraged asset position).

4. In general, the U.S. P&C insurance sector appears to be reacting to the low interest rate environment in a rational manner, reducing the risk posed by the potential for a sudden rise in interest rates by shortening the duration of assets. Accordingly, the risk of widespread solvency problems due to a sudden rise of interest rates appears low.
5. In general, larger companies are reacting more conservatively than small to medium sized companies. Some small to medium sized entities appear to be taking greater investment risk that could negatively impact these companies in the case of a sudden rise in interest rates/inflation.

The remainder of this report provides information and considerations that led to these conclusions.

1. INTRODUCTION

1.1 Background

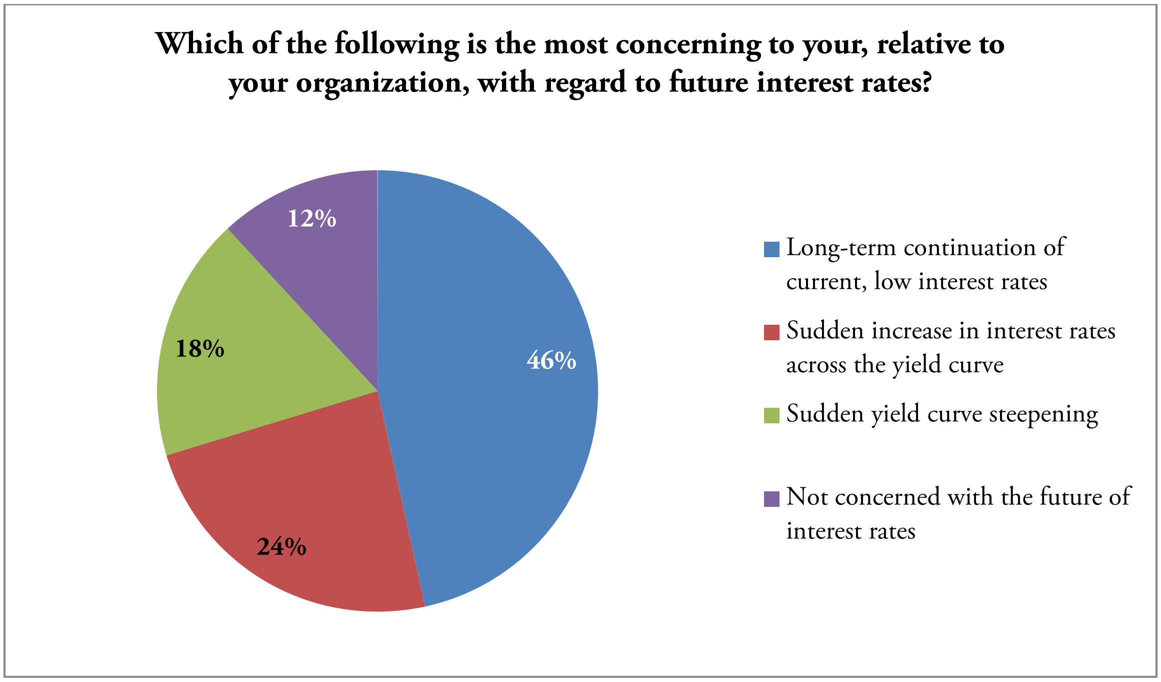
A recent survey[1] conducted by the consulting firm of Towers Watson indicated that over a three-year horizon, one of the biggest concerns for P&C insurance CFOs was the interest rate environment. While all of the survey respondents indicated that they "expect low interest rates to be among their companies' biggest challenges … half of respondents indicated that the risk of rapidly rising rates would also be one of their biggest challenges". This result is not surprising considering that low interest rates erode investment income and create pressure to increase underwriting profitability, while rapidly increasing interest rates have the effect of decreasing the value of bond portfolios which represent the bulk of P&C insurers' assets.

In 2011, the Low Interest Rate Environment Working Party (LIREWP) was formed to explore issues related to this new environment of historically low levels of current interest rates with the purpose of uncovering and communicating potential problems before they occur.

A survey of CAS members conducted by the LIREWP showed that the biggest concern for most actuaries (47% of respondents) with regard to the future interest rates is represented by the continuation of low interest rates, but for almost as many (41% of the respondents), a sudden increase in interest rates across the yield curve or a sudden yield curve steepening is even more concerning.

[1] Towers Watson, "Insights — Property & Casualty Insurance CFO Survey #3: Investment Strategies," September 2012, http://www.towerswatson.com/en-US/Insights/IC-Types/Survey-Research-Results/2012/09/Property-Casualty-Insurance-CFO-Survey-3.

Figure 1



As the surveys referenced above indicate, there are challenges posed to the P&C industry from this new environment, both with regard to income statements (reduced investment income if rates stay low) as well as with the strength of balance sheets (market value of fixed income assets will drop if rates return to more normal levels). The working party focused its efforts on the impact of low interest rates on insurance pricing policy, investment strategy, risks to solvency, use of debt, and long-term impacts.

1.2 Disclaimer

In this paper, references to "we," "our," "the working party," and "LIREWP" refer to the CAS Low Interest Rate Environment Working Party.

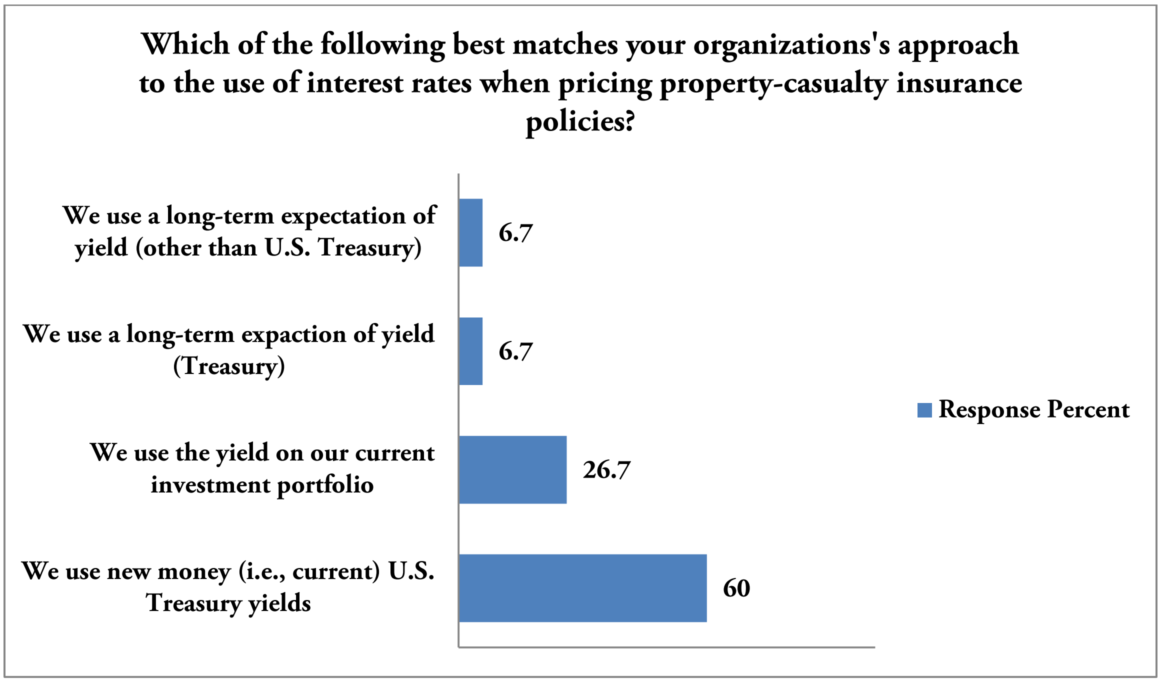
The analysis and opinions expressed in this report are solely those of the authors, the working party members, and in particular are not those of the members' employers, the Casualty Actuarial Society, or the American Academy of Actuaries.

LIREWP makes no recommendations to any other body. LIREWP material is for the information of CAS members, policy makers, actuaries and others who are interested in the issues P&C companies may face in a low interest rate environment.

2. PROFITABILITY AND PRICING

As insurers appear to be shortening the duration of their fixed income investments, one result is a lower total return creating a need to increase prices to offset the reduced investment return. However, for pricing, some insurers are using long term expectations of yields or the yield imbedded in their current investment portfolio. This is shown in Figure 2 by the responses to one of our survey questions.

Figure 2

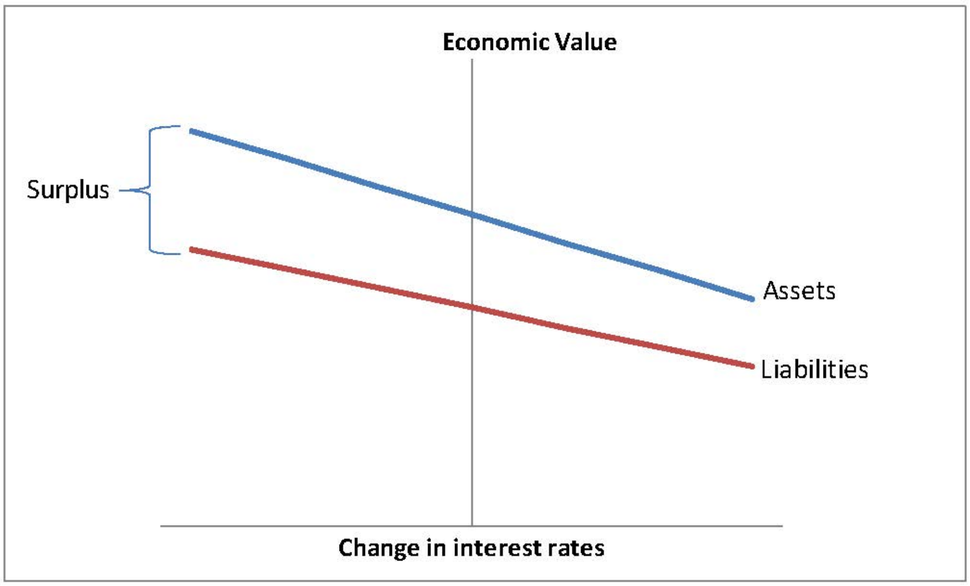


In most contexts, it is commonly assumed that new money yields are more appropriate than portfolio yields for pricing financial contracts such as insurance policies. Relying on a portfolio yields when pricing insurance policies could be problematic in the current low rate environment, as actual future returns on invested premiums would be less than assumed in pricing. However, since P&C insurance contracts are short-term contracts, generally with one-year terms with the potential for re-pricing, this problem is generally foreseeable and manageable. The bigger potential risk is with regard to balance sheet strength, if interest rates rise suddenly.

3. BALANCE SHEET RISK AND THE IMPACT OF INFLATION

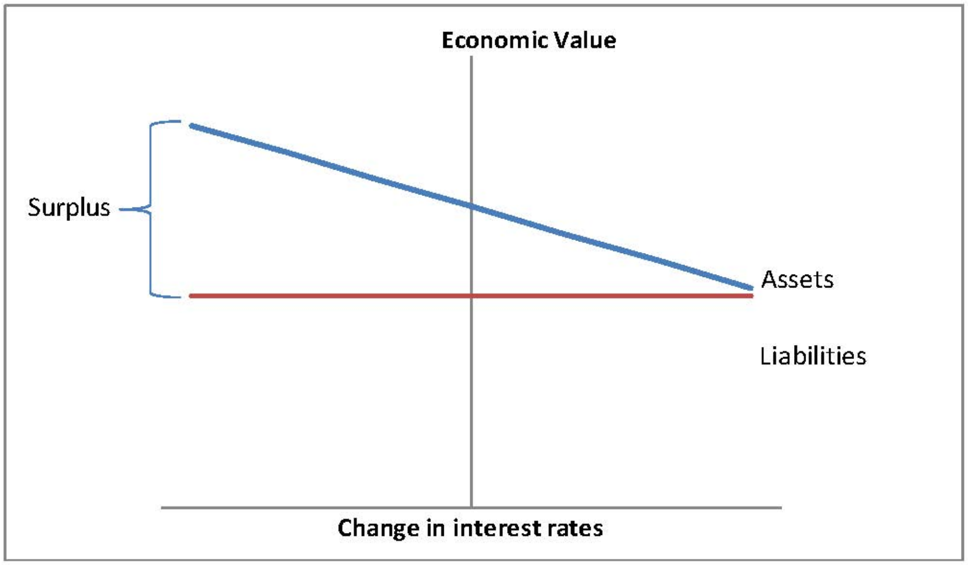
Classic asset-liability management deals with potential impacts to the balance sheet from changes in interest rates. The following chart reflects a scenario in which duration of assets is set equal to the duration of liabilities. This results in a duration of surplus that is also equal to that of the liabilities and a relatively stable balance sheet, at least with regard to changes in interest rates.

Figure 3



However, if we assume that inflation and interest rates move perfectly together, and that the inflation impacts future claims payments through the payment date, the present value of the liabilities is unchanged when interest rates change. This is illustrated in Figure 4.

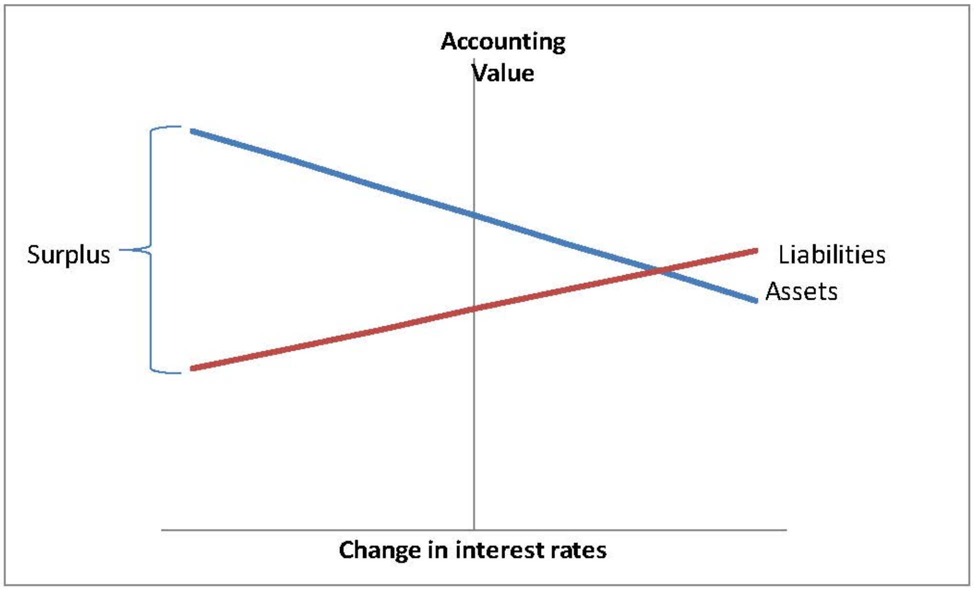
Figure 4



So if these assumptions are correct, classic immunization approaches become useless, and the surplus can be thought of as a very leveraged position with regard to the asset duration. This illustrates the importance of ascertaining the inflation sensitivity of P&C reserves, which is considered in the next section.

Figures 4 and 5 reflect the economic value of assets and liabilities. What about the results reflected in financial statements at the time of the shock? If we assume that companies understand the full extent of a shift to a higher inflation environment, and reflect the new environment in their booked (undiscounted) loss reserves within their accounting value, the result could look like Figure 6.

Figure 6



This is potentially an even more dire view, although it is not clear that companies would fully react to the change in inflation/interest environment in their reserving. Note also that the graph above assumes that assets are booked at market value. To the extent that fixed income assets may be held at amortized cost, the asset line would be flatter, providing some relief on the accounting view. It is important to remember regardless, that the reconciling item between accounting value and economic value is time. Anything that is true from an economic perspective, but not an accounting one, will emerge over time in the accounting. Any differences are temporary in nature only.

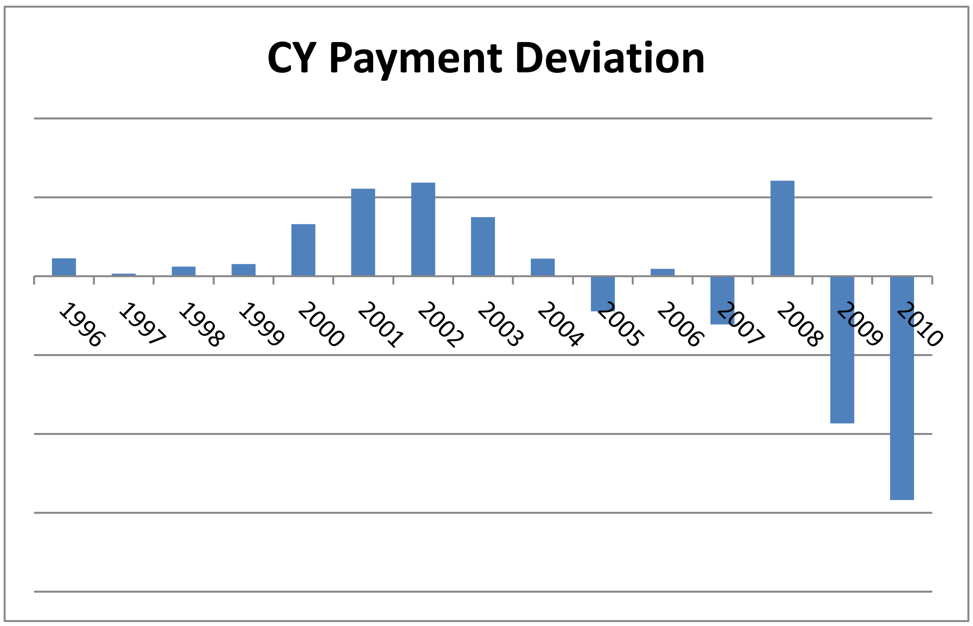
4. INFLATION SENSITIVITY OF P&C CLAIM PAYMENTS

It is difficult to measure the inflation sensitivity of reserves directly, because the true impact of inflation on the actual future payments may not be discerned by the actuary estimating the reserves, and the reserve amount booked by company management may be influenced by other considerations which obscure the effect of changes in inflation.

Claim payments themselves, however, are much less likely to suffer from these types of effects, and we should be able to test the hypothesis of inflation sensitivity by the following reasoning. In calendar periods with increased inflation, if the claim payments are inflation sensitive, we should see higher observed loss development factors. If the inflation is lower, we should see lower development factors. Therefore if we calculate long term average development factors, and "predict" the historical payments using these patterns, the errors of these predictions should coincide with inflation by calendar period.

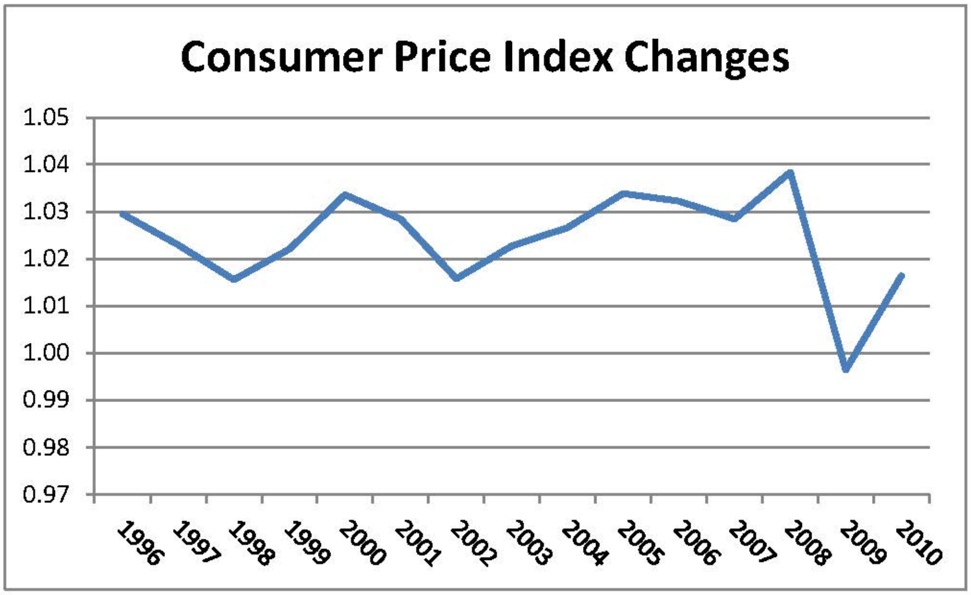
Using Schedule P paid triangles from AM Best Aggregates and Averages, the percentage of incremental paid claims at each point in development, relative to the first year of paid claims, was calculated by Schedule P line. This triangle gave us a benchmark of paid ratios. The average paid ratio across all years by age was calculated as our "expected paid ratio." The deviation from this expectation was calculated by line, accident year and age. This error term was then aggregated across calendar periods and lines, and is shown in Figure 7.

Figure 7



We then compared the deviation from expected (the sum of the errors) to calendar year inflation. The change in the Consumer Price Index (shown in the chart below) was used as our measure of inflation.

Figure 8



While more research could certainly be done in this area, this initial comparison suggests that P&C insurance liabilities give some evidence of inflation sensitivity, in particular regarding 2009 and 2010. Duration matching approaches that only reflect expected payouts, but not this inflation sensitivity, could prove inadequate to manage interest rate risk if interest rates and inflation move together (i.e., *effective* duration of liabilities could be close to zero, leaving a highly leveraged asset position).

5. INVESTMENT RISK IN THE CURRENT ENVIRONMENT

The Towers Watson survey referenced in the introduction found that 31% of CFOs expect that their companies' investment strategies over the following year to become "slightly more aggressive," while none expected their strategies to become more conservative or significantly more aggressive. This investment approach may result from the low interest rate environment creating an incentive for some companies to take more risk in order to improve portfolio returns.

However, how can P&C companies improve their portfolio returns? First, they could change their investment portfolio structure towards riskier investments, such as stock, high yield debt and real estate. AM Best data shows the percentage of riskier investments has increased over time, though this might be due to credit downgrades of existing investments. In addition, there are regulatory restrictions on these types of investments.

Second, portfolio returns could be improved by increasing the duration of fixed income assets.

Given that the term structure of interest rates is upward sloping, companies can choose to increase the duration of their bond portfolio to gain higher yields on their investments, but doing so will result in locking funds into relatively low yields. In fact, it has been observed that the duration of bond portfolio across the P&C industry has shrunk, which may indicate companies are willing to wait for Federal Reserve to increase interest rates rather than tie their assets in long term duration investments. In other words, companies are willing to sacrifice present investment income rather than risk losing future investment income and losing the market value of their portfolios if interest rates decrease.

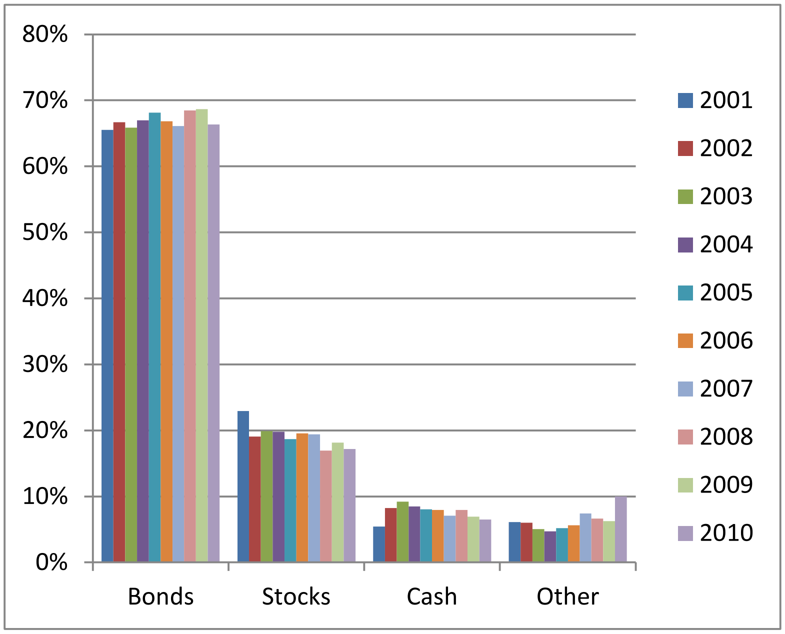
In the LIREWP survey of actuaries, 41% of respondents indicated that their organization's risk management strategy or tactics changed as a result of the current low interest rate environment. The changes undertaken involved adjusting investment strategy and reducing interest rate/investment income assumptions. The lower yield assumptions would result (all else being equal) in lower target combined ratios for underwriting.

A review of the mix of invested assets by asset class (stock, bond, etc.) and the mix of bonds by type (government, corporate, etc.) was performed to study changes in investment decisions in light of the interest rate environment (and the recent financial crisis). Our study of investments by P&C companies resulted in the following observations:

- The percentage of invested assets in stocks decreased in 2008 and, while it increased slightly in 2009, it returned to the lower level in 2010. Because the market had made up a sizeable portion of the 2008/09 loss by 12/31/10, it appears the insurers have not moved to stocks in an effort to achieve higher total returns and may have, in fact, reduced their exposure to stocks in light of the very recent reminder of their volatility.
- There appears to have been some movement of invested assets from Bonds to "Other" in 2010 that could be considered an attempt by insurers to achieve higher returns. However, the entirety of the change is driven by one large entity. Also, the data we have available to us is not in enough detail to shed more light on this change.

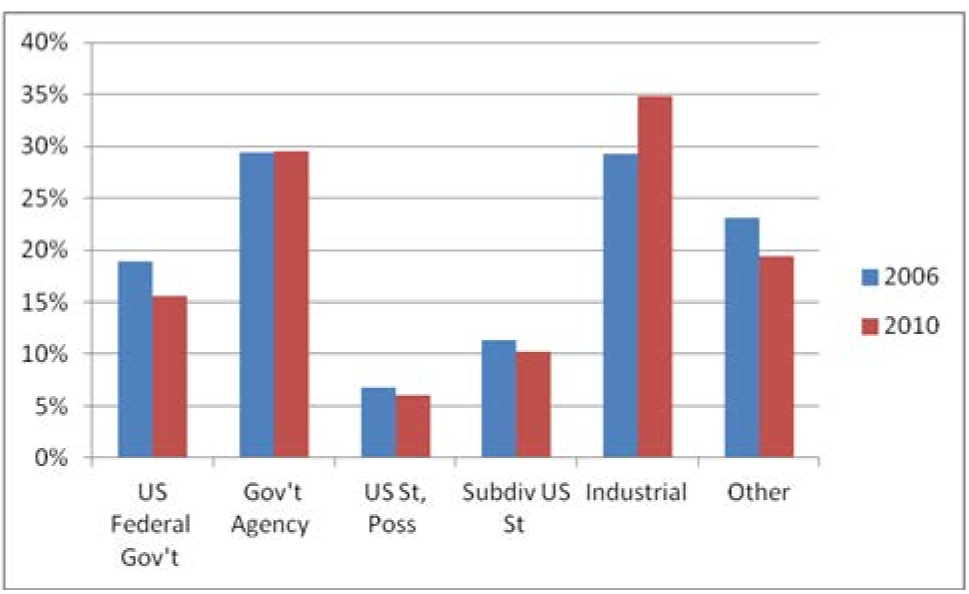
Figure 9 shows the mix of investments over time:

Figure 9



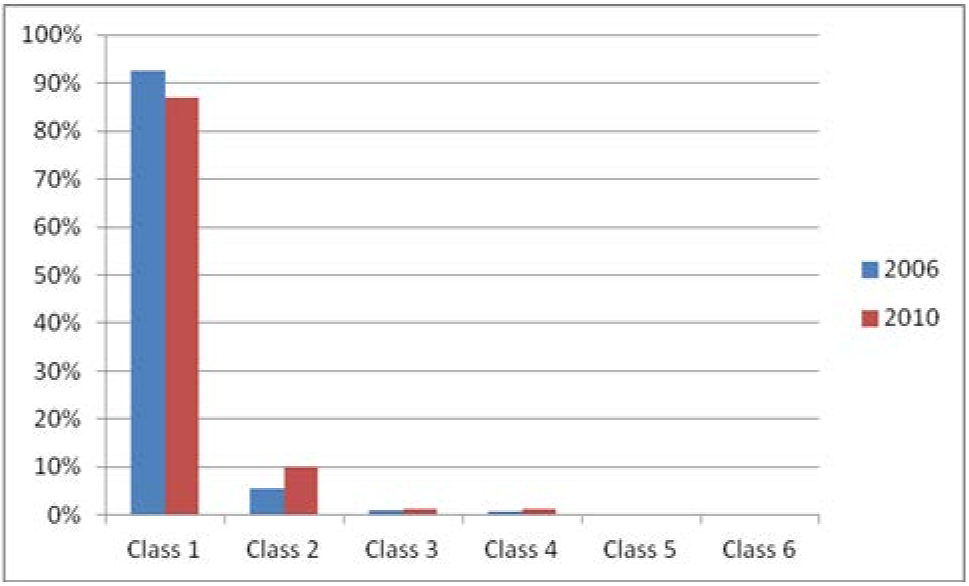
As is shown in the Figure 10, there is a shift in the mix of bonds from the various categories of government bonds (excluding government agencies which are presumably primarily MBS) to corporate bonds, as insurers try to achieve the higher returns typically available from corporate bonds relative to government bonds. There is a slight shift away from municipal bonds, but it appears to be the result of the shift to corporate bonds from government bonds generally and does not appear to us to be primarily driven by a change in strategy driven by income tax rules.

Figure 10



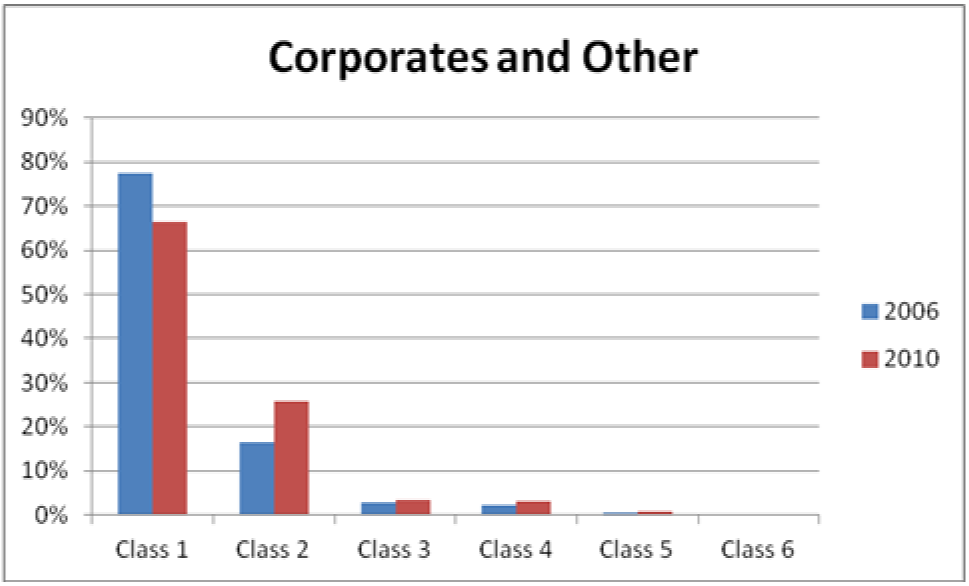
There is also a reduction in the percentage of bonds in Class 1 and increases in classes 2 – 4 (shown in Figure 11 below).

Figure 11



Even if the various types of government bonds are excluded from Class 1 (as shown on the chart below), there is a significant shift in the mix of bonds between Classes 1 and 2, indicating that not only are insurers moving to Corporates to attain higher yields, but are also carrying lower quality corporates. It is important to note, however, that the bond classes over time may not necessarily be static in terms of their measurement of credit quality. It is possible that a bond with identical risk characteristics could be rated differently at different points in time. In this particular case, the financial crisis may well have resulted in more bonds being rated Class 2 than would have been before the crisis.

Figure 12

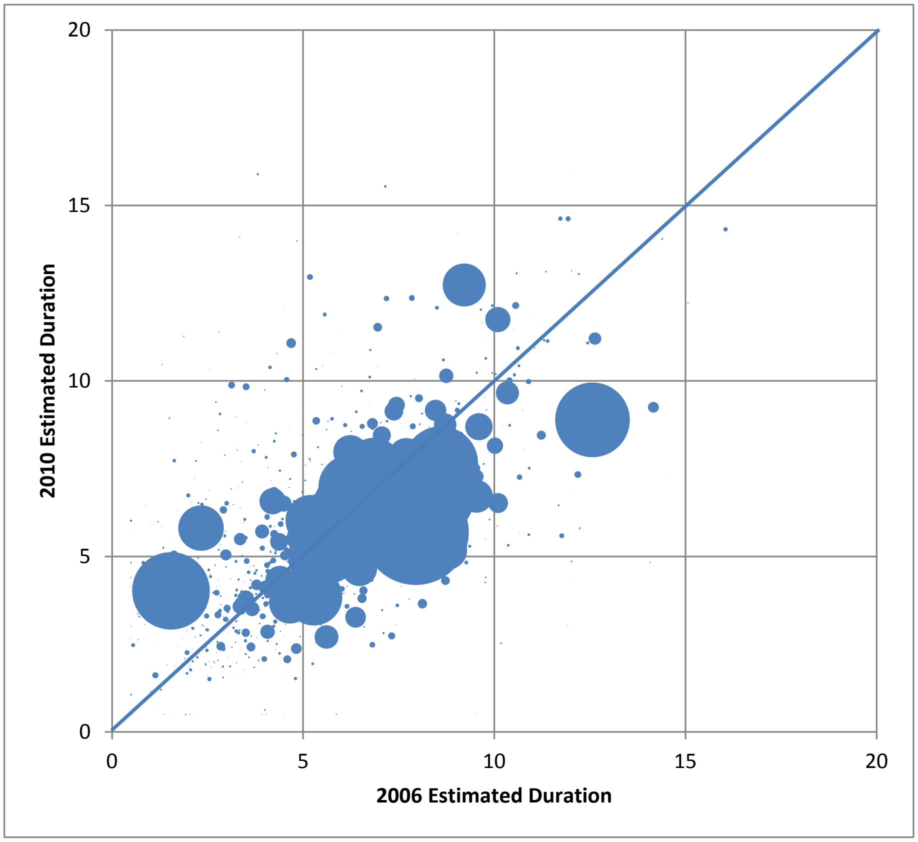


While there may be some indication that asset class mix may be somewhat more aggressive in the current environment, the asset mix is generally still conservative. The heavy use of fixed income assets within the industry leaves interest rate sensitivity as a significant threat to balance sheet strength. Here we find the industry generally acting prudently with regard to this risk.

To reach this conclusion, we utilized statutory Schedule D data for the U.S. P&C insurance industry (Source: SNL FINANCIAL LC). We estimated the duration of assets in years for each U.S. P&C insurance company group based upon examining the term of the assets they held and making assumptions regarding coupon rates that incorporated the term structure of interest rates. We performed these calculations for each company group as of December 31, 2006, and December 31, 2010.

In the Figure 13, each bubble represents a U.S. P&C insurance company group, with the area of the bubbles corresponding to the size of each company group as measured by the average total carrying value of bonds between 2006 and 2010. Company groups that are plotted below the blue diagonal line have lower estimated durations as of year-end 2010 than they had as of year-end 2006, and company groups plotted above the diagonal showed an increase in estimated duration over the same period. We observed that the estimated durations as of year-end 2010 are generally lower than those estimated as of year-end 2006. This shift would allow the majority of company groups to mitigate the risk posed by a sudden rise in interest rates.

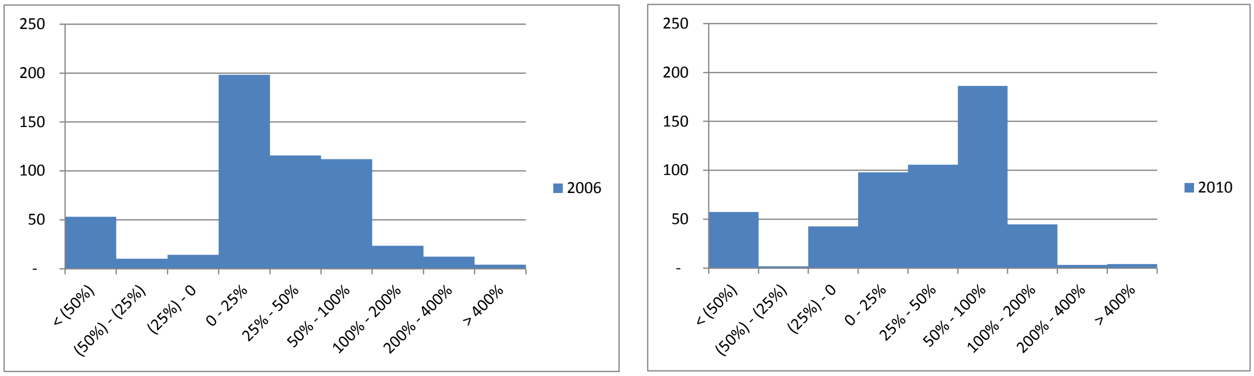
Figure 13



Upon further scrutiny of these results, the larger company groups appear to be behaving more conservatively in this regard than some of their smaller competitors. Some small- to medium-sized entities appear to be taking greater risk that could become problematic in the case of a sudden rise in interest rates/inflation. One potential explanation could be that the smaller company groups which are above the diagonal are attempting to boost their investment returns.

Using statutory Schedule D and balance sheet data for U.S. P&C insurance company groups, we also analyzed the carrying value of bonds held relative to loss reserve levels as of year-end 2006 and year-end 2010 and sensitivity tested the results for increases in interest rates and inflation. We first established a baseline understanding of the underlying data by producing the following graphs in Figure 14.

Figure 14

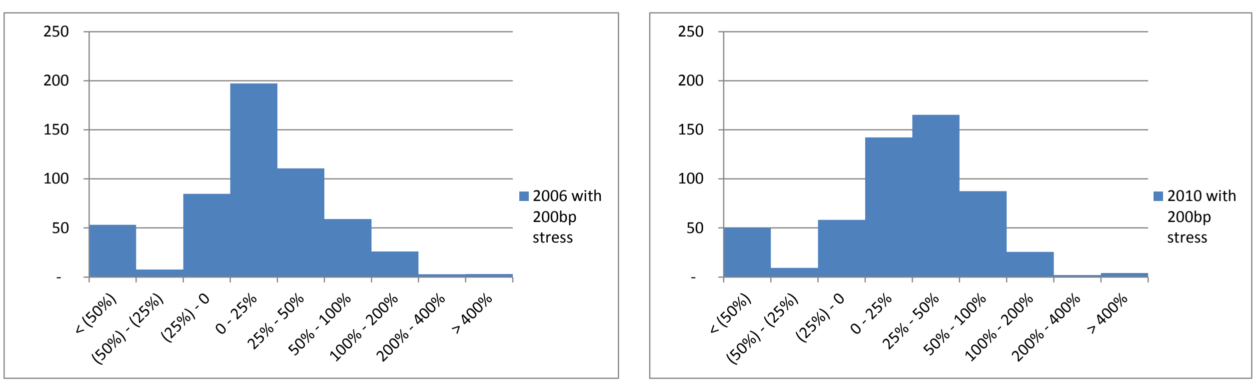


The X-axis represents the "loss reserve coverage ratio" of (Carrying Value of Bonds – Loss Reserves) / Loss Reserves, with common tiers of this percentage established to facilitate visual comparisons between the two dates. This ratio was established as a proxy for the level of risk that investments would not adequately fund the loss reserves. The Y-axis represents the total $ billion value of loss reserves for the company groups that fell into each X-axis tier.

We note that between year-end 2006 and year-end 2010, there has been a general shift toward higher loss reserve coverage ratios, meaning that company groups have generally moved toward higher carrying values of bonds relative to loss reserves as interest rates have declined.

Next, we evaluated the impact on the baseline graphs by stressing the interest rate upward by 200 basis points (Figure 15). In this scenario, we assumed no inflationary impact/increase on loss reserves.

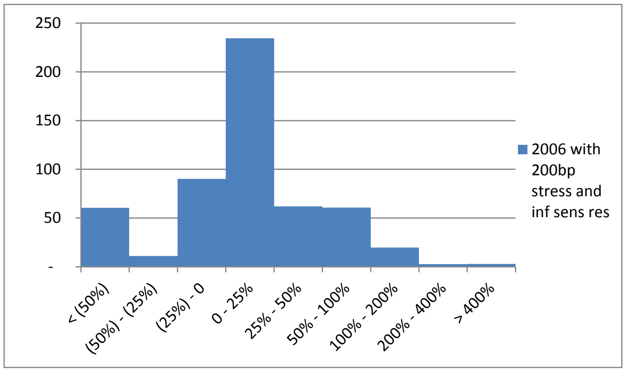
Figure 15

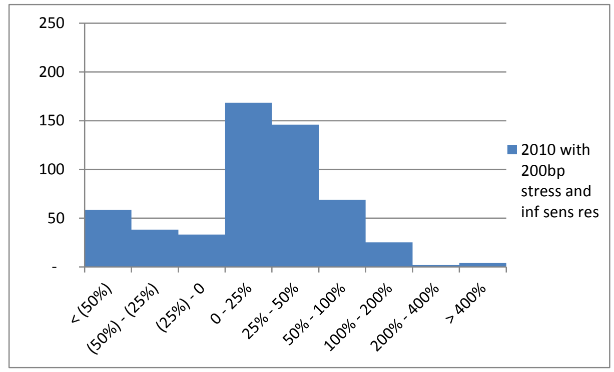


As would be expected, the loss reserve coverage ratios declined under this scenario as of both year-end 2006 and year-end 2010. However, the 2010 results indicate that fewer company groups would have loss reserve coverage ratios that fall below the theoretical "break even" point of 0%.

Finally, we sensitivity tested the results to include the impact of a 200 basis point increase in interest rates coupled with a corresponding inflationary increase in loss reserve balances (Figure 16).

Figure 16





Under this scenario, the 2006 results were once again more severely impacted than the 2010 results, with a significant increase observed in loss reserve coverage ratios less than 0%.

Figure 17 summarizes the percentage of total industry loss reserves with loss coverage ratios below 0% under each scenario.

Figure 17

Scenario Description	2006	2010
Baseline	14%	19%
Interest Rates + 200 basis points	27%	22%
Interest Rates + 200 basis points and Inflationary Increase in Loss Reserves	30%	24%

6. CONCLUSIONS

The Low Interest Rate Environment Working Party's (LIREWP) of the Casualty Actuarial Society (CAS) exploration of the impact of low interest rates led them to the following five conclusions:

- The low interest rate environment puts pressure on profitability, but companies are generally able to respond appropriately with regard to pricing of insurance products.
- P&C insurance liabilities give some evidence of inflation sensitivity, which is potentially an important consideration if interest rates and inflation move together.
- If interest rates were to rise suddenly to higher historical levels, balance sheet problems could emerge for some companies.
- The risk of widespread solvency problems due to a sudden rise in interest rates appears low.
- The largest companies appear to be behaving more conservatively on duration changes compared to some smaller competitors.

Perhaps the biggest conclusion drawn in the review by LIREWP is that the interest rate environment requires continued attention of actuaries in the work that they do. The impacts of interest rates on pricing, reserving, investment strategy, and solvency require monitoring and potential action.

REFERENCES

[1.] AM Best, "Aggregates & Averages — Property/Casualty, United States & Canada," 2014, www. ambest.com.
[2.] SNL Financial LC, Schedule D data for the U.S. P&C insurance industry, www.snl.com.
[3.] Towers Watson, "Insights — Property & Casualty Insurance CFO Survey #3: Investment Strategies," September 2012, http://www.towerswatson.com/en-US/Insights/IC-Types/Survey-Research-Results/2012/09/Property-Casualty-Insurance-CFO-Survey-3.

Medicare Secondary Payer Status: The Impact of Section 111 Reporting Requirements

Prepared for
The Casualty Actuarial Society
Committee on Health Care Issues

Prepared by
Guy A. Avagliano, FCAS, MAAA
Philip S. Borba, Ph.D.
Christine M. Fleming, J.D., ACAS, MAAA
Craig P. Taylor, ACAS, MAAA
Milliman, Inc.

July 6, 2015

TABLE OF CONTENTS

LIST OF TABLES

EXECUTIVE SUMMARY

Section 111 of the Medicare, Medicaid, and SCHIP Extension Act of 2007 (MMSEA) requires property-casualty insurers and self-insureds to report to the Centers for Medicare and Medicare Services (CMS) certain information on medical treatments received by Medicare beneficiaries. The information concerns the medical treatments received by a Medicare beneficiary whose injury or illness is subject to a property-casualty insurance or self-insurance coverage. Medicare has long been the secondary payer for medical payments attributable to a property-casualty insurance or self-insurance coverage, and this has not changed under Section 111. It is the reporting requirements that have changed, and these changes may increase the losses for cases where Medicare has been making payments and has not been reimbursed by a primary payer (in this case, the property-casualty insurer or self-insured). [1]

The reporting requirements concern claims for workers' compensation, automobile, homeowners, and other liability coverages.[2] For Medicare beneficiaries receiving ongoing medical treatment, insurers and self-insureds were required to report claims with more than $750 of medical payments as of January 1, 2010. Thresholds for lump sum payments for workers' compensation became effective for payments made on or after October 1, 2010. Thresholds for reporting lump sum payments for liability insurance became effective for payments made on or after October 1, 2011.[3]

This study was undertaken to investigate the potential impacts of the Section 111 reporting requirements on property-casualty losses, and in particular to assist practicing casualty actuaries with the potential impacts of the reporting requirements. A short time has passed since Section 111 became effective and there have been delays in the full implementation of the reporting requirements. Consequently, there is little information with which to estimate the financial impact of the new reporting requirements. For this study, we show through case illustrations how losses may increase for insurers and self-insureds. With some very generalized assumptions, we present possible aggregate estimates for a hypothetical insurer for workers' compensation and private passenger automobile coverages. This study provides the practicing actuary with an approach for evaluating the impact of Section 111 claims where Medicare has been making payments and has not

---

[1] CMS refers to "liability insurance (including self-insurance, no-fault insurance, and workers' compensation)". For simplicity, we will collectively refer to these arrangements as "insurance" or "insurance and self-insurance", and the parties providing these coverages as "insurers" or "insurers and self-insureds".

[2] See Centers for Medicare and Medicaid Services, MMSEA Section 111, Chapter I, Sections 4.2 and 4.3 for further information on covered incidents.

[3] See Appendix A in this report and Centers for Medicare and Medicare Services, MMSEA Section 111, Chapter III, Sections 6.3 and 6.4 for further information on the reporting amount thresholds and phase-in dates for ongoing medical treatments and lump sum payments (referred to as "Total Payment Obligation to the Claimant," or TPOC, in the CMS materials).

been reimbursed by the property-casualty insurer or self-insured.

We found that the Section 111 reporting requirements may cause modest increases in losses for injured workers and individuals 65 and over for cases where Medicare has been making payments without being reimbursed by the property-casualty insurer or self-insured. In this report, we illustrate the potential impact on losses for 10 workers' compensation, private passenger automobile, and homeowners cases, including estimates for the broader financial impact on losses for the six workers' compensation cases. For the hypothetical insurer with the conditions or types of workplace injuries described in this report, we estimate the impact to be an increase in total losses (medical and indemnity) between 0.9% and 5.7% for workers 65 and over. Using a set of generalized assumptions, we estimate the aggregate impact on medical losses for injured workers 65 and over to be between 11% and 25%, which when spread across all workers the estimated increase is from 0.5% to 1.3% depending on the condition or type of injury. For private passenger automobile injuries (and again, using a set of generalized assumptions), the estimated impact is for a 0.4% to 0.8% increase in total losses for individuals 65 and over, and an estimated increase of 0.07% to 0.13% in total losses for all ages. Finally, while we include a homeowners claim in the case illustrations, we did not estimate an aggregate impact due to the lack of information on medical payments for homeowners claims.

Section 111 Reporting Requirements

Under Section 111, insurers and self-insureds are required to report to CMS certain information on incidents where a Medicare beneficiary has received medical treatment or where a one-time payment (such as a lump sum, settlement, or judgment) includes provisions for medical treatments. This information includes identifiers for the claimant and the insurer (or self-insured) and diagnostic information for the medical treatments (such as the International Classification of Diseases 9th (or 10th) Revision (ICD-9 or ICD-10) diagnosis codes). When a Medicare beneficiary receives medical treatment in the future for which payment is sought under Medicare, CMS will use this information to determine whether the medical treatment was related to a previous injury that was covered by an insurer or self-insured. If CMS determines the medical service was related to the prior injury, CMS will seek reimbursement for payment for the medical service from the insurer or self-insured.

Prior to Section 111, CMS did not have a coordinated process for identifying Medicare beneficiaries receiving treatment for injuries covered by insurers and self-insureds. Consequently, CMS was unable to easily identify claims where Medicare was a secondary payer and was not pursuing potential reimbursements from insurers and self-insureds. Prior to and with the Section 111 reporting requirements, the practice has been for CMS to pay medical providers for their services. However, these payments are "conditional payments" and do not remove a primary payer's financial responsibility for the medical treatments. If CMS determines the medical treatments were for an injury from a prior property-casualty incident, CMS will seek reimbursement from the insurer or self-insured.

If an insurer paid for a Medicare beneficiary's medical services prior to Section 111, the new reporting requirements may have no impact on its financial liabilities. This presumes the insurer paid for all medical services to Medicare beneficiaries that could be attributed to the property-casualty covered incident. However, there may have been situations where the insurer was not aware of all medical services for a covered injury or where a Medicare beneficiary received medical treatment without associating the injury to a work-related, automobile, property, or other incident covered by an insurer. For example, suppose a Medicare beneficiary suffers a work-related injury that requires a knee replacement and the insurer makes full payment for the injury. Prior to Section 111, this might have been the last the insurer heard from the injured worker. However, Section 111 requires the insurer to report the injury and the diagnostic information to CMS, and if the injured worker receives another knee replacement in the future, CMS will have the ability to reach back and relate the second replacement to the workplace injury, and then bill the insurer for the second replacement.

At the outset, it is important to distinguish between the Section 111 reporting requirements and a Medicare Set-Aside Arrangement (MSA). Section 111 requires insurers and self-insureds to report to CMS personal identifier and diagnostic information for Medicare beneficiaries receiving medical treatments for an incident subject to a property-casualty insurance coverage (including incidents covered by self-insurance). A Medicare Set-Aside Arrangement is a voluntary financial agreement that allocates a portion of a settlement to pay for future medical services related to a claim.[4] Section 111 reporting is required by statute; Medicare Set-Aside Arrangements are voluntary. Also, as a practical matter Section 111 concerns all claims with medical payments over $750, including claims with ongoing medical treatment. By contrast, MSAs only concern large settlements. CMS will only review MSA submissions where the claimant is a Medicare beneficiary and the total settlement is greater than $25,000 or the claimant has a reasonable expectation of enrolling for Medicare within the next 30 months and the total settlement is greater than $250,000. The impact of the Section 111 reporting requirements, which may increases losses for cases where Medicare has been making payments that have not been reimbursed by the insurer or self-insured, is the focus of the present study.

[4] In the past, MSAs have been limited to workers' compensation settlements. Recently, MSAs have started to be considered for settlements involving Medicare beneficiaries for other types of property-casualty coverages.

Methodology

We studied the potential impacts of the Section 111 reporting requirements from two perspectives.

- First, we developed 10 cases to illustrate situations that may arise and require special attention from property-casualty practitioners (e.g., casualty actuaries, claim specialists). The cases were developed to highlight a variety of situations across different liability coverages. For the six workers' compensation cases, we extended the discussion to the potential broader financial impacts covered by the particular case. For example, for the case concerning an injured worker 65 or over who was a Medicare beneficiary with a knee replacement, we extended to discussion to injured workers 65 and over receiving ankle, hip, and shoulder replacements.
- Second, we developed aggregate estimates of the impact of Section 111 reporting requirements for a hypothetical insurer or self-insured by applying a set of assumptions to aggregate data for workers' compensation and automobile injury insurance claims.

For the case illustrations, broader financial impacts, and aggregate estimates, we relied on information that can be arranged into three broad areas, with differing implications as to the variability that may be observed in a particular book of business.

- First, we used reports from insurance industry and government agency sources for information on claim frequency and costs and worker demographics. This information was the starting point to illustrate the potential impacts for an average or typical book of business. Nevertheless, this injury and worker demographic information may need to be adjusted when calculating the impact for a specific book of business.
- Second, from discussions with actuaries and claims consultants, we developed estimates of case reserves for the case illustrations and the range of possible impacts for the aggregate estimates for a hypothetical insurer or self-insured. To the extent injury severities and reserving practices differ across insurers and self-insureds, there will be differences across books of business. Also, the aggregate impacts that may be calculated in the future will reflect the differences in books of business and reserving practices, as well as the extent to which insurers and self-insureds may have been making medical payments for individuals 65 and over prior to Section 111.
- And third, from discussions with claim consultants and information from medical studies, we developed assumptions concerning the frequency and costs of medical services for certain

low-frequency, high-cost medical treatments (such as a liver replacement or joint replacement). Injury severity and medical needs are likely to vary greatly across individuals needing these medical treatments, and these differences will have an impact on the cost estimates in our illustrations.

In sum, we used information from several types of sources and while we made efforts to use credible information for the illustrations, there will be departures in the actual experience and the extent of these departures is likely to be related to the general type of information.

Case Illustrations

We developed 10 cases to illustrate situations that may arise under the Section 111 reporting requirements. Six cases concern work-related injuries covered by workers' compensation, three cases were injuries subject to automobile coverage, and one case was for a homeowners coverage incident. The cases were developed to show a variety of situations across different liability coverages. A summary of the 10 cases is presented in Table ES-1. While the case illustrations are not exhaustive, the cases capture situations that may produce some of the largest impacts on losses.

Table ES-1 Summary of Case Studies

Case	Line of Business	Abstract
1	Workers' compensation	Workers' compensation claimant with knee replacement
2	Workers' compensation	Workers' compensation claimant with a needle-stick injury
3	Workers' compensation	Workers' compensation claimant with lung cancer
4	Workers' compensation	Medicare beneficiary with a work-related injury relocates
5	Workers' compensation	Workers' compensation claimant with long-term pharmaceutical prescription needs
6	Workers' compensation	Workers' compensation claimant receiving SSDI with a shortened life expectancy
7	Automobile no-fault	Passenger in automobile accident covered by driver's no-fault automobile coverage
8	Automobile liability (other driver)	Medicare makes conditional payments for a 67-year-old automobile accident claimant
9	Automobile	Automobile accident claimant with a traumatic brain injury
10	Homeowners	Medicare beneficiary injured on neighbor's property

We expanded the six workers' compensation cases to other similar cases. For example, the case concerning a work-related knee replacement was extended to other joint replacements (Case 1 in

Table ES-1). The case concerning lung cancer was extended to claims with other types of cancer that might be attributed to a workplace exposure (Case 3). For each case, we developed a "broader financial impact" framework for the potential losses for the group of similarly-situated claims. For the broader financial impacts, we took the following points into consideration:

- the frequency of and average costs for the particular injury or medical condition,
- the representation of Medicare eligible claimants among all workers' compensation claimants,
- the frequency of a particular injury or medical condition among all Medicare-eligible injured workers with the injury or medical condition,
- estimates for the pre-Section 111 case reserves, and
- potential losses with the Section 111 reporting requirements.[5]

For the conditions associated with the case illustrations, the estimated financial impact to the insurer or self-insured was the difference between the current case reserve estimates and the potential losses.

Table ES-2 presents the estimated impacts on losses for the six scenarios. For example, for joint replacements (Case 1 in Table ES-2 and the report), we estimated that approximately 15% of all Medicare beneficiaries incur a knee, shoulder, ankle, or hip injury that could lead to a joint replacement and injuries to these four body parts account for approximately 20% of all incurred losses for claims from Medicare beneficiaries.[6] For the small number of such injuries that result in a joint replacement, we estimated that CMS's ability to associate the joint replacement back to a primary payer could increase losses for injured workers 65 and over with a knee, shoulder, ankle, or hip injury by approximately 18.8%, by approximately 3.8% for all workers 65 and over, and by approximately 0.2% for workers of all ages.[7] Depending on the condition or type of injury addressed by the case illustration, we estimated the impact to be an increase of total losses between 0.9% and 5.7% for workers 65 and over, which translated into increases of 0.1% to 0.3% for all workers of all ages. These scenarios assume Medicare has been making payments and has not been reimbursed by the insurer or self-insured.

---

[5] Injury frequencies and average costs by type of injury were obtained from workers' compensation unit statistical plan data. The shares of Medicare eligible claimants were developed from US Bureau of Labor Statistics data. Assumptions concerning Medicare eligible with an injury condition, case estimates, and potential losses were developed in consultation with casualty claim consultants.

[6] The share of and average costs of knee, shoulder, ankle, and hip injuries were from unit statistical plan data.

[7] The presumption here (as with the other estimated impacts) is that prior to Section 111 CMS paid for the medical services and did not receive reimbursement from the primary payer. This presumption is because CMS did not have the tracking system for medical payments (and particularly for diagnoses) that was created to support the reporting requirements in Section 111.

The total impacts of Section 111 could be greater than the sum of the broader financial impacts in the case illustrations. First, the present set of cases does not exhaust all possibilities and the estimated impacts are very sensitive to the underlying assumptions. Also, the primary purpose of the case illustrations and broader financial impact discussions was to present a set of cases with special circumstances that might come up under Section 111 and a template for evaluating the potential impacts on Medicare-eligible and all injured-worker losses. These assumptions are described in the report and are presented in templates a reader can vary to assess the impact of alternative assumptions.

Table ES-2 Summary of Broader Financial Impacts From Case Illustrations for Workers' Compensation

				Impact on Incurred Losses for -		
Case Number	Type of Injury/Condition	% of Medicare-Eligible Claims	% of Incurred Losses for Medicare-Eligible Claims (prior to Section 111)	Medicare-Eligible With Condition/Type of Injury	All Medicare-Eligible	All Workers
1	Knee, shoulder, ankle, hip injury leading to a Joint replacement	14.6%	20.4%	18.8%	3.8%	0.2%
2	Long latency	5.1%	1.8%	115.2%	2.1%	0.1%
3	Lung cancer	3.6%	6.3%	81.0%	5.1%	0.3%
4	Medicare beneficiary relocates	62.6%	52.1%	2.2%	0.9%	0.05%
5	Pharmaceutical	100.0%	9.9%	N/A	5.7%	0.3%
6	SSDI with shortened life expectancy	3.1%	4.8%	60.7%	2.9%	0.1%

Aggregate Estimates: Workers' Compensation

The preceding analyses presented estimates for specific types of injuries. To develop an aggregate estimate for the hypothetical insurer or self-insured, we applied assumptions to aggregate data for workers' compensation and private passenger automobile claims. We did not calculate an estimate for homeowners coverages due to the lack of information on medical payments. Also, while the case illustrations covered all losses (medical and indemnity), our analyses for the aggregate impact was limited to medical payments.

For workers' compensation, we developed separate estimates for medical-only, indemnity claims with no lump sum, and indemnity claims with a lump sum. We estimated increases in medical losses for three levels of change in average medical losses: low, moderate, and high.[8] The

[8] We developed the range of possible impacts from discussions with actuaries and claim consultants. The actual experience that may be calculated in the future will depend on the additional payments reimbursed to CMS, reserving

assumptions and results are summarized in Table ES-3. For the "moderate" change, we assumed average medical losses for medical-only claims increase by 10%, average medical losses for indemnity claims without a lump sum increase by 15%, and average medical losses for indemnity claims with a lump sum increase by 25%.[9] Aggregating across the three claim groups, we estimated medical losses for workers 65 and over could increase by 17% (top panel in Table ES-3), which converts to an increase of 0.9% across all workers (bottom panel in Table ES-3). Across the three assumed levels of impact, we estimated medical losses for injured workers 65 and over could increase by 11% to 25%, which when spread across all workers the estimated increases are from 0.5% to 1.3%.[10]

Table ES-3 Estimated Impact of Section 111 Reporting Requirements on Workers' Compensation Medical Losses

	Assumed Increase in Average Medical Losses			Estimated Impact on Total Medical Losses	
Scenario / Level of Increase in Average Medical Losses	**Medical Only**	**Lost-Time Claims without Lump Sum**	**Lost-Time Claims with Lump Sum**	**Injured Workers 65 and Over**	**All Injured Workers**
Base Case					
Low	5%	10%	15%	10.9%	0.5%
Moderate	10%	15%	25%	17.3%	0.9%
High	15%	20%	40%	25.1%	1.3%
Assuming a 50% Decrease in the Incidence of Lump Sum Settlements					
Low	5%	15%	25%	15.8%	0.8%
Moderate	10%	20%	40%	22.5%	1.1%
High	15%	25%	50%	28.4%	1.4%

Although the present study concerned the Section 111 reporting requirements and not Medicare

practices, and the extent to which insurers and self-insureds may have been tracking medical payments for individuals 65 and over prior to Section 111.

[9] Again, these assumptions were developed from discussions with actuaries, claim consultants, and other property-casualty insurance industry practitioners.

[10] While at a very high level the size of the financial impacts from the case illustrations in Table ES-2 are consistent with the aggregate estimates in Table ES-3, we advise against making a direct link between the two sets of results. While the case illustrations concerned the impact on medical and indemnity losses, the analyses at the aggregate level were limited to the impact on medical losses. Also, the case illustrations were developed to illustrate the types of situations that might be impacted by the Section 111 requirements and are a subset of all medical treatments that will be impacted by Section 111. It would be very speculative to suggest to scope of the potential additional losses accounted for the case illustrations.

Set-Aside Arrangements (MSAs), for reasons described in the report, Section 111 may decrease the incidence of CMS-approved MSAs for workers' compensation claims. To test the potential impact against the assumptions for the base scenario, we assumed a 50% reduction in the pre-Section 111 incidence of lump sum settlements and larger increases in the medical losses for lost-time claims. These assumptions were developed from discussions with actuaries, claims consultants, and other property-casualty practitioners. The lower incidence of lump sum settlements can be attributed to larger settlements being needed for CMS approval, which is causing a decrease in the willingness of insurers and self-insureds to enter into settlements. The higher amounts for the assumed increases in average medical losses would take into account a larger than expected capture of medical losses by the Section 111 reporting requirements. The results for the alternative scenario were increased total medical losses of 15.8% to 28.4% for injured workers 65 and over, and 0.8% to 1.4% when these losses are spread across all workers.

Aggregate Estimates: Private Passenger Automobile

We developed for private passenger automobile estimates for injuries under five separate coverages and for injuries under all coverages. We used information on the percentage of payments for medical care and the average medical payments. The assumptions and results are summarized in Table ES-4.

Our analyses indicates that the Section 111 reporting requirements may increase the average medical payments for individuals 65 and over by $842 to $1,685 (based on 2012 loss experience), or by 1.3% to 2.6% for this age group. The 1.3% to 2.6% estimated impact on medical payments for individuals 65 and over translates to an estimated increase of 0.2% to 0.4% in medical payments for all ages. For total losses, the estimated impact is for a 0.4% to 0.8% increase in total losses across injured individuals 65 and over, and an estimated increase of 0.07% to 0.13% for all ages.

Table ES-4 For Private Passenger Automobile Coverages, Estimated Impact on Total Medical Payments and Total Payments for Injured Individuals 65 and Over

Assumed Impact (Increase) on Medical Payments Due to Section 111 Reporting Requirements	All Types of Injuries	Bodily Injury	Personal Injury Protection	Medical Payments	Uninsured Motorist	Underinsured Motorist
	Estimated impact on average medical payments for injured individuals 65 and over					
10%	$842	$758	$912	$520	$904	$6,106
15%	$1,263	$1,138	$1,638	$780	$1,355	$9,159
20%	$1,685	$1,517	$1,824	$1,041	$1,807	$12,212
	Estimated impact as a percent of total medical payments					
10%	1.3%	1.0%	1.3%	1.7%	1.4%	2.8%
15%	2.0%	1.5%	2.0%	2.6%	2.0%	4.1%
20%	2.6%	2.0%	2.6%	3.5%	2.7%	5.5%
	Estimated impact as a percent of total payments					
10%	0.4%	0.4%	0.3%	1.7%	0.3%	0.7%
15%	0.6%	0.6%	0.5%	2.6%	0.5%	1.0%
20%	0.8%	0.8%	0.7%	3.5%	0.7%	1.4%

INTRODUCTION

Under Section 111 of the Medicare, Medicaid, and SCHIP Extension Act of 2007 (MMSEA), liability insurers, no-fault insurers, workers' compensation insurers, and entities self-insuring their property-casualty medical liabilities are required to report to the Centers of Medicare and Medicaid Services (CMS) certain information concerning claims with ongoing medical treatment, settlements, judgments, awards, or other one-time and lump sum settlements received by or on behalf of Medicare beneficiaries.[11] This information includes claimant and insurer identifiers and diagnostic information for the medical treatments. When a Medicare beneficiary receives medical treatment in the future, CMS will use this information to determine whether the medical treatment was related to a previous injury that was covered by the liability policy or self-insurance arrangement.

The reporting requirements concern claims for workers' compensation, automobile, homeowners, and other liability coverages.[12] For Medicare beneficiaries receiving ongoing medical treatment,

[11] CMS refers to "liability insurance (including self-insurance, no-fault insurance, and workers' compensation"). For simplicity, we will collectively refer to these arrangements as "insurance" or "insurance and self-insurance", and the parties providing these coverages as "insurers" or "insurers and self-insureds".

[12] See Centers for Medicare and Medicaid Services, MMSEA Section 111, Chapter I, Sections 4.2 and 4.3 for further information on covered incidents.

insurers and self-insureds were required to report claims with more than $750 of medical payments as of January 1, 2010. Thresholds for lump sum payments for workers' compensation became effective for payments made on or after October 1, 2010. Thresholds for reporting lump sum payments for liability insurance became effective for payments made on or after October 1, 2011. [13]

This study was undertaken to investigate the potential impacts of the Section 111 reporting requirements on property-casualty losses, and in particular to assist practicing casualty actuaries with the potential impacts of the reporting requirements. A short time has passed since Section 111 became effective and there have been delays in the full implementation of the reporting requirements. Consequently, there is little information with which to estimate the financial impact of the new reporting requirements. For this study, we show through case illustrations how losses may increase for insurers and self-insureds. With some very generalized assumptions, we present possible aggregate estimates for a hypothetical insurer for workers' compensation and private passenger automobile coverages. This study provides the practicing actuary with an approach for evaluating the impact of Section 111 claims where Medicare has been making payments and has not been reimbursed by the property-casualty insurer or self-insured.

At the outset, it is important to distinguish between the Section 111 reporting requirements and a Medicare Set-Aside Arrangement (MSA). Section 111 requires insurers and self-insureds to report to CMS personal identifier and diagnostic information for Medicare beneficiaries receiving medical treatments for an incident subject to a property-casualty insurance coverage (including incidents covered by self-insurance). A Medicare Set-Aside Arrangement is a voluntary financial agreement that allocates a portion of a settlement to pay for future medical services related to a claim.[14] Section 111 reporting is required by statute; Medicare Set-Aside Arrangements are voluntary. Also, as a practical matter Section 111 concerns all claims with medical payments over $750, including claims with ongoing medical treatment. By contrast, MSAs only concern large settlements. CMS will only review MSA submissions where the claimant is a Medicare beneficiary and the total settlement is greater than $25,000 or the claimant has a reasonable expectation of enrolling for Medicare within the next 30 months and the total settlement is greater than $250,000. The impact of the Section 111 reporting requirements, which may increases losses for cases where Medicare has been making payments that have not been reimbursed by the insurer or self-insured, is the focus of the present study.

---

[13] See Appendix A in this report and Centers for Medicare and Medicare Services, MMSEA Section 111, Chapter III, Sections 6.3 and 6.4 for further information on the reporting amount thresholds and phase-in dates for ongoing medical treatments and lump sum payments (referred to as "Total Payment Obligation to the Claimant," or TPOC, in the CMS materials).

[14] In the past, MSAs have been limited to workers' compensation settlements. Recently, MSAs have started to be considered for settlements involving Medicare beneficiaries for other types of property-casualty coverages.

Section II presents a very brief discussion of the current Section 111 reporting requirements with the focus on reporting thresholds. In Section III, we discuss potential impacts of Section 111 reporting on insurer and self-insured losses, as well as other potential financial impacts. Section IV provides the results from our interviews with claims consultants and actuaries with experience with claims and losses subject to the Section 111 reporting requirements. Section V presents 10 cases we developed to illustrate the types of situations in which Medicare is a secondary payer for injuries and illnesses covered by workers' compensation, automobile, or homeowners insurance, or a self-insured program. In Section VI, we review related past research and use summary-level data to estimate the potential impact of Section 111 on workers' compensation and automobile losses. We did not estimate an the impact for homeowners coverage due to the lack of information on medical payments. Concluding comments are provided in Section VII.

II. SECTION 111 REPORTING REQUIREMENTS

Section 111 requirements concern Medicare beneficiaries who are receiving medical treatment for a work-related injury or an injury where the incident is covered by an insurer or self-insurance arrangement. Under Section 111, insurers and self-insureds are required to report to CMS certain information on incidents where a Medicare beneficiary has received medical treatment or when a one-time payment (such as a lump sum, settlement, or judgment) is made to a Medicare beneficiary.[15] This information includes identifier information for the claimant and the insurer (or self-insured), and diagnostic information for the medical treatments (such as the International Classification of Diseases 9th (or 10th) Revision (ICD-9 or ICD-10) diagnosis codes). When a Medicare beneficiary receives medical treatment in the future for which payment is sought under Medicare, CMS will use this information to determine whether the medical treatment was related to a previous injury that was covered by an insurer or self-insured.

Section 111 distinguishes between two broad types of medical services.

- **Ongoing responsibility for medicals** (ORM) refers to the ongoing responsibility for payment of the injured party's medical treatment, including medical-only claims with more than $750 in payments and all indemnity claims.
- **Total payment obligation to the claimant** (TPOC) refers to the settlement, judgment, award, or other payment in addition to the ORM. A TPOC is generally a one-time or lump sum settlement, judgment, or award. Structured settlements are considered TPOCs.

The reporting requirements became effective May 1, 2009. Each class of medical services is subject to certain reporting thresholds, which in the case of the TPOC payments have been decreasing over the past several years.[16] There is no threshold for TPOC claims for no-fault insurance—all TPOC payments made under a no-fault coverage must be reported to CMS. Thresholds for reporting TPOC payments for liability insurance became effective for payments made on or after October 1, 2010, and thresholds for these types of payments for workers' compensation became effective for payments made on or after October 1, 2011.

Table 1 presents the recent reporting thresholds and effective dates for TPOC payments for

---

[15] The reference materials produced by the Centers for Medicare and Medicare Services (CMS) refers to "liability insurance (including self-insurance, no-fault insurance, and workers' compensation)". For simplicity, we will collectively refer to these arrangements as "insurance" or "insurance and self-insurance", and the parties providing these coverages as "insurers" or "insurers and self-insureds".

[16] See Appendix A for a very brief discussion of the legislative history of the Medicare program, coverages provided under the Medicare program, Medicare as a secondary payer, the enactment of the Medicare, Medicaid, and SCHIP Extension Act of 2007 (which included Section 111), and the reporting thresholds.

workers' compensation and liability insurance. As of January 1, 2014, an insurer or self-insured was required to report TPOC payments made on or after October 1, 2013, that were over $2,000. As of January 1, 2015, the threshold for workers' compensation and liability claims is $300 for payments made on or after October 1, 2014.

Table 1 Total Payment Obligation to the Claimant Reporting Dates and Thresholds for Workers' Compensation and Liability Insurance

Section 111 Reporting Required in the Quarter Beginning	TPOC Date on or After	TPOC Threshold
January 1, 2014	October 1, 2013	TPOC over $2,000
January 1, 2015	October 1, 2014	TPOC over $300

III. POTENTIAL IMPACTS: GENERAL DISCUSSION

We arrange our general discussion on the potential impacts into two areas: (1) impacts as measured through claim experience metrics, specifically claim frequency, claim severity, and claim settlements, and (2) financial impacts, specifically the impacts on reserves and pricing. Within these two broad areas, we expect the Section 111 to have the most impact on claim severity and case reserves.

A. Claim Experience Measures

The following discusses briefly the potential impacts of the Section 111 reporting on three broad claim experience measures: claim frequency, claim severity, and claim settlements. As will become evident in the next section, we expect most of the impact to be on claim severity, and particularly higher losses for known claims.

- **Claim frequency:** Insurers and self-insureds may experience an increase in the number of claims for individuals 65 and over.[17] The reporting thresholds for one-time and lump sum settlements have decreased over the past several years and the lower thresholds will increase the number of claims that must be reported to CMS.[18] Furthermore, given the ORM threshold is set at $750, medical inflation will cause more claims with ORM to exceed this threshold, and as a consequence more ORM claims will be reported to CMS. As more claims are reported to CMS, the increased surveillance by CMS may cause some amounts previously paid under Medicare to be shifted back to the liability and workers' compensation coverage.
- **Claim severity:** Insurers and self-insureds may experience an increase in the losses (and especially medical losses) for known claims. Section 111 reporting requirements for ORMs will provide CMS with the means for closer surveillance of the medical services administered to Medicare beneficiaries. With the ongoing reporting for ORMs, it will be easier for CMS to identify medical services previously considered part of the aging process (e.g., low back injuries, joint injuries) to have been caused by a work-related or other incident, such as an automobile accident or an incident on another person's property. With Section 111, CMS will have the personal identifier and diagnostic information for medical treatments paid by insurers and self-insureds. When an individual 65 or over receives medical treatment that is submitted to CMS for payment under Medicare, CMS will be able to tie the diagnostic

---

[17] To the extent there are Medicare beneficiaries under 65 (such as individuals receiving SSDI), insurers and self-insureds may see an increase in the number of claims for individuals under 65.

[18] See Table A-3 in Appendix A for the history of reporting thresholds for liability insurance and Table 33 for the history for workers' compensation.

information from the prior treatments to the diagnostic information for the recent treatments. CMS will consider the recent treatments to be a continuation of the prior treatments (same diagnosis) and seek reimbursement from the insurer or self-insured.

- **Claim settlements:** Claims severity may also increase if there is an increase in the size of claims settlements. Looking at the medical needs of a work-related condition over a Medicare beneficiary's remaining life expectancy, CMS may demand larger settlements than prior to the Section 111 reporting requirements. (See Case #1 in Section V.) Also, the rules that impose responsibility of exhausted settlements on claimants and claimants' attorneys could result in increased settlement demands. Insurers will need to ensure that settlement funds are being used for the claimant's medical expenses. An insurer may be responsible for the medical expenses even if the settlement funds are spent for other (nonmedical) uses.

B. Potential Financial Impacts

The most significant financial impacts are likely to be a need to increase case reserves for claims involving property-casualty claimants who are also Medicare beneficiaries. Any notable pricing impacts are likely to be limited to situations where Medicare beneficiaries comprise a notable share of the exposure.

- **Reserving impact (case reserves and IBNR reserves):** The cases in Section V are intended to illustrate the variety of situations that might arise under the increased reporting requirements for situations where Medicare is the secondary payer. Prior to the Section 111 reporting requirements, there were no reporting requirements, and consequently there was no process for CMS to identify and seek reimbursement from primary payers for payments for Medicare beneficiaries' medical treatments. Through the case illustrations, we will show how losses for insurers and self-insureds may increase now that CMS will have the information to seek reimbursement.
- **Pricing impact:**
    - There may be increases in the rates for classes of workers 65 and over that in the past may have had some medical expenses paid by Medicare. Examples may include certain retail and office-worker classes with a relatively older workforce for workers' compensation, and certain age groups for automobile coverages.
    - There may be increases in the rates for classes of workers who are more likely to receive serious injuries and who may seek coverage under the Social Security Disability Insurance (SSDI) program. With stricter reporting under Section 111,

these injured individuals will be directed back to an insurer or self-insured (and not the Social Security Administration) for payment.

There may be other areas where the increased reporting requirements are of concern to the practicing actuary but the overall impact is likely to be smaller than the impacts for the preceding points. These other points include reinsurance (and especially excess-loss considerations), financial statement reporting (e.g., 10-K statements), enterprise risk management, and capital-market volatility (e.g., changes in financial- or accounting-statement equity or market value).

C. Assumptions for Estimating the Impacts on Losses

For the case illustrations, broader financial impacts, and aggregate estimates, we relied on information that can be arranged into three broad areas, with differing implications as to the variability that may be observed in a particular book of business.

- First, we used reports from insurance industry and government agency sources for information on claim frequency and costs and worker demographics. This information was the starting point to illustrate the potential impacts for an average or typical book of business. Nevertheless, this injury and worker demographic information may need to be adjusted when calculating the impact for a specific book of business.
- Second, from discussions with actuaries and claims consultants, we developed estimates of case reserves for the case illustrations and the range of possible impacts for certain components of the aggregate estimates. To the extent injury severities and reserving practices differ across insurers and self-insureds, there will be differences across books of business. Also, the aggregate impacts that may be calculated in the future will reflect the differences in books of business and reserving practices, as well as the extent to which insurers and self-insureds may have been making medical payments for individuals 65 and over prior to Section 111.
- And third, from discussions with claim consultants and information from medical studies, we developed assumptions concerning the frequency and costs of medical services for certain low-frequency, high-cost medical treatments (such as a liver replacement or joint replacement). Injury severity and medical needs are likely to vary greatly across individuals needing these medical treatments, and these differences will have an impact on the cost estimates captured in our illustrations.

In sum, we used information from several types of sources and while we made efforts to use credible information for the illustrations, there will be departures in the actual experience and the extent of these departures is likely to be related to the general type of information.

IV. INTERVIEWS WITH CLAIMS CONSULTANTS AND ACTUARIES

Given little time has passed to accumulate enough experience to evaluate the financial impact of Section 111 reporting requirements for an insurer or self-insured, we interviewed several claims consultants and actuaries with recent experience performing claims reviews and actuarial analyses for books of business that include large numbers of claims for injured workers and individuals 65 and over. These interviews were intended to give insights into the financial impacts that may be observed in the next few years. For our interviews, we focused on the following six questions.

1. Since Section 111 was implemented are insurers settling fewer claims from Medicare beneficiaries (that is, are claims being kept open that would have normally settled prior to the reporting requirements)?
2. Since Section 111 was implemented, CMS appears to have become more vigilant in monitoring payments by primary payers and others that may be responsible for medical payments (such as claimants and claimants' attorneys). Have insurers seen an increase in the value of settlement demands from claimants and claimants' attorneys?
3. If insurers are seeing an increase in the value of settlement demands since Section 111 was implemented, what claims are most typically affected (e.g., claims with small, modest, or large payments)?
4. For insurers that have been reporting since Section 111 was implemented, is CMS disputing payments related to comorbidities that were paid by Medicare in the past?
5. Since Section 111 was implemented, have insurers changed their case reserving practices for Medicare beneficiaries?
6. Since Section 111 was implemented, have insurers changed their IBNR reserves for reasons that would be due to increased future payments for claims from Medicare beneficiaries?

The following points summarize the responses from our interviews.

- A Medicare Set-Aside Arrangement (MSA) is a voluntary financial agreement that allocates a portion of a settlement to pay for future medical services related to a claim.[19] CMS will only review MSA submissions where the claimant is a Medicare beneficiary and the total settlement is greater than $25,000 or the claimant has a reasonable expectation of enrolling for Medicare within the next 30 months and the total settlement is greater than $250,000. If a CMS-approved set-aside amount is exhausted, Medicare will pay primary for future Medicare-covered expenses related to the workers' compensation injury that exceed the

[19] In the past, MSAs have been limited to workers' compensation settlements. Recently, MSAs have started to be considered for settlements involving Medicare beneficiaries for other types of property-casualty coverages.

approved set-aside amount.[20] Insurers, self-insureds, and claimants used MSAs for workers' compensation for several years prior to the MMSEA legislation to establish some certainty to the payment of future medical treatments provided to Medicare beneficiaries. For claims prior to Section 111 covered by a CMS-approved MSA, the insurer or self-insured should be able to limit their losses to the CMS-approved MSA amount. However, if an insurer or self-insured did not use MSAs prior to Section 111, they may be more exposed to increased losses with the Section 111 reporting requirements. For claims without a MSA, CMS will be collecting information the agency can use to make demands for ongoing medical payments. Such ongoing payments may be for known treatments (for claims where the insurer or self-insured knew the injured worker was receiving medical care) or for unknown treatments (such as the case with a second knee replacement as described in Case #1 in Section V).

- The Workers' Compensation Medicare Set-Aside Arrangement (WCMSA) process is causing medical settlements for workers' compensation claims to be delayed, deferred, or forgone.[21] [22] (Also, because medical settlements are forgone, there are fewer indemnity settlements.) Generally, it is taking longer to achieve a medical settlement and in many (if not most) situations, multiple proposals are made to CMS before a WCMSA is accepted. In many situations, a submitted proposal that is not accepted is put aside by the insurer, revised at a later time with additional information gathered in the meantime, and then resubmitted to CMS.
- The increased oversight and claims monitoring that has been undertaken by CMS is overlaid on state insurance programs that are heavily influenced by state statutes and regulations. While CMS may be attempting to impose a consistent scheme for managing the federal Medicare program, state statutes and regulations concerning the handling of workers' compensation and liability claims are likely to lead to differences in the impact of the Section 111 reporting across states. In many states, the number of settlements has been significantly reduced, and in at least one state (Kentucky) there have been very few medical settlements in recent years.

[20] WCMSA Reference Guide, January 5, 2015, page 4.

[21] Although not directly part of the Section 111 reporting requirements, the set-aside process is a tool used by CMS to protect Medicare from payments that should be the responsibility of other liability coverages (such as workers' compensation, automobile, or homeowners). Medicare will review and approve a set-aside so the insurer or self-insured can proceed with a settlement that protects Medicare and resolves the primary payer from future exposure.

[22] The National Council on Compensation Insurance (NCCI) has reported that almost all MSAs are for claimants who are entitled to Medicare benefits at the time of settlement (NCCI, 2014, Slide 12).

- Another impact of the WCMSA process that is having an impact on Section 111 reporting is the increased use by insurers and self-insureds of third-party vendors to handle the filing and negotiations for the WCMSA with the CMS. While the services provided by these third-party vendors are helpful in obtaining a WCMSA (that is, if an arrangement is obtained), they are increasing loss adjustment expenses.
- For claims with settlements, there has been a lesser impact on small and mid-sized settlements from the period before Section 111 than on larger settlements. The large settlements as a group appear to be getting larger—that is, there is a longer tail to the distribution of settlement amounts.
- The preceding point notwithstanding, there are other factors that might influence the distribution of settlements, and these factors may have an offsetting effect. Treatment guidelines (including pharmaceutical formularies), as well as state statutes and regulations, may limit or control the amount of treatment, especially the use of opioid pain medications, provided to an injured worker. The implication is that the medical treatment administered to a Medicare beneficiary who experiences a work-related injury may be limited or controlled by the prevailing workers' compensation treatment guidelines or state regulations. Examples include limits and controls on the number of physical therapy treatments and the prior authorization requirements for certain types of treatment to ensure the medical necessity of the treatment.
- Under Section III, insurers and self-insureds are required to report the injury and illness diagnostic information for the medical care received by the injured individual. If an injured worker received medical treatment for a comorbidity that was reported to CMS as part of the treatment for the covered injury, the insurer or self-insured may be liable for future treatments for the comorbidity (even though the comorbidity was not caused by the covered incident). For example, suppose a worker with an injured back received treatment for obesity. If the insurer reports both the low back and obesity diagnoses, then CMS is likely to consider the treatment for obesity as due to a work-related condition and require reimbursement for future treatments the individual receives for obesity.[23] The issue with comorbidities becoming the responsibility of insurers and self-insureds has been observed in a small number of states and is a significant problem in California. Recently in California there has been an increased practice of listing multiple body parts as part of the injury

[23] An insurer can avoid this problem by limiting reports to CMS to the diagnoses for the covered injuries and illnesses. See Swedlow 2011 for additional examples.

description, with the range of listed body parts creating some suspicion. Because the insurer or self-insured may reject certain body parts that CMS accepts, this creates further uncertainty as to which party pays what costs.

- Although the claims specialists are not seeing an increase in case reserves for claimants 65 and over, they suspect it is because the reserve specialists do not have enough experience with the Section 111 reporting or the WCMSAs. In particular, there is not enough experience with the approved WCMSA settlements to form a basis to change reserving practices. The most typical situation is a reserve specialist leaving a claim open with no change in reserving practice, and then changing the reserve after a settlement is reached.
- Although the Medicare Set-Aside (MSA) process has been around since the 1990s, it was not available to liability coverages until after Section 111 went into effect. Also, different regional CMS offices have had different procedures for handling liability MSAs, so the ability of a primary payer to get an MSA has varied from region to region. To date, there have been very few MSAs for liability coverages other than workers' compensation.

V. CASE STUDIES

A. Introduction

In this section, we present 10 cases that may arise due to the Section 111 reporting requirements and require special attention from a casualty actuary. We developed the cases with the intention of showing a variety of situations across several lines of liability coverage, including workers' compensation, automobile, and homeowners, and to illustrate situations where the insurer or self-insurer had no knowledge of the medical treatment and the payments are for treatments that were not expected.

Each claim in the case illustrations satisfies the Section 111 reporting requirements.

Where appropriate (and for most cases), we address the following.

- **Profile:** The demographics of the individual (usually an individual 65 or over), line of insurance, and the nature and seriousness of the injury.
- **Medicare secondary payer:** The reasons an insurer or self-insured is likely to be responsible for paying the medical services, and in some cases why the insurer or self-insured may not be responsible for certain medical services.
- **Section 111 reporting implications:** The reason(s) the insurer or self-insured will be required to report the claim under the Section 111 provisions.
- **Significance for a casualty actuary:** The most prominent implications for a casualty actuary. In most instances, the implications concern reserving considerations.
- **Financial illustration:** Past and future (expected) information on the medical and disability payments for the injury, and in some cases a breakdown for the type of medical services.
- **Broader considerations:** For the workers' compensation cases, the case illustrations were extended to other similarly situated cases. For example, for the case concerning a work-related knee replacement, the discussion is extended to other joint replacements. For the case concerning lung cancer, the discussion is extended to claims with other types of cancer that might be attributed to a workplace exposure.

In the discussion of the case illustrations, we present two types of financial impacts.

1. The "financial illustration" concerns the case reserves that might have been expected prior to the Section 111 reporting requirements and the potential losses that might be expected given the new reporting requirements. The reserves are for a single case and presume the insurer was not making payments on the Medicare beneficiary's tail experience. The financial illustrations include the impact of tail costs. The case-specific financial illustrations are

intended to provide information concerning the potential magnitude of a special set of circumstances (i.e., the specific case). Care is needed when extrapolating the financial impacts of a specific case to all claims with the same injury or medical condition.

2. The "broader financial impacts" present a framework for developing the potential losses for a group of similarly situated claims. For the broader financial impacts, we take into consideration the frequency of the particular injury or medical condition, the representation of Medicare-eligible claims among all workers' compensation claims, the frequency of a particular injury or medical condition among all Medicare-eligible injured workers with the injury or medical condition, estimates for the case reserves before Section 111 reporting requirements, and potential losses with them in place now. These considerations are presented in templates in the case illustrations in which a casualty actuary can insert their own assumptions or experience to estimate the potential financial impacts of the Section 111 reporting requirements.

We made the following considerations to develop the broader financial impacts for the case illustrations for workers' compensation claims (Cases #1-#6 in this section).

1. We developed baseline case incurred losses for an injured population. We started with Unit Stat Plan data for California that provided incurred losses by body party, nature of injury, and cause of accident and converted the first-report incurred losses to U.S. ultimate losses. The purpose of the conversion from California to U.S. was to have U.S. ultimate losses by body part, nature of injury, and cause of accident for the case illustrations.
   We started with first-report, incurred losses from Unit Stat Plan data for California claims broken down by body part, nature of injury, and cause of accident. Although the California workers' compensation system is often regarded to have unusually high costs, present interest is with the distribution of injuries, distribution of costs, and relative costs across different categories of injuries, such as body part, nature of injury, and cause of accident.[24] The distribution of injuries by body part, nature of injury, and cause of accident were used for columns (1) and (2) for Cases #1-#4 and #6.
2. We used first-to-ultimate factors for the U.S. and California to convert the first-report, incurred losses for California claims to first-report, incurred losses for U.S. claims. We then used a first-to-ultimate factor for the U.S. to convert the first-report, incurred losses for the

[24] California has a large, diverse economy. We assumed that the distribution of injuries and relative costs between types of injuries in California can be generalized to the United States. Nevertheless, in the financial illustrations described later in this section, a user could adjust the distribution or relative costs of the injuries.

U.S. to an ultimate basis. These ultimate losses were used for the average incurred loss in column (3) for Cases #1-#4 and #6.

3. In developing the broader financial impacts, we made several assumptions concerning the incidence of Medicare-eligible workers that may be altered in the template depending on the book of business. We assumed that all injured workers 65 and over were Medicare-eligible and that injured workers 65 and over account for approximately 5% of all employed persons. (Column (5) for Cases #1-#4.)[25] The 65-and-over assumption permitted us to estimate the impact on an easily identified cohort of injured workers—65 and over. While there may be exceptions—in particular, workers receiving SSDI—we assumed most of the impact will be on the injured workers who are 65 and over.
4. In consultation with claims consultants and various data sources, we developed case estimates that would have been typical prior to the Section 111 reporting requirements (that is, without the tail experience). These pre-Section 111 case estimates appear in Column (8) for Cases #1-#4 and #6.
5. The potential losses include the additional losses that might have been missed (and consequently paid for by Medicare) prior to the Section 111 requirements. For some cases, these additional losses concern medical care likely to occur several years in the future and other losses may have been leakages in the system (such as when an injured worker relocated to a different state). These potential losses appear in Column (9) for Cases #1-#4 and #6.

The potential losses from the broader financial impact calculations are related to:

- Medicare-eligible injured workers with the injury or medical condition,
- All Medicare-eligible injured workers, and
- All injured workers.

When reviewing the broader financial impacts discussed below and working with this template, it is important to keep in mind that the potential losses will be sensitive to several points in the calculations.

- Frequency of claims with an injury to a particular body part, nature of injury, or cause of injury (Column (2) in Tables 4, 6, 8, 10, and 14),
- Average incurred costs (Column (3)),
- Percentage of injured workers who are eligible for Medicare (Column (5)),

[25] Discussion of the 5% assumption for workers 65 and over is provided in Part B and Table 21 in the next section.

- Percentage and number of Medicare-eligible who experience the injury or medical condition (Columns (6) and (7)),
- Pre-Section 111 case estimate (Column (8)), and
- Potential loss (Column (9)).

The assumptions for claim frequency, average incurred costs, and the percentage of injured workers who are Medicare-eligible were developed from government agency and insurance industry sources. These assumptions are generally market averages and likely to need adjusting for a particular book of business. Someone using these illustrations as templates for their own analysis should review these assumptions in light of the frequency, cost, and demographics for their book of business.

The assumptions concerning the incidence of Medicare-eligible with a particular injury or medical condition, case estimates, and potential losses were developed from based on information from property-casualty claim consultants and medical literature. While we worked to make these assumptions realistic, actual incidence and loss experience may be very different across different books of business. Someone using these templates for their own analysis should consult claim adjusters and medical professionals for information on the book of business under review.

Finally, while in the near term we expect the significant impacts will be on case reserves and IBNR reserves, actuaries should expect over time to see higher case reserves from claims adjusters for injured workers close to or over 65. However, it may take several years before case reserves are higher because (1) claims adjusters will need to become more familiar with CMS's procedures and (2) claims adjusters will need to gain experience with the tail of medical treatments for injured workers 65 and over.

B. 10 Case Studies

We developed 10 case studies to describe a sampling of the special circumstances that might come up with the Section 111 reporting requirements. The cases are summarized in Table 2.

Table 2 Summary of Case Studies

Case	Line of Business	Abstract	Relevance for Medicare Secondary Payer Status and Section 111 Reporting
1	Workers' compensation	Workers' compensation claimant with knee replacement	Future medical expenses that may be several years in the future.
2	Workers' compensation	Workers' compensation claimant with a needle-stick injury	Medical expenses for a slow-developing illness (hepatitis C with potential liver transplant).
3	Workers' compensation	Workers' compensation claimant with lung cancer	CMS may challenge settlement as inadequate for the life expectancy of a 66-year-old claimant.
4	Workers' compensation	Medicare beneficiary with a work-related injury relocates	Treating physicians at new location unaware of the workers' compensation claim submit bills directly to Medicare rather than to the workers' compensation insurer.
5	Workers' compensation	Workers' compensation claimant with long-term pharmaceutical prescription needs	Medicare Part D (pharmaceutical prescriptions) coverage is secondary to workers' compensation.
6	Workers' compensation	Workers' compensation claimant with a shortened life expectancy	CMS is challenging the settlement for not providing hospice care.
7	Automobile no-fault	Passenger in automobile accident covered by driver's no-fault automobile coverage	ORM for automobile insurer.
8	Automobile liability (other driver)	Medicare makes conditional payments for a 67-year-old automobile accident claimant	Conditional payments for TPOC claim.
9	Automobile	Automobile accident claimant with a traumatic brain injury	Case complicated by a preexisting Alzheimer condition.
10	Homeowners	Medicare beneficiary injured on neighbor's property	Primary care provider misreports injury as covered by Medicare.

Case #1: Workers' compensation claimant with knee replacement

Starting considerations

Case #1 concerns a Medicare beneficiary with a work-related injury that requires a joint replacement. Given the injured worker's age, the years of service that can be expected from a joint replacement, and the injured worker's life expectancy, it can be expected the joint replacement will require replacing in the future. Prior to Section 111 reporting requirements, the likely scenario was that a reserve was established and losses were paid for the first replacement and Medicare paid for subsequent replacements. Reporting procedures were not in place to associate the future replacements back to the work-related injury. The challenge with Section 111 reporting is that the casualty actuary will need to determine whether the present case reserves include amounts for future replacements or whether IBNR reserves will be needed for the additional losses. While this specific case concerns a knee replacement, it can be extended to include hip, shoulder, and ankle replacements, and more generally other types of durable medical equipment where the injured worker's life expectancy is longer than the expected years of service from the equipment.

Case profile

John is 66 years old with a work-related injury that requires a knee replacement. The injury is likely to be a permanent partial disability covered by workers' compensation. Given his life expectancy and the expected life of a knee replacement, it is likely the first knee replacement may require replacing in the future. Although several years will pass between the medical care treatments for the knee replacements, the workers' compensation insurer will be responsible for future knee replacements. While the claim was open, the insurer will have ORM and the claim will need to be reported to CMS per Section 111 reporting requirements. The claim is likely to settle and therefore there will be a TPOC. The insurer will be responsible for future knee replacements.

Financial illustration

Table 3 presents assumptions for the medical and disability payments that may occur with the present case. The first knee replacement is estimated to cost $56,550. Given the injured worker's life expectancy and expected years of service from a knee replacement, the workers' compensation insurer may also need to reserve for two additional replacements, for a total estimated cost of $169,650. Adding the expected disability payment of $125,000, the total estimated cost for this claim is $294,650, and consequently this claim would need to be reported under the Section 111 TPOC reporting requirements.

Broader considerations

The principal consideration with the present case is the need to consider future medical payments for the knee replacements after the first replacement. [26] While the case describes a knee replacement, it can also relate to other cases in which a joint replacement is likely to require future replacements. In particular, an ankle, hip, or shoulder replaced because of a work-related incident may require additional replacements in the future.

Broader financial impact

Table 4 extends the financial illustration for a knee replacement to replacements for a shoulder, ankle, or hip. Column (1) presents the number of claims for the injured body part, column (2) presents the frequency distribution of claims across injured body parts, column (3) presents the average incurred loss (that is, case reserve), and column (4) presents the distribution of case-incurred losses. Column (5) presents the assumptions for the percentage of claims that are Medicare-eligible, column (6) presents the percentage of Medicare-eligible claims that will receive a joint replacement, and column (7) presents the number of Medicare-eligible claimants with a joint replacement. Column (8) presents current case reserves and column (9) presents new case reserves with Section 111 reporting.

The following points summarize the estimated financial impacts given the assumptions in Table 4.

- The increase in costs for Medicare-eligible beneficiaries with a knee, shoulder, ankle or hip injury is 18.8%.
- The increase in costs for all Medicare-eligible beneficiaries is 3.8%.
- The increase in costs across all injured workers is 0.1%.

[26] From a study by the American Academy of Orthopaedic Surgeons, the American Association of Retired Persons reported a 61% increase in total knee replacements (TKR) between 2004 and 2008 for men and women 45-64 years (American Association of Retired Persons). A study concerning the prevalence of TKRs in 2012 found that 4.1% of men and 4.9% of women 60-69 years have had a TKR, and 7.1% of men and 8.2% of women 70-79 years have had a TKR (Weinstein, et. al. 2012).

Table 3 Case #1: Workers' Compensation Claimant With Knee Replacement

Consideration	**Commentary**
Profile	66 years old, male, with a permanent partial workers' compensation (WC) injury that calls for 250 weeks of indemnity benefits, no home health aide or painkiller pharmaceutical products, but with a knee replacement that is likely to require two subsequent replacements in eight and 16 years.
Medicare secondary payer	Because the knee injury was caused by a work-related incident, the WC insurer will be responsible for the knee replacement and the rehabilitation care. The WC insurer will also be responsible for future knee replacements because the need for the replacements relates to the work-related injury.
Section 111 reporting implications	The injured worker is 66 years old, eligible for Medicare, and the medical costs are expected to exceed the reporting thresholds. Prior to the Section 111 reporting requirements, the knee replacement would likely have been paid for by the WC insurer but the follow-up rehabilitation care and future knee replacements may have been paid for by Medicare because there was not a systematic process for relating the future medical care back to the work-related injury.
Significance for a casualty actuary	Case reserves are likely to have been established for one knee replacement without taking into consideration the likelihood of future knee replacements.
Financial illustration	Assumed case reserves: Medical: • Knee replacement: $50,000 • Rehabilitation: $4,000 • Physical therapy: $2,550 Disability: $125,000 ($500/week, for 250 weeks) Total assumed case reserves: $181,550 Potential losses: Medical: • Two additional replacements in the future (every eight years) • Total: $169,650 ($56,550 x 3 replacements) Disability: $125,000 ($500/week, for 250 weeks) Total estimated loss: $294,650
Broader considerations	Although this case concerns a knee replacement, similar impacts can be considered for other types of joint replacements, including hip, shoulder, and ankle. As with the case described above, attention should be given to the distribution of injuries, frequency of future joint replacements, and costs associated with the future replacements.
Broader financial impacts	Potential impacts for Medicare-eligible beneficiaries with a joint replacement: • Increase in costs for all Medicare-eligible beneficiaries: 3.8% • Increase in costs across all injured workers: 0.1%

Table 4 Case #1: Workers' Compensation Claimants With Joint Replacements: Broader Financial Impacts

Part A: Development of the Potential Loss Under Section 111 Reporting

Injured Body Part	(1) # of Claims for a Book of 100,000 Claims	(2) % of Claims	(3) Average Incurred Loss	(4) % of Losses	(5) % of Claims Medicare-Eligible	(6) % of Medicare-Eligibles With Replacement	(7) # of Joint Replacements for Medicare-Eligible	(8) Pre-Section 111 Case Reserve	(9) Potential Loss
Lower extremities, knee	5,951	6.0%	19,449	8.8%	5.0%	6.0%	18	181,550	294,650
Upper extremities, shoulder	4,476	4.5%	22,540	7.6%	5.0%	1.0%	2	100,000	200,000
Lower extremities, ankle	3,406	3.4%	10,824	2.8%	5.0%	1.0%	2	100,000	200,000
Lower extremities, hip	746	0.7%	20,574	1.2%	5.0%	3.0%	1	100,000	200,000
Total, selected injured body parts	14,579	14.6%		20.4%			23	3,746,965	6,271,993
Total, all injured body parts	100,000		1,320,363,949		5.0%				
Change in case reserves									2,525,028

Part B: Potential Losses as a Percentage of Medicare-Eligible and All Workers

Impact	Change in Case Reserves	Total Incurred Losses	% Impact on Incurred Losses
Medicare-eligible with selected body parts	2,525,028	13,442,031	18.8%
All Medicare-eligible		66,018,197	3.8%
All injured workers		1,320,363,949	0.2%

Case #2: Workers' compensation claimant with a needle-stick injury

Starting considerations

Case #2 concerns a Medicare beneficiary who experienced a workplace injury that did not produce a serious medical condition until several years later. The case concerns a needle-stick injury which caused a hepatitis C exposure that did not develop into a chronic liver condition until several years after the injury. This case can be expected to be similar to other workplace injuries with a long-latency medical condition, including cumulative trauma and loss of hearing. (Work-related cancers caused by extended exposures to hazardous conditions or materials are covered in Case #3.)

Case profile

Ann is a 65-year-old healthcare worker who filed a workers' compensation claim two years ago following a needle-stick injury. Other than the initial and recurring tests for hepatitis, there was no significant medical treatment. However, shortly after becoming a Medicare beneficiary, Ann developed the early symptoms for hepatitis C, a condition that could lead to a liver transplant. Because this condition can be traced back to the needle-stick injury, CMS may seek payment from the workers' compensation insurer (or self-insured).

Financial illustration

Table 5 presents the assumptions for the medical and disability payments that may occur with the present case. Estimated medical costs for the needle-stick injury can be between $20,000 and $577,100, depending on whether Ann needs a liver transplant.[27] This uncertainty translates to a considerable uncertainty over the indemnity benefits, which have been estimated to be between $39,000 and $570,000. Consequently, total losses have been estimated to be between $59,000 and $1,147,100.

The insurer will need to monitor the medical services administered to Ann so that payment is limited to services related to the needle-stick injury. The insurer should not be responsible for medical services for other conditions (such as tests for comorbidity conditions, e.g., diabetes, hypertension), even if these tests were administered during visits when medical services were provided for treatment related to the needle-stick injury.

Broader considerations

Although there have been significant improvements in workplace safety procedures, workers in healthcare and correctional healthcare occupations, dental workers, and first responders (e.g., firefighters, police officers, and emergency medical technicians) continue to be exposed to needle-

[27] Bentley and Hanson 2011 reported that the estimated U.S. average billed charges for a liver transplant during 2011 was $577,100.

stick injuries. The Centers for Disease Control, the Food and Drug Administration, and the National Institute for Occupational Safety and Health have published information identifying several occupations with exposures to blood or other bodily fluids.[28] According to a report from the Canadian Public Health Association, 80% of those infected with the hepatitis C virus will develop lifelong symptoms, and about 20% who have lifelong symptoms will develop liver cirrhosis.[29]

Broader financial impact

For the broader financial impact, we included causes of injury that could give rise to needle-stick injuries (and puncture injuries, in general) and other causes that might include a penetration to the body that could lead to an organ transplant. We assumed Medicare eligible workers make up 5% of the injured worker population (column (5)) and that 0.5% of the needle-stick cases will require an organ transplant.[30] Finally, we used the case reserve and potential loss amount from the financial illustration for this case.

The following points summarize the estimated financial impacts given the assumptions in Table 6.

- The increase in costs for Medicare-eligible beneficiaries with a long-latency condition is 78.5%.
- The increase in costs for all Medicare-eligible beneficiaries is 1.4%.
- The increase in costs across all injured workers is 0.1%.

[28] Centers for Disease Control 2011, Food and Drug Administration 2012, National Institute for Occupational Safety and Health 2010.

[29] Canadian Public Health Association undated.

[30] Data from the US Bureau of Labor Statistics finds that, in 2014, 5.4% of employed persons were 65 years and over (see Table 21 in this report). The 0.5% assumption for organ transplants was made for illustrating the calculation of the potential financial impact.

Table 5 Case #2: Workers' Compensation Claimant With a Needle-Stick Injury That May Require a Liver Transplant in the Future

Consideration	Commentary
Profile	65 years old, female, healthcare worker who filed a claim following a needle-stick. Injured worker receiving recurring tests for the possibility that the needle-stick injury could lead to a hepatitis C condition. Initially, a medical-only claim with recurring treatments for the needle-stick tests and the possibility of a liver transplant in the future.
Medicare secondary payer	Medicare is the secondary payer for all medical treatments concerning the needle-stick injury, including all recurring tests and the liver transplant, if necessary.
Section 111 reporting requirements	The individual may be receiving Medicare benefits for treatments not associated with the needle-stick injury; however, the workers' compensation insurer (or self-insured) will be responsible for the ongoing medical treatments and would be responsible for the liver transplant that might occur in the future. The insurer or self-insured may seek a WCMSA; however, given the possibility of a liver transplant, CMS may expect an amount over $1,100,000, and the insurer may decide to keep the claim open and process under ORM.
Significance for a casualty actuary	If the individual later receives a liver transplant and it is not identified to the medical providers as caused by a work-related injury, then payments will be processed through Medicare. Prior to the Section 111 reporting requirements, this probably would have gone unnoticed by Medicare. The transplant would have been paid for by Medicare because CMS did not know the cause was a work-related injury from several years past. With the Section 111 reporting requirements, because of the insurer's obligation to report the claim CMS is aware that this is a work-related injury and payment for the subsequent transplant will be the responsibility of the workers' compensation insurer. Before Section 111 reporting requirements, the case reserve might have been $369,000. After the Section 111 reporting requirements, the case reserve may need to be over $1,100,000.
Financial illustration	Medical: $20,000 - $577,100 Disability: $39,000 - $570,000 Total estimated loss: $59,000 - $1,147,100
Broader considerations	Workers in healthcare and correctional healthcare occupations, dental workers, and first responders (e.g., firefighters, police officers, and emergency medical technicians) continue to be exposed to needle-stick injuries.
Broader financial considerations	Potential impacts for Medicare-eligible beneficiaries with a latent cause: • Increase in costs for all Medicare-eligible beneficiaries: 2.1% • Increase in costs across all injured workers: 0.1%

Table 6 Case #2: Workers' Compensation Claimants With a Needle-Stick Injury That May Require a Liver Transplant: Broader Financial Impacts

Part A: Development of the Potential Loss Under Section 111 Reporting

Cause of Injury	(1) # of Claims for a Book of 100,000 Claims	(2) % of Claims	(3) Average Incurred Loss	(4) % of Losses	(5) % of Claims Medicare-Eligible	(6) % of Medicare-Eligible Requiring a Liver Transplant	(7) # of Medicare-Eligible Requiring a Liver Transplant	(8) Pre-Section 111 Case Reserve	(9) Potential Loss
Cut, Puncture, Scrape or Injury By, NOC	3,335	3.3%	3,214	0.8%	5.0%	0.5%	0.8	59,000	1,147,100
Struck or Inj by - Fellow Workers, Patient or Oth Person	940	0.9%	10,182	0.7%	5.0%	0.5%	0.2	59,000	1,147,100
Absorption, Ingestion or Inhalation, NOC	646	0.6%	4,203	0.2%	5.0%	0.5%	0.2	59,000	1,147,100
Burn or Scald - Dusts, Gases, Fumes, Vapors or Radiation	228	0.2%	5,751	0.1%	5.0%	0.5%	0.1	59,000	1,147,100
Total, selected causes of injury	5,149	5.1%		1.8%			1.3	75,946	1,476,569
Total, all causes of injury	100,000		1,320,272,232		5.0%				
Change in case reserves									1,400,623

Part B: Potential Losses as a Percentage of Medicare-Eligible and All Workers

Impact	Change in Case Reserves	Total Incurred Losses	% Impact on Incurred Losses
Medicare-eligible with selected causes of injury	1,400,623	1,215,645	115.2%
All Medicare-eligible		66,013,612	2.1%
All injured workers		1,320,272,232	0.1%

Case #3: Workers' compensation claimant with lung cancer

Starting considerations

Case #3 concerns a Medicare beneficiary who developed a cancerous condition several years after being exposed to a cancer-causing agent. With closer tracking of medical treatments associated with workplace incidents, there will be greater opportunities for CMS to identify Medicare beneficiaries whose cancer may have been caused by a workplace exposure.

Case profile

Kevin, who is 66 years old, retired two years ago after working 20 years in the asbestos removal industry. At his last employer, where he worked for three years, Kevin held an inside supervisory position. After turning 65, Kevin was diagnosed with lung cancer, which his physician attributed to his 17 years of working in jobs where he was exposed to asbestos (the last exposure being over five years ago).

Financial illustration

Although he is a Medicare beneficiary, the workers' compensation insurer at the last exposure (Kevin's next-to-last employer) will be responsible for the medical payments. Kevin, his attorney, and the workers' compensation insurer have agreed to a $170,000 settlement, of which $118,000 is for medical expenses and $52,000 is for disability payments. CMS, however, is disputing that the medical provision is sufficient to cover Kevin's future medical expenses. Whether or not the insurer accepts the settlement, it will be required to report under Section 111 requirements. If the insurer does not agree to the $170,000 settlement, the insurer will be required to report this claim because the claim exceeds the $750 threshold for ORM payments. If the insurer agrees to the settlement, the insurer will be required to report this claim to CMS because the claim exceeds the TPOC threshold.

Broader considerations

Although the principal consideration with the present case is an exposure to asbestos, the circumstances can be extended to other workers exposed to cancer-causing agents. Examples include exposures to certain gases and fumes in the workplace and to large amounts of secondhand smoke and pollution, as well as to arsenic, paint or dyeing products, and radiation.[31,32]

It has been reported that approximately 20,000 cancer deaths and 40,000 new cases of cancer each year in the United States are attributable to a workplace exposure,[33] and 4% to 10% of all U.S. cancer cases are caused by occupational exposures.[34] The median age of cancer patients at diagnosis is

[31] American Cancer Society, 2007.

[32] National Institutes of Health, 2014.

[33] Centers for Disease Control and Prevention, 2013.

[34] Centers for Disease Control and Prevention, 2012.

66 years and 50% of all cancer patients are between the ages of 55 and 74 years when diagnosed with cancer.[35] Furthermore, exposures to carcinogens in the workplace may not result in cancer until 15 to 40 years after the exposure.[36] Finally, with additional testing, it can be expected that more chemicals will be identified as cancer-causing agents, which could increase the incidence of new cases in the future.[37]

Broader financial impact

For the broader financial impact illustration in Table 8, we assumed a pre-Section 111 case reserve of $20,000 and a potential loss of $200,000 for each of the cases that may become cancer claims. The columns and calculations in Table 8 are the same as described for Table 4 above. Briefly, column (1) presents the nature of injury conditions likely to be associated with a cancer claim, column (6) presents the assumptions for the incidence among Medicare beneficiaries, column (8) presents the case reserves before Section 111, and column (9) presents the potential losses with the Section 111 reporting requirements.

The following points summarize the estimated financial impacts given the assumptions in Table 8.

The increase in costs for Medicare-eligible beneficiaries with a long-latency condition is 81.0%

The increase in costs for all Medicare-eligible beneficiaries is 5.1%

The increase in costs across all injured workers is 0.3%

[35] Howlander, et. al, Tables 1-11 and 1-12.
[36] U.S. Department of Health and Human Services, Publication No. 2010-145.
[37] Centers for Disease Control and Prevention, 2013.

Table 7 Case #3: Workers' Compensation Claimant With Lung Cancer

Consideration	**Commentary**
Profile	66 years old, male, with a permanent total injury that is due to lung cancer, which was attributed to a workplace asbestosis exposure.
Medicare secondary payer	The workers' compensation insurer will be responsible for all medical expenses related to the asbestos exposure, even if the medical expenses exceed $118,000.
Section 111 reporting requirements	Whether or not the workers' compensation insurer settles, the insurer will be required to report the claim under Section 111. The claim exceeds the thresholds for both ORM and TPOC.
Significance for a casualty actuary	Although a typical case reserving workup may be performed for this case, attention will need to be given to the possibility that CMS considers the settlement inadequate to cover future medical expenses.
Financial illustration	Medical: $118,000 ▪ Surgery: $40,000 ▪ Chemotherapy: $30,000 ▪ Radiation: $48,000 ($2,000 per month) Disability: $52,000 over two years ($500 per week) Total estimated losses: $170,000 Complication: Although the injured worker, his attorney, and the WC insurer have agreed to a $170,000 settlement, CMS is not willing to agree to this amount.
Broader considerations	The circumstances in this case can be extended to other workers exposed to cancer-causing agents. Examples include exposures to certain gases and fumes in the workplace and to large amounts of secondhand smoke and pollution, as well as to arsenic, paint or dyeing products, and radiation.
Broader financial considerations	Potential impacts for Medicare-eligible beneficiaries with a long-latency condition: • Increase in costs for all Medicare-eligible beneficiaries: 5.1% • Increase in costs across all injured workers: 0.3%

Table 8 Case #3: Workers' Compensation Claimants With Cancer Attributable to Workplace Exposures: Broader Financial Impact

Part A: Development of the Potential Loss Under Section 111 Reporting

Nature of Injury	(1) # of Claims for a Book of 100,000 Claims	(2) % of Claims	(3) Average Incurred Loss	(4) % of Losses	(5) % of Claims Medicare-Eligible	(6) % of Medicare-Eligible With Slow-Developing Diseases	(7) # of Medicare-Eligible With Slow-Developing Diseases	(8) Pre-Section 111 Case Reserve	(9) Potential Loss
Asbestosis, Silicosis, Byssinosis, Black Lung	8	0.0%	4,301	0.0%	5.0%	50.0%	0.2	20,000	200,000
Cancer (incl Hepatitis Losses)	4	0.0%	17,772	0.0%	5.0%	50.0%	0.1	20,000	200,000
Carpal Tunnel Syndrome	652	0.7%	26,044	1.3%	5.0%	10.0%	3.3	20,000	200,000
Contagious Disease	142	0.1%	3,335	0.0%	5.0%	20.0%	1.4	20,000	200,000
Hearing Loss or Impairment	43	0.0%	10,332	0.0%	5.0%	5.0%	0.1	20,000	200,000
Mental Disorder, Psychiatric	150	0.1%	14,051	0.2%	5.0%	10.0%	0.7	20,000	200,000
Respiratory Disorders and Dust Disease, NOC	17	0.0%	8,976	0.0%	5.0%	10.0%	0.1	20,000	200,000
All Other Occ Dis Inj, NOC (incl VDT-Related)	178	0.2%	9,650	0.1%	5.0%	10.0%	0.9	20,000	200,000
All Other Cumulative Injury, NOC	2,388	2.4%	25,670	4.6%	5.0%	10.0%	11.9	20,000	200,000
Total, selected natures of injury	3,581	3.6%		6.3%			18.7	374,894	3,748,941
Total, all natures of injury	100,000		1,320,363,949		5.0%				
Change in case reserves									3,374,047

Part B: Potential Losses as a Percentage of Medicare-Eligible and All Workers

Impact	Change in Case Reserves	Total Incurred Losses	% Impact on Incurred Losses
Medicare-eligible with selected natures of inj	3,374,047	4,163,896	81.0%
All Medicare-eligible		66,018,197	5.1%
All injured workers		1,320,363,949	0.3%

Case #4: Medicare beneficiary with a work-related injury relocates to a different state

Starting considerations

Case #4 concerns a Medicare beneficiary who has been receiving medical treatment for a work-related injury and relocates to a different state (or to a different area within a state and changes treating physicians). While the injury was related to a workplace incident, it was a common, soft-tissue injury (e.g., back sprain) that was easily presumed to be a condition brought on by the aging process. When starting treatment in the new state, the Medicare beneficiary did not indicate the injury was the result of a work-related incident and the treating physician presumed Medicare coverage. Under Section 111 reporting requirements, the insurer will have to report the injury and CMS will be able to associate the medical treatment received in the relocation state to the workplace injury. This easier tracking is due to the ability of CMS to associate an individual's Social Security number (SSN) and diagnosis in the original state to the medical treatment received under the same SSN and diagnosis in the relocation state.

Case profile

Dan is 67 years old with a permanent partial workers' compensation injury for a back injury caused by a workplace fall from a ladder that occurred in 2010. His condition has stabilized but he continues to suffer periodic back pain that is lessened through physical therapy. Dan had been living in a Northern state but relocated to Florida six months ago. Shortly after relocating, Dan started receiving medical treatment for conditions not related to the back injury or the back pain. For those treatments, Dan identified himself as a Medicare beneficiary, the physician submitted the bills to Medicare, and Medicare paid for the treatment.[38]

Financial illustration

Recently, the back pain returned and Dan's physician prescribed a series of x-rays, a two-week course of painkillers, and three weeks of physical therapy. The physician bills Medicare. The Medicare benefits coordinator identifies the treatments for the back pain as related to the 2010 workplace injury, classifies the payments to the physician as conditional payments, and contacts the workers' compensation insurer in 2010 for payment.

---

[38] When a worker relocates, medical care continues to be subject to the regulations in the jurisdiction states, which is usually the state the injured worker resided in. Provisions such as the medical fee schedule for reimbursement, treatment guidelines, and prior authorization do not change with the relocation to a different state.

Broader considerations

Data from the U.S. Census Bureau report (2013, Table 2) indicates that 1% of not-employed persons 65 and over lived in a different county in 2013 than had been their residence in 2012. The 4% assumption takes into account that an individual may move over period of years.[39]

Broader financial impact

For the broader financial impact analysis, we selected injuries that often occur outside the workplace and where there is little likelihood of it being reported as a workplace injury. We assumed that 4% of the Medicare-eligible injured workers would relocate after being injured, case reserves for movers were $10,000 before Section 111, and that on average there could be an additional $5,000 in medical expenses after relocation, and consequently the potential medical losses were $15,000 for injured workers that relocated.[40]

The following points summarize the estimated financial impacts given the assumptions in Table 10.

- The increase in costs for Medicare-eligible beneficiaries who relocated to a different state and had work-related injuries that might have been paid by Medicare prior to Section 111 is 2.2%.
- The increase in costs for all Medicare-eligible beneficiaries is 0.9%.
- The increase in costs across all injured workers is 0.05%.

[39] U.S. Census Bureau (November 2013). Current Population Survey, 2013 Annual Social and Economic Supplement, Table 2.

[40] In a January 2010 NCCI report, for 2000-2006 claims, the average medical payment per claim for injured workers 65 and over was approximately $12,000 (not adjusted for inflation).

Table 9 Case #4: Medicare Beneficiary With a Work-Related Injury Relocates to a Different State

Consideration	Commentary
Profile	67 years old, male, with a permanent partial workers' compensation injury that causes periodic back pain, relocates to a different state. In the new location, the physician initially treats the individual for conditions not related to the back injury, but subsequently the individual needs treatment for back pain that can be attributed to the back injury.
Medicare secondary payer	The workers' compensation insurer will be responsible for the after-relocation medical treatments for the back pain that can be attributed to the back injury.
Section 111 reporting requirements	Given that the claim occurred after Section 111 reporting requirements became effective and that medical payments are greater than $750, this claim should be reported as an ORM.
Significance for a casualty actuary	Prior to the Section 111 reporting requirements, the workers' compensation insurer probably would not have known about the after-relocation medical treatments. Given the closer tracking with the Section 111 reporting requirements, the actuary can expect that CMS will be able to identify these claims but it may be difficult to establish case reserves for claims where an individual relocates. It may be prudent to establish an IBNR reserve that can be used for these types of cases.
Financial illustration	Medical (attributed to the workplace injury): Prior to relocating: $10,000 After relocating: $5,000 Total: Without the after-relocation medical: $10,000 With the after-relocation medical: $15,000
Broader considerations	This case can be extended to other cases where soft-tissue medical conditions (e.g., sprains and strains) are presumed to have been brought on by the aging process but can also be associated with a prior work-related incident. Prior to Section 111, medical providers in the new location may have presumed the soft-tissue condition was age-related. With Section 111 reporting, these medical treatments will be passed back to the workers' compensation insurer.
Broader financial considerations	Potential impacts for Medicare-eligible beneficiaries who relocate to a different state: Increase in costs for all Medicare-eligible beneficiaries: 0.9% Increase in costs across all injured workers: 0.05%

Table 10 Case #4: Medicare Beneficiaries With Work-Related Injuries Relocating to a Different State: Broader Financial Impact

Part A: Development of the Potential Loss Under Section 111 Reporting

Nature of Injury	(1) **# of Claims**	(2) **% of Claims**	(3) **Average Incurred Loss**	(4) **% of Incurred Losses**	(5) **% of Claims Medicare-Eligible**	(6) **% Relocating With Further Medical Treatment**	(7) **# of Medicare-Eligible**	(8) **Pre-Section 111 Case Reserve**	(9) **Potential Loss**
Strain or tear	25,757	25.8%	11,772	28.1%	5.0%	4.0%	52	10,000	15,000
Sprain or tear	12,188	12.2%	10,649	12.0%	5.0%	4.0%	24	10,000	15,000
Contusion	10,043	10.0%	6,430	6.0%	5.0%	4.0%	20	10,000	15,000
Laceration	11,918	11.9%	3,003	3.3%	5.0%	4.0%	24	10,000	15,000
Inflammation	2,705	2.7%	10,525	2.6%	5.0%	4.0%	5	10,000	15,000
Total, selected nature of injury	62,611	62.6%		52.1%			125	1,252,217	1,878,326
Total, all claims	100,000		1,320,595,999		5.0%				
Change in case reserves									626,109

Part B: Potential Losses as a Percentage of Medicare-Eligible and All Workers

Impact	**Change in Case Reserves**	**Total Incurred Losses**	**% Impact on Incurred Losses**
Medicare-eligible with selected natures of injury	626,109	28,091,662	2.2%
All Medicare-eligible		66,029,800	0.9%
All injured workers		1,320,595,999	0.05%

Case #5: Workers' compensation claimant with long-term pharmaceutical prescription needs

Starting considerations

Case #5 concerns a severely injured Medicare beneficiary who is expected to receive painkilling pharmaceutical prescriptions for the remainder of his life. Beginning January 1, 2006, Medicare drug coverage became available to anyone eligible for the Medicare program. Given that the Section 111 reporting requirements will include the identity of the Medicare beneficiary and the diagnosis, CMS will be able to associate payments submitted under Medicare Part D back to a work-related injury.

Case profile

Ken, who is 65 years old, has a work-related permanent total injury that is due to severe nerve damage to his upper and lower extremities. He does not require home healthcare services but will require painkilling pharmaceutical prescriptions for the remainder of his life. The insurer intends to close this claim with a lump sum settlement, which will exceed the TPOC threshold and thus subject it to the Section 111 reporting requirements.

The injured worker elected to purchase the additional coverage under Medicare Part D. The workers' compensation insurer will be responsible for the pain medication associated with the work-related injury but will not be responsible for pharmaceutical prescriptions for other conditions (such as diabetes or hypertension). The workers' compensation insurer can also expect to be responsible for medical treatments associated with the nerve damage to the injured worker's extremities.

Financial illustration

For the financial illustration, we assume there will be a physician visit semiannually, along with magnetic resonance imaging (MRI) and transcutaneous electrical nerve stimulation (TENS) sessions. We also assume weekly pharmaceutical prescriptions, indemnity payments, and a 20-year life expectancy. Prior to the Section 111 reporting requirements, if the pharmaceutical prescriptions were not fully reflected in the case reserves (because the injured worker might have made submissions for payment under Medicare Part D), the actuary would have been working with understated reserves. Under the Section 111 reporting requirements, the tracking system will inform CMS to monitor the pain-medication prescriptions associated with the workplace injury for the life of the injured worker.

Broader considerations

Payments for Part D coverage will be monitored in the same manner as payments for hospital and medical treatments covered by Medicare. For the broader financial impact calculations, we developed a pharmaceutical prescriptions payout pattern and assumed that, prior to Section 111, all prescription payments three or more years after the injury were paid by Medicare. The calculations in Table 12 permit altering the payout pattern and share of the prescriptions paid by Medicare.

Broader financial impact

For the broader financial impact, we began with an ultimate medical payment amount and used medical development factors to develop the medical payment amounts in Part A, column (1) of Table 12 and the incremental medical payments in column (2). We used information on Rx payments by service year to develop the Rx payout shares of medical costs in column (3).[41] The pharmaceutical prescription payments in Part A, column (4) are supported by two recent publications on pharmaceutical prescription payment experience for workers' compensation. First, from a study of 17 large states, the Workers Compensation Research Institute (WCRI) has reported that for claims with an average of 24 months of experience, pharmaceutical prescriptions account for between 1% and 7% of medical costs (where the median state payout was 3%).[42] Second, for accident years 2009 to 2011, NCCI has reported that pharmaceutical prescriptions account for 18% to 19% of total medical costs, which compares to the 17% share in the calculations in Part A (1,256 / 7,430 = 0.17).[43]

We assumed that, prior to the Section 111 reporting, the workers' compensation insurer paid for all pharmaceutical prescriptions through three years after the injury and for 70% of the prescriptions more than three years after the injury, and that Medicare paid for 30% of the pharmaceutical prescriptions more than three years after the injury. The 70% paid by the insurer can be attributed to lump sum arrangements (including Medicare Set-Aside Arrangements) that included amounts for long-term pharmaceutical prescriptions and claims where the insurer continued to make payments for prescriptions more than three years after the injury. The 30% paid by Medicare can be for workers' compensation claimants 65 and over who, more than three years after the injury, were receiving reimbursements from Medicare.

The following points summarize the estimated financial impacts given the assumptions in Table 12.

- The increase in costs for all Medicare-eligible beneficiaries is 5.7%
- The increase in costs across all injured workers is 0.3%

---

[41] NCCI, September 2013, Exhibits 2-3.
[42] WCRI, July 2011, Table L1.
[43] NCCI, September 2013, Exhibit 1.

Table 11 Case #5: Workers' Compensation Claimant With Long-Term Pharmaceutical Prescription Needs

Consideration	Commentary
Profile	65 years old, male, with a permanent total workers' compensation injury that does not require home health aide but will require pain medication for the remainder of his life. (Disability is severe nerve damage to the individual's upper and lower extremities.)
Medicare secondary payer	As with hospital and medical treatments covered by Parts A and B under Medicare, pharmaceutical prescriptions covered by Part D are secondary to workers' compensation coverage.
Section 111 reporting requirements	The insurer intends to settle the claim and, because the amount is expected to be greater than the TPOC threshold, the insurer will be required to report the claims under Section 111 reporting requirements.
Significance for a casualty actuary	After the initial years following an injury, payments for pharmaceutical prescriptions account for a considerable amount of medical payments. Prior to Section 111, over time the pain medication needs for the injury might have been included in the individual's other medications (e.g., for diabetes, hypertension) and inadvertently paid for by Medicare. Based on historical experience, case reserves might have only provided for only a few years of prescriptions.
Financial illustration	Medical: ▪ Semiannually: 1 physical visit, 1 MRI treatment, 1 TENS treatment ▪ Weekly: pharmaceutical products ($150/week x 52 weeks = $7,800 annually) ▪ Total: $279,600 over 20 years ($13,980 annually) Disability: $520,000 over 20 years ($500 per week) Total settlement: $799,600
Broader considerations	Payments for Part D coverage will be monitored in the same manner as payments for hospital and medical treatments covered by Medicare. The broader considerations concern all claims with pharmaceutical prescriptions, regardless of the injured body part or nature of injury. The impacts are likely to concern the timing of prescription payments from the date of injury.
Broader financial considerations	Potential impacts for Medicare-eligible beneficiaries with long-term pharmaceutical prescription needs: • Increase in costs for all Medicare-eligible beneficiaries: 5.7% • Increase in costs across all injured workers: 0.3%

Table 12 Case #5: Workers' Compensation Claimants With Long-Term Pharmaceutical Prescription Needs: Broader Financial Impact

Part A: Development of Prescription Payments by Service Year

Service Year	(1) Medical Costs	(2) Incremental Medical Costs	(3) Rx as a Share of Incremental Medical Costs	(4) Rx Amount
1	2,283	2,283	3%	68
2	4,283	2,000	5%	100
3	4,917	634	10%	63
4	5,241	325	16%	52
5	5,446	204	22%	45
6	5,598	152	29%	44
7	5,716	118	34%	40
8	5,818	103	36%	37
ultimate	7,430	1,612	50%	806
Total				1,256

Part B: Development of the Potential Loss Under Section 111 Reporting

Type of Claim	(1) # of Claims	(2) Total Ultimate	(3) Medical Ultimate	(4) Rx Ultimate	(5) Rx Through 3 Years plus 70% of Rx After 3 Years	(6) % of Claims Medicare-Eligible	(7) # of Medicare-Eligible	(8) Pre-Section 111 Rx	(9) Potential Loss
All claims	100,000	12,678	7,431	1,256	539	5%	5,000	2,695,000	6,279,214
Change in reserves									3,584,214

Part C: Potential Losses as a Percentage of Medicare-Eligible and All Workers

Impact	Change in Case Reserves	Total Incurred Losses	% Impact on Incurred Losses
All Medicare-eligible	3,584,214	63,390,000	5.7%
All injured workers		1,267,800,000	0.3%

Case #6: Workers' compensation claimant receiving SSDI with a shortened life expectancy

Starting considerations

In some cases, the injured worker or claimant need not be 65 in order to be a Medicare beneficiary. People younger than 65 with certain disabilities or kidney failure can also apply for Medicare. Moreover, for purposes of determining future medical cost estimates, the life expectancy of the individual is taken into consideration.

Case profile

Ron, who is 45 years old, suffered an extensive third-degree burn in an industrial accident that has significantly shortened his life expectancy and he will require hospice care. He has applied for and expects approval for SSDI for at least 24 months; however, SSDI is a secondary payer to the workers' compensation coverage. If he is approved and becomes a Medicare beneficiary, the primary payer will need to report this claim to CMS under Section 111 reporting requirements.

The injured worker and the workers' compensation insurer have reached a settlement agreement that includes an amount expected to cover future medical costs and disability payments. However, Medicare may reject the settlement because there is no provision for hospice care, and Medicare pays for certain types of hospice care.

Financial illustration

Assuming that all past surgeries have been paid for by the primary payer (e.g., surgical skin grafts, etc.) and that the injured worker is now in "medical maintenance" mode, the future medical projections should include all Medicare-eligible medical treatment costs, including covered hospice care. The age of the claimant should be adjusted to reflect a reduced life expectancy.

Broader considerations

It is not uncommon for casualty insurance professionals to think of Medicare as benefits for the elderly. However, it is important to be familiar with the eligibility requirements with respect to end-stage renal disease and particularly with respect to SSDI as they can also trigger Medicare and in turn the Section 111 reporting requirements. When settling the future medical aspects of a claim, the life expectancy of the claimant should be taken into account if preparing a life care plan. Remember to include all components of future care that are covered by Medicare, including hospice care.

Broader financial impact

For the broader financial impact, we started with causes of injury that may be associated with injured workers who also are receiving or may apply for SSDI. We assumed that 2% of these workers are eligible for SSDI and that 10% of the workers eligible for SSDI filed a workers' compensation claim.

The following points summarize the estimated financial impacts given the assumptions in Table 14.

- The increase in costs for all Medicare-eligible beneficiaries is 2.9%.
- The increase in costs across all injured workers is 0.1%.

Table 13 Case #6: Workers' Compensation Claimant Receiving SSDI With a Shortened Life Expectancy

Consideration	Commentary
Profile	45 years old, male, with a permanent total injury that is due to a third-degree burn that will require recurring monitoring and hospice care. Given the severity of the injury, the injured worker applied for and is eligible for SSDI payments.
Medicare secondary payer	Workers' compensation insurer will be responsible for the initial treatments and potential complications. Also, the workers' compensation insurer may be responsible for the hospice care.
Section 111 reporting requirements	Because the settlement is for a one-time payment, the Section 111 reporting requirements for TPOC apply. The one-time payment exceeds the threshold, and consequently the workers' compensation insurer will be required to report. However, as indicated above, CMS may not accept the proposed settlement because it is perceived to be inadequate.
Significance for a casualty actuary	Although a typical case reserving workup may be performed for this case, attention will need to be given to the possibility that the workers' compensation insurer will be responsible for the hospice care.
Financial illustration	Medical: Without complications, $1,617,000. ▪ Five potential complications: – Disfigurement, scarring: $28,000 - $35,000 – Psychological: $16,000 - $75,000 – Fragile skin or skin breakdown: $38,000 - $107,000 – Infections, including pneumonia or organ failure: $58,000 - $120,000 – Delayed wound healing or skin graft failure: $37,000 - $110,000 – Total: $1,929,000 (without complications) Disability: $650,000 over 25 years ($500 per week) Total estimated losses: $2,267,000 (which is challenged by Medicare for not providing for hospice care)
Broader considerations	It is important to be familiar with the eligibility requirements with respect to end-stage renal disease and particularly with respect to SSDI as they can also trigger Medicare and in turn the Section 111 reporting requirements. When settling the future medical aspects of a claim, the life expectancy of the claimant should be taken into account if preparing a life care plan, including hospice care.
Broader financial considerations	Potential impacts to consider: • Frequency of workers' compensation claims with SSDI • Life expectancy for workers' compensation claims with SSDI

Table 14 Case #6: Workers' Compensation Claimant Receiving SSDI With a Shortened Life Expectancy

Part A: Development of the Potential Loss Under Section 111 Reporting

Cause of Injury	(1) # of Claims	(2) % of Claims	(3) Average Incurred Loss	(4) % of Incurred Losses	(5) % of Workers SSDI-Eligible	(6) % of SSDI-Eligible With WC Claim	(7) # of Medicare-Eligible	(8) Pre-Section 111 Case Reserve	(9) Potential Loss
Burn or Scald - Electrical Current	126	0.1%	11,194	0.1%	2.0%	10.0%	0.3	100,000	225,000
Burn or Scald - Fire or Flame, Hot Objects, Radiation	773	0.8%	5,946	0.3%	2.0%	10.0%	1.5	100,000	225,000
Caught In - Machine or Machinery	723	0.7%	20,200	1.1%	2.0%	10.0%	1.4	100,000	225,000
Fall - From Ladder or Scaffolding	1,252	1.3%	32,187	3.1%	2.0%	10.0%	2.5	100,000	225,000
Struck or Injured By - Moving Parts of Machine	219	0.2%	12,477	0.2%	2.0%	10.0%	0.4	100,000	225,000
Total, selected cause of injury	3,093	3.1%		4.8%			6.2	618,533	1,391,699
Total, all claims	100,000		1,319,772,191		2.0%				
Change in case reserves									773,166

Part B: Potential Losses as a Percentage of Medicare-Eligible and All Workers

Impact	Change in Case Reserves	Total Incurred Losses	% Impact on Incurred Losses
Medicare-eligible with selected causes of injury	773,166	1,272,737	60.7%
All Medicare-eligible		26,395,444	2.9%
All injured workers		1,319,772,191	0.1%

Case #7: Passenger in automobile accident covered by driver's no-fault automobile coverage

On March 1, 2014, Nancy, who is 65, was a passenger in her daughter's vehicle when they were involved in an accident in which Nancy's daughter was driving the vehicle. Nancy's injuries required emergency room medical treatment at a local hospital. The daughter has personal injury protection/medical payments (Med Pay) coverage as part of her automobile insurance. The hospital bill for Nancy was $1,500, of which $900 was covered by the no-fault automobile insurance policy. Although there is ongoing medical and the TPOC threshold for automobile liability insurance was $2,000 at the time of the accident, Nancy's automobile insurer is required to report this claim under Section 111 because there is no threshold for TPOC claims for no-fault coverages.

Table 15 Case #7: Passenger in Automobile Accident Covered by Driver's No-Fault Automobile Coverage

Consideration	Commentary
Profile	Nancy, who is 65, was injured in an accident on March 1, 2014 while a passenger in her daughter's car, which the daughter was driving. Nancy's injuries required emergency room medical treatment at a local hospital. The daughter has personal injury protection/medical payments (Med Pay) coverage as part of her automobile insurance.
Medicare secondary payer	While at the hospital emergency room, the mother is asked about available coverage related to the accident and tells the hospital that her daughter has Med Pay coverage. Because this coverage pays regardless of fault, it is considered no-fault insurance. The hospital bills the no-fault insurance for the emergency room services, and only bills Medicare if any Medicare-covered services are not paid for by the no-fault insurance.
Section 111 reporting requirements	Because this was no-fault coverage, the daughter's automobile insurer is required to report the claim under the no-threshold provision for TPOC claims of Section 111. For claims occurring between October 1, 2013, and October 1, 2014, the TPOC threshold is $2,000 for liability and workers' compensation claims. However, there is no threshold for payments covered by no-fault insurance.
Significance for a casualty actuary	Assuming there are no further complications to the mother, there are no ultimate loss implications.
Financial illustration	The hospital bill was for $1,500, of which $900 was covered by the automobile insurer.

Case #8: Medicare makes conditional payments for a 67-year-old automobile accident claimant

Joan is 67 years old and is driving her car when someone in another car hits her. Joan is taken to the hospital for treatment.[44] The hospital tries to bill the other driver's liability insurer for $30,000 but the insurer disputes liability and does not pay the claim. Medicare makes a conditional payment of $20,000.

The claim is settled with the other driver's liability insurer for $200,000. Joan, her attorney, and the liability insurer will be responsible for making sure that Medicare receives the $20,000 conditional payment made to the hospital.

[44] This case was developed from an example in Centers for Medicare and Medicaid Services (April 2014), Medicare & Other Health Benefits: Your Guide to Who Pays First, p. 18.

Table 16 Case #8: Medicare Makes Conditional Payment for a 67-year-old Automobile Accident Claimant

Consideration	Commentary
Profile	Joan is driving her car when someone in another car hits her and she has to go to the hospital.
Medicare secondary payer	The hospital tries to bill the other driver's liability insurer but the insurance company disputes liability and does not pay the claim right away. The hospital bills Medicare $30,000, and Medicare makes a conditional payment to the hospital of $20,000 for healthcare services received by Joan.
Section 111 reporting requirements	Prior to Section 111, the $20,000 paid by Medicare had a decent chance of not being repaid by the liability insurer because CMS would not have known there was an insurance settlement. With Section 111 reporting requirements in effect, the liability insurer is required to report the settlement. CMS will track the claim and identify that a conditional payment was made and demand repayment.
Significance for a casualty actuary	If all of the $20,000 that CMS paid was related to the accident, then the entire $20,000 needs to be paid back to Medicare. If some of the $20,000 was for treatment unrelated to the accident, then only the part related to the accident gets paid back. The insurer should set up a reserve for this claim when the insurer knew about the exposure. The insurer should expect to be responsible for the conditional payment and the additional amounts related to the accident.
Financial illustration	The claim is settled for $200,000, of which $20,000 will need to be paid to Medicare for the conditional payment made for medical treatment in the hospital. Joan, her attorney, and the liability insurer will be responsible for making sure that Medicare receives its money for the conditional payment.

Case #9: Automobile accident claimant with a traumatic brain injury that aggravated an existing Alzheimer condition

Kate is 70 years old and suffered a traumatic brain injury caused by an automobile accident. Kate was receiving medical care for the early stages of Alzheimer prior to the accident. Since the accident, Kate's Alzheimer condition has accelerated and she will require home health care in the near future.

As the liable party, the automobile insurer will be responsible for the hospitalization and medical treatments directly related to the automobile accident. Medicare should pay for the medical treatments related to the Alzheimer condition but does not cover all types of home healthcare services. Medicare covers services such as intermittent skilled nursing care and physical therapy but does not cover 24-hour-a-day care or meals delivered to the home.[45] Given the uncertainties concerning the apportionment for the acceleration of the Alzheimer condition, the insurer may need to establish a case reserve or increase IBNR reserves.

[45] Centers for Medicare and Medicaid Services, Your Medicare Coverage.

Table 17 Case #9: Automobile Accident Claimant With a Traumatic Brain Injury That Aggravated an Existing Alzheimer Condition

Consideration	**Commentary**
Profile	70 years old, female, with a traumatic brain injury (TBI) caused by an automobile accident. Prior to the accident she was receiving medical care for the early stages of Alzheimer, paid for by Medicare. The TBI from the automobile accident accelerated the Alzheimer condition and the woman will require home health care in the near future.
Medicare secondary payer	As the liable party, the automobile insurer will be responsible for the hospitalization and medical treatments directly related to the automobile accident. Medicare should pay for the medical treatments related to the Alzheimer condition but does not cover all types of home healthcare services.
Section 111 reporting requirements	Given the uncertainty with a settlement, this claim will be reported under Section 111 as an ORM. If there is a settlement, the claim will become a TPOC.
Significance for a casualty actuary	Given the uncertainties concerning the apportionment for the acceleration of the Alzheimer condition, a case reserve or an increase in IBNR reserves may be needed.
Financial illustration	Medical: • Hospitalization and medical treatments that are due to the accident: $70,000 • Home healthcare: $15,000 per year • Medical treatments related to the Alzheimer condition: $12,000 per year

Case #10: Medicare beneficiary injured on neighbor's property

Mary, who is 72 years old, falls and twists her ankle while visiting a neighbor's yard sale. Mary goes to her primary care provider, who has a series of x-rays performed, prescribes a two-week course of painkillers, and then refers Mary to a physical therapist. The primary care provider, radiology laboratory, and physical therapist submit the medical bills to the neighbor's homeowner insurer, which pays for the treatments. Mary submits her pharmaceutical prescriptions to Medicare for payment under Part D coverage.

The medical bills for the primary care provider, radiology laboratory, and physical therapy are $950, and consequently the homeowner insurer will need to report the claim to CMS because the payment exceeds the ORM threshold. Furthermore, with the information reported to CMS, the agency will be able to associate Mary's pharmaceutical prescriptions with the treatments paid to the medical providers. CMS will consider the payment for the prescriptions to be a conditional payment and pursue the homeowner insurer for reimbursement.

Table 18 Case #10: Medicare Beneficiary Injured on Neighbor's Property

Consideration	**Commentary**
Profile	72 years old, female, twists her ankle while on her neighbor's property. The injury requires medical attention, radiology tests, pain medication, and physical therapy.
Medicare secondary payer	The neighbor's homeowner insurance policy covers medical expenses for individuals injured on the neighbor's property.
Section 111 reporting requirements	The claim must be reported under Section 111 because, as an ORM claim, the total medical payments are greater than $750.
Significance for a casualty actuary	Prior to Section 111, it is likely that the homeowner's insurer would not have known about the payment for the pharmaceutical prescriptions With the reporting under Section 111, CMS will consider this payment to be a conditional payment and pursue the homeowner's insurer for reimbursement.
Financial illustration	Medical: ▪ Primary care provider: $350 ▪ Radiology tests: $300 ▪ Prescription painkillers: $175 ▪ Physical therapy: $300 Disability: $0 Total estimated costs: $1,025

C. Summary

For the six workers' compensation illustrations above, we presented a template for estimating the impact of the Section 111 reporting requirements on losses where Medicare has been making payments and has not been reimbursed by the property-casualty insurer or self-insured. While the case illustrations are not exhaustive, the cases captured situations that should produce the largest impacts on losses. The cases include medical conditions with unusually adverse experience after age 65, the tail for pharmaceutical prescription costs, and cases where a Medicare beneficiary relocated to a different state. Nevertheless, the present set of cases does not exhaust all possibilities, and consequently the total impacts of Section 111 are likely to be greater than the sum of the broader financial impacts in the case illustrations.

Table 19 presents the estimated impacts on losses for the six scenarios. For example, for joint replacements (Case Number 1), we estimated that approximately 15% of all Medicare beneficiaries incur a knee, shoulder, ankle, or hip injury that could lead to a joint replacement and injuries to these four body parts account for approximately 20% of all incurred losses for claims from Medicare beneficiaries.[46] For the small number of such injuries that result in a joint replacement, we estimated that CMS's ability to associate the joint replacement back to a primary payer could increase losses for injured workers 65 and over with a knee, shoulder, ankle, or hip injury by approximately 18.8%, by approximately 3.8% for all workers 65 and over, and by approximately 0.2% for workers of all ages.[47] Depending on the condition or type of injury addressed by the case illustration, we estimated the impact to be an increase of total losses between 0.9% and 5.7% for workers 65 and over, which translated into increases of 0.1% to 0.3% for all workers of all ages. These scenarios assume Medicare has been making payments and has not been reimbursed by the insurer or self-insured.

The total impacts of Section 111 could be greater than the sum of the broader financial impacts in the case illustrations. First, the present set of cases does not exhaust all possibilities and the estimated impacts are very sensitive to the underlying assumptions, particularly the assumptions concerning the covered conditions, percentage of Medicare-eligible claimants, and the case reserves prior to and after the Section 111 reporting requirements. Also, the primary purpose of the case illustrations and broader financial impact discussions was to present a set of cases with special circumstances that might come up under Section 111 and a template for evaluating the potential impacts on Medicare-eligible and all injured-worker losses. Finally, the case illustrations focused on

[46] The share of and average costs of knee, shoulder, ankle, and hip injuries were from unit statistical plan data.

[47] The presumption here (as with the other estimated impacts) is that prior to Section 111 CMS paid for the medical services and did not receive reimbursement from the primary payer. This presumption is because CMS did not have the tracking system for medical payments (and particularly for diagnoses) that was created to support the reporting requirements in Section 111.

situations where the insurer or self-insurer was not likely to be aware of the medical treatment. There will be situations where medical treatment was known but payment was made under Medicare and CMS did not have the means to identify the primary payer.

Table 19 Summary of Broader Financial Impacts From Case Illustrations for Workers' Compensation

Case Number	Type of Injury/Condition	% of Medicare-Eligible Claims	% of Incurred Losses for Medicare-Eligible Claims (prior to Section 111)	Impact on Incurred Losses for - Medicare-Eligible With Condition/Type of Injury	All Medicare-Eligible	All Workers
1	Knee, shoulder, ankle, hip injury leading to a Joint replacement	14.6%	20.4%	18.8%	3.8%	0.2%
2	Long latency	5.1%	1.8%	115.2%	2.1%	0.1%
3	Lung cancer	3.6%	6.3%	81.0%	5.1%	0.3%
4	Medicare beneficiary relocates	62.6%	52.1%	2.2%	0.9%	0.05%
5	Pharmaceutical	100.0%	9.9%	N/A	5.7%	0.3%
6	SSDI	3.1%	4.8%	60.7%	2.9%	0.1%

VI. ESTIMATES FOR AGGREGATE IMPACTS ON LOSSES

A. Background

In the two preceding sections, we looked into specific issues and situations where the Section 111 reporting requirements might have an impact on an insurer's or self-insured's costs. The industry experts indicated that Section 111 could decrease the use of lump sum settlements, increase the time to reach a lump sum settlement, and increase the size of settlements (partially due to the Medicare Set-Aside Arrangements). With the case illustrations, we described ten situations likely to increase the liabilities for an insurer or self-insured. The results for the six workers' compensation cases for which we developed estimated impacts are summarized in Table 19. Assuming these cases are generally mutually exclusive, the summed impact would be an approximately 21% increase in total losses (medical and indemnity) for Medicare-eligible workers, which could translate into a 37% increase in incurred medical losses.

These results were background for aggregate estimates we developed for workers' compensation for a hypothetical insurer or self-insured. We present in this section a base case where there is no change in prior settlement practices. We started with claims classified as medical-only, lost-time with no lump sum, and lost-time with lump sum. For each claim type, we developed assumptions for low, moderate, and high impacts on average medical losses. For the medical-only claims, we assumed increases of 5%, 10%, and 15% for average medical losses. For lost-time claims with no lump sum, we assumed increases of 10%, 15%, and 20%, and for lost-time claims with lump sum we assumed increases of 15%, 25%, and 40%.

We developed a second set of aggregate estimates assuming a 50% decrease in the incidence of lump sum claims – that is, we assumed that some claims that might have settled as low or medium range lump sums would stay open as lost-time claims with no lump sum. We also assumed a larger impact on the incurred medical losses. For lost-time claims with no lump sum, we assumed low, moderate, and high impact increases of 15%, 20%, and 25%, respectively. For lost-time claims with lump sum, we assumed increases of 25%, 40%, and 50%.

In this section, we describe related research and the underlying assumptions using information on the population, labor market, and loss experience for the workers' compensation and automobile lines.

B. Future Exposure Considerations: Population and Employment Trends

For the present discussion, the bulge of the Baby Boom that followed World War II is important because it creates increasing shares of individuals 65 and over in the population and among employed persons, and this could increase payments in Medicare Secondary Payer (MSP) situations.

An increase in the number of persons 65 and over could increase the number of automobile and liability insurance claimants in this age group. Further, while workers 65 and over are considered to account for only 5% of all workers' compensation losses in Accident Year 2013, this share could increase as relatively more workers enter the 65 and over group. On a calendar year basis, this percentage will also increase as workers who were injured at earlier ages reach age 65.

Table 20 presents the population totals for all ages and persons 65 and over for 1965 through 2050. While persons 65 and over accounted for approximately 10% of the U.S. population when Medicare was enacted, this age group accounted for 13% of the U.S. population in 2010 and is projected to increase to 16% of the U.S. population by the end of this decade. The significance of these trends is that larger shares of automobile claims and claims for other liability coverages are likely to involve MSP situations.

Table 20 Number of Persons, All Ages and 65 and Over: 1965-2050

	(1)	(2)	(3)	(4)	(5)
	U.S. Population				
	All Ages		**65 and Over**		
Year	**# of Persons**	**Change From Prior Period**	**# of Persons**	**Change From Prior Period**	**% of All Ages**
1965	191.3	---	18.3	---	10%
1970	203.2	6%	20.1	10%	10%
1980	226.5	11%	25.5	27%	11%
1990	248.7	10%	31.2	22%	13%
2000	281.4	13%	35.0	12%	12%
2010	310.2	10%	40.2	15%	13%
2020	341.4	10%	54.8	36%	16%
2030	373.5	9%	72.1	32%	19%
2040	405.7	9%	81.2	13%	20%
2050	439.0	8%	88.5	9%	20%

Note: Number of persons in millions.
Source: U.S. Census Bureau.

Table 21 presents the number of employed persons 16 and over and 65 and over for 1965 through 2014. Since Medicare was enacted, the number of employed persons 65 and over has more than doubled—from 3.0 million in 1965 to 8.0 million in 2014, with most of this increase occurring in the last decade. When Medicare was enacted, 4.2% of employed persons were 65 and over, and this share remained below 4% until the middle of the last decade. As of 2010, the share of employed persons 65 and over increased to 4.5%, and has increased in each of the past four years. In 2014, 5.4% of U.S. employment was 65 and over.

Table 21 Number of Employed Persons, 16 and Over and 65 and Over: 1965-2014

	(1)	(2)	(3)	(4)	(5)	(6)
	Employment					
	16 and over		**65 and over**			
Year	**# Employed**	**Change From Prior Period**	**# Employed**	**Change From Prior Period**	**% of 16 and Over Employment**	**Employment-Population Ratio**
1965	71.1		3.0		4.2%	16.4
1970	78.7	11%	3.1	4%	4.0%	15.5
1980	99.3	26%	3.0	-5%	3.0%	11.6
1990	118.9	20%	3.4	14%	2.8%	10.8
2000	136.9	15%	4.2	24%	3.1%	11.9
2010	139.1	2%	6.3	50%	4.5%	15.6
2011	139.9	1%	6.6	6%	4.8%	----
2012	142.5	2%	7.2	9%	5.1%	----
2013	143.9	1%	7.7	6%	5.3%	----
2014	146.3	2%	8.0	4%	5.4%	----

Note: Number of persons in millions.
Source: U.S. Bureau of Labor Statistics.

C. Comorbidities and the Reporting of Diagnoses Under Section 111

Comorbidities, such as obesity, hypertension, and diabetes, can add significant costs to work-related injuries. In a study using a nationwide sample of medical payment transactions, NCCI reported that the share of workers' compensation claims with a comorbidity diagnosis nearly tripled between Accident Year 2000 and Accident Year 2009 (from 2.4% to 6.6%).[48] This study also reported that injured workers with a comorbidity diagnosis are typically older than other injured workers and the initial comorbidity diagnosis tends to occur early in the life of a claim. Finally, injured workers with a comorbidity diagnosis have about twice the medical costs of otherwise comparable claims. In a recent study of claims in California with dates of injury between January 2002 and September 2013, CWCI found that the obesity comorbidity was among the top 10 factors causing the increase in medical costs since the second quarter of 2007.[49]

Diagnoses not related to the work-related injury may have implications on a workers' compensation payer's liabilities under the Section 111 reporting requirements. In the preceding section on case illustrations, we described situations where the present work-related injury may have future medical expenses that may have gone undetected prior to Section 111 reporting requirements.

[48] NCCI 2012.
[49] CWCI 2014.

However, Section 111 may also have implications associated with the scope of diagnoses reported by the workers' compensation payer. If the scope of reported diagnoses extends beyond the diagnoses specific to the work-related injury, CMS may consider the payer responsible for the future medical treatments for all reported diagnoses.

In a study of the potential impacts of Section 111 reporting, CWCI arranged diagnoses for a work-related injury into three groups according to the appropriateness of the diagnosis for the nature of the injury: appropriate, unacceptable, and potentially inappropriate.[50] "Appropriate" diagnoses included diagnoses that pertained to the primary diagnosis and that Medicare would reimburse. "Unacceptable" diagnoses were diagnoses that Medicare would not reimburse.[51] "Potentially inappropriate" diagnoses were diagnoses not directly related to the primary diagnosis.[52] For example, in one situation, CWCI described how treatment for a back injury included treatment for a hypothyroid condition (ICD-9 244.9) and a stress disorder (ICD-9 308.0).

The illustrations in the CWCI study were intended to point out that a payer reporting unacceptable or potentially inappropriate diagnoses under the Section 111 reporting process may become liable for the future medical services for these diagnoses because CMS will associate the medical treatments back to the work-related injury. In the preceding example, although the workers' compensation payer was reporting for a low back injury, CMS will not consider the unacceptable diagnoses covered by Medicare and will associate the potentially inappropriate diagnoses as treatment for the work-related injury.

To test the potential impact, CWCI reviewed the ICD-9 diagnoses and medical payments for 50 randomly selected indemnity claims. CWCI found that on average 44.3% of the medical paid amounts were for medical treatments outside the appropriate diagnosis (that is, for unacceptable or potentially inappropriate diagnoses). For 7 of the 50 cases, 75% of the medical payments were for unacceptable or potentially inappropriate diagnoses.

D. Workers' Compensation

1. Estimated Impact: Base Case

Table 22 presents the assumptions and results for the base case, which is the scenario where there is no change in the frequency of settlements. The following points describe the assumptions and calculations.

[50] Swedlow 2011.

[51] Medicare will not reimburse for certain non-specified diagnoses, such as ICD-9 959 (Injury Other and Unspecified).

[52] CWCI used MSP clinical grouper software to identify the "potentially inappropriate" diagnoses.

- **Share of estimated medical losses for injured workers 65 and over:** Reports from the U.S. Bureau of Labor Statistics indicate that workers 65 and over account for approximately 3.5% of all workplace injuries and illnesses and the number of lost workdays is greater than for workers under 65. Taken together, we calculated that workers 65 and over accounted for approximately 5% of medical losses.[53]
- **Distribution of claims by claim type:** We are assuming that all claims for injured workers 65 and over are either claims that can be considered as ongoing responsibility for medicals (ORM) claims by CMS (generally, open claims or claims closed without a one-time payment) or TPOC claims (claims with a one-time or lump sum settlement, judgment, award, or other payment intended to resolve or partially resolve a claim). We assumed an 80/20 medical-only/indemnity distribution of claims, and that one-half of the medical-only claims would fall below the reporting threshold for ongoing responsibility for medicals.[54] We also assumed that 20% of indemnity claims were resolved with a lump sum settlement.[55]
- **Average incurred medical:** The average incurred for medical-only claims is based on removing low-cost medical-only claims.[56] The average medical incurred for lost-time claims with no lump sum was derived using an average medical for all indemnity claims, assuming medical losses of $40,000 for lump sum settlements per the California Workers' Compensation Institute (CWCI) study on submitted MSAs, and the assumption that 20% of lost-time claims were resolved with a lump sum settlement.[57] [58] The average incurred medical for all types of claims is the weighted average of the distribution of claims by claim type and the average incurred medical amounts for the ORM and TPOC claims.
- **Estimated impact, ORMs/TPOC:** We assumed a percentage change in medical losses for low-, moderate-, and high-impact scenarios. The first percentage is the assumed impact on the average costs of medical-only ORM claims, the second is the assumed impact on lost-

[53] Although we used 5% for the share of losses for workers 65 and over, it would also be reasonable to use a slightly higher share. According to the NCCI, average severity is higher for workers 65 and over. Also, in a series of studies for eight states, WCRI reported that injured workers 65 and over accounted for 4% to 5% of workers with seven or more days of lost work time (WCRI 2014).

[54] The 80/20 distribution is based on information from National Council on Compensation Insurance, 2013, Exhibit 12, and Workers' Compensation Research Institute, October 2013, Table 2.

[55] In a study of 11 large states, WCRI found the median experience was for 21.6% of claims with more than seven days of lost work time to be resolved with a lump sum settlement. Workers Compensation Research Institute, October 2013, Table 2.

[56] Claims with less than $750 in medical payments are not reportable under Section 111.

[57] For the CWCI study, see Swedlow 2011.

[58] The starting average medical for all indemnity claims was $26,575 (NCCI, Annual Statistical Bulletin, 2013). In Table 22, the weighted average for the lost-time claims without and with lump sum is $26,659.

time ORM claims that have resolved as a lump sum, and the third is the impact on lump sum TPOC claims. The dollar amounts are the product of the assumed impact multiplied by the average incurred medical.

- **Estimated impact as a percent of total estimated medical losses, 65 and over:** The percentages are the estimated impacts of ORMs/TPOC divided by the average incurred medical.
- **Estimated impact as a percent of total estimated medical losses, all injured workers:** The percentages are the estimated impacts of ORMs/TPOC multiplied by the percentage of workers 65 and over.

The results indicate an increase in medical payments of between 10.9% to 25.1% for injured workers 65 and over, and an increase between 0.5% and 1.3% for all workers (that is, when the increase for injured workers 65 and over is related to all injured workers). Recent countrywide workers' compensation experience indicates that medical payments are 57% total workers' compensation losses, and consequently, the estimates are for an increase in total losses of 6.2% to 14.3% for injured workers 65 and over, and an increase between 0.3% and 0.7% when the increase in medical payments for these workers is related to all workers.[59]

[59] Medical payments as a percent of workers' compensation losses are from NCCI Annual Statistical Bulletin 2013.

Table 22 Estimated Impact of Section 111 Reporting Requirements: Workers' Compensation Losses, Base Case

Number	Consideration	Ongoing Responsibility for Medicals		Total Payment Obligation to the Claimant (TPOC)	
		Large Medical-Only Claims (ORM-MO)	Lost-Time Claims Without Lump Sum (ORM-LT)	Lump Sum	All Types of Losses
1	Share of estimated medical losses for injured workers 65 and over	5%	5%	5%	5%
2	Distribution of claims (excluding small medical-only claims)	66%	27%	7%	100%
3	Average incurred medical	$1,500	$23,200	$40,000	$10,054
4	Estimated impact on average incurred medical: ORM-MO / ORM-LT / TPOC				
	Low: 5% / 10% / 15%	$75	$2,320	$6,000	$1,096
	Moderate: 10% / 15% / 25%	150	3,480	10,000	1,739
	High: 15% / 20% / 40%	225	4,640	16,000	2,521
5	Estimated impact as a percent of total estimated medical losses, 65 and over				
	Low				10.9%
	Moderate				17.3%
	High				25.1%
6	Estimated impact as a percent of total estimated medical losses, all injured workers				
	Low				0.5%
	Moderate				0.9%
	High				1.3%

Sources: U.S. Bureau of Labor Statistics; WCRI; Milliman analysis.

2. Estimated Impact with a Decrease in One-Time Payments to Claimants (Settlements)

The time needed to get an MSA approved by CMS and the prospect that approved MSAs may be higher than amounts acceptable to insurers and self-insureds may cause a decrease in the frequency of lump sum settlements for workers 65 and over. To test the impact of a reduced frequency of lump sum settlements, we assumed that one-half of the lump sum claims would be lost-time claims without a lump sum (that is, shift from TPOC claims to ORM claims). This shift is reflected in (2) in Table 23. We also assumed that the average incurred medical would be 25% higher for the claims that resolved as lump sum settlements and that the average incurred medical for the lost-time claims without lump sum increases to reflect the inclusion of the shifted lump sum claims.[60] These adjustments to the average incurred medicals are shown in (3) in Table 23. Finally, we also increased the low, moderate, and high estimated impacts in (4) for the lost-time claims.[61]

Using the same calculation steps as for the base case, the results for the shift in lump sum claims and higher estimated impacts are shown in (5) and (6) in Table 23. The results are similar to the base case. The results indicate an increase in medical payments of between 15.8% to 28.4% for injured workers 65 and over, and an increase between 0.8% to 1.4% for all workers. Again assuming that medical payments are 57% of total workers' compensation losses, the estimates are for an increase in total losses of 9.0% to 16.2% for injured workers 65 and over, and an increase between 0.4% and 0.8% when the increase in medical payments is related to all workers.

[60] These adjustments were performed so that the starting average incurred medical losses were approximately the same for the base case ($10,054 in Table 22) and the alternative case ($10,060 in Table 23).

[61] These assumptions were developed from discussions with actuaries, claim consultants, and other property-casualty insurance industry practitioners.

Table 23 Estimated Impact of Section 111 Reporting Requirements: Workers' Compensation Losses, With Decrease in One-Time Payments (settlements)

Number	Consideration	Ongoing Responsibility for Medicals		Total Payment Obligation to the Claimant (TPOC)	All Types of Losses
		Large Medical-Only Claims (ORM-MO)	Lost-Time Claims Without Lump Sum (ORM-LT)	Lump Sum	
1	Share of estimated medical losses for injured workers 65 and over	5%	5%	5%	5%
2	Distribution of claims (excluding small medical-only claims)	66%	30.5%	3.5%	100%
3	Average incurred medical	$1,500	$24,000	$50,000	$10,060
4	Estimated impact on average incurred medical: ORM-MO / ORM-LT / TPOC Low: 5% / 15% / 25% Moderate: 10% / 20% / 40% High: 15% / 25% / 50%	 $ 75 150 225	 $3,600 4,800 6,000	 $12,500 20,000 25,000	 $1,585 2,263 2,854
5	Estimated impact as a percent of total estimated medical losses, 65 and over Low Moderate High				 15.8% 22.5% 28.4%
6	Estimated impact as a percent of total estimated medical losses, all injured workers Low Moderate High				 0.8% 1.1% 1.4%

Sources: U.S. Bureau of Labor Statistics' WCRI; Milliman analysis.

E. Automobile Coverages

1. Related Research

The Insurance Research Council (IRC) has compiled databases for automobile injury insurance claims closed during 2007 and 2012.[62] This database includes information on the age of the injured individual, type of automobile insurance coverage, and the amount of medical payments.

The following points summarize the results from the IRC data, which indicate that the costs of medical care for individuals 65 and over are higher than the costs for individuals under 65. The following summary points hold for the all-coverages experience, and generally hold for the five individual coverages.

- The percentage of claims accounted for by individuals 65 and over increased between 2007 and 2012.
- The average payments of medical care are higher for individuals 65 and over, and the age-related medical payment differences increased between 2007 and 2012.
- The distribution of medical payments has been longer for individuals 65 and over, and became longer between 2007 and 2012.

Table 24 presents the average medical payments for claims closed during 2007 and 2012, by age of the injured individual and automobile insurance coverage.

- For all automobile injury insurance claims, the percentages of claims and total medical payments accounted for by individuals 65 and over increased between 2007 and 2012. In 2007, individuals 65 and over accounted for 8.5% of all claims and 10.4% of all medical payments. In 2012, these percentages increased to 9.3% and 13.0%, respectively.
- Between 2007 and 2012, for all claims and for four of the five coverages, the average medical payments for injured individuals 65 and over increased more than the average medical payments for individuals under 65. For all claims, the average medical payment increased by 37% for individuals 65 and over, compared to an increase of 24% for individuals under 65.
- For claims closed in 2007 and 2012, the average medical payment was higher for injured individuals 65 and over than for injured individuals under 65, and the larger increases in medical payments for injured individuals 65 and over increased the differences in average medical payments between these two age groups. For 2007, the average medical payment was $6,160 for individuals 65 and over and $4,669 for individuals under 65 (a 32% difference).

[62] For the latest report summarizing information in the database, see Insurance Research Council, 2014.

For 2012, the average medical payment was $8,423 for individuals 65 and over and $5,782 for individuals under 65 (a 46% difference).

Table 24 Distribution of Claims, Medical Payments, and Mean Medical Payments, by Type of Automobile Coverage and Age of Injured Individual

Age at Date of Final Payment/Automobile Coverage	2007			2012			% Change in Mean Medical Payment: 2007-2012
	% of Claims	% of Total Medical Payments	Mean Medical Payment	% of Claims	% of Total Medical Payments	Mean Medical Payment	
Under 65							
All injury claims	91.5%	89.6%	$4,669	90.7%	87.0%	$5,782	23.8%
Bodily injury	93.7%	92.4%	$4,740	92.1%	90.1%	$5,662	19.5%
Personal injury protection	90.0%	87.7%	$5,116	90.5%	86.8%	$6,395	25.0%
Medical payments	88.1%	87.1%	$3,023	86.5%	82.6%	$3,886	28.5%
Uninsured motorist	92.0%	87.4%	$5,278	89.6%	86.5%	$6,486	22.9%
Underinsured motorist	87.5%	84.7%	$18,900	86.8%	72.5%	$23,743	25.6%
65 and over							
All injury claims	8.5%	10.4%	$6,160	9.3%	13.0%	$8,423	36.7%
Bodily injury	6.3%	7.6%	$6,210	7.9%	9.9%	$7,584	22.1%
Personal injury protection	10.0%	12.3%	$6,996	9.5%	13.2%	$9,122	30.4%
Medical payments	11.9%	12.9%	$3,666	13.5%	17.4%	$5,203	41.9%
Uninsured motorist	8.0%	12.6%	$9,282	10.4%	13.5%	$9,035	-2.7%
Underinsured motorist	12.5%	15.3%	$20,920	13.2%	27.5%	$61,058	191.9%

Source: Insurance Research Council.

For all coverages and the individual coverages, Table 25 presents the medical payments at four percentiles for the 2007 and 2012 claims broken down into age groups under and over 65. The medical payments in Table 25 indicate a lengthening of the tail for the two age groups, with the shift greater for individuals 65 and over. For all coverages, the median medical payment for individuals under 65 was $2,145 for claims closed in 2007 and $2,627 for claims closed in 2012—an increase of 22%. For individuals over 65, the median medical payments were $2,500 and $3,711—an increase of 48%.

Table 25 Mean and Percentile Medical Payments: 2007 and 2012, by Automobile Insurance Coverage and Age of Injured Individual (**Source:** Insurance Research Council.)

	Age Under 65		Age 65 and Over		% Change: 2007-2012	
	2007	2012	2007	2012		
Automobile Coverage	Medical Payment (mean and percentile)	Medical Payment (mean and percentile)	Medical Payment (mean and percentile)	Medical Payment (mean and percentile)	Age Under 65	Age 65 and Over
All injury claims	$4,669	$5,782	$6,160	$8,423	23.8%	36.7%
Percentile 25	$814	$1,000	$995	$1,451	22.9%	45.8%
Percentile 50	$2,145	$2,627	$2,500	$3,711	22.5%	48.4%
Percentile 75	$5,000	$5,597	$5,000	$8,148	11.9%	63.0%
Percentile 95	$15,000	$19,713	$20,154	$27,124	31.4%	34.6%
Bodily injury	$4,740	$5,662	$6,210	$7,584	19.5%	22.1%
Percentile 25	$857	$969	$1,000	$1,352	13.1%	35.2%
Percentile 50	$2,253	$2,619	$2,653	$3,415	16.2%	28.7%
Percentile 75	$4,579	$5,557	$5,471	$8,283	21.4%	51.4%
Percentile 95	$16,658	$18,985	$25,000	$29,000	14.0%	16.0%
Personal injury protection	$5,116	$6,395	$6,996	$9,122	25.0%	30.4%
Percentile 25	$746	$1,298	$855	$1,517	74.0%	77.4%
Percentile 50	$2,500	$2,693	$2,500	$3,956	7.7%	58.2%
Percentile 75	$5,940	$8,062	$6,667	$10,000	35.7%	50.0%
Percentile 95	$14,298	$20,000	$18,467	$29,612	39.9%	60.4%
Medical payments	$3,023	$3,886	$3,666	$5,203	28.5%	41.9%
Percentile 25	$732	$1,000	$974	$1,487	36.6%	52.7%
Percentile 50	$1,487	$2,113	$2,000	$3,756	42.1%	87.8%
Percentile 75	$3,895	$5,000	$5,000	$5,000	28.4%	0.0%
Percentile 95	$9,217	$10,000	$10,000	$20,000	8.5%	100.0%
Uninsured motorist	$5,278	$6,486	$9,282	$9,035	22.9%	-2.7%
Percentile 25	$900	$1,265	$1,333	$1,594	40.6%	19.6%
Percentile 50	$2,530	$3,194	$3,020	$3,740	26.2%	23.8%
Percentile 75	$5,000	$6,590	$6,642	$11,007	31.8%	65.7%
Percentile 95	$20,123	$25,000	$50,000	$32,420	24.2%	-35.2%
Underinsured motorist	$18,900	$23,743	$20,920	$61,058	25.6%	191.9%
Percentile 25	$5,000	$6,533	$5,000	$9,000	30.7%	80.0%
Percentile 50	$10,000	$15,000	$10,045	$15,927	50.0%	58.6%
Percentile 75	$22,644	$30,303	$25,000	$50,000	33.8%	100.0%
Percentile 95	$56,202	$75,000	$90,157	$222,276	33.4%	146.5%

2. Estimated Impact

Table 26 presents the assumptions and results for the estimated impact of the Section 111 reporting requirements on the medical and total payments for automobile liability coverages. The following points describe the assumptions and calculations.

- For injured individuals 65 and over, the percent of claims and percent of medical payments and the average medical payment for claims closed in 2012 were obtained from the IRC—(1), (2), and (3) in Table 26.
- The assumed impact on medical payments due to Section 111 reporting requirements were developed from interviews with Milliman's claims consultants—(4) in Table 26. The assumed impacts were for low (10%), moderate (15%), and high (20%) increases on average medical payments.
- The estimated impact on the average medical payments for injured individuals 65 and over— (5) in Table 26—is the product of the average medical payment for claims closed in 2012 multiplied by the estimated impact in (4).
- The assumptions for medical payments as a share of total liability payments for all coverages and the individual coverages are found in (6) in Table 26. The estimated impacts on total payments for injured individuals 65 and over in (7) is the product of the estimated impact in (5) times the assumption for medical as a percent of total payments in (6).[63]

This rather simple analysis indicates that Section 111 reporting requirements may increase the average medical payments across all injured individuals 65 and over by $842 to $1,685 for the 2012 loss experience, or by 1.3% to 2.6% for this age group. The estimated impact is for a 0.4% to 0.8% increase in total losses across injured individuals 65 and over.

The Federal Highway Administration has reported that in 2012 drivers 65 and over accounted for 17% of all drivers.[64] Assuming that medical and total payments are proportional to the age distribution of drivers, the 1.3% to 2.6% estimated impact on medical payments for individuals 65 and over translates to an estimated increase of 0.2% to 0.4% in medical payments for all ages, and the 0.4% to 0.8% estimated impact on total payments for individuals 65 and over translates to an estimated increase of 0.07% to 0.13% for all ages.

[63] The results in (6) can also be produced by dividing the estimated impact on average medical payments in (5) by the average medical payment in (3), and then multiplying by the assumption for medical as a share of total payments in (6).
[64] Federal Highway Administration 2012.

Table 26 Estimated Impact of Section 111 Reporting Requirements: Automobile Injury Insurance Claims Closed in 2012

Number	Consideration	All Types of Injuries	Bodily Injury	Personal Injury Protection	Medical Payments	Uninsured Motorist	Underinsured Motorist
	Injured individual 65 and over						
1	Percent of claims	9.3%	7.9%	9.5%	13.5%	10.4%	13.2%
2	Percent of medical payments	13.0%	9.9%	13.2%	17.4%	13.5%	27.5%
3	Average medical payment for claims closed in 2012	$8,423	$7,584	$9,122	$5,203	$9,035	$61,058
4	Assumed impact on medical payments that is due to Section 111 reporting requirements	**Estimated impact on average medical payments for injured individuals 65 and over**					
	10%	$842	$758	$912	$520	$904	$6,106
	15%	$1,263	$1,138	$1,368	$780	$1,355	$9,159
	20%	$1,685	$1,517	$1,824	$1,041	$1,807	$12,212
5	Assumed impact on medical payments that is due to Section 111 reporting requirements	**Estimated impact as a percent of total medical payments for injured individuals 65 and over**					
	10%	1.3%	1.0%	1.3%	1.7%	1.4%	2.8%
	15%	2.0%	1.5%	2.0%	2.6%	2.0%	4.1%
	20%	2.6%	2.0%	2.6%	3.5%	2.7%	5.5%
6	Medical payments as a percent of total payments	30%	40%	25%	100%	25%	25%
7	Assumed impact on medical payments that is due to Section 111 reporting requirements	**Estimated impact as a percent of total payments for injured individuals 65 and over**					
	10%	0.4%	0.4%	0.3%	1.7%	0.3%	0.7%
	15%	0.6%	0.6%	0.5%	2.6%	0.5%	1.0%
	20%	0.8%	0.8%	0.7%	3.5%	0.7%	1.4%

Source: Insurance Research Council, Milliman analysis.

F. Homeowners

We did not find adequate information on medical payments covered by homeowners insurance to develop an estimated impact that is due to Section 111 reporting. We suspect the paucity of data on medical payments covered by homeowners insurance is because of the small share of total incurred losses and of liability losses attributed to payments for medical services.

Table 27 presents the distribution of incurred losses by cause of loss for physical and liability causes and for the different types of liability causes for accident years 2005 to 2007. Across all types of causes, medical payments accounted for 0.2%. When the attention is limited to liability losses, medical payments accounted for 3.6% of all liability losses when catastrophes are included and 2.9% when catastrophes are excluded.

In our interviews with claim consultants, they expect there will be a notable increase in the number of claims with medical payments and an increase in the amounts of medical payments covered by homeowners policies. They expect there will be an increase in the situations illustrated by Case #10 above (where a Medicare beneficiary's injury can be attributed to an incident covered by a homeowners policy).

In sum, while there is the expectation that claims frequency and total medical payments will increase for homeowners insurance, there is not a sufficient amount of information to calculate an estimated impact. While the impact may be material for individual claims, the overall impact for the homeowners line of business is likely to be de minimis.

Table 27 Distribution of Incurred Losses Covered by Homeowners Insurance: Accident Years 2005-2007

Cause of Loss	Including Catastrophes	Excluding Catastrophes
TOTAL, ALL LOSSES	100.0%	100.0%
Property Causes of Loss		
Total, Property Losses	94.5%	93.0%
Liability Causes of Loss		
Bodily Injury	2.7%	3.4%
Property Damage	1.1%	1.4%
Medical Payments	0.2%	0.2%
All Other Liability	1.6%	2.0%
Total, Liability Losses	5.5%	7.0%
TOTAL, LIABILITY LOSSES	100.0%	100.0%
Liability Causes of Loss		
Bodily Injury	48.2%	48.6%
Property Damage	19.6%	20.0%
Medical Payments	3.6%	2.9%
All Other Liability	28.6%	28.6%

Source: American Association of Insurance Services, 2009.

VI. CONCLUDING COMMENT

We relied on a variety of information and data concerning Section 111 reporting requirements, population and employment trends, and insurance losses. We did not audit or verify these data and other information. If the underlying data or information we have relied on is inaccurate or incomplete, the results of our analysis may likewise be inaccurate or incomplete. In that event, the results of our analysis may not be suitable for the intended purpose.

We performed a limited review of the data used directly in our analysis for reasonableness and consistency and did not find material defects in the data. If there are material defects in the data, it is possible that they would be uncovered by a detailed, systematic review and comparison of the data to search for data values that are questionable or for relationships that are materially inconsistent. Such a review was beyond the scope of our assignment. The estimates contained herein are intended to be illustrative. The actual impact for any payer will depend on a variety of factors including their mix of claims, classes of business and states of operations.

This paper was prepared solely for the benefit of the Casualty Actuarial Society's Committee on Healthcare Issues. Milliman does not intend to legally benefit any third-party recipient of this paper. The Casualty Actuarial Society may publicly distribute the final, non-draft version of the paper to third parties provided the paper is distributed in its entirety.

APPENDIX A
LEGISLATIVE SUMMARY: MEDICARE, MEDICARE SECONDARY PAYER, AND SECTION 111 REPORTING

A. Historical Background

In 1965, under Title XVIII of the Social Security Act, Congress created the Medicare program to provide health insurance to individuals 65 and over, regardless of income or medical history. Since 1965, Congress has expanded Medicare to include individuals under 65 who have permanent disabilities and receive Social Security Disability Insurance (SSDI) payments and individuals of any age with end-stage renal disease (ESRD)—permanent kidney failure requiring dialysis or kidney transplant.

Under the present program, individuals who are eligible for Medicare benefits can receive payment under several coverages:

- **Hospital insurance (Part A)**, which covers inpatient care in hospitals and skilled nursing facilities, but no custodial or long-term care. This coverage also applies to hospice care and some home healthcare. There is no premium for Part A coverage.
- **Medical insurance (Part B)**, which covers physician and other supplier items and services, as well as hospital outpatient care. Part B also covers some medical services not covered by Part A, such as some physical and occupational therapy and some home healthcare. There is a premium for Part B coverage.
- **Medicare Advantage Plan coverage (Part C)**, which pay for services under certain health plan options—such as health maintenance organizations (HMOs) and preferred provider organizations (PPOs)—approved by Medicare. Part C is an alternative to the fee-for-service Part A and Part B coverage, and often provides extra coverage for services such as vision or dental care.
- **Prescription drug coverage (Part D)**, provides prescription drug coverage to Medicare beneficiaries. Most beneficiaries pay a monthly premium.

The preceding points notwithstanding, Medicare does not cover every medical service and uses a fee schedule to establish the payments to medical providers.

At the time Medicare was created in 1965, workers' compensation remained the primary payer for work-related injuries and Medicare was the secondary payer for these injuries. Beginning in 1980, Congress enacted a series of provisions that has made Medicare the secondary payer for certain types of other insurance plans and self-insured programs. The liability insurance coverages include, but are not limited to, homeowners liability, malpractice, product liability, and general casualty liability. Medicare is secondary to payments under state wrongful death statutes that provide payment for medical damages. Medicare is also secondary to no-fault insurance coverages, including all forms of automobile no-fault insurance, automobile medical payments, and non-automobile no-fault insurance.[65]

B. Section 111 Provisions for Reporting Medical Services Provided to Medicare Beneficiaries

Under Section 111 of the Medicare, Medicaid, and SCHIP Extension Act of 2007 (MMSEA), liability insurers (including self-insureds), no-fault insurers, and workers' compensation insurers are obligated to notify Medicare about claims involving ongoing medical responsibility, settlements, judgments, awards, or other one-time and lump sum settlements received by or on behalf of Medicare beneficiaries. The reporting requirements for Section 111 concern Medicare beneficiaries (that is, individuals who are eligible for and may be receiving treatment covered by Medicare) who also are receiving medical treatment for a work-related injury or an injury where the incident was covered by a liability policy or self-insurance arrangement.[66]

CMS defines a responsible reporting entity (RRE) to be an entity that provides or administers liability, no-fault, or workers' compensation insurance coverage, including self-insureds, and as a consequence is responsible for complying with Section 111 reporting requirements.[67,68] Liability insurance includes, but is not limited to, homeowners, automobile, product, malpractice, uninsured motorist, and underinsured motorist. No-fault insurance includes, but is not limited to, certain forms of automobile insurance, certain homeowners insurance, commercial insurance plans, and medical payments coverage/personal injury protection/medical expense coverage. Workers' compensation includes the statutory plans in the 50 states, the District of Columbia, U.S. territories, the Federal Employees' Compensation Act, and the Longshore and Harbor Workers' Compensation Act.[69]

Section 111 reporting distinguishes between two broad types of medical services. Each class of medical services is subject to certain reporting thresholds, which in the case of the TPOC payments have been decreasing over the past several years. The reporting requirements became effective May 1,

---

[65] The Medicare secondary payer provisions can be found at Section 1862(b) of the Social Security Act and in Chapter 1 of the Medicare Secondary Payer Manual.

[66] Claims that must be reported under Section 111 are slightly different from claims that can be covered by Medicare Set-Aside Arrangements (MSAs). Section 111 is limited to Medicare beneficiaries. MSAs are for individuals who are "Medicare-eligible," which is defined to include individuals who are within 30 months of being eligible for Medicare.

[67] CMS, User Guide, Chapter III: Policy Guidance, Chapter 6: Responsible Reporting Entities.

[68] For a primer on Section 111 reporting requirements, see MMSEA Section 111 Liability Insurance (Including Self-Insurance), No-Fault Insurance, and Workers' Compensation User Guide: Reportable Claims, Version 3.4, January 13, 2014.

[69] CMS, User Guide, Chapter 1: Introduction and Overview, Chapter 4: MSP Overview.

2009.

- **Ongoing responsibility for medicals (ORM)** refers to the ongoing responsibility for payment of the injured party's medical treatment, including medical-only claims with more than $750 in payments and all indemnity claims.[70]
- **Total Payment Obligation to the Claimant (TPOC)** refers to the settlement, judgment, award, or other payment in addition to the ORM. A TPOC is generally a one-time or lump sum settlement, judgment, or award. Structured settlements are considered TPOCs.[71]

RREs are responsible for complying with the Section 111 reporting requirements. RREs can report payments through either an electronic file exchange or a manual direct data exchange. The report must include the identity of the Medicare beneficiary and other information to enable an appropriate determination for the coordination of benefits between Medicare and the primary payer.

1. Ongoing Responsibility for Medicals (ORM)

Ongoing responsibility for medicals concerns the recurring, ongoing payments for medical treatments received by individuals with a work-related injury or covered by a liability policy.

An RRE is required to report to CMS all medical payments received by a Medicare beneficiary that exceed $750. For each type of insurance (no-fault, liability, and workers' compensation), an RRE is required to report ORM payments that were made on or after January 1, 2010.

2. Total Payment Obligation to Claimant (TPOC)

The initial reportable dates for TPOCs differed across the three types of insurance (see Table A-1). RREs were required to report TPOCs for no-fault and workers' compensation insurance for payments made on or after January 1, 2010. For liability insurance, reporting was required for TPOC payments made on or after January 1, 2011.

Another difference across the three types of insurance concerns the thresholds for reporting to CMS. There is no threshold for no-fault insurance—all TPOC payments made under a no-fault coverage must be reported to CMS. By contrast, thresholds for reporting TPOC payments for liability insurance became effective for payments made on or after October 1, 2010, and thresholds for these types of payments for workers' compensation became effective for payments made on or after October 1, 2011.

---

[70] For a primer on ORM, see MMSEA, ibid., Ongoing Responsibility for Medicals (ORM), Version 3.4, January 13, 2014.

[71] For a primer on Total Payment Obligation to the Claimant, see MMSEA, ibid., Total Payment Obligation to Claimant (TPOC), Version 3.4, January 13, 2014.

Table A-1 Reportable Dates for Total Payment Obligation to Claimant (TPOC)

Insurance Type	Reportable TPOC Dates	Reportable Amounts	Threshold Applicable
No-fault	October 1, 2010 & subsequent	Any amount	No
Liability insurance (including self-insurance)	October 1, 2011 & subsequent	Cumulative TPOC amount that exceeds threshold	Yes
Workers' compensation	October 1, 2010 & subsequent	Cumulative TPOC amount that exceeds threshold	Yes

Table A-2 presents the reporting thresholds and effective dates for TPOC payments for liability insurance. For liability insurance TPOC payments made on or after October 1, 2011, the RRE was required to report payments over $100,000 beginning January 1, 2012. Since then, the thresholds have been reduced. As of January 1, 2015, the threshold for liability claims is $300 for payments made on or after October 1, 2014.

Table A-2 TPOC Thresholds and Reporting Dates for Liability Insurance

Section 111 Reporting Required in the Quarter Beginning	TPOC Date on or After	Total TPOC Amount
January 1, 2012	October 1, 2011	TPOCs over $100,000
July 1, 2012	April 1, 2012	TPOCs over $50,000
October 1, 2012	July 1, 2012	TPOCs over $25,000
January 1, 2013	October 1, 2012	TPOCs over $5,000
January 1, 2014	October 1, 2013	TPOCs over $2,000
January 1, 2015	October 1, 2014	TPOCs over $300

The reporting requirements for workers' compensation started earlier and have had lower thresholds over time. Table A-3 presents the reporting thresholds and effective dates for TPOC payments for workers' compensation insurance. For workers' compensation TPOC payments made on or after October 1, 2010, the RRE was required to report payments over $5,000. As of January 1, 2015, the threshold was $300 for payments made on or after October 1, 2014.

Table A-3 TPOC Thresholds and Reporting Dates for Workers' Compensation

Section 111 Reporting Required in the Quarter Beginning	TPOC Date on or After	Total TPOC Amount
January 1, 2011	October 1, 2010	TPOCs over $5,000
January 1, 2014	October 1, 2013	TPOCs over $2,000
January 1, 2015	October 1, 2014	TPOCs over $300

REFERENCES

- American Association of Insurance Services (January 13, 2009). AAIS issues expanded 'Cause of Loss Report' for homeowners insurance. Press release. Retrieved August 1, 2014, from http://www.aaisonline.com/AAISFrame/ConnectFrame/PressReleasesFrame/tabid/165/ArticleID/137/AAIS-Issues-Expanded-Cause-of-Loss-Report-for-Homeowners-Insurance.aspx.
- American Association of Retired Persons (Beth Levine), "8 Key Facts About Knee Replacement Surgery," from the AARP Bulletin print edition, March 1, 2011. Retrieved January 27, 2015, from http://www.aarp.org/health/conditions-treatments/info-03-2011/knee-replacement-surgery.html.
- American Cancer Society (2007). Occupation and Cancer. Information sheet. Retrieved August 1, 2014, from http://www.cancer.org/acs/groups/content/@nho/documents/document/occupationandcancerpdf.pdf
- Bartelt, R., Sperling, J.W., Schleck, C.D., Colfield, R.H., "Shoulder Arthroplasty in Patients Aged Fifty-Five Years or Younger with Osteoartritis," Journal of Shoulder and Elbow Surgery, 2011 (20, 123-130). Retrieved January 27, 2015, from http://www.jshoulderelbow.org/article/S1058-2746(10)00209-0/abstract.
- Bentley, T. Scott and Steven G. Hanson, "2011 U.S. Organ and Tissue Transplant Cost Estimates and Discussion," Milliman Research Report, April 2011. Retrieved August 18, 2014, from http://publications.milliman.com/research/health-rr/pdfs/2011-us-organ-tissue.pdf.
- California Workers' Compensation Institute (July 2014), Claim Monitoring Report: Analysis of Medical and Indemnity Benefit Payments, Medical Treatment and Pharmaceutical Cost Trends in the California Workers' Compensation System. Oakland, California.
- Canadian Public Health Association, Hepatitis C in the Workplace. Retrieved January 27, 2015 from http://www.bccdc.ca/NR/rdonlyres/3246DF1F-AC21-4B72-AFE1-4C93F8AC0AE4/0/HepC_Intheworkplace.pdf.
- Centers for Disease Control and Prevention:
  - "Bloodborne Infectious Diseases: HIV/AIDS, Hepatitis B, Hepatitis C" (December 29, 2011). Retrieved July 21, 2014 from http://www.cdc.gov/niosh/topics/bbp/occupations.html.
  - "Cancer, Reproductive, and Cardiovascular Diseases" (August 22, 2013). NIOSH Program Portfolio. Retrieved August 1, 2014, from http://www.cdc.gov/niosh/programs/crcd/.
  - Occupational Cancer (May 2, 2012). Workplace Safety and Health Topics. Retrieved August 1, 2014, from http://www.cdc.gov/niosh/topics/cancer/.
  - Table 1.11: Age Distribution (%) of Incidence Cases by Site, 2007-2011, All Races,

Both Sexes (2011). *SEER Cancer Statistics Review* 1975-2011, National Cancer Institute. Retrieved August 1, 2014, from http://seer.cancer.gov/csr/1975_2011/results_merged/topic_age_dist.pdf.

- Centers for Medicare and Medicaid Services:
    - "Medicare and Other Health Benefits: Your Guide to Who Pays First" (April 2014). CMS Product No. 02179. Retrieved August 1, 2014, from http://www.medicare.gov/Pubs/pdf/02179.pdf.
    - *Medicare Secondary Payer Manual* (August 3, 2012). Publication 100-05, Revision R87MSP. Retrieved August 1, 2014, from http://www.cms.gov/Regulations-and-Guidance/Guidance/Manuals/Internet-Only-Manuals-IOMs-Items/CMS019017.html.
    - MMSEA Section 111, Liability Insurance (Including Self-Insurance), No-Fault Insurance and Workers' Compensation User Guide, Chapter I: Introduction and Overview, Version 4.5 (February 2, 2015). Retrieved March 23, 2015, from http://www.cms.gov/Medicare/Coordination-of-Benefits-and-Recovery/Mandatory-Insurer-Reporting-For-Non-Group-Health-Plans/Downloads/New-Downloads/NGHPUserGuideVer45Ch1IntroAndOverview.pdf
    - MMSEA Section 111, Liability Insurance (Including Self-Insurance), No-Fault Insurance and Workers' Compensation User Guide, Chapter III: Policy and Guidance, Version 4.5 (February 2, 2015). Retrieved March 23, 2015, from http://www.cms.gov/Medicare/Coordination-of-Benefits-and-Recovery/Mandatory-Insurer-Reporting-For-Non-Group-Health-Plans/Downloads/New-Downloads/NGHPUserGuideVer45Ch3Policy.pdf
    - MMSEA Section 111 Mandatory Insurer Reporting – Quick Reference Guide," Version 1.1 (May 1, 2013).
    - Workers' Compensation Medicare Set Aside Arrangements (June 3, 2014). Retrieved August 1, 2014, from http://go.cms.gov/wcmsa.
    - Workers' Compensation Medicare Set-Aside Arrangement (WCMSA) Reference Guide (January 5, 2015). COBR-Q1-2015-v2.3. Retrieved March 26, 2015, from http://www.cms.gov/Medicare/Coordination-of-Benefits-and-Recovery/Workers-Compensation-Medicare-Set-Aside-Arrangements/Downloads/WCMSA-Reference-Guide-Version-2-3.pdf
    - Your Medicare Coverage: Home Health Services. Retrieved August 18, 2014 from http://www.medicare.gov/coverage/home-health-services.html.
- Congressional Research Service (March 22, 2013). Medicare Secondary Payer: Coordination of Benefits. RL33587. (accessed May 27, 2014).
- Federal Highway Administration, Department of Transportation (US). Highway Statistics 2012. Washington DC: FWWA Retrieved August 18, 2014, from http://www.fhwa.dot.gov/policyinformation/statistics/2012/dl22.cfm.

- Food and Drug Administration, "Blunt-Tip Surgical Suture Needles Reduce Needlestick Injuries and the Risk of Subsequent Bloodborne Pathogen Transmission to Surgical Personnel," a FDA, NIOSH, & OSHA Joint Safety Communication, May 30, 2012. Retrieved January 27, 2015 from http://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/ucm305757.htm
- Fraser, Crystal (2011). The complexity of the mandatory Medicare Section 111 reporting rules and its practical legal affects – is there a break in sight? *Connecticut Law Journal*, Volume 17:2. Retrieved August 1, 2014, from http://insurance journal.org/wp-content/uploads/2011/12/Fraser.pdf.
- Government Accountability Office (March 2012). Medicare Secondary Payer: Additional Steps Are Need to Improve Program Effectiveness for Non-Group Health Plans. GAO-12-333. (accessed May 27, 2014).
- Howlader, N., Noone, A.M., Krapcho, M. et al., eds. (April 2014). SEER Cancer Statistics Review, 1975-2011. National Cancer Institute. Bethesda, Maryland. Retrieved August 3, 2014, from http://seer.cancer.gov/csr/1975_2011/. See, specifically, Table 1.11, http://seer.cancer.gov/csr/1975_2011/results_merged/topic_age_dist.pdf and Table 1.12, http://seer.cancer.gov/csr/1975_2011/results_merged/topic_med_age.pdf.
- Insurance Research Council (February 2014) *Auto Injury Insurance Claims: Countrywide Patterns in Treatment, Cost and Compensation*. Insurance Research Council. Malvern, Pennsylvania.
- Mäkelä, K.T., Eskelinen, A., Pulkkinen, P., Paavolainen, P., Remes, V., "Total Hip Arthroplasty for Primary Osteoarthritis in Patients Fifty-Five Years of Age or Older. An Analysis of the Finnish Arthroplasty Registry," Journal of Bone and Joint Surgery (American Version), October 2008. Retrieved January 27, 2015 from http://www.ncbi.nlm.nih.gov/pubmed/18829914.
- MedlinePlus (July 9, 2014). Chronic Obstructive Pulmonary Disease. National Institutes of Health. Retrieved August 3, 2014, from http://www.nlm.nih.gov/medlineplus/ency/article/000091.htm.
- National Institute for Occupational Safety and Health, "Preventing Exposures to Bloodborne Pathogens among Paramedics," April 2010, DHHS (NIOSH) Publication No. 2010-139. Retrieved January 27, 2015 from http://www.cdc.gov/niosh/docs/wp-solutions/2010-139/.
- National Council on Compensation Insurance:
  - Annual Statistical Bulletin, 2013 edition.
  - Laws. C. & Colón, D. (October 2012). Comorbidities in Workers Compensation. NCCI Research Brief. Retrieved September 26, 2014, from https://www.ncci.com/documents/Research-Brief-Comorbidities-in-Workers-Compensation-2012.pdf.
  - Lipton, B., Colón, D., & Robertson, J. (September 2013). Workers Compensation

Prescription Drug Study: 2013 Update. NCCI Research Brief. Retrieved August 3, 2014, from https://www.ncci.com/documents/Prescription_Drugs-2013.pdf.

  - Lipton, B. (May 9, 2014). Medicare Set-Asides and Workers Compensation. 2014 Annual Issues Symposium. Retrieved August 3, 2014, from https://www.ncci.com/Documents/AIS2014-Lipton.pdf.
  - Restrepo, T. & Shuford, H. (December 2011). Workers Compensation and the Aging Workforce.
- Sengupta, I., Baldwin, M., & Reno, V. (August 2013). Workers' Compensation: Benefits, Coverage, and Costs, 2011. National Academy of Social Insurance.
- Swedlow, A. (2011). Intersections and Uncertainties Between Medicare and Workers' Compensation. California Workers' Compensation Research Institute. Presented at the November 2011 NCCI Actuarial Meeting and the March 2011 CWCI Annual Meeting.
- U.S. Census Bureau (November 2013). Geographical Mobility/Migration. Current Population Survey, 2013 Annual Social and Economic Supplement. Retrieved August 3, 2014, from https://www.census.gov/hhes/migration/data/cps/cps2013.html.
- U.S. Department of Health and Human Services. Work-Related Cancer. Publication No. 2010-145. Retrieved August 3, 2014, from http://www.cdc.gov/niosh/docs/2010-145/pdfs/2010-145.pdf.
- Weinstein, A.M. et. al (February 2012), "How Many Americans are Currently Living with Total Knee Replacement?" presented at the 2012 Annual Meeting of the American Academy of Orthopaedic Surgeons. Retrieved January 27, 2015, from http://www.abstractsonline.com/Plan/ViewAbstract.aspx?sKey=65a71ec2-6fba-429b-b9a0-97db92e78fba&cKey=8e9d5320-3ca0-403e-8e73-c682c9240961
- Workers Compensation Research Institute:
  - Belton, S.E. (October 2013). *CompScope Benchmarks for Wisconsin, 14th Edition*. Workers Compensation Research Institute, WC-13-38: Cambridge, Massachusetts.
  - Tanabe, R.P. (March 2012). Workers Compensation Laws (as of January 2012). Workers Compensation Research Institute, WC-12-18: Cambridge, Massachusetts.
  - Tanabe, R.P. (February 2013). Workers Compensation Medical Cost Containment: A National Inventory, 2013 (as of January 1, 2013). Workers Compensation Research Institute, WC-13-02: Cambridge, Massachusetts.
  - Thumula, V., Savych, B., & Victor, R.A. (June 2014). Predictors of Worker Outcomes in Wisconsin. Workers Compensation Research Institute. WC-14-27: Cambridge, Massachusetts. **Note:** These authors also produced reports for Indiana, WC-14-20; Massachusetts, WC-14-21; Michigan, WC-14-22; Minnesota, WC-14-23; North Carolina, WC-14-24; Pennsylvania, WC-14-25; and Virginia, WC-14-26.
  - Wang, D. & Liu, T. (July 2011). *Prescription Benchmarks, 2nd Edition: Trends and Interstate Comparisons*. Workers Compensation Research Institute, WC-11-31:

Cambridge, Massachusetts.

Credibility and Other Modeling Considerations for Loss Development Factors

Uri Korn, FCAS, MAAA

Abstract

In this paper, we discuss various credibility and modeling strategies for loss development factors. We present several improvements to the popular inverse power curve to help it better fit to the data. Using a basic approach to credibility weighting curves often produces results that do not lie in between the original curve and the overall average, as would be expected. We show a technique to deal with this issue. We also discuss how to model across continuous variables as well as show formulas for converting and modeling across different loss caps, retentions, and policy limits.

Keywords. Loss Development Factors, Credibility, Generalized Additive Models, Splines

1. INTRODUCTION

Unlike other businesses, due to the delay from the date an event occurs until it is reported and ultimately paid, insurance companies do not know whether their products are being adequately charged for or whether they were sold at a profit or at a loss. Actuaries rely on loss development patterns to help estimate all of this. A book of business is typically made up of insureds having different characteristics with policies written at various retentions and limits, all of which can be expected to have different development patterns. Not reflecting these differences properly can lead to inaccurate estimates of what is performing well and what is not, not to mention an inaccurate total result if there have been changes over time. But it is difficult to account for these differences since dividing up the data often results in portions that are too volatile to analyze on their own, especially under the typical approach which involves selecting a separate parameter for the loss development factor of each period.

This paper discusses some modeling strategies for loss development factors and for differentiating across segments while still leveraging the credibility across the divisions of the data. Specifically, this paper discusses the following:

1. An improved method of fitting curves to loss development factors
2. Credibility weighting techniques, both for individual LDFs and fitted curves. For fitted curves, ensuring that the credibility weighted results lie in between the original curve and the complement.
3. Methods to model across continuous variables
4. Formulas for converting and modeling across different loss caps, retentions, and policy

limits

All of the models in this paper can be implemented as full Bayesian models solved using Markov Chain Monte Carlo, or more simply in spreadsheets. This allows for easier adoption and also facilitates implementation in account rating engines where credibility weighting can be performed on an account's specific loss development pattern. Both versions will be discussed.

1.1 Outline

To illustrate credibility weighting of loss development factors, three types of credibility models will be shown: the first involves credibility weighting each LDF individually, the second involves a parametric curve (the inverse power curve), and last can be thought of as a compromise between these two and involves using a Generalized Additive Model, which will be explained. For the latter two models, an approach is shown to help ensure that the resulting credibility weighted curves lie in between the original curve and the overall average, which is often violated using a more basic approach. We also discuss some improved strategies for fitting curves to loss development factors. After that, modeling across continuous variables as well as different retentions, policy limits, and loss caps is discussed.

1.2 Technical Background

For the models that we will be discussing in this paper, we will be assuming that the variance of each LDF is inversely proportional to the volume of cumulative paid or reported losses in the previous age of the triangle. (So, for example, the variance of the first LDF is related to the losses from the first age.) This must be the case since the variance of the losses for a subsequent age for two equally sized accounts is equal to twice the variance of one of these accounts. To convert these losses into LDFs, they are divided by the sum of the losses in the previous age, and so the variance is divided by the square of this sum (since it is not a random variable). Thus, the denominator of the LDF variance for both equally sized accounts combined will be two squared greater than that of a single account. And so the variance of the combined LDF will be $2 / 2^2$ or half of that of each of the accounts separately. Assuming any other relationship between variance and losses will not agree with this result and will lead to inconsistencies.

To calculate the variance of each LDF, the Buhlmann-Straub formula for the "within variance" can be used, using the previous cumulative losses as the weight (Dean 2005):

$$\hat{EPV} = \frac{\sum_{g=1}^{G} \sum_{n=1}^{N_g} W_{gn} (X_{gn} - \bar{X}_g)^2}{\sum_{g=1}^{G} (N_g - 1)} \tag{1.1}$$

Where G are the number of risks, N_g are the number of periods for group g, W_{gn} is the weight for group g in period n, X_{gn} is the value for group g in period n, and $\bar{X}_g$ is the average value for group g.

Note how this formula multiplies by the weight, but does not divide by it. This is because this parameter is really more accurately described as a within variance factor, rather than the within variance for anything in particular. If we take a closer look at the Buhlmann-Straub credibility formula as well, we can see that this factor is divided by the total weight in order to calculate the actual within variance. The ratio of the between variance to the within variance determines the amount of credibility given to the risk.

$$Z = \frac{N}{N + W/A} = \frac{1}{1 + \frac{W/N}{A}} = \frac{1}{1 + V/A} \tag{1.2}$$

Where Z is the credibility given, N is the weight, A is the between variance, W is the between variance factor, and V is the actual between variance. So to calculate the variance of an individual LDF in the triangle, the within variance factor should be divided by the cumulative losses from the previous age. For the variance of the overall average LDFs for each age, the weight used should be the sum of the cumulative losses in the previous age that were used for calculating the LDF.

Once the within variance factors are calculated at every age, they should be smoothed by fitting a curve. A logarithmic curve on the logarithm of the age seems to provide a good fit. In practice, the first one or two ages may need to be removed, as well as the latter, extremely volatile tail portion to be able to fit more accurately.

We will be using the normal distribution to calculate the likelihood of each fitted loss development factor. Since we are allowing our variances to vary for each LDF, this approach is more similar to Kernel smoothing than to assuming that LDFs are actually normally distributed. Taking these two assumptions together of using normal distributions with variances inversely proportional to the losses produces the same result as taking a weighted average of the LDFs, as is commonly done, and so is consistent with traditional actuarial practice. This type of model works well in practice and is the easiest to implement and understand, although other assumptions are possible as well.

Most of the credibility models presented in this paper use Bayesian credibility. These models can be implemented without the use of special Bayesian software. Since we are using the normal distribution for the LDFs and we will also be assuming that the prior distribution is normal (that is, the distribution of the hypothetical means for each group, in Bayesian terms), which is the common assumption, this is a conjugate prior and the resulting posterior distribution (the credibility weighted result) is normal as well. Using MLE returns the mode of a distribution, which will also be equal to the mean for the normal distribution, and so will return identical results to that produced using special Bayesian software. Further details will be discussed later.

2. Credibility Weighting Individual LDFs

The first LDF credibility model we will discuss involves credibility weighting the individual loss development factors. Only age-to-age factors should be used since age-to-ultimate factors have a high degree of dependency on one another.

To credibility weight individual LDFs, Buhlmann-Straub credibility can be used. The "between variance" should be calculated for every age. The formula for calculating the between variance is shown below (Dean 2005):

$$\hat{VHM} = \frac{\sum_{g=1}^{G} W_g (\bar{X}_g - \bar{X})^2 - (G-1)\hat{EPV}}{W - \frac{\sum_{g=1}^{G} W_g^2}{W}} \tag{2.1}$$

Where all terms are the same as above, $\bar{X}$ is the average value across all groups, W_g is the sum of the weights for group *g*, and W is the sum of the weights across all groups.

Either a curve should be fit to these points similar to the within variance factors, or they can be determined as a constant factor of the within variance factors.

The downside to this simple credibility approach is that each LDF is treated individually, and not as part of a curve. This discards a large amount of useful information about the relationship between the LDFs that can be used to improve the accuracy of our selections. As mentioned in England and Verrall 2002 (and others), selecting parameters for every single age is over-parameterized, meaning that more parameters are being chosen than necessary, which will increase the prediction variance. Therefore, using a curve is highly recommended. A problem with using a curve along with credibility, however, is that normal credibility weighting techniques often result in curves that do not lie between the original curve and the overall mean, as we would hope. The next section discusses a technique to address this issue.

3. Applying Credibility to the Inverse Power Curve

The inverse power curve is a well-known method used to help smooth LDFs (Sherman 1984). This curve can be fit by using the regression equation, as mentioned in the paper[1]:

$$log(LDF - 1) = A + B \times log(t) \qquad \textbf{(3.1)}$$

Where A and B are the regression coefficients and t is the age. In our experience, it can be a useful tool to help smooth out some LDFs, especially in the latter portion of the curve, although it often has trouble fitting the entire curve. This depends on the type of business being modeled, however. Also, solving this regression equation using ordinary regression gives too much weight to the tail portion of the curve as mentioned in Lowe et al (1985). This is not an issue if using an extrapolation from earlier more stable points to predict later ages in the curve, as is commonly done, but can be an issue when attempting to fit to the entire curve. An improved way to fit this curve will be discussed.

Instead of using ordinary regression to solve for the parameters, maximum likelihood estimation (MLE) can be used instead. (This can be implemented using a weighted GLM as well.) Doing this makes the weights by age more appropriate and helps provide a better fit than simple regression. MLE can be performed either on each individual LDF or on the weighted averages by age; the results will be the same if the normal distribution is used. If using the weighted averages, the losses used for calculating the variances should be the sum of the cumulative losses in the previous period that were used in calculating the average LDF. The only real reason to use the individual LDFs is when constructing a full Bayesian model (which solves for the within and between variances as part of the model). The log-likelihoods of the fitted LDFs for each age (using equation 3.1) should be added together, and this sum should be maximized. In practice, it may help to exclude the LDFs that do not provide a good fit to the curve or that are too volatile, such as the first few LDFs or the latter portion of the curve that is very sparse and volatile.

1 The paper actually uses the logarithm of the inverse of the age, but the regression equations are equivalent.

To perform credibility weighting among the segments, normally Bayes' formula would be used: *f(Parameters | Data) = f(Data | Parameters) × f(Parameters)*, or equivalently, *Posterior(Parameters, Data) = Likelihood(Data, Parameters) × Prior(Parameters)*, and the regression parameters would be used for calculating this prior likelihood component, which is the credibility component of the likelihood. However, doing so often results in poor behaving curves, as mentioned. Instead, we suggest reparameterizing the curve as will be explained.

The first step is to invert the regression equation (3.1) to solve for the LDFs. Doing so results in the following equations. Since there are two parameters, we need two LDFs at two separate ages to solve for them.

$$B = \frac{\log\left(\frac{LDF_1 - 1}{LDF_2 - 1}\right)}{\log\left(\frac{t_1}{t_2}\right)} \quad \textbf{(3.2)}$$

$$A = \log(LDF_1 - 1) - B\log(t_1) \quad \textbf{(3.3)}$$

Now, given any two LDFs of the fitted curve, we can solve for the original regression parameters. And given these, we can calculate all of the LDFs of the curve. Ignoring the middle step, we can construct the entire curve from these two LDFs. Since the entire curve can be defined by these two LDFs, we can consider these as the parameters of the curve. This being the case, we can alternatively calculate the prior likelihood, that is the credibility component of the likelihood, using these new parameters instead. When doing so, the between variance used should be consistent with our new LDF parameters and not the original regression parameters. This between variance can be estimated by calculating the between variance of the actual LDFs using equation 2.1 above[2]. The ages for these LDF parameters can be selected as being equally spaced along the ages used to perform the fit, but they can be tweaked if needed. Note that even though we are only performing the credibility weighting on two LDFs of the curve, we are still credibility weighting the entire curve, since changing these LDFs affects the entire curve as they are the new curve parameters.

The equations should be inverted when implementing a full Bayesian model. For an MLE model, it is not necessary to actual invert the equations (assuming we are not implementing a

2 Note that including the likelihood of the between variance of every LDFs, as was done in the previous section, is not correct here, since following Bayes' equation, only the parameters should be included in the prior likelihood; in the above section, each LDF was considered separately and so is considered a parameter. This is not the case here.

multidimensional model or modeling across continuous variables, which will be discussed later), since we can solve for any fitted LDF along the curve and use this LDF to calculate the prior likelihood component that we need, effectively "pretending" that we have inverted the equation. Doing this will yield the exact same results as if we had actually performed the inversion. For the MLE model, the complement of credibility for each parameter should be taken from the results from fitting a curve to all segments combined, and not the actual empirical LDFs. (For the Bayesian model, the complement is determined as part of the model.) To summarize, the log-likelihood for this model is:

$$\sum_{d=\,Durations} N\,(Fitted\ LDF_d\,, Actual\ LDF_d\,, Within\,Variance_d) \\ + \sum_{c=2\ Durations\,Selected\ For\ Credibility\,Weighting} N\,(Fitted\ LDF_c\,, Average\ LDF_c\,, Between\,Variance_c) \tag{3.4}$$

Where $N(A, B, C)$ is the logarithm of the probability density function (PDF) of a normal distribution at A, with mean and variance of B and C, respectively. The fitted LDFs are determined from the inverse power curve equation (3.1). The parameters of this equation are determined by a maximization routine that maximizes this likelihood. The within variances are calculated by dividing the within variance factor by the cumulative paid or reported losses, as mentioned. (As a practical matter if implementing with MLE, a minimum value, such as 1×10^{-20} should be set for the values of the normal PDFs, so that they are not too close and rounded to zero, which will cause errors with the logarithm function. Also, for the earlier ages, it sometimes improves the fit to use the within variance factor at a point a few ages later.)

4. Applying Credibility to an Additive Model

The following model can be described as a combination of the inverse power curve and the Generalized Additive Model suggested by England and Verrall 2001 in which they use this to model the incremental paid or reported loss amounts. Here, however, we will be modeling on the actual LDFs instead, as we did for the inverse power curve, because it works better with credibility weighting. It also involves solving for fewer parameters so that it can be implemented from within spreadsheets.

Before we begin explaining how this model works, we will briefly explain splines and additive models. An ordinary regression model has a dependent variable that is a linear function of one or more predictive variables and has the form:

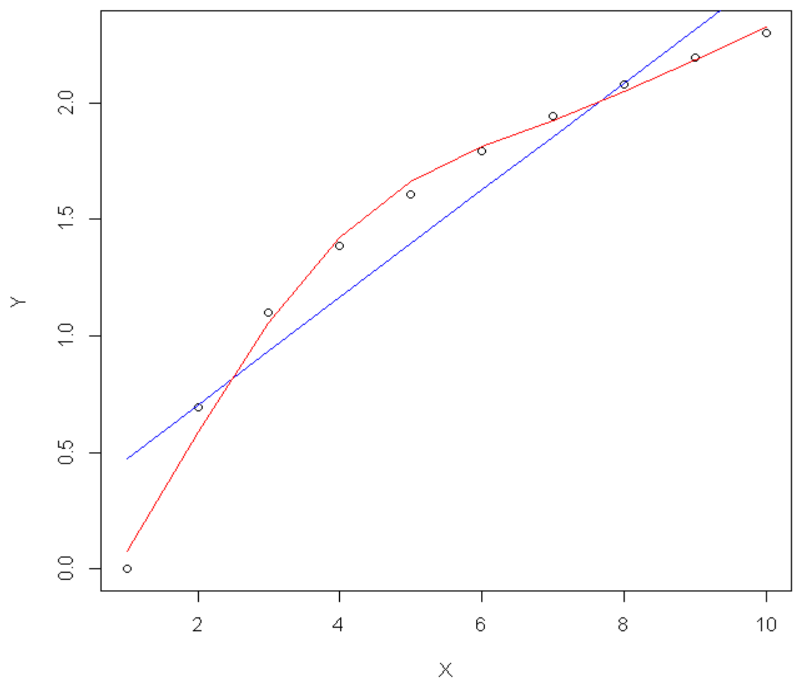
$$Y_i = \sum^{i} B_i X_i$$

An additive model, instead of just linear functions, allows for any function, and has the form:

$$Y_i = \sum^{i} f(X_i)$$

Usually, some type of smoothing function is used that helps adapt the curve to the actual data, even if the relationship is not perfectly linear. Cubic splines are a very common choice since they do a good job of adapting the curve to the data and results in nice, smooth curves.

For example, if we were trying to fit a regression model to the data below and were not able to find a simple transformation of the independent variable that nicely fit the data, such as a logarithm, we might consider using an additive model. The results using a linear regression model (blue line) versus an additive model (red line) are shown below. Note how the additive model nicely adapts the shape of the curve to the data.



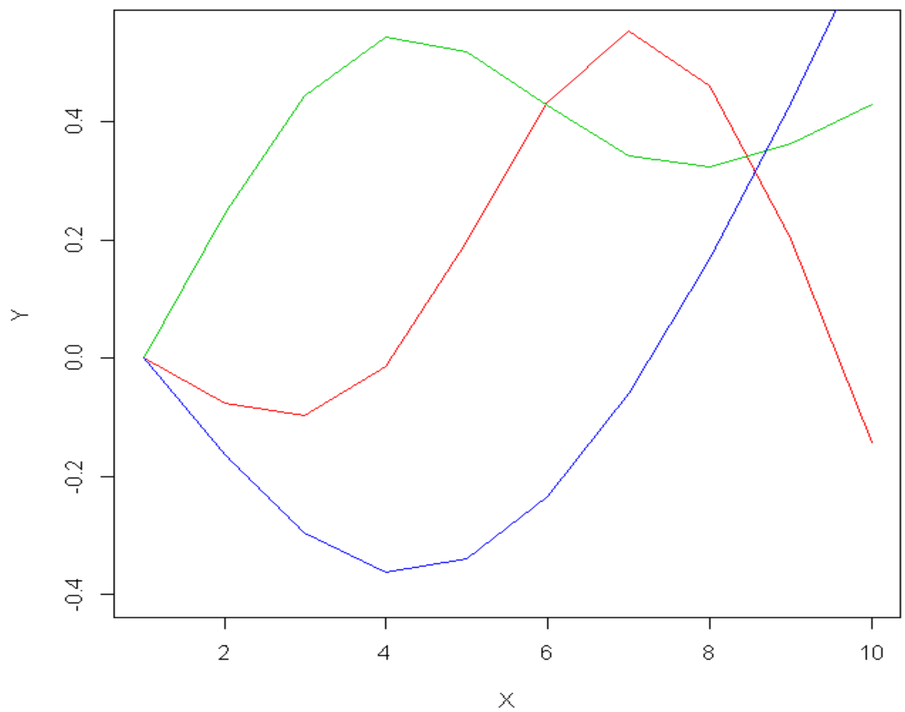
An additive model can also be implemented with an ordinary regression model using splines[3]. These are functions that generate multiple new numeric sequences based off of the original sequence that can be used for smoothing. These new variables can then be plugged into a standard regression model with the same result as an additive model. The example shown above used three natural cubic spline transformations off of the numeric sequence from one to ten and are graphed below. Each of these resulting curves represents one of the degrees of freedom of the spline. By multiplying each curve by a coefficient and adding the results together, smooth curves can be fit to data of multiple forms and shapes. The benefits of this approach is that splines work better for our credibility procedure and it also allows additive models to be implemented from within spreadsheets[4]. A full discussion of additive models is outside of the scope of this paper.

---

3 A full additive model may also help decide how many new variables should be generated (known as the degrees of freedom), etc. but this is not crucial.

4 One way this can be done is to generate the spline numeric sequences outside of the spreadsheet and then paste them in. Natural cubic splines can be generated in R using the ns method of the splines package. For example, the following code can be used to generate a spline with three degrees of freedom (that is, equivalent of three variables) starting at the second age, ending at the 20th, but having a tail that goes out to the 40th, all on a log scale as we will mention a bit later:

```
library(splines)
ns( log(2:40), Boundary.knots=c(log(2),log(20)), df=3 )
```



Having described the benefits of additive models and how they work, it becomes clear why we would want to use them in a loss development model; it is very difficult to find a nice parametric shape that fits nicely to the entire curve. Additive models solve this problem by adapting the curve to the data. A downside, however, is that they can sometimes over-fit. When fitting volatile data with splines, it is often necessary to remove the later, more volatile points from the fitting. (When this is done, the spline should only be constructed for the actual ages being fit, although the tail can be extended further. See the code in the footnote above for how to generate a spline like this in R.) These models may have trouble fitting to the first one or two LDFs as well, and these may need to be removed from the fitting and selected outside of this model.

This method works best when the spline is generated on the logarithm of age, and so is very similar to the inverse power curve, but with additional smoothing to help fit the data even better. We refer to this model as the smoothed inverse power curve. The data we examined worked best using a spline with three degrees of freedom and so we will assume this is the case below, but a different number can be used as well.

Compared to the inverse power curve, the spline/additive model usually provides a much better fit to the data. Also, having more parameters, the credibility weighting occurs at more points in the curve and is often better behaved. This makes it better able to handle situations when a curve intersects with the credibility complement, for example; the resulting credibility weighted splines curve usually does a good job of staying in between the original curve and the complement. The points at which credibility is being done can also be tweaked, which can help sometimes if needed.

The regression equation used here is:

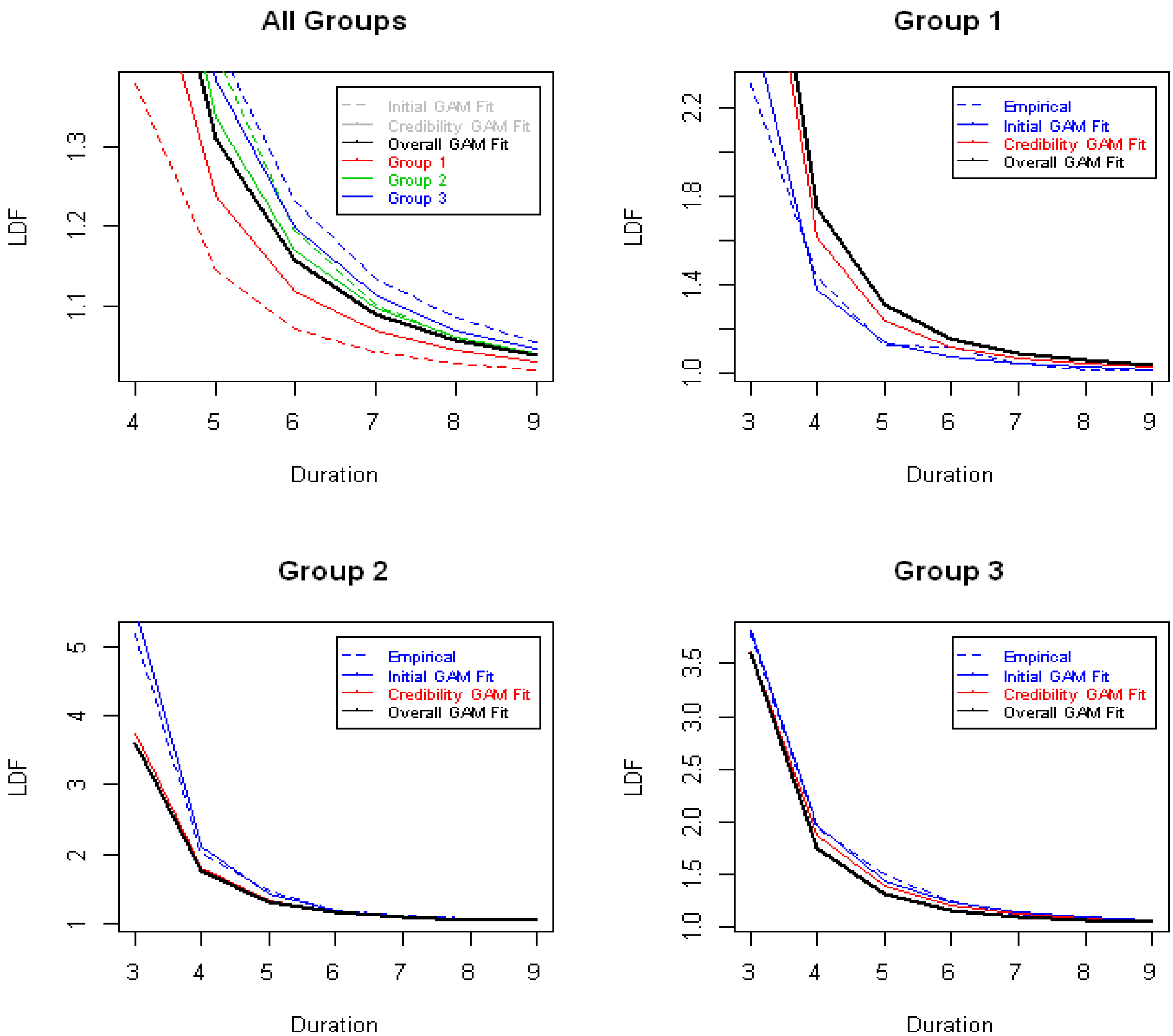
$$\log(LDF-1) = A + B \times s(\log(t))$$

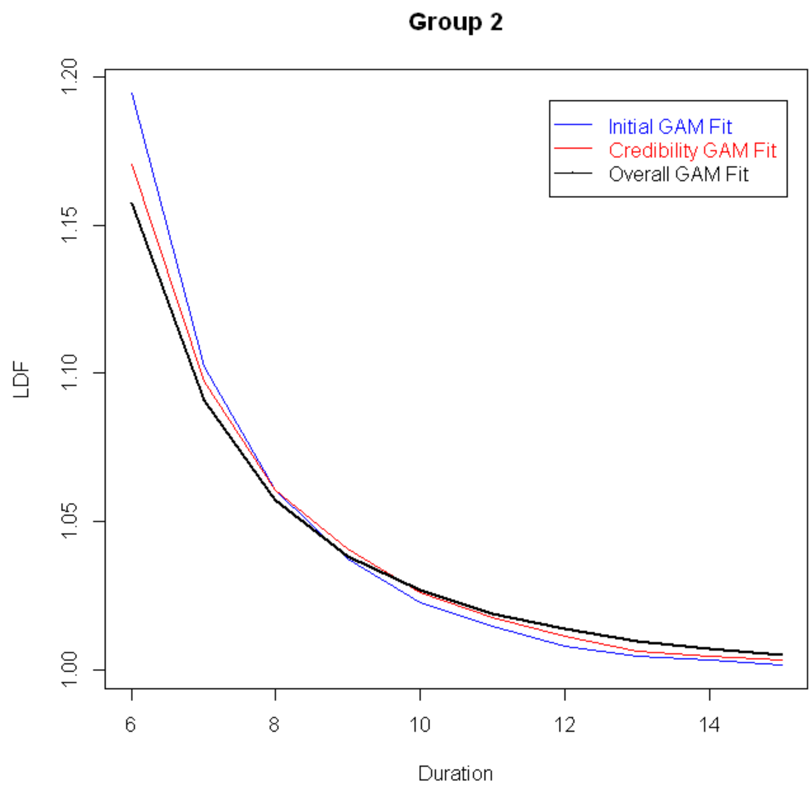
Where *A* and *B* are the regression coefficients, *t* is the age, and *s* is a smoothing cubic spline function. Using splines, this can be extended to:

$$\log(LDF-1) = A + Bt^1 + Ct^2 + Dt^3 \tag{4.1}$$

Where *A* is the intercept of the curve and *B, C,* and *D* are the slope parameters for each of the generated spline variables, t^1 , t^2 , and t^3 on the logarithm of the age. (We used superscripts to denote the different spline variables.) To fit such a model, similar to the inverse power curve, we use maximum likelihood to solve for the parameters. Implementing credibility is also very similar to what we did for the inverse power curve, except that here the prior likelihood should be calculated for four different LDFs instead of two since this regression equation has a total of four parameters including the intercept.

Below are some examples of implementing credibility weighting with this method on real data. (The resulting LDFs have been modified so as not to reveal any propriety information.) The spline curves provide a good fit to the data and the credibility weighted curves lie in between the original and the overall. The second graph zooms in on the second segment to show that the credibility curve does a good job of staying in between the original and the overall curve even when these two curves cross over each other. (All of these fits were produced in Excel using the Solver feature to maximize the log-likelihood.)


All Groups
Initial GAM Fit
Credibility GAM Fit
Overall GAM Fit
Group 1
Group 2
Group 3
LDF
1.1
1.2
1.3
4
5
6
7
8
9
Duration
Group 1
Empirical
Initial GAM Fit
Credibility GAM Fit
Overall GAM Fit
LDF
1.0
1.4
1.8
2.2
3
4
5
6
7
8
9
Duration
Group 2
Empirical
Initial GAM Fit
Credibility GAM Fit
Overall GAM Fit
LDF
1
2
3
4
5
3
4
5
6
7
8
9
Duration
Group 3
Empirical
Initial GAM Fit
Credibility GAM Fit
Overall GAM Fit
LDF
1.0
1.5
2.0
2.5
3.0
3.5
3
4
5
6
7
8
9
Duration



The equations for inverting these curves are shown in Appendix A for both three and four parameter curves.

5. Multidimensional Credibility Models

The models we have been discussing up to this point were one dimensional models as the credibility weighting was done across a single variable. A multidimensional model can also be constructed that considers the differences across more than a one variable. Assuming that our two variables are state and industry, a two dimensional model can be built by defining a relationship for the (inverted) LDF parameters, such as the following:

$$\log(LDF_{s,i}) = Intercept + State\,Coefficient_s + Industry\,Coefficient_i \quad \textbf{(5.1)}$$

We used a log-link here to make the relationship multiplicative, since this usually works best for multidimensional models. The total log-likelihood would be calculated by summing up the log-likelihood of each fitted LDF and the log-likelihood of the priors for each coefficient. The equation would be as follows:

$$\sum_{s=States}\sum_{i=Industries} N(Fitted\ LDF_{s,i}, Actual\ LDF_{s,i}, Within\ Variance_{s,i}) + \sum_{s=States} N(State\ Coef_{s}, 0, State\ Between\ Variance) + \sum_{i=Industries} N(Industry\ Coef_{i}, 0, Industry\ Between\ Variance) \quad \textbf{(5.2)}$$

Where, once again, *N(A, B, C)* is the logarithm of the probability density function evaluated at *A*, with a mean of *B* and variance of *C*. Each state and industry coefficient is credibility weighted back towards zero, which pushes each curve back towards the intercept, which will be the complement of credibility. It is also possible to add an interaction term for state and industry and have that credibility weighted back towards zero as well. This will give the model more flexibility to better reflect the differences of state-industry combinations that differ from the average.

This type of model can be solved without the use of special Bayesian software as well. Since MLE parameters are known to be approximately normal, and since the prior distribution is normal, the posterior (credibility weighted result) will be approximately normal as well. And, as we discussed, this type of model can be solved with MLE. However, unlike the one dimensional models discussed above, every segment needs to be maximized together. Because of this, the number of parameters may be too many to have accurately solved with a maximization routine, but this depends on the circumstance.

6. Modeling across Continuous Variables

For modeling LDFs across most continuous predictive variables in the data, such as account size or retention (which will also be discussed more thoroughly in the next section), we would usually not want to credibility weight these curves back towards the mean, since we usually expect there to be an order to these curves, and credibility weighting would just bump up the lower curves and bump down the higher ones. Instead, we can define a relationship between the different curves that depends on the continuous variable. To implement, the inverted, reparameterized version of the curves should be used. For each group, the LDF parameters should be set to a function of the continuous variable. For example, the following formula can be used to determine the LDF parameters for each retention group:

$$log(LDF\ Parameter) = Intercept + exp(Coefficient) \times log(Retention) \quad \textbf{(6.1)}$$

We took the exponent of the coefficient to guarantee that the actual coefficients used are positive and so will result in curves that can only increase by retention, which is usually the expectation.

As an alternative, sometimes it works better to simply constrain the LDF parameters to the expected order. This can be implemented by setting each LDF parameter for each group to the LDF parameter of the group below it plus the exponent of another parameter. The exponent is used to ensure that the difference is positive. For both of the approaches mentioned, when working with volatile data, setting a minimum value for the slope or difference parameters to something small, such as 1% or lower, often produces results that fall more in line with expectations.

7. Loss Caps, Retentions, and Policy Limits

Besides for the strategy mentioned in the previous section, when modeling across different loss caps, retentions, and/or policy limits, we can leverage information from the severity distribution to help define the relationships between the groups. This method assumes that the loss severity distribution has already been estimated. It also requires claim count development factors. Our approach differs from that in Sahasrabuddhe 2010, which suggests using the severity distribution to modify the actual data of the triangle; here we convert the LDFs themselves. Note that this strategy uses the regular (non-inverted, that is) versions of the curves (unless credibility weighting is being done as well.)

We will start off with the following relationship mentioned in Siewert 1996 (although in a slightly different syntax). This formula simply states that loss development consists of the arrival of new claims as well as increased severity of both the existing and new claims.

$$LDF_t = CCDF_t \times SDF_t \quad \textbf{(7.1)}$$

Where CCDF is the claim count development factor and SDF is the severity development factor, which accounts for the increase in the average claim severity as a year matures. Flipping the equation around, this becomes:

$$SDF_t = \frac{LDF_t}{CCDF_t} \quad \textbf{(7.2)}$$

We will use these relationships to demonstrate modeling across different loss caps assuming that we are basing the LDFs of other, less stable caps on one particular, more stable cap. We will then generalize to include retentions and policy limits and also allow modeling of all groups simultaneously.

For a particular cap, c1:

$$SDF_t(c1) = \frac{LEV_T(c1)}{LEV_t(c1)} \tag{7.3}$$

Where $LEV_t(x)$ is the limited expected value at *x* at age *t* and *T* is infinity (although *t+1* can be used to convert age-to-age factors as well). If we have an assumption for how severity development affects claims, we can use this to derive the LDFs. For now, we will assume that all uncapped losses increase on average by the same multiplicative factor as a year matures, and we adjust the loss severity distribution by a scale adjustment. To explain, most distributions have a way of modifying one of the parameters which causes each claim to increase or decrease by the same multiplicative factor. For example, the mu parameter of the lognormal distribution is a log-scale parameter and adding the natural logarithm of 1.1, for example, will increase each claim by 10%. For a mixed exponential distribution, each theta parameter would be multiplied by 1.1. We rewrite equation 7.3 to show the scale parameters instead of the ages, where $LEV(\theta; c1)$ is the LEV with a scale parameter of θ at a cap of c1[5]:

$$SDF_t(c1) = \frac{LEV(\theta; c1)}{LEV(\theta / a_t; c1)} \tag{7.4}$$

Since we know the SDF and can calculate $LEV(\theta; c1)$, we can back into the factor, *a*, that satisfies this equation. If losses are uncapped, there are no policy limits, and c1 is infinity, then the factor, *a*, would equal the SDF. Otherwise, it will be slightly higher. Once we have the loss severity distribution at time *t,* we can use this to derive the severity development factor at another loss cap, c2:

5 As a side note, applying this SDF to the claims of each year can also be used as a strategy for developing the severity distribution to ultimate when fitting increased limit factors.

$$SDF_t(c2) = \frac{LEV(\theta; c2)}{LEV(\theta/a_t; c2)} \quad \textbf{(7.5)}$$

And we can then use this to calculate the loss development factor, at a loss cap of *c2*:

$$LDF_t(c2) = CCDF_t \, x \, SDF_t(c2) \quad \textbf{(7.6)}$$

The above assumed that all claims were ground up. If this is not the case, and there is a retention (assuming that it is uniform across all policies, for now), the average severities can be calculated as:

$$\frac{LEV(AP + Cap) - LEV(AP)}{s(AP)} \quad \textbf{(7.7)}$$

Where *AP* is the retention. We divided by the survival function at the retention to produce the average severities conditional on having a claim above the retention, which is consistent with the claims we observe in the triangle.

For modeling across different retentions, the strategy changes slightly since the claim counts are not at the same level. We can control for this by making the average severities for a retention conditional of having a claim at another retention by dividing by the survival function at this retention. When converting the severity development factor to an LDF, the claim count development factor at this retention should be used. The formulas are as follows, where *SDF(x, y, Relative to z)* is the severity development factor at a retention of *x*, a cap of *y*, and expressed relative to the claim counts of retention *z*.

$$SDF_t(AP2, Cap, Relative \text{ to } AP1) = \frac{(LEV_T(AP2 + Cap) - LEV_T(AP2)) / s_T(AP1)}{(LEV_t(AP2 + Cap) - LEV_t(AP2)) / s_t(AP1)} \quad \textbf{(7.8)}$$

$$LDF_t(AP2, Cap) = CCDF_t(AP1) \times SDF_t(AP2, Cap, Relative \text{ to } AP1) \quad \textbf{(7.9)}$$

If just converting from LDFs of one retention to another once the *a* factors are already known, the

SDFs can also be expressed relative to first dollar CCDFs (even if these are not available) to simplify the formula. The formula is:

$$LDF_t(AP2, Cap2) = LDF_t(AP1, Cap1) \times \frac{SDF\,(AP2, Cap2, Relative \text{ to } 0)}{SDF\,(AP1, Cap1, Relative \text{ to } 0)} \tag{7.10}$$

To leverage credibility in the claim count development factors as well, claim counts from one retention can be converted to another using this formula:

$$CCDF_t(AP2) = CCDF_t(AP1) \times \frac{s_T(AP2) / s_T(AP1)}{s_t(AP2) / s_t(AP1)} \tag{7.11}$$

To give an example, if the (age-to-ultimate) LDF for a particular age for a group of ground-up policies with limits of one million is 1.3 and the claim count development factor is 1.2, this would indicate that the severity development factor is 1.3 / 1.2 = 1.083, using equation 7.2. Assuming the severity distribution (at ultimate) is lognormal with mu and sigma parameters of 10 and 2, respectively, we can back into the scale adjustment using equation 7.5. Using an *a* value of 1.115 produces the desired SDF of 1.083. Using this same equation and same value of *a*, the SDF for a group of policies with limits of five million is equal to 1.101, which implies an LDF of 1.101 x 1.2 = 1.321, slightly higher than the original LDF of 1.3, as expected. Similarly, using equations 7.8 and 7.9 for excess policies, the SDF for a group of policies with retentions and policy limits of one million, expressed relative to group up claim counts, is 1.144, which implies an LDF of 1.372.

In the above discussion, we assumed that every policy is written at the same retention or policy limit. For a more realistic scenario with different limits and retentions within each group, the average expected severity should be calculated across all policies. If we assume that the expected frequency of each policy is equal to the (on-level) premium divided by the expected average severity, the average severity is equal to the total premium divided by the total number of expected claims, or:

$$\frac{\sum_i Premium_i}{\sum_i Premium_i / Expected\ Average\ Severity_i} \tag{7.12}$$

If the retentions or policy limits within each group are not too far apart, it is possible that calculating the average severities using a premium weighted average limit and/or retention may not be too far off. This strategy can also be used to adjust LDFs if there are shifts in the average retentions and/or limits by year. We ignored the effects of trend in the above which can easily be added by applying a de-trending factor to the scale parameter of the loss severity distribution.

As we mentioned, the above discussion was geared towards converting LDFs from one retention/limit/cap to another, but it is also possible to model across all groups simultaneously using these relationships. To do so, instead of backing into the *a* factors, since we are using MLE, they can be included in the parameters being maximized. A curve can be fit to the age-to-age *a* factors, and then they can be multiplied together to produce the age-to-ultimate factors, which are needed to calculate the SDFs. If simultaneously fitting the CCDFs, parameters will be needed for these as well (at one particular retention). The log-likelihoods can then be calculated and added up across all LDFs and CCDFs, and this sum can be maximized. Alternatively, the claim counts can be ignored and the parameters being maximized can include the *a* factors and the parameters for the LDFs of one of the groups. Once we have all of these, the SDFs can be calculated and equation 7.10 can be used to convert these LDFs to different retentions, caps, and/or limits. This approach, however, does not utilize the data in the claim count develop factors and so is not as strong.

We assumed here that every claim increases by the same amount using a scale factor adjustment, but since we are backing into (or maximizing) the adjusted value of $LEV_t(x)$ using the SDF, this procedure allows for any sort of parameter transformations. For example, for excess losses modeled with a one- or two-parameter Pareto, allowing the alpha parameter to vary instead of the Beta parameter, which is a scale parameter, has the effect of increasing or decreasing the tail of the distribution.

8. Individual Account Credibility

Most of the models discussed above can be implemented relatively simply without use of any specialized software. This allows the use of these credibility models in account rating engines, often implemented in spreadsheets. The complement of credibility for each account should be the selected LDFs for the portfolio with the between variances and the within variance factors calculated at the portfolio level. The between variance should represent the variance of the differences across accounts and can be calculated by looking at a sampling of accounts. The within variance can be calculated by dividing the within variance factor by the account's losses and credibility weighted LDFs can be produced.

9. Conclusion

In this paper we discussed several loss development models that perform very well in practice and that are relatively simple to implement. Using these models will allow for more accurate differentiation between risks that properly reflects the differences in the patterns in which losses arrive.

Appendix A

The following are the equations for inverting a splines regression equation with four parameters in total, an intercept and a spline with three degrees of freedom. The equation for this curve is as follows:

$$\log(LDF-1)=A+Bt^1+Ct^2+Dt^3$$

Where, once again, superscripts here denote each resulting spline variable. The following substitution variables will be used:

$$X=\log\left(\frac{LDF_1-1}{LDF_2-1}\right)-\frac{t_1^1-t_2^1}{t_3^1-t_4^1}\times\log\left(\frac{LDF_3-1}{LDF_4-1}\right)$$

$$I=(t_1^2-t_2^2)-\frac{(t_3^2-t_4^2)\times(t_1^1-t_2^1)}{t_3^1-t_4^1}$$

$$J=(t_1^3-t_2^3)-\frac{(t_3^3-t_4^3)\times(t_1^1-t_2^1)}{t_3^1-t_4^1}$$

$$Y=\log\left(\frac{LDF_1-1}{LDF_3-1}\right)-\frac{t_1^1-t_3^1}{t_2^1-t_4^1}\times\log\left(\frac{LDF_2-1}{LDF_4-1}\right)$$

$$K=(t_1^2-t_3^2)-\frac{(t_2^2-t_4^2)\times(t_1^1-t_3^1)}{t_2^1-t_4^1}$$

$$L=(t_1^3-t_3^3)-\frac{(t_2^3-t_4^3)\times(t_1^1-t_3^1)}{t_2^1-t_4^1}$$

The equations for each of the four parameters are:

$$D = \frac{X - Y \times I/K}{J - L \times I/K}$$

$$C = \frac{(t_1^1 - t_2^1)[\log(\frac{ldf_3 - 1}{ldf_4 - 1}) - D(t_3^3 - t_4^3)] - (t_3^1 - t_4^1)[\log(\frac{ldf_1 - 1}{ldf_2 - 1}) - D(t_1^3 - t_2^3)]}{(t_3^2 - t_4^2)(t_1^1 - t_2^1) - (t_1^2 - t_2^2)(t_3^1 - t_4^1)}$$

$$B = \frac{\log(\frac{LDF_1 - 1}{LDF_2 - 1}) - C(t_1^2 - t_2^2) - D(t_1^3 - t_2^3)}{t_1^1 - t_2^1}$$

$$A = \log(LDF_1 - 1) - Bt_1^1 - Ct_1^2 - Dt_1^3$$

To help facilitate implementation, the R code for performing this inversion is as follows, where *xx* represents *x* above, etc., *spline1*, *spline2*, and *spline3* are vectors which contain the three spline transformations, *age* is a vector which contains the four ages being used for the parameters, *b3* represents *D*, *b2* represents *C*, etc., and *g* represents the group index of each LDF curve:

```
xx[g] <- log( ( ldf.param1[g] - 1 ) / ( ldf.param2[g] - 1 ) )-( ( spline1[age[1]] - spline1[age[2]] ) / ( spline1[age[3]] - spline1[age[4]] ) ) * log( ( ldf.param3[g] - 1) / ( ldf.param4[g] - 1 ) )

ii[g] <- ( spline2[age[1]] - spline2[age[2]] ) - ( ( spline2[age[3]] - spline2[age[4]] ) * ( spline1[age[1]] - spline1[age[2]] ) ) / ( spline1[age[3]] - spline1[age[4]] )

jj[g] <- ( spline3[age[1]] - spline3[age[2]] ) - ( ( spline3[age[3]] - spline3[age[4]] ) * ( spline1[age[1]] - spline1[age[2]] ) ) / ( spline1[age[3]] - spline1[age[4]] )

yy[g] <- log( ( ldf.param1[g] - 1 ) / ( ldf.param3[g] - 1 ) )-( ( spline1[age[1]] - spline1[age[3]] ) / ( spline1[age[2]] - spline1[age[4]] ) ) * log( ( ldf.param2[g] - 1) / ( ldf.param4[g] - 1 ) )

kk[g] <- ( spline2[age[1]] - spline2[age[3]] ) - ( ( spline2[age[2]] - spline2[age[4]] ) * ( spline1[age[1]] - spline1[age[3]] ) ) / ( spline1[age[2]] - spline1[age[4]] )

ll[g] <- ( spline3[age[1]] - spline3[age[3]] ) - ( ( spline3[age[2]] - spline3[age[4]] ) * ( spline1[age[1]] - spline1[age[3]] ) ) / ( spline1[age[2]] - spline1[age[4]] )

b3[g] <- ( xx[g] - yy[g] * ii[g] / kk[g] ) / ( jj[g] - ll[g] * ii[g] / kk[g] )

b2[g] <- ( ( spline1[age[1]] - spline1[age[2]] ) * ( log( ( ldf.param3[g] - 1 ) / ( ldf.param4[g] - 1 ) ) - b3[g] * ( spline3[age[3]] - spline3[age[4]] ) ) - ( spline1[age[3]] - spline1[age[4]] ) * ( log( ( ldf.param1[g] - 1) / ( ldf.param2[g] - 1 ) ) - b3[g] * ( spline3[age[1]] - spline3[age[2]] ) ) ) / ( ( spline2[age[3]] - spline2[age[4]] ) * ( spline1[age[1]] - spline1[age[2]] ) - ( spline2[age[1]] - spline2[age[2]] ) * ( spline1[age[3]] - spline1[age[4]] ) )

b1[g] <- ( log( ( ldf.param1[g] - 1 ) / ( ldf.param2[g] - 1 ) ) - b2[g] * ( spline2[age[1]] - spline2[age[2]] ) - b3[g] *
```

```
( spline3[age[1]] - spline3[age[2]] ) ) / ( spline1[age[1]] - spline1[age[2]] )
b0[g] <- log( ldf.param1[g] - 1 ) - ( b1[g] * spline1[age[1]] ) - ( b2[g] * spline2[age[1]] ) - ( b3[g] *
spline3[age[1]] )
```

For Excel, if the three spline transformations are on the top 3 rows of the spreadsheet for the four ages being used as parameters going across and starting at cell A1, and the four LDF parameters to be inverted are in cells A5 to D5, then the formulas for each of the intermediate parameters are as follows:

X=LN((A5-1)/(B5-1))-(A1-B1)/(C1-D1)*LN((C5-1)/(D5-1))

I=(A2-B2)-((C2-D2)*(A1-B1))/(C1-D1)

J=(A3-B3)-((C3-D3)*(A1-B1))/(C1-D1)

Y=LN((A5-1)/(C5-1))-(A1-C1)/(B1-D1)*LN((B5-1)/(D5-1))

K=(A2-C2)-((B2-D2)*(A1-C1))/(B1-D1)

L=(A3-C3)-((B3-D3)*(A1-C1))/(B1-D1)

If these formulas are placed on row 6 going across starting with column A, then the formulas for each of the curve parameters are as follows, assuming that these are placed in row 7 going across and starting from the column A:

D=LN(A5-1)-B7*A1-C7*A2-D7*A3

C=(LN((A5-1)/(B5-1))-C7*(A2-B2)-D7*(A3-B3))/(A1-B1)

B=((A1-B1)*(LN((C5-1)/(D5-1))-D7*(C3-D3))-(C1-D1)*(LN((A5-1)/(B5-1))-D7*(A3-B3)))/((C2-D2)*(A1-B1)-(A2-B2)*(C1-D1))

A=(A6-D6*B6/E6)/(C6-F6*B6/E6)

The equations for inverting a curve with only three parameters, an intercept and a spline with two degrees of freedom are shown below. The regression equation is as follows:

$$\log(LDF-1)=A+Bt^1+Ct^2$$

The following substitution variables are used:

$$X = t_1^1 - t_2^1$$

$$Y = t_1^2 - t_2^2$$

$$W = t_2^1 - t_3^1$$

$$Z = t_2^2 - t_3^2$$

The equations for inverting each of the variables are:

$$C = \frac{\frac{X}{W}\log\left(\frac{LDF_2}{LDF_3}\right) - \log\left(\frac{LDF_1}{LDF_2}\right)}{\frac{XZ}{W} - Y}$$

$$B = \frac{\frac{Y}{Z}\log\left(\frac{LDF_2}{LDF_3}\right) - \log\left(\frac{LDF_1}{LDF_2}\right)}{\frac{YW}{Z} - X}$$

$$A = \log(LDF_1) - Bt_1^1 - Ct_1^2$$

Formulas for R and Excel are not shown for this version since the equations are much less complicated than the four parameter version.

8. References

[1] Dean, C., "Topics in Credibility Theory," Education and Examination Committee of the Society of Actuaries, 2005, https://www.soa.org/files/pdf/c-24-05.pdf

[2] England P., and Verrall, R., "A Flexible Framework for Stochastic Claims Reserving," Proceedings of the Casualty Actuarial Society, 2001: LXXXVIII, pp. 1-38. http://www.casact.org/pubs/proceed/proceed01/01001.pdf

[3] England, P. D. and Verrall, R. J. 2002. Stochastic Claims Reserving in General Insurance. British Actuarial Journal 8:443-544.

http://www.cassknowledge.com/sites/default/files/article-attachments/371~~richardverrall_-_stochastic_claims_reserving.pdf

[4] Lowe, S. P., and Mohrman, D. F., "Extrapolating, Smoothing and Interpolating Development Factors [Discussion]," Proceedings of the Casualty Actuarial Society Casualty Actuarial Society, 1985: LXXII, pp. 182-189. http://www.casact.org/pubs/proceed/proceed85/85182.pdf

[5] Sahasrabuddhe, R., "Claims Development by Layer: The Relationship between Claims Development Patterns, Trend and Claim Size Models," CAS E-Forum, Fall 2010, pp. 457-480

https://www.casact.org/pubs/forum/10fforum/Sahasrabuddhe.pdf

[6] Sherman, R. E., "Extrapolating, Smoothing and Interpolating Development Factors," Proceedings of the Casualty Actuarial Society Casualty Actuarial Society, 1984: LXXI, pp. 122-155. https://www.beanactuary.com/pubs/proceed/proceed84/84122.pdf

[7] Siewert, J. J., "A Model for Reserving Workers Compensation High Deductibles," CAS Forum,

Summer 1996, pp. 217-244.

https://www.casact.org/pubs/forum/96sforum/96sf217.pdf

Biography of the Author

Uri Korn is an AVP & Actuary at Axis Insurance serving as the Research and Development support for all commercial lines of insurance. Prior to that, he was a Supervising Actuary at AIG in the Casualty pricing department. His work and research experience includes practical applications of credibility, trend estimation, increased limit factors, non-aggregated loss development methods, and Bayesian models. Uri Korn is a Fellow of the Casualty Actuarial Society and a member of the American Academy of Actuaries.

Incorporating Model Error into the Actuary's Estimate of Uncertainty

Abstract

Current approaches to measuring uncertainty in an unpaid claim estimate often focus on parameter risk and process risk but do not account for model risk. This paper introduces simulation-based approaches to incorporating model error into an actuary's estimate of uncertainty. The first approach, called Weighted Sampling, aims to incorporate model error into the uncertainty of a single prediction. The next two approaches, called Rank Tying and Model Tying, aim to incorporate model error in the uncertainty associated with aggregating across multiple predictions. Examples are shown throughout the paper and issues to consider when applying these approaches are also discussed.

Keywords

Model uncertainty, model risk, model error, parameter risk, process risk, model variance, parameter variance, process variance, mean squared error, unpaid claim estimate, uncertainty, reserve variability, bias, simulation, scaling, weighted sampling, rank tying, model tying.

Table of Contents

1 Introduction

One of the core practices performed by property and casualty actuaries is the estimation of unpaid claims, which according to Actuarial Standard of Practice Number 43 (ASOP 43), *Property/Casualty Unpaid Claim Estimates*, is defined as:

> Unpaid Claim Estimate – The actuary's estimate of the obligation for future payment resulting from claims due to past events.

Estimates by their nature are subject to uncertainty and our profession has strived to communicate the uncertainty inherent in unpaid claim estimates to the users of our services. In the past, communications were mostly verbal in the sense that they warned the user of the risk that the actual outcome may vary, perhaps materially, from any estimate, but were rarely accompanied by a quantification of the magnitude of this uncertainty. More recently, actuaries have developed approaches to measure uncertainty and have included this information in their communications.

ASOP 43 suggests that there are three sources of uncertainty in an unpaid claim estimate.

> Section 3.6.8 Uncertainty – "When the actuary is measuring uncertainty, the actuary should consider the types and sources of uncertainty being measured and choose the methods, models and assumptions that are appropriate for the measurement of such uncertainty…Such types and sources of uncertainty surrounding unpaid claim estimates may include uncertainty due to model risk, parameter risk, and process risk." (emphasis added)

ASOP 43 defines each risk as follows:

> 2.7 Model Risk – "The risk that the methods are not appropriate to the circumstances or the models are not representative of the specified phenomenon."

> 2.8 Parameter Risk – "The risk that the parameters used in the methods or models are not representative of future outcomes."

> 2.10 Process Risk – "The risk associated with the projection of future contingencies that are inherently variable, even when the parameters are known with certainty."

Common approaches to measuring uncertainty, such as the Bootstrapping approach described by England and Verrall (1999, 2002 and 2006) and England (2001) and the distribution-free methodology described by Thomas Mack (1993), are based on the premise that a single model in isolation is representative of the unpaid claims process, and as a result, uncertainty is measured only for parameter and process risk. We believe that circumstances exist in current practice where model risk is evident in the uncertainty surrounding an unpaid claim estimate, and as a result, this paper introduces methodologies to incorporate its impact. These methodologies leverage existing approaches that measure parameter and process risk by supplementing their results with the inclusion of model risk. Examples are shown throughout the paper that, to the extent practical, are based on a single case study which is discussed in more detail in Appendix A.

1.1 Background

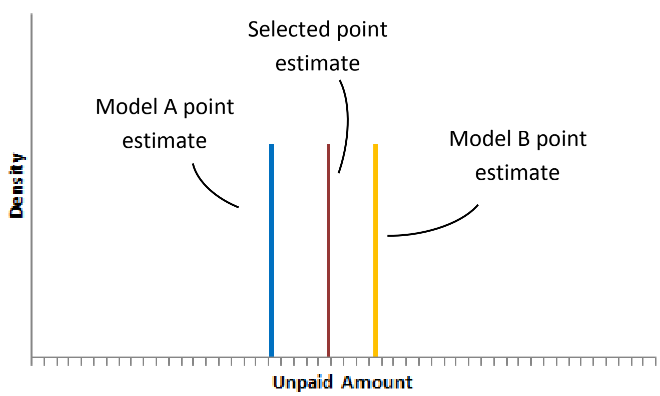
The genesis of this paper and the methodologies presented herein are the result of a dilemma that the authors observed when estimating uncertainty associated with an unpaid claim estimate. This dilemma is perhaps best explained through a hypothetical example.

Consider a hypothetical situation where an actuary uses two actuarial projection methodologies (i.e. models) to estimate unpaid claims for a book of business: Model A and Model B, which both produce a point estimate. Based on the actuary's expertise and professional judgment, the actuary selects the central estimate (colloquially referred to as a "best estimate") to be the straight average of the two point estimates. In other words:

$$Central\ Estimate = \frac{(Model\ A\ Point\ Estimate + Model\ B\ Point\ Estimate)}{2}$$

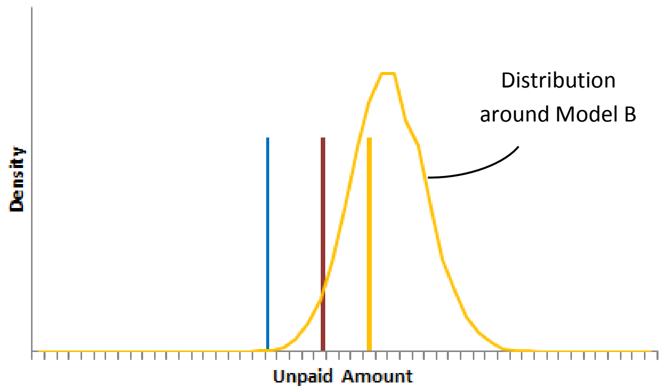
Graphically, these point estimates are shown in Figure 1.

Figure 1. Actuarial central estimate



In order to convey uncertainty in this example, the actuary uses Model B as the basis for estimating uncertainty and observes the following distribution in Figure 2.

Figure 2. Distribution around Model B



If it is assumed that the distribution in Figure 2 is intended to represent the range of uncertainty in the actuary's estimate, then a couple of observations raise concern:

- The actuarial central estimate is not centrally located within the distribution; and
- The distribution implies that the point estimate from Model A is an unlikely outcome, which conflicts with the actuary's professional judgment to equally weight the point estimates from Model A with Model B in selecting a central estimate.

This example is not unique in that it is common for an actuary to estimate unpaid claims with more than one model and it is rare for different models to produce point estimates that are equivalent. Furthermore, current approaches to estimating uncertainty tend to model uncertainty within the context of a single model, which often is not equivalent to the actuary's selected central estimate.

2 Scaling

One approach to dealing with this dilemma is to shift the distribution about Model B so that the mean of the distribution is set equal to the actuary's selected central estimate. This approach, referred herein as scaling, can be done additively, which maintains the same variance, or multiplicatively, which maintains the same coefficient of variation, where:

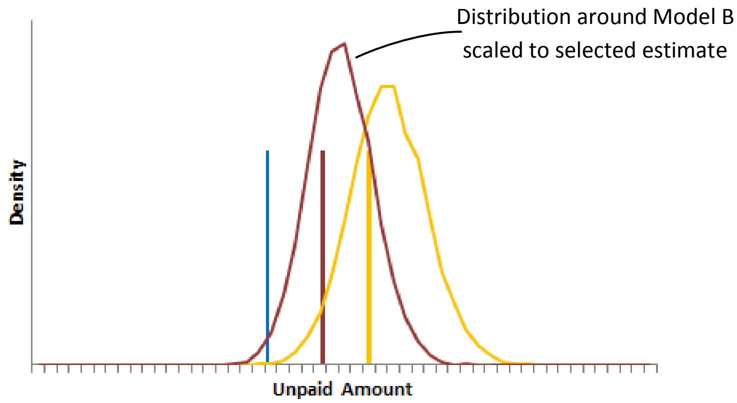
For each point, x_i, within a distribution with mean equal to $\bar{x}$, the corresponding scaled points, x'_i, in the distribution are equal to:

$$Additive\ Scaling: x'_i = x_i + [central\ estimate - \bar{x}]$$

$$Multiplicative\ Scaling: x'_i = x_i \frac{[central\ estimate]}{\bar{x}}$$

Scaling a distribution can be a suitable approach when the magnitude of scaling is immaterial, however, this approach tends to produce unsatisfactory results as the magnitude of the difference between the point estimates increase. For example, consider the hypothetical results before and after scaling multiplicatively to the actuarial central estimate in Figure 3.

Figure 3. Scaling



In this situation, the mean of the implied distribution after scaling reconciles with the actuarial central estimate, however, the point estimate from Model A continues to appear as an outlier. While this example may be an exaggeration, it highlights a dilemma that an actuary faces when the indications from various models diverge.

3 Mean Squared Error

In order to address this dilemma it may be helpful to explore uncertainty in an estimate from a mathematical perspective. [Authors note: The mathematical terms and formulas in this section are used only for the purpose of establishing a theoretical foundation for uncertainty and its relationship with model error. The approaches introduced afterward for incorporating model error do not rely on these formulas and this section of the paper, however, these formulas are believed to be useful for understanding the basic concepts of uncertainty.]

Uncertainty, as used in the context of this paper, implies that the actual outcome may turn out to be different from our estimate (i.e. prediction). In statistics, the Mean Squared Error (MSE) measures this difference. Consider an outcome as a random variable, y and a prediction, $\hat{y}$. The mean squared error is:

$$E[(y - \hat{y})^2]$$

Expanding this term through additive properties yields:

$$E[(y - \hat{y})^2] = E[(y - \hat{y} + (E[y] - E[y]) + (E[\hat{y}] - E[\hat{y}]))^2]$$

Reordering yields

$$E[(y - \hat{y})^2] = E\left[\left((y - E[y]) - (\hat{y} - E[\hat{y}]) + E[y] - E[\hat{y}]\right)^2\right]$$

If we assume y and $\hat{y}$ are independent, then the formula reduces to

$$E[(y - \hat{y})^2] = E[(y - E[y])^2] + E[(\hat{y} - E[\hat{y}])^2] + (E[y] - E[\hat{y}])^2$$

Appendix B derives this formula in more detail. This equation as it is currently structured highlights a key relationship: the mean squared error equals the sum of process variance, parameter variance and squared bias, where:

$$\boldsymbol{Process\ Variance = Var(y) = E\left[(y - E[y])^2\right];}$$

$$\boldsymbol{Parameter\ Variance = Var\ (\hat{y}) = E\left[(\hat{y} - E[\hat{y}])^2\right]; and}$$

$$\boldsymbol{Squared\ Bias = (Bias(y, \hat{y}))^2 = (E[y] - E[\hat{y}])^2.}$$

These terms are discussed further below.

3.1 Process Variance

$\boldsymbol{Var(y) = E\left[(y - E[y])^2\right]}$

The formula for process variance uses the terms y and $E[y]$. The variable y is the actual outcome we are trying to predict, which is presumed to be a random variable that is generated from a distribution with mean equal to $E[y]$. In other words, process variance measures the variance of actual outcomes.

Insurance is believed to be a stochastic process (or nearly stochastic in the sense that the sheer number of conditions which contribute to an actual outcome makes it appear random simply because we are unable to account for all of that information) and the variability inherent in a single outcome occurring is measured by process variance. Consider the flipping of a coin where the probability of a "head" occurring is equal to the probability of a "tail." Despite this knowledge of the underlying probabilities, we are still unable to accurately predict the outcome from a single flip of the coin because there is an element of randomness to any single observation. The estimation of unpaid claims in insurance is similar in that the actual outcome to which we are predicting is a single observation that is one of many probable outcomes which could occur.

3.2 Parameter Variance

$\boldsymbol{Var\ (\hat{y}) = E[(\hat{y} - E[\hat{y}])^2]}$

The formula for parameter variance uses the terms $\hat{y}$ and $E[\hat{y}]$ where the variable $\hat{y}$ is the prediction. Actuaries make predictions of unpaid claims through the application of projection methodologies that attempt to model the overall insurance process using parameters that are estimated from a data sample. Generally speaking, not every point within the distribution of probable predictions from a model is a suitable candidate for an actuarial prediction. Our goal as actuaries is to parameterize the model such that the resulting prediction, $\hat{y}$, is central to the distribution, however, this prediction may not be equal to the true underlying mean of the model, $E[\hat{y}]$, because of our uncertainty in estimating the model's parameters from the data sample. Parameter variance is also called estimation variance because this term of the MSE measures the uncertainty in the estimation of the model parameters.

3.3 Squared Bias

$(\boldsymbol{Bias}(\boldsymbol{y}, \widehat{\boldsymbol{y}}))^2 = (\boldsymbol{E}[\boldsymbol{y}] - \boldsymbol{E}[\widehat{\boldsymbol{y}}])^2$

In statistics, a prediction, $\hat{y}$, is considered unbiased if the expected value of the prediction is equal to the expected value of the outcome, y, to which we are trying to predict. Otherwise, statistical bias exists and is measured through this term of the mean squared error. Squared bias is relevant when attempting to estimate the parameters of the MSE, which is beyond the scope of this paper. Some methods of estimation, such as maximum likelihood techniques, may produce biased estimates and will require squared bias to be incorporated into the MSE but for simplicity of discussion we will assume squared bias is equal to zero and we will not address it further in this paper when discussing the MSE.

3.4 Estimating the MSE – Single Model

Although the formula for the mean squared error provides theoretical insights into the components of uncertainty in a prediction, it remains a quandary to apply in an actuarial context since it requires us to be able to measure statistical properties (namely mean and variance) of outcomes that could occur, which are unknown. In many industries, the statistical properties of actual outcomes can be derived by observing a sufficiently large number of trials, but unfortunately, the unpaid claim process is not a repeatable exercise.

One way actuaries have dealt with this predicament is by estimating uncertainty on the condition that a particular actuarial projection methodology (i.e. model) in isolation is representative of the random variable, y. In other words, if the unknown distribution of probable outcomes, $f(y)$, is defined by the distribution of probable predictions from Model A, represented as $f_A(y)$, such that:

$$f(y) = f_A(y)$$

then

$$[MSE|f(y) = f_A(y)] = E[(y_A - \hat{y}_A)^2]$$

where,

y_A is the actual outcome, y, generated from Model A, and

$\hat{y}_A$ is the prediction, $\hat{y}$, from Model A.

Under this conditional assumption, process variance can be defined as the distribution of probable outcomes generated from Model A and parameter variance can be defined as the variance in actuarial estimates generated from Model A.

An interesting observation is that the distribution of uncertainty corresponding to the MSE represents a range that is at least as wide and most likely wider than the range of probable outcomes (i.e. process variance) since it must also incorporate the uncertainty associated with the actuary's estimate of the model's parameters (i.e. parameter variance). In other words the distribution of uncertainty, such as the one shown for Model B in Figure 2, represents the actuary's estimate of potential outcomes conditional on the particular model (i.e. process variance) and the data sample used to estimate the model's parameters (i.e. parameter variance).

3.5 Estimating the MSE – Multiple Models

In isolation, a distribution derived from a single model has intuitive appeal since it represents the only information available. In practice, however, it is uncommon for an actuary's analysis of unpaid claims to be comprised of evaluating only a single model in isolation. ASPOP 43 states:

> Section 3.6.1 <u>Methods and Models</u> – "The actuary should consider the use of multiple methods or models appropriate to the purpose, nature and scope of the assignment and the characteristics of the claims, unless in the actuary's professional judgment, reliance upon a single method or model is reasonable given the circumstances. If for any material component of the unpaid claim estimate the actuary does not use multiple methods or models, the actuary should disclose and discuss the rationale for this decision in the actuarial communication."

Therefore, if multiple models are utilized by the actuary to estimate unpaid claims it seems prudent that the measure of uncertainty recognize the additional knowledge gained from the application of more than one model. As previously hypothesized in Section 1.1, if an actuary uses two models to estimate unpaid claims for a book of business, Model A and Model B with corresponding distributions of probable predictions that could be used to define the distribution of outcomes, $f_A(y)$ and $f_B(y)$ respectively, then two alternatives for estimating the MSE are:

$$[MSE|f(y) = f_A(y)] = E[(y_A - \hat{y}_A)^2]$$

$$[MSE|f(y) = f_B(y)] = E[(y_B - \hat{y}_B)^2]$$

However, it is very likely that

$$f_A(y) \neq f_B(y)$$

and hence the actuary is left with two conflicting solutions for the MSE in this example. If both models are believed to be reasonable representations of $f(y)$, then it may not be appropriate to assume that only one is representative of $f(y)$ because of the ramification it implies with the other model.

$$If\ f(y) = f_A(y), then\ f(y) \neq f_B(y)$$

And likewise

$$If\ f(y) = f_B(y), then\ f(y) \neq f_A(y)$$

Perhaps both models are reasonable representations of $f(y)$ but each model suffers from some unknown function of inaccuracy that we will characterize as model error, such that

$$Model\ Error\ of\ Model\ A = \xi_A = f(y) - f_A(y)$$

$$Model\ Error\ of\ Model\ B = \xi_B = f(y) - f_B(y)$$

Then the introduction of model error can be used to explain the inconsistency between models:

$$f(y) = f_A(y) + \xi_A = f_B(y) + \xi_B$$

Unfortunately, we revert to the predicament of defining uncertainty with unknown terms since model error is unknown. If we use Model A and its corresponding model error to define the distribution, $f(y)$, then:

$$[MSE|f(y) = f_A(y) + \xi_A] = E[(y_A - \hat{y}_A)^2] + \Xi_A$$

is equal to

$$[MSE|f(y) = f_B(y) + \xi_B] = E[(y_B - \hat{y}_B)^2] + \Xi_B$$

where Ξ_A represents the unknown inaccuracy in the MSE as a result of model error in Model A (i.e. ξ_A) and Ξ_B represents the unknown inaccuracy in the MSE as a result of model error in Model B (i.e ξ_B).

If the distribution of uncertainty reflects the uncertainty in outcomes defined by a particular model (i.e. process variance) and the uncertainty associated with estimating that model's parameters (parameter variance) it seems reasonable to incorporate the additional uncertainty associated with the potential error in the underlying model (i.e. model error). Otherwise, the actuary's estimate of uncertainty may be incomplete.

Model error and its corresponding impact on the MSE are both unknown, however, as a general rule the actuary strives to minimize model error. Nevertheless, some model error may remain because it is not possible or practical to identify and correct for it. In the context of selecting a central point estimate, the actuary must choose a single number and oftentimes that number will be based on a weighted average of the reasonable indications from multiple models rather than being set equal to the estimate from any single model. The philosophy underlying this approach, which is akin to hedging one's bet, is that a weighted average of models results in a corresponding unknown model error that is **preferred** to relying on the unknown model error of any single model.

This same philosophy is proposed as our approach to incorporating model error into the actuary's distribution of uncertainty. Revisiting our previous hypothetical that an actuary uses two models to estimate unpaid claims for a book of business, Model A and Model B, and after minimizing model error in Model A and Model B to the extent appropriate the actuary uses expertise and professional judgment to assign weight to the point estimates from these models in accordance with their perceived value as a reasonable predictor such that:

$$Central\ Estimate = w\hat{y}_A + (1 - w)\hat{y}_B$$

where

$$0 \leq w \leq 1;$$

$$\hat{y}_A = the\ prediction\ from\ Model\ A; and$$

$$\hat{y}_B = the\ prediction\ from\ Model\ B$$

Then, the MSE and corresponding distribution of uncertainty expressed as a weighted average of predictions from Model A and Model B where each model is separately considered in isolation as representative of the random variable, y,

$$[MSE|f(y) = wf_A(y) + (1-w)f_B(y)]$$

is preferred to the MSE and corresponding distribution conditional only on Model A

$$[MSE|f(y) = f_A(y)]$$

or the MSE and corresponding distribution conditional only on Model B

$$[MSE|f(y) = f_B(y)]$$

if the unknown model error inherent in this weighted averaging of models, $w(\xi_A) + (1-w)(\xi_B)$, is preferred to relying solely on the unknown model error inherent in Model A,ξ_A, or the unknown model error inherent in Model B,ξ_B.

It should be noted that the word "preferred" is used rather than a mathematical relationship such as "less than" in the context of this discussion because this is a philosophical approach. Ideally, we wish to develop a solution that eliminates model error but in the absence of being able to do so, a reasonable alternative is to attempt to recognize our uncertainty in whatever model error remains.

4 Model Error

Before progressing further, it may be helpful to differentiate model error from other types of error. Previously, model risk was defined as "the risk that the methods are not appropriate to the circumstances or the models are not representative of the specified phenomenon."

Many actuarial projection methodologies (i.e. models) can be shown to have no model error when applied in a controlled environment under specific limitations; however, these conditions rarely exist, if at all, in practice. For example, the approach used to extrapolate link ratios into the "tail" of a traditional chain ladder model can introduce model error. An important point to make about model error is that its resulting bias on the actuary's prediction, if any, should be unknown.

4.1 User Error

User error is different from model error. User error occurs when actions, or inactions, of the actuary lead to the **expectation** that the resulting prediction will be biased high or low. Generally accepted actuarial practice is based on the presumption that an actuary's work product is void of significant or material user error, and hence this type of error should not be incorporated as a component of uncertainty in the actuary's estimate.

4.2 Historical Error

Implicit within most actuarial projection methodologies is the assumption that observations of patterns and trends in the past are indicative of patterns and trends in the future, but future conditions can change and result in materially different processes and outcomes that are often too speculative to estimate. This type of error is a subset of model error and while some changes to future conditions may be reasonably estimable and therefore can be incorporated as an element of uncertainty within the MSE, actuaries oftentimes consider this type of error to be out of scope of their analysis. If so, then the approaches discussed herein will also exclude uncertainty associated with this type of error.

Regardless of the type of error that may exist in a prediction, a goal should be to minimize error within each model to the extent appropriate. Unfortunately, model error often still exists and should therefore be incorporated into the actuary's estimate of uncertainty.

5 Incorporating Model Error

At this point we are ready to introduce a methodology for incorporating model error into an estimate of uncertainty. Various suitable methods exist for estimating the MSE conditional on a single model in isolation so it will be assumed that this analysis has already been performed for each model relied upon by the actuary to derive the central point estimate. This methodology is a simulation-based approach as opposed to a mathematical approach aimed at computing the formulas discussed previously and is perhaps best described through a simplistic example.

5.1 Weighted Sampling

Consider a single actuarial central estimate, $\hat{y}$, to be based on a 50%-50% weighting of estimates produced from two projection methodologies, Model A and Model B, such that:

$$\hat{y} = \sum_{m=A,B} w_m \hat{y}_m$$

Where,

$$\hat{y}_A = the\ prediction\ from\ Model\ A;$$

$$\hat{y}_B = the\ prediction\ from\ Model\ B;$$

$$w_A = 0.5; and$$

$$w_B = 0.5$$

Assume that two distributions of the MSE conditional on Model A and separately for Model B are already estimated and that each distribution is comprised of a series of 10 simulations where each simulation, denoted x_i, is shown in Figure 4.

Figure 4. Single prediction model simulations

Model A Simulations

Sim	Value
1	3.4
2	2.5
3	1.8
4	3.8
5	4.4
6	3.0
7	2.0
8	6.0
9	3.7
10	6.4

Model B Simulations

Sim	Value
1	3.6
2	4.6
3	5.2
4	4.4
5	3.4
6	3.6
7	4.4
8	3.9
9	3.4
10	3.0

E.g. simulation x_5 from Model A equals 4.4

A distribution reflecting the inclusion of model error can be estimated by taking a weighted sample without replacement of simulations from Model A and Model B in accordance with their weights. To accomplish this with the example given above, we first create a matrix where we use the weights as the basis for sampling between Model A and Model B for each of the 10 simulations. Because this matrix defines which model to sample for each simulation, we will refer to it as a "Model Matrix," which is shown in Figure 5.

Figure 5. Single prediction Model Matrix

	Wt
Model A	50%
Model B	50%

Model Matrix

Sim	Method
1	B
2	A
3	A
4	B
5	A
6	A
7	B
8	B
9	A
10	A

Once a Model Matrix is created, we select the value corresponding to the simulation number and model to create a series of sampled simulations, which are shown in Figure 6.

Figure 6. Single prediction sampled simulations

Model A Simulations

Sim	Value
1	3.4
2	2.5
3	1.8
4	3.8
5	4.4
6	3.0
7	2.0
8	6.0
9	3.7
10	6.4

Model B Simulations

Sim	Value
1	3.6
2	4.6
3	5.2
4	4.4
5	3.4
6	3.6
7	4.4
8	3.9
9	3.4
10	3.0

	Wt
Model A	50%
Model B	50%

Model Matrix

Sim	Method
1	B
2	A
3	A
4	B
5	A
6	A
7	B
8	B
9	A
10	A

Sampled Simulations

Sim	Value
1	3.6
2	2.5
3	1.8
4	4.4
5	4.4
6	3.0
7	4.4
8	3.9
9	3.7
10	6.4

If we increase the number of simulations in this example to a larger sample size the MSE of the resulting distribution can be estimated by computing the variance of the simulations and the mean of the resulting distribution will be equal to the actuarial central estimate.

Figure 7 shows the results of the distribution before and after incorporating model error when the number of simulations in this example is increased to 10,000.

Figure 7. Single prediction weighted sampling

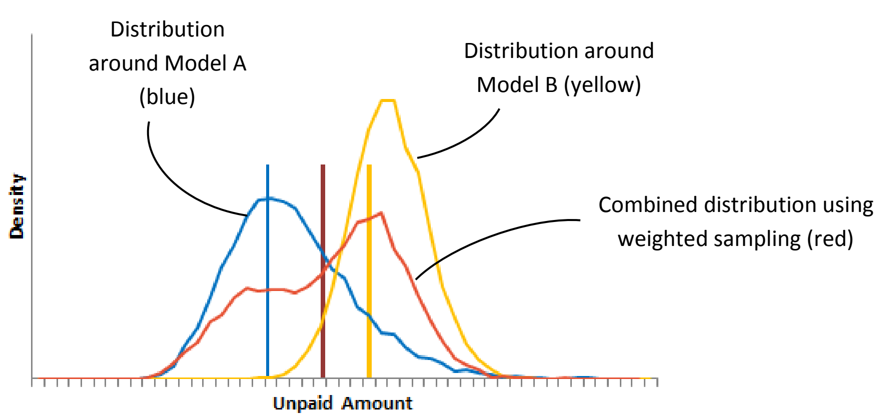
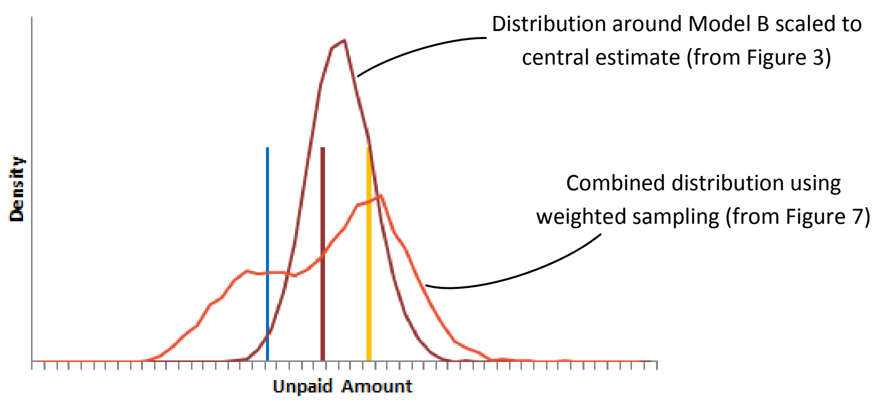


Figure 8 compares weighted sampling in this example to multiplicative scaling Model B's simulations to the central estimate.

Figure 8. Single prediction weighted sampling versus multiplicative scaling



5.2 Considerations

Before we progress the methodology further, it is worth discussing a few points about this approach thus far.

5.2.1 Simulations

It should be noted that in this example, Model B is generated 4 times and Model A is generated 6 times in the Model Matrix. Ideally each model would have been generated an equal number of times since the weighting between the models were equal but the low sample count has led to sample error. For statistically significant sample sizes, we would expect each model in this example to be generated close to 50% of the time.

Sample error must also be considered when evaluating the resulting distribution. Although there is no single number of simulations that is suitable for every circumstance, the user should incorporate a sufficient number to adequately represent the range of potential outcomes, especially if the user is interested in evaluating outcomes generated for extreme tail probabilities.

5.2.2 Individual Model Distributions

Weighted sampling assumes that a distribution of the MSE reflecting the combined effects of process variance and parameter variance is already developed for each model in isolation. Various approaches to estimating the distribution and deriving simulations exist in the literature and example approaches include but are not limited to:

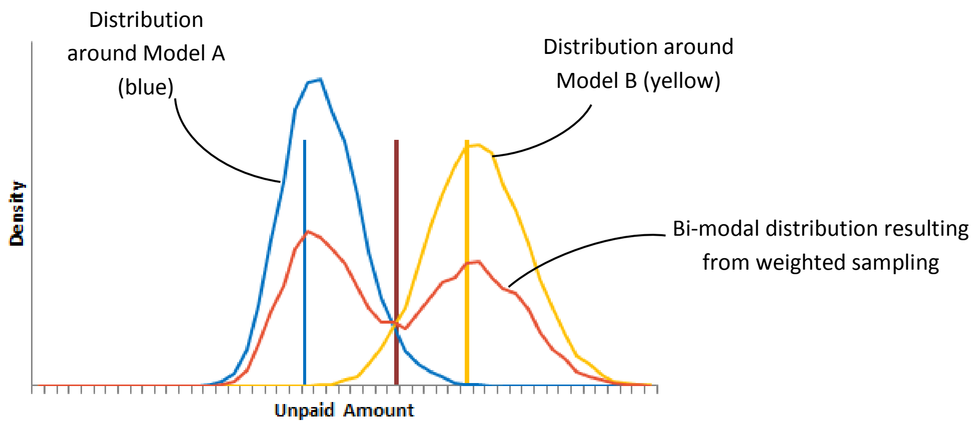
- Simulated approaches – Bootstrapping, Markov-Chain Monte-Carlo simulation or straightforward simulation of outcomes from an assumed distribution using benchmark statistical properties, for example, can be used;
- Analytical approaches – The methodology presented by Thomas Mack is an example of approaches that estimate the statistical properties underlying a model. From this, the user can simulate outcomes once a distributional form is selected; and

- Replicating and scaling – Simulations generated for a particular model can be scaled, either additively or multiplicatively, to the mean of a different model such that an implied distribution of the different model is approximated.

5.2.3 Lumpiness

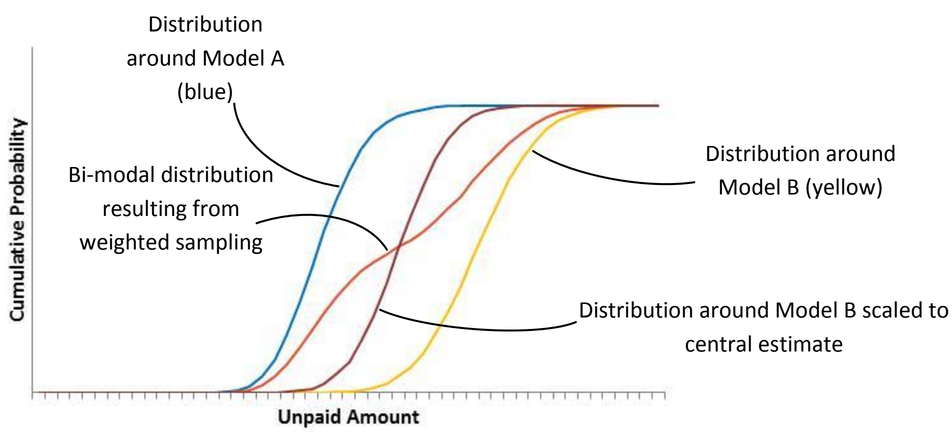
In practice, the user may find the resulting probability density function from weighted sampling to be lumpy, in that there may be multiple modes to the distribution. Figure 9 shows a comparison of weighted sampling from two underlying distributions.

Figure 9. Multi-mode distribution



As a result, it may be challenging to interpret relative probabilities associated with particular outcomes but it is less of an issue when evaluating probabilities associated with a range of outcomes as shown by the corresponding cumulative probability density function for the same example in Figure 9, shown as Figure 10 (also shown in Figure 10 is the distribution around Model B scaled to the selected central estimate).

Figure 10. Multi-mode cumulative probability function



If the shape of the probability density function resulting from weighted sampling is determined to be problematic, the following adjustments could be made:

- Compute the indicated coefficient of variation from the resulting lumpy distribution and re-simulate a newly defined distribution with the same mean and coefficient of variation. Figures 11 and 12 show an example where the lumpy distribution was re-simulated using a Gamma distribution with the same mean and coefficient of variation. It should be noted that a potentially undesired consequence of this adjustment is that probabilities associated with various outcomes within the distribution will be different.
- Probabilities within the range of outcomes where the nodes occur can be re-distributed according to some user-selected smoothed distribution, such as a uniform distribution. An advantage of this adjustment approach is that tail probabilities are unaffected. Figures 13 and 14 show an example of this approach with the probability density graph and the cumulative probability graph, respectively. Note that the actuary should use caution with this approach and be aware that in achieving a more intuitive 'shape' to the distribution, the mean and the coefficient of variation should be maintained.

Figure 11. Re-simulated distribution – probability density

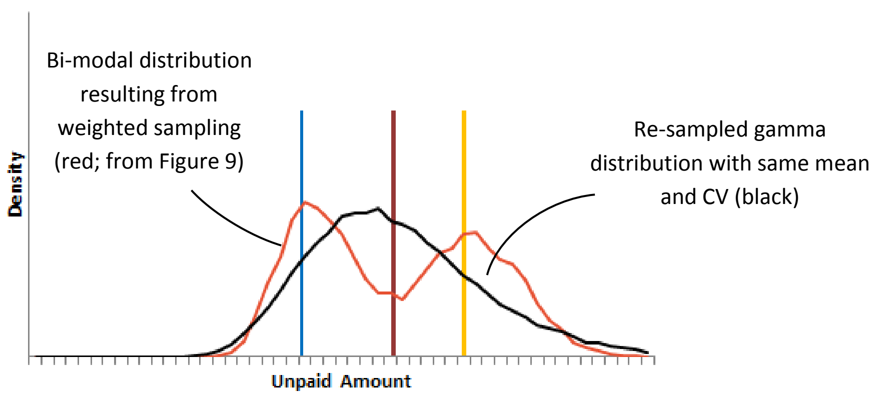


Figure 12. Re-simulated distribution – cumulative probability

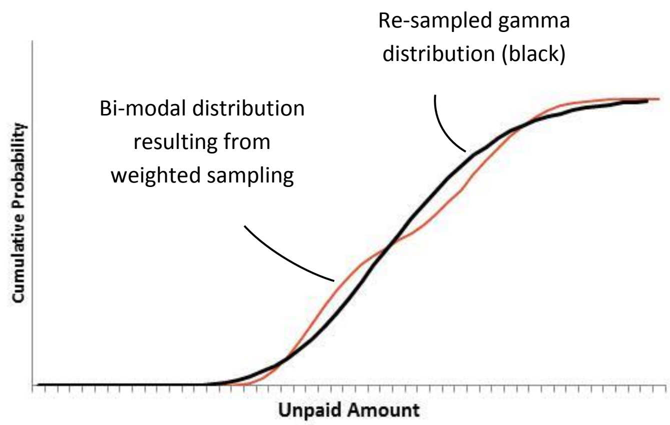


Figure 13. Re-distributed distribution – probability density

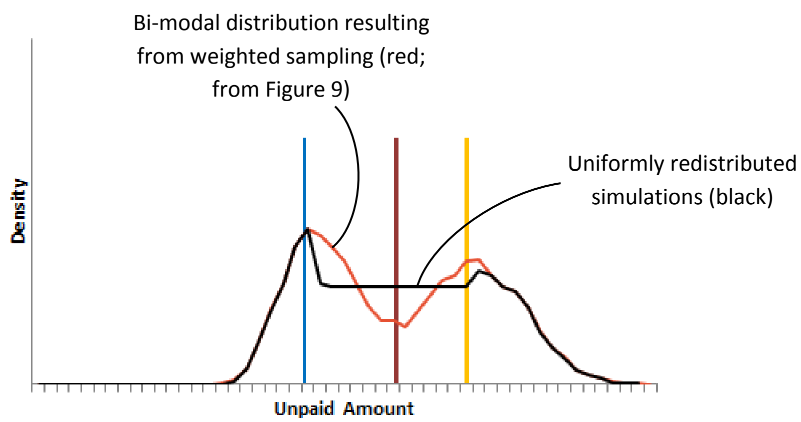
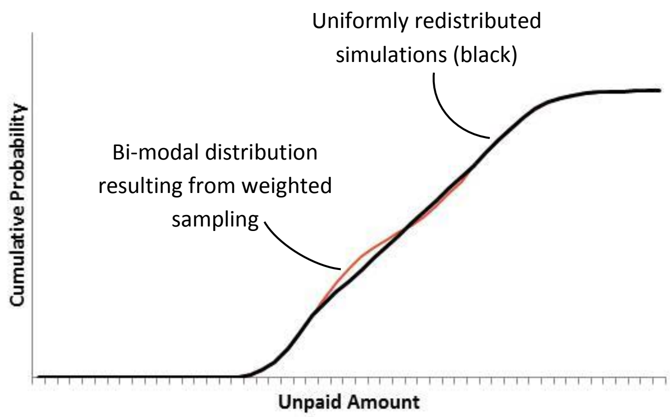


Figure 14. Re-distributed distribution – cumulative probability



5.2.4 Assigning Weights to Models

Assigning weight to a model when using the weighted sampling approach implies that the actuary believes the model is a reliable predictor because otherwise the user may be introducing additional variability that is attributable to user error. Bad practices can exist without harm to deriving a central point estimate, such as having two models that are known to be biased but offset each other so that the average produces a reasonable point estimate (e.g. "two wrongs can make a right" philosophy), but this practice should not be used when estimating uncertainty. In such cases where the models have any known bias, the user may want to consider scaling as a solution instead of weighted sampling.

5.2.5 Effect on MSE

The effect that weighted sampling has on the MSE depends on two factors:

1. The dispersion in the means of the underlying models before weighted sampling; and
2. The MSE of the model distributions before weighted sampling.

As the mean of each model converges to the same point, the resulting MSE using weighted sampling will essentially be an average of the MSE from the various models before weighted sampling. As the mean of each model diverges, the resulting MSE will increase and can be larger than the MSE before weighted sampling of each underlying model.

6 Aggregating Variability

The weighted sampling approach described thus far is an approach to incorporating model error for a ***single*** prediction. Projection methodologies used by actuaries often generate ***multiple*** predictions where each prediction corresponds to a certain subset of claims generally grouped according to a predefined time interval (e.g. accident year, report year, policy quarter, etc.), which we will refer to generically as an origin period. Weighted sampling is suitable for estimating the distribution of any single origin period prediction, however, a separate and more complex approach must be considered when aggregating the variability across multiple origin period predictions.

Consider a situation where each model used by the actuary generates a prediction, $\hat{y}_m$, for multiple different origin periods, t, such that:

$$\hat{y}_{m,t} = \left[\hat{y}_{m,t=1}, \hat{y}_{m,t=2}, \hat{y}_{m,t=3}, \dots\right]$$

and the actuary's selected central estimate for each origin period, t, is

$$\hat{y}_t = \sum_{m=A,B,\dots} w_{m,t}\hat{y}_{m,t}$$

where $w_{m,t}$ corresponds to the weight assigned to model m and origin period t and

$$\sum_{m=A,B,\dots} w_{m,t} = 1$$

Then we wish to derive an approach for aggregating the Mean Squared Error of predictions across all origin periods,

$$MSE = E\left[\left(\sum_{t=1}^{N}\left(y_t - \sum_{m=A,B,\dots} w_{m,t}\hat{y}_{m,t}\right)\right)^2\right] = ?$$

6.1 Weighted Sampling Revisited

Expanding on the previous example in Section 5.1, consider actuarial central estimates for three separate origin periods, $\hat{y}_{t=1}, \hat{y}_{t=2}$ *and* $\hat{y}_{t=3}$, to be based on a 50%-50% weighting of predictions produced from two projection methodologies, Model A and Model B, such that:

$$For\ origin\ periods\ t = 1, 2\ and\ 3$$

$$\hat{y}_t = \sum_{m=A,B,\dots} w_{m,t}\hat{y}_{m,t}$$

Where,

$$\hat{y}_{A,t} = the\ prediction\ from\ Model\ A\ for\ origin\ period\ t;$$

$$\hat{y}_{B,t} = the\ prediction\ from\ Model\ B\ for\ origin\ period\ t;$$

$$w_{m,t} = \begin{bmatrix} w_{A,1} & w_{A,2} & w_{A,3} \\ w_{B,1} & w_{B,2} & w_{B,3} \end{bmatrix} = \begin{bmatrix} 0.5 & 0.5 & 0.5 \\ 0.5 & 0.5 & 0.5 \end{bmatrix}$$

Assume that distributions of the MSE for each origin period conditional on Model A and separately for Model B are already estimated and that each origin period distribution is comprised of a series of 10 simulations where each simulation, denoted x_i, is shown in Figure 15.

Figure 15. Multiple prediction model simulations

Model A Simulations

Sim	t = 1	t = 2	t = 3
1	3.4	5.8	28.8
2	2.5	12.5	28.0
3	1.8	6.5	24.0
4	3.8	8.8	20.0
5	4.4	8.7	14.5
6	3.0	10.7	14.0
7	2.0	9.4	16.9
8	6.0	7.6	24.9
9	3.7	9.7	25.0
10	6.4	8.6	29.0

Model B Simulations

Sim	t = 1	t = 2	t = 3
1	3.6	12.0	19.9
2	4.6	13.3	26.9
3	5.2	16.1	27.2
4	4.4	11.3	22.7
5	3.4	17.2	26.9
6	3.6	11.3	15.7
7	4.4	10.7	22.9
8	3.9	13.3	22.6
9	3.4	13.5	20.4
10	3.0	13.2	15.0

Once again, a distribution incorporating model error can be estimated for each origin period by taking a weighted sample without replacement of simulations from the distributions of Model A and Model B for each origin period independently in accordance with their weights. As before, this is accomplished by creating a Model Matrix, shown in Figure 16, where the weights are used as the basis for sampling between Model A and Model B for each set of origin period simulations.

Figure 16. Multiple prediction Model Matrix

Weighting Selections

	t = 1	t = 2	t = 3
Model A	50%	50%	50%
Model B	50%	50%	50%

Model Matrix

Sim	t = 1	t = 2	t = 3
1	B	B	B
2	A	B	A
3	A	B	A
4	B	B	A
5	A	A	B
6	A	A	A
7	B	B	A
8	B	A	B
9	A	B	A
10	A	A	B

Then based on the Model Matrix, we select the value corresponding to the simulation number, model and origin period to create a series of sampled simulations, which can be used as a distribution incorporating model error for each origin period's actuarial central estimate as shown in Figure 17.

Figure 17. Multiple prediction sampled simulations

Model Matrix

Sim	t = 1	t = 2	t = 3
1	B	B	B
2	A	B	A
3	A	B	A
4	B	B	A
5	A	A	B
6	A	A	A
7	B	B	A
8	B	A	B
9	A	B	A
10	A	A	B

Sampled Simulations

Sim	t = 1	t = 2	t = 3
1	3.6	12.0	19.9
2	2.5	13.3	28.0
3	1.8	16.1	24.0
4	4.4	11.3	20.0
5	4.4	8.7	26.9
6	3.0	10.7	14.0
7	4.4	10.7	16.9
8	3.9	7.6	22.6
9	3.7	13.5	25.0
10	6.4	8.6	15.0

The weighted sampling approach works for multiple separate estimates much in the same way it works for a single estimate; however, dependencies need to be considered before aggregating uncertainty across multiple origin periods. In this example, a total distribution of the three origin periods remains unanswered as depicted in Figure 18.

Figure 18. Multiple prediction weighted sampling

Sampled Simulations

Sim	t = 1	t = 2	t = 3	Total
1	3.6	12.0	19.9	?
2	2.5	13.3	28.0	?
3	1.8	16.1	24.0	?
4	4.4	11.3	20.0	?
5	4.4	8.7	26.9	?
6	3.0	10.7	14.0	?
7	4.4	10.7	16.9	?
8	3.9	7.6	22.6	?
9	3.7	13.5	25.0	?
10	6.4	8.6	15.0	?

6.2 Dependencies

If it can be assumed that within each model the predictions for each origin period are independent then an aggregate distribution representing the total of the three origin periods above can be created quite easily by summing across the values generated above for each simulation (assuming the weighted sampling used to derive the Model Matrix was generated randomly).

Unfortunately, the assumption of independence among different origin periods within a particular model is generally not true. Instead, origin period dependencies are generally inherent within the structure of a model and the process of weighted sampling among various different models for each origin period independently (as described in this example thus far) will break these origin period dependencies. Before discussing an approach to establishing a dependency, if any, among origin periods, it is useful to consider how origin period dependencies may exist within the components that make up uncertainty.

6.2.1 Origin Period Dependency – Process Error

Given that the actual outcome, y, is assumed to be a random variable, we would not expect there to be any dependency in the order in which actual outcomes occur. Therefore, it is usually assumed that the outcome of any given origin period is independent of the outcomes in any other origin period.

6.2.2 Origin Period Dependency - Parameter Error

Parameter variance measures the uncertainty in the actuary's estimate of the model's parameters used to generate a prediction. For many actuarial models, the same parameters and assumptions are used to generate predictions for all origin periods, and as such, any change to a parameter estimate or assumption will permeate through some or all of the origin periods and result in a dependency. Approaches, such as Bootstrapping, produce results which enable the user to measure this dependency.

6.2.3 Origin Period Dependency - Model Error

The model we use to predict $\hat{y}$ is likely an imperfect representation of the true model that defines the actual outcome, y, and as such may result in an unknown tendency to overestimate or underestimate the intended measure. The degree to which a model's error, if any, is dependent across different origin periods is debatable and may depend on the circumstances.

In certain circumstances, it may be argued that a model's error will be consistent across all origin periods. Consider a hypothetical example where the only difference between two chain-ladder models is the approach used to select the tail factor, which results in different values being chosen. Because the tail factor affects the predictions for all origin periods, any error may affect all origin periods.

In other circumstances, it may be argued that error, if any, in any given model may not be consistent across origin periods. For example, chain ladder models tend to be sensitive to the magnitude of cumulative amounts to which the link-ratios are applied and it may be that the cumulative amounts across origin periods exhibit an amount of reasonable volatility with respect to their size relative to historical experience simply because the volume of business being analyzed is not statistically voluminous. If the volatility observed is somewhat random across the origin periods, then the corresponding error in the model, if any, may also be random across origin periods as a result of this attribute.

Because it can be argued that model error dependency may or may not exist across origin periods, we discuss two different approaches to aggregating the weighted sampling distributions across origin periods so that a range of model error dependency assumptions can be used.

6.3 Rank Tying

One approach to aggregating the weighted sampling results across origin periods is to borrow a dependency structure from one of the underlying sampled models. Since process variance does not usually create a dependency across origin periods, any dependency observed is wholly attributable to parameter variance in standard models.

Continuing with the example discussed in Section 6.1, we can create another type of matrix, called a Rank Matrix, that identifies the "rank order" of each simulation within a given model and origin period where the largest value of all simulated values is assigned a rank value of 1. Then, the second largest value of all simulated values within that same model and origin period is assigned a rank value of 2. This process is repeated until all simulations are assigned a rank order value. The Rank Matrix for Model A and Model B are shown in Figure 19.

Figure 19 – Rank Matrix for Model A and Model B

Model A Simulations

Sim	t = 1	t = 2	t = 3
1	3.4	5.8	28.8
2	2.5	12.5	28.0
3	1.8	6.5	24.0
4	3.8	8.8	20.0
5	4.4	8.7	14.5
6	3.0	10.7	14.0
7	2.0	9.4	16.9
8	6.0	7.6	24.9
9	3.7	9.7	25.0
10	6.4	8.6	29.0

Model A Rank Matrix

Sim	t = 1	t = 2	t = 3
1	6	10	2
2	8	1	3
3	10	9	6
4	4	5	7
5	3	6	9
6	7	2	10
7	9	4	8
8	2	8	5
9	5	3	4
10	1	7	1

Model B Simulations

Sim	t = 1	t = 2	t = 3
1	3.6	12.0	19.9
2	4.6	13.3	26.9
3	5.2	16.1	27.2
4	4.4	11.3	22.7
5	3.4	17.2	26.9
6	3.6	11.3	15.7
7	4.4	10.7	22.9
8	3.9	13.3	22.6
9	3.4	13.5	20.4
10	3.0	13.2	15.0

Model B Rank Matrix

Sim	t = 1	t = 2	t = 3
1	7	7	8
2	2	4	3
3	1	2	1
4	4	9	5
5	8	1	2
6	6	8	9
7	3	10	4
8	5	5	6
9	9	3	7
10	10	6	10

Currently, the weighted sample results for each origin period in Figure 18 produces a different Rank Matrix from the Rank Matrix of Model A and Model B because the underlying Model Matrix was generated randomly in accordance with the weights and therefore broke the origin period links intrinsic to the underlying models. Figure 20 shows the implied Rank Matrix from Figure 18 which is crossed out to denote that the origin period dependencies may not be appropriate.

Figure 20. Rank Matrix from weighted sampling

Sampled Simulations

Sim	t = 1	t = 2	t = 3
1	3.6	12.0	19.9
2	2.5	13.3	28.0
3	1.8	16.1	24.0
4	4.4	11.3	20.0
5	4.4	8.7	26.9
6	3.0	10.7	14.0
7	4.4	10.7	16.9
8	3.9	7.6	22.6
9	3.7	13.5	25.0
10	6.4	8.6	15.0

Sampled Implied Rank Matrix

Sim	t = 1	t = 2	t = 3
1	7	4	7
2	9	3	1
3	[illegible]	[illegible]	4
4	[illegible]	[illegible]	6
5	2	8	2
6	8	[illegible]	10
7	[illegible]	6	8
8	[illegible]	10	5
9	6	2	3
10	1	9	9

If we select Model B as the model to use as the basis for dependency in aggregating simulations across all origin periods, then all we have to do is reorder our sampled simulation values in Figure 20 within each origin period separately so that the Rank Matrix of Model B is replicated. Then we can aggregate across each simulation as shown in Figure 21 (differences in the total occur because of rounding).

Figure 21. Reordered simulations using Model B Rank Matrix

Sampled Simulations

Sim	t = 1	t = 2	t = 3
1	3.6	12.0	19.9
2	2.5	13.3	28.0
3	1.8	16.1	24.0
4	4.4	11.3	20.0
5	4.4	8.7	26.9
6	3.0	10.7	14.0
7	4.4	10.7	16.9
8	3.9	7.6	22.6
9	3.7	13.5	25.0
10	6.4	8.6	15.0

Model B Simulation Ranks

Sim	t = 1	t = 2	t = 3
1	7	7	8
2	2	4	3
3	1	2	1
4	4	9	5
5	8	1	2
6	6	8	9
7	3	10	4
8	5	5	6
9	9	3	7
10	10	6	10

Sampled Simulations: Re-ordered by Model B

Sim	t = 1	t = 2	t = 3	Total
1	3.6	10.7	16.9	31.2
2	4.4	12.0	25.0	41.4
3	6.4	13.5	28.0	47.8
4	4.4	8.6	22.6	35.6
5	3.0	16.1	26.9	46.1
6	3.7	8.7	15.0	27.5
7	4.4	7.6	24.0	35.9
8	3.9	11.3	20.0	35.2
9	2.5	13.3	19.9	35.7
10	1.8	10.7	14.0	26.5

Note that the resulting reordered simulations are not color-coded because the link to the Model Matrix no longer exists.

The Rank Tying approach is a means to combine the simulations across origin periods while maintaining the same parameter variance dependency structure associated with one of the underlying projection models. In essence, this approach assumes that the introduction of model uncertainty does not produce any additional dependency across origin periods.

6.4 Model Tying

The Model Tying approach attempts to incorporate dependencies associated with model error into the aggregate estimate. In order to accomplish this, we will need to revisit the case study in Section 6.1 and revert to the step where the Model Matrix was created in Figure 16. The Model Matrix in Figure 16 and underlying model simulations in Figure 15 are summarized in Figure 22.

Figure 22. Multiple prediction Model Matrix

Model A Simulations

Sim	t = 1	t = 2	t = 3
1	3.4	5.8	28.8
2	2.5	12.5	28.0
3	1.8	6.5	24.0
4	3.8	8.8	20.0
5	4.4	8.7	14.5
6	3.0	10.7	14.0
7	2.0	9.4	16.9
8	6.0	7.6	24.9
9	3.7	9.7	25.0
10	6.4	8.6	29.0

Model B Simulations

Sim	t = 1	t = 2	t = 3
1	3.6	12.0	19.9
2	4.6	13.3	26.9
3	5.2	16.1	27.2
4	4.4	11.3	22.7
5	3.4	17.2	26.9
6	3.6	11.3	15.7
7	4.4	10.7	22.9
8	3.9	13.3	22.6
9	3.4	13.5	20.4
10	3.0	13.2	15.0

Weighting Selections

	t = 1	t = 2	t = 3
Model A	50%	50%	50%
Model B	50%	50%	50%

Model Matrix

Sim	t = 1	t = 2	t = 3
1	B	B	B
2	A	B	A
3	A	B	A
4	B	B	A
5	A	A	B
6	A	A	A
7	B	B	A
8	B	A	B
9	A	B	A
10	A	A	B

Under the Model Tying approach, we will rearrange the Model Matrix with the goal of maximizing the degree to which the same model is selected across as many origin periods as possible within a given simulation. In this specific example, we want to maximize the degree to which 'A's in one origin period are grouped with 'A's in other origin periods, and the degree to which 'B's are grouped with 'B's. The resulting reordered Model Matrix might look like the example in Figure 23.

Figure 23. Reordered Model Matrix

Model Matrix

Sim	t = 1	t = 2	t = 3
1	B	B	B
2	A	B	A
3	A	B	A
4	B	B	A
5	A	A	B
6	A	A	A
7	B	B	A
8	B	A	B
9	A	B	A
10	A	A	B

Model Matrix: Reordered

Sim	t = 1	t = 2	t = 3
1	A	B	A
2	A	A	A
3	B	B	B
4	A	A	A
5	A	A	A
6	B	B	B
7	A	A	A
8	B	B	B
9	A	B	A
10	B	B	B

Note that sampling error in this example means that we do not achieve an exact 50/50 split reflecting the weights chosen in each year between Model A and Model B so 'perfect strings' are not possible for all simulations.

With the reordered Model Matrix, we are now ready to select the value corresponding to the simulation number, model and origin period to derive our values for each origin period as shown in Figure 24. Also, the total can be derived by aggregating across each simulation (differences in the total occur because of rounding). It should be noted that the resulting distributions for each origin period from this approach should produce similar results to the distributions derived from weighted sampling because the reordered Model Matrix maintains the exact same weighting between the models.

Figure 24. Model Tying simulations

Model Matrix: Reordered

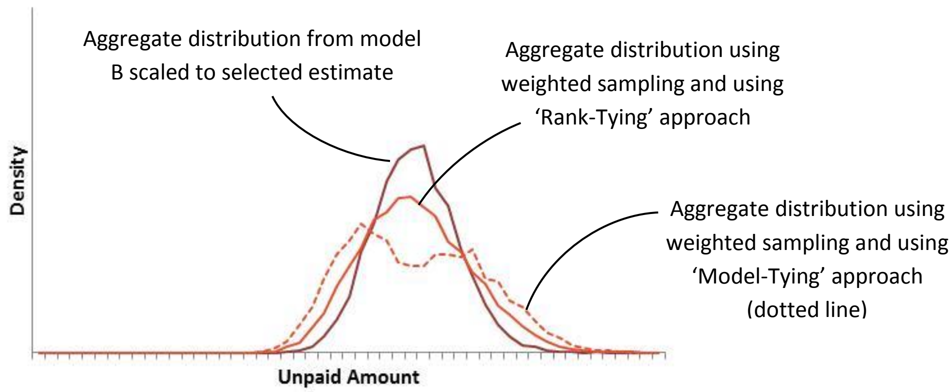
Sim	t = 1	t = 2	t = 3
1	A	B	A
2	A	A	A
3	B	B	B
4	A	A	A
5	A	A	A
6	B	B	B
7	A	A	A
8	B	B	B
9	A	B	A
10	B	B	B

Sampled Simulations: Using reordered Model Matrix

Sim	t = 1	t = 2	t = 3	Total
1	3.4	12.0	28.8	44.2
2	2.5	12.5	28.0	43.0
3	5.2	16.1	27.2	48.6
4	3.8	8.8	20.0	32.7
5	4.4	8.7	14.5	27.6
6	3.6	11.3	15.7	30.6
7	2.0	9.4	16.9	28.2
8	3.9	13.3	22.6	39.7
9	3.7	13.5	25.0	42.2
10	3.0	13.2	15.0	31.3

Figure 25 shows the resulting aggregate distribution for all three origin periods combined resulting from Model Tying, Rank Tying to Model B's dependency structure and scaling the distribution (multiplicatively) around Model B to the selected central estimate when the number of simulations in this example is increased to 10,000. All three approaches have the same mean value, which is equal to the actuarial selected central estimate for all three origin periods combined.

Figure 25. Aggregating multiple predictions: Model Tying versus Rank Tying to Model B



The difference between Model Tying and Rank Tying occurs only in the aggregate results. Rank Tying uses the parameter variance dependency attributable to only one of the models whereas Model Tying incorporates parameter variance dependencies from all models in accordance with their weights. Rank Tying excludes origin period dependencies associated with model error whereas Model Tying incorporates origin period dependency associated with model error.

6.5 Aggregation Considerations

A few points about using the Rank Tying or Model Tying approaches are noteworthy.

6.5.1 Broken Strings

With respect to the Model Tying approach, a broken string refers to a Model Matrix simulation where the same model is not identified for all origin periods. Examples of broken strings and perfect strings are shown in Figure 26.

Figure 26. Broken strings versus perfect strings

Model Matrix: Reordered

Sim	t = 1	t = 2	t = 3	
1	A	B	A	← 'Broken' string
2	A	A	A	
3	B	B	B	
4	A	A	A	
5	A	A	A	
6	B	B	B	
7	A	A	A	
8	B	B	B	
9	A	B	A	← 'Broken' string
10	B	B	B	

Broken strings can occur because of sample error as demonstrated in the previous example or because of the particular weighting attributed to the various models by origin period. A broken string is noteworthy for two reasons. First, a broken string raises the question of how to address parameter variance dependency since values are being pulled from different models within that particular simulation. One solution is to pre-sort the simulations within each model in ascending order by some measure, such as the total unpaid claim estimate across all origin periods, before applying the Model Matrix. The result will be an approximate Rank Tying of parameter variance dependency between models.

Second, a broken string implies that a dependency associated with model error does not run throughout all origin periods in that particular simulation. This should be considered a desirable effect if the broken string was caused by the particular weighting chosen for each model and origin period.

6.5.2 Increasing Complexity

The example used for Rank Tying and Model Tying was simplistic in that it used only two models, three origin periods and equal weights across all origin periods. The Rank Tying and Model Tying approaches are scalable to multiple models, an increased number of origin periods and varying weights across origin periods, however, some considerations are worth noting.

As mentioned previously, Rank Tying superimposes the parameter variance dependency structure from a single model. As the number of models is increased the relevance of any single parameter variance dependency structure is diminished accordingly. If Rank Tying is used, preference for the selected parameter variance dependency structure should be given to one of the models that contribute to the largest proportion of the total unpaid claim estimate.

Increasing the number of models and origin periods and varying the weights with Model Tying may result in broken strings and a situation where there are multiple solutions for the Model Matrix. Weightings among models should be sensible such that broken strings produce a desirable effect on the resulting distribution. An example of a desirable effect is if the actuary believes that a particular model is appropriate and hence given weight in the actuarial central estimate for only a subset of origin periods. As a result, a perfect string will not exist across all origin periods if the weight for some origin periods is zero.

With regards to multiple solutions for the Model Matrix, consider the following example in Figure 27 where we have three models used to estimate three origin periods:

Figure 27. Multiple prediction model simulations

Model A Simulations

Sim	t = 1	t = 2	t = 3
1	3.4	5.8	28.8
2	2.5	12.5	28.0
3	1.8	6.5	24.0
4	3.8	8.8	20.0
5	4.4	8.7	14.5
6	3.0	10.7	14.0
7	2.0	9.4	16.9
8	6.0	7.6	24.9
9	3.7	9.7	25.0
10	6.4	8.6	29.0

Model B Simulations

Sim	t = 1	t = 2	t = 3
1	3.6	12.0	19.9
2	4.6	13.3	26.9
3	5.2	16.1	27.2
4	4.4	11.3	22.7
5	3.4	17.2	26.9
6	3.6	11.3	15.7
7	4.4	10.7	22.9
8	3.9	13.3	22.6
9	3.4	13.5	20.4
10	3.0	13.2	15.0

Model C Simulations

Sim	t = 1	t = 2	t = 3
1	3.6	12.5	19.4
2	4.6	14.1	26.2
3	5.3	17.3	26.5
4	4.4	11.7	22.1
5	3.4	18.5	26.2
6	3.6	11.7	15.4
7	4.5	11.1	22.3
8	3.9	14.0	22.0
9	3.4	14.2	19.9
10	3.0	13.9	14.7

We can, again, create a Model Matrix, shown in figure 28, based on the selected weights from each of the Models A, B and C across 10 simulations:

Figure 28. Multiple predictions Model Matrix

Weighting Selections

	t = 1	t = 2	t = 3
Model A	33%	33%	33%
Model B	33%	33%	33%
Model C	33%	33%	33%

Model Matrix

Sim	t = 1	t = 2	t = 3
1	B	C	B
2	C	B	A
3	A	A	A
4	C	C	C
5	A	A	A
6	B	C	B
7	A	A	B
8	B	B	C
9	A	C	B
10	C	B	C

Under the Model Tying approach, we rearrange the Model Matrix with the goal of maximizing the degree to which the same model is selected across as many origin periods as possible within a given simulation. Two unique solutions exist and are shown in Figure 29:

Figure 29. Multiple solutions

Model Matrix

Sim	t = 1	t = 2	t = 3
1	B	C	B
2	C	B	A
3	A	A	A
4	C	C	C
5	A	A	A
6	B	C	B
7	A	A	B
8	B	B	C
9	A	C	B
10	C	B	C

Model Matrix: Re-ordered (solution 1)

Sim	t = 1	t = 2	t = 3
1	C	C	C
2	C	C	C
3	A	A	A
4	B	C	B
5	C	C	C
6	A	B	B
7	B	B	B
8	A	A	A
9	A	A	A
10	B	B	B

Model Matrix: Re-ordered (solution 2)

Sim	t = 1	t = 2	t = 3
1	A	C	C
2	B	B	B
3	A	A	A
4	C	C	C
5	A	A	A
6	C	C	B
7	C	C	C
8	A	A	A
9	B	B	B
10	B	B	B

Removing common strings in Figure 30 helps identify the differences:

Figure 30. Isolated differences

Model Matrix

Sim	2009	2010	2011
1	B	C	B
2	C	B	A
3	A	A	A
4	C	C	C
5	A	A	A
6	B	C	B
7	A	A	B
8	B	B	C
9	A	C	B
10	C	B	C

Model Matrix: Re-ordered (solution 1)

Sim	t = 1	t = 2	t = 3
1			
2			
3			
4	B	C	B
5	C	C	C
6	A	B	B
7			
8			
9			
10			

Model Matrix: Re-ordered (solution 2)

Sim	t = 1	t = 2	t = 3
1	A	C	C
2	B	B	B
3			
4			
5			
6	C	C	B
7			
8			
9			
10			

Although both solutions maximize origin period dependency as measured on the Model Matrix, the origin period dependency measured on the sampled simulations (i.e. values) between both solutions may differ and the preferred solution may depend on the circumstances.

6.5.3 Effects on MSE

It is difficult to make blanket statements about the impact between Rank Tying and Model Tying approaches on the overall variance of aggregate origin period predictions because it will depend on each unique situation. With regards to model error, the dependency assumed in Model Tying will generally increase the aggregate variance as compared to Rank Tying in situations where the predictions of the underlying models diverge in the same direction relative to the actuarial central estimate across origin periods. However, model error dependency assumed in Model Tying can reduce the aggregate variance in situations where the predictions of the underlying models fluctuate between being greater and less than the actuarial central estimate across origin periods.

With regards to parameter variance, the dependency assumed in Rank Tying is unaffected by the complexity in the number of models, origin periods and weights, and the dependency structure selected may be different from the dependency structures observed in other models. On the other hand, parameter variance dependency structures across models will be averaged under Model Tying and their effect may be diminished as the complexity of the approach increases.

7 Summary

It has been shown that the uncertainty in a prediction, as defined by the mean squared error, is comprised of the sum of three components: process variance, parameter variance and squared bias. Suitable approaches exist in the literature to measure these components and its corresponding distribution when a single model is considered in isolation. When multiple models are considered reasonable indicators of unpaid claims, it may be appropriate to incorporate model uncertainty into the actuary's distribution of uncertainty. Various approaches for incorporating model uncertainty were introduced. The first approach, called weighted sampling, is an approach that can be used to incorporate model uncertainty into a single prediction. Rank Tying and Model Tying are approaches that can be used to incorporate model uncertainty into an aggregation of multiple predictions that exhibit dependencies in either parameter or model uncertainty. These approaches are somewhat more complex to apply but are nevertheless important to consider when measuring the aggregate uncertainty of multiple predictions.

References

Actuarial Standards Board, *Actuarial Standard of Practice No. 43 Property/Casualty Unpaid Claim Estimates*, June 2007, Updated for Deviation Language Effective May, 1, 2011, Doc. No. 159, http://www.actuarialstandardsboard.org/pdf/asops/asop043_159.pdf

England, P. D., and Verrall, R. J., *Analytic and bootstrap estimates of prediction errors in claims reserving*, Insurance: Mathematics and Economics, 1999, 25, pp. 281-293

England, P. D., *Addendum to Analytic and bootstrap estimates of prediction errors in claims reserving*, 2001, Actuarial Research Paper No. 138a, Department of Actuarial Science and Statistics, City University, London, EC1V 0HB

England, P. D., and Verrall, R. J., *Stochastic Claims Reserving in General Insurance*, British Actuarial Journal, 8, III, 2002, pp. 443-544, http://www.actuaries.org.uk/system/files/documents/pdf/sm0201.pdf

England, P.D., and Verrall, R. J., *Predictive Distributions of Outstanding Liabilities in General Insurance*, Annals of Actuarial Science, 2006, Vol. 1, No. 2, pp. 221-270, http://cassknowledge.co.uk/sites/default/files/article-attachments/371~~richardverrall_-_predictive_distributions_of_general_insurance_outstanding_liabilities.pdf

Mack, T, *Measuring the Variability of Chain Ladder Reserve Estimates*, Casualty Actuarial Society Forum, Spring 1994, pp. 102-182, http://www.casact.org/pubs/forum/94spforum/94spf101.pdf

Appendix A

Excerpts of the following case study are used throughout this paper. In this appendix we will discuss the complete case study and will highlight relevant sections corresponding to the Figures displayed in the body of the paper.

Overview of data and selections

- This case study is based on data spanning a nine year history of origin periods, where an origin period represents an accident year.
- Development factor models (i.e. chain ladder models) were applied to each of the paid ('model A') and incurred ('model B') data in order to project to ultimate.
- A 'central estimate' was selected based on a simple average of the two development factor models for each accident year.
- Distributions reflecting process and parameter variance for each model were achieved using stochastic methods. The type of stochastic methods used is irrelevant for this illustration, but in this instance a 'practical stochastic' method was applied to Model A and a Bootstrapping approach to Model B. 'Practical stochastic' in this instance is used to describe a process whereby the analyst generates samples from a selected distribution with a user-defined mean and coefficient of variation.

For the purpose of this case study we are going to concentrate on results for just the three most recent accident years, however, any totals shown will represent the cumulative results of the full nine years of accident period history (rounding may occur with totals).

Central Estimate

The table in Figure A.1 summarizes the point estimates produced by each model for 'prior' years (1997 – 2008), 2009, 2010 and 2011 accident years, alongside the weighting used to determine the selected central estimate and the resulting amount of that estimate.

Figure A.1. Selected central estimates

	Model A	Weight	Model B	Weight	Selected Central Estimate
Prior	$2,784	50%	$8,783	50%	$5,783
2009	2,774	50%	3,838	50%	3,306
2010	8,275	50%	12,871	50%	10,573
2011	19,114	50%	23,534	50%	21,324
Total	$32,947		$49,026		$40,987

Implicit in the equal weightings used in this case study is the assumption that each model is an equally reliable predictor of the final outcome. The challenge is to estimate the corresponding uncertainty around this prediction that adequately reflects this inherent assumption.

Distributions conditional on each model

We begin the process of estimating uncertainty by developing distributions around each of the underlying models that reflect both process and parameter variance. The table in Figure A.2 summarizes the results of the stochastic uncertainty analyses performed around each of the underlying models in terms of the prediction error ("Pred. Error", $000s) of the resulting distributions as well as the coefficient of variation ("CV", prediction error as a percentage of the mean), for the most recent three accident years and in total.

Figure A.2. Summary of uncertainty conditional on each model

Model A

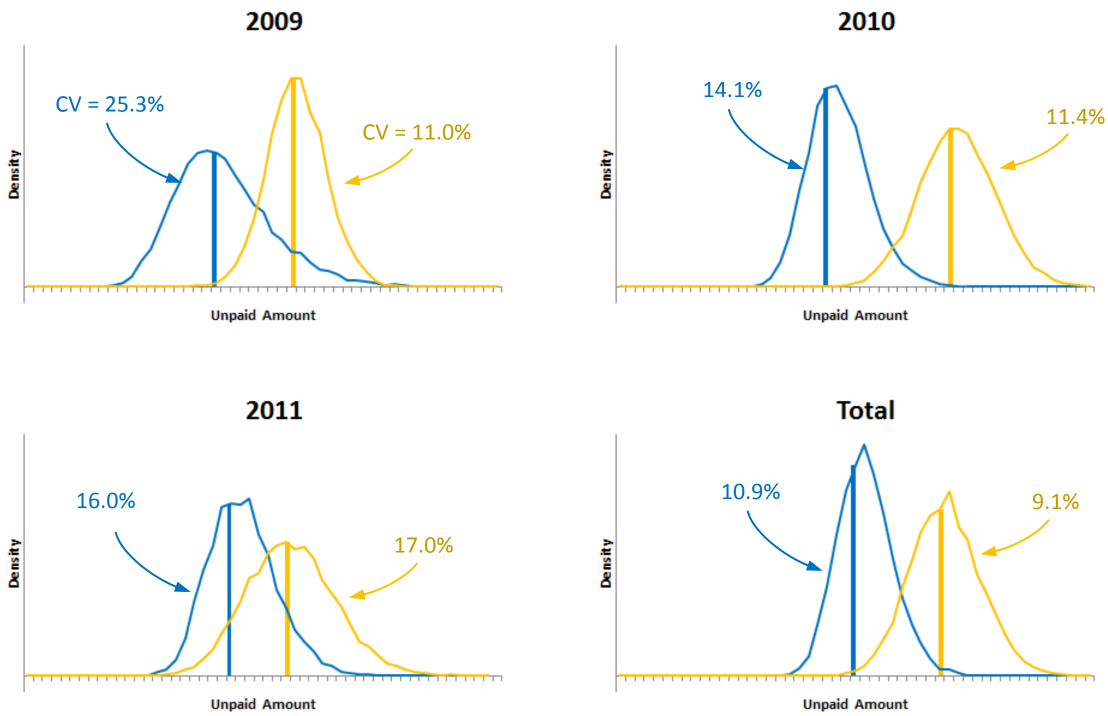
	Mean	Pred. Error	CV
2009	$2,774	$702	25.3%
2010	8,275	1,167	14.1%
2011	19,114	3,058	16.0%
Total	$32,947	$3,595	10.9%

Model B

	Mean	Pred. Error	CV
2009	$3,838	$423	11.0%
2010	12,871	1,465	11.4%
2011	23,534	3,995	17.0%
Total	$49,026	$4,441	9.1%

These distributions are also shown graphically in Figure A.3 along with the means (represented by the vertical bar) and corresponding CV's from each model (blue line is Model A, yellow line is Model B).

Figure A.3. Distributions around Model A and Model B



It should be noted that the distributions for each origin period and in total are not generated independently but rather collectively as a single process defined by the stochastic methods. As a result, origin period dependencies exist and can be measured. As a precursor for what is to come, each origin period can be treated as a 'single period prediction' as discussed in the paper through weighted sampling, however, the intrinsic origin period dependencies created by these stochastic methods will be broken. Rank Tying and Model Tying are options to restoring some sort of origin period dependency in order to recreate a 'total' aggregate distribution.

Distribution around selected central estimate using scaling

Once we have generated our distributions reflecting process and parameter uncertainty for each of the underlying models, we are faced with the challenge of producing a distribution around our selected central estimate.

One commonly-used approach is to select an underlying model and scale the associated simulated output from that model in an appropriate manner (see Section 2, Scaling).

In this example, we might select underlying Model B as our preferred model and choose multiplicative scaling to generate a distribution of simulated outcomes with a mean equal to our selected central estimate.

Figure A.4 summarizes the statistical properties of our distribution around our selected central estimate derived by multiplicatively scaling the simulations from Model B. Again, we show the prediction error ("Pred. Error", $000s) of the resulting distribution as well as the coefficient of variation ("CV", prediction error as a percentage of the mean), for the most recent three accident years and in total.

Figure A.4. Summary of uncertainty for selected central estimate using scaling

Uncertainty Summary: Selected - Scaling ($000s)

	Mean	Pred. Error	CV
2009	$3,306	$364	11.0%
2010	10,573	1,203	11.4%
2011	21,324	3,620	17.0%
Total	$40,987	$3,958	9.7%

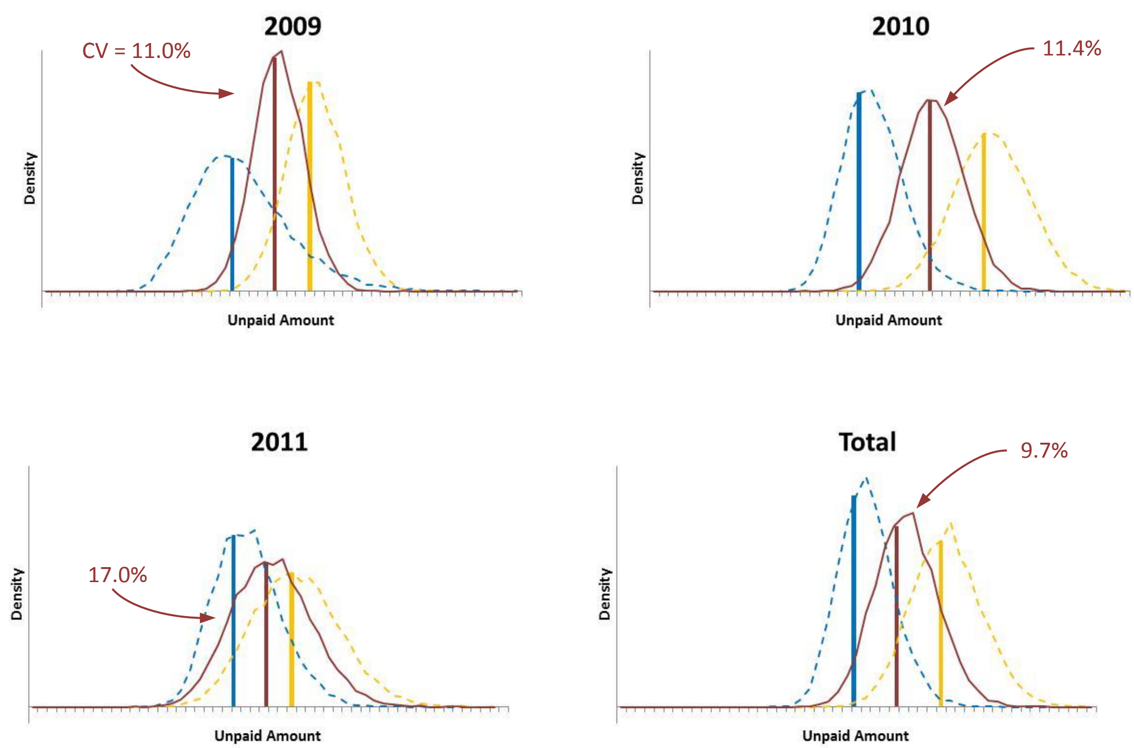
Note that, because we selected to use multiplicative scaling, the mean of the distribution is equal to our selected central point estimate and the coefficients of variation for each accident year are equivalent to the corresponding measure from the distribution developed around Model B.

Had we selected to scale additively, the mean of our distributions would still align with our selected central estimate but the coefficient of variation for each accident year would change when compared to Model B. Under additive scaling, the prediction error for each accident year remains equivalent instead of the CV.

Note also that the 'Total' coefficient of variation from multiplicative scaling is not equivalent to the 'Total' coefficient of variation from Model B. This is due to differences in the magnitude of scaling for each year.

Figure A.5 shows these scaled distributions for each accident year and in total. The selected mean and the scaled distributions are shown as solid green lines, and the distributions and means from our underlying models are shown as blue (Model A) and yellow (Model b) broken lines.

Figure A.5. Distributions using scaling

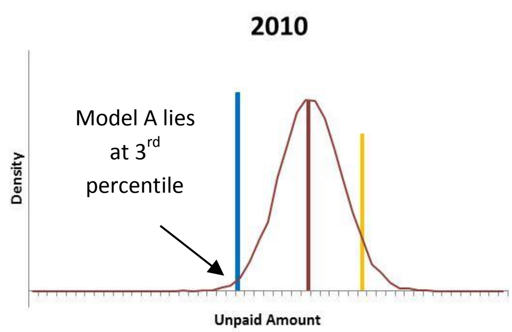


It should be noted that the graph shown in Figure A.5 for 2009 is similar to the graph shown in Figure 3 in the main text.

With regards to scaling, we are simply *borrowing* a distribution from one of our underlying models, which the actuary is forced to select. This may not adequately reflect the assumption that both models are considered to be equally valid as implied by the equal weighting used in the selection of the central estimate.

Furthermore, we may end up in a situation where our selected scaled distribution around our central estimate implies that the prediction from one of our underlying models is a relatively unlikely outcome. If we consider the 2010 accident year, our scaling approach suggests that the point estimate projected by Model A, as shown as the blue bar in Figure A.6, lies at the 3rd percentile of our range of probable outcomes.

Figure A.6. Distribution using scaling for 2010



Distribution around selected estimate using weighted sampling

We can instead employ weighted sampling for each accident year in a manner that reflects the weights selected for the determination of our selected central estimate that perhaps better represents the full distribution of possible outcomes suggested by the underlying models (see Section 5.1, Weighted Sampling).

For each accident year, we sample randomly and without replacement from each of the underlying distributions – in this case, we select 50% of the sample from the distribution around Model A and 50% from the distribution around Model B.

The table in Figure A.7 summarizes the statistical properties of our distribution around our selected central estimate derived by weighted sampling from each of the underlying models. Again, we show the prediction error ("Pred. Error", $000s) of the resulting distribution as well as the coefficient of variation ("CV", prediction error as a percentage of the mean), for the last three accident years.

Figure A.7. Summary of uncertainty using weighted sampling

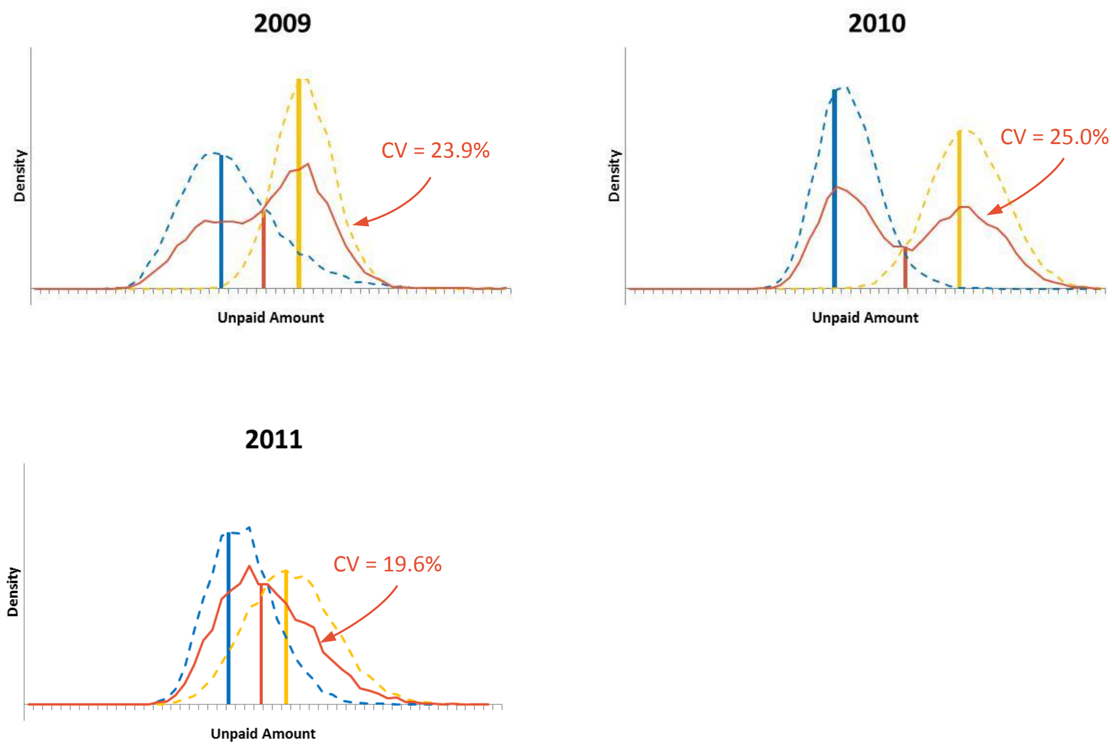
Uncertainty Summary: Selected - Wtd Sampling ($000s)

	Mean	Pred. Error	CV
2009	$3,306	$790	23.9%
2010	10,573	2,646	25.0%
2011	21,324	4,174	19.6%
Total	$40,987	?	?

As noted previously, the origin period dependencies intrinsic in the stochastic methods have been broken as a result of weighted sampling so the total aggregate distribution is no longer discernible.

The graphs in Figure A.8 show these distributions for each of the last three accident years. The selected mean and the weighted sampling distributions are shown as solid red lines, and the distributions and the means from our underlying models are again shown as broken lines.

Figure A.8. Distributions using weighted sampling



It should be noted that the graphs shown in Figure A.8 for 2009 and 2010 are similar to the graphs shown in the main text as Figures 7 and 9, respectively.

Weighted sampling will produce distributions for each accident year in isolation (as discussed for single period predictions in Section 5.1). In order to create a distribution around the selected total central estimate of unpaid claims across multiple accident years we must decide how to reintroduce an origin period dependency.

As suggested by this paper, we have the options of using either:

- Rank Tying, which reorders the year-by-year simulations such that a pre-defined accident-year correlation is targeted (as discussed in Section 6.3); or
- Model Tying, which uses a Model Matrix designed in such a manner to maximize the degree to which the same model is selected across as many different accident years as possible within a given simulation (as discussed in Section 6.4)

If using Rank Tying, the analyst should produce the Rank Matrix that is to be used to reorder the simulation. In this example, we have selected to use the Rank Matrix from the simulated distribution around Model B.

The tables in Figure A.9 summarize the point estimates and statistical properties of our distribution around each of:

- Model A;
- Model B;
- Selected central estimate using multiplicative scaled simulations from Model B;
- Selected central estimate using weighted sampling and Rank Tying accident years according to the correlation matrix suggested by Model B; and
- Selected central estimate using weighted sampling and optimized Model Tying.

Figure A.9. Summary comparing uncertainty from various models

Point Estimate Selection Summary ($000s)

	Model A	Model B	Selected: Scaled	Selected: Wtd Sample (Rank Tying)	Selected: Wtd Sample (Model Tying)
2009	$2,774	$3,838	$3,306	$3,306	$3,306
2010	8,275	12,871	10,573	10,573	10,573
2011	19,114	23,534	21,324	21,324	21,324
Total	$32,947	$49,026	$40,987	$40,987	$40,987

Uncertainty Summary: Comparison (Prediction Error)

	Model A	Model B	Selected: Scaled	Selected: Wtd Sample (Rank Tying)	Selected: Wtd Sample (Model Tying)
2009	$702	$423	$364	$790	$785
2010	1,167	1,465	1,203	2,646	2,664
2011	3,058	3,995	3,620	4,174	4,187
Total	$3,595	$4,441	$3,958	$5,854	$8,973

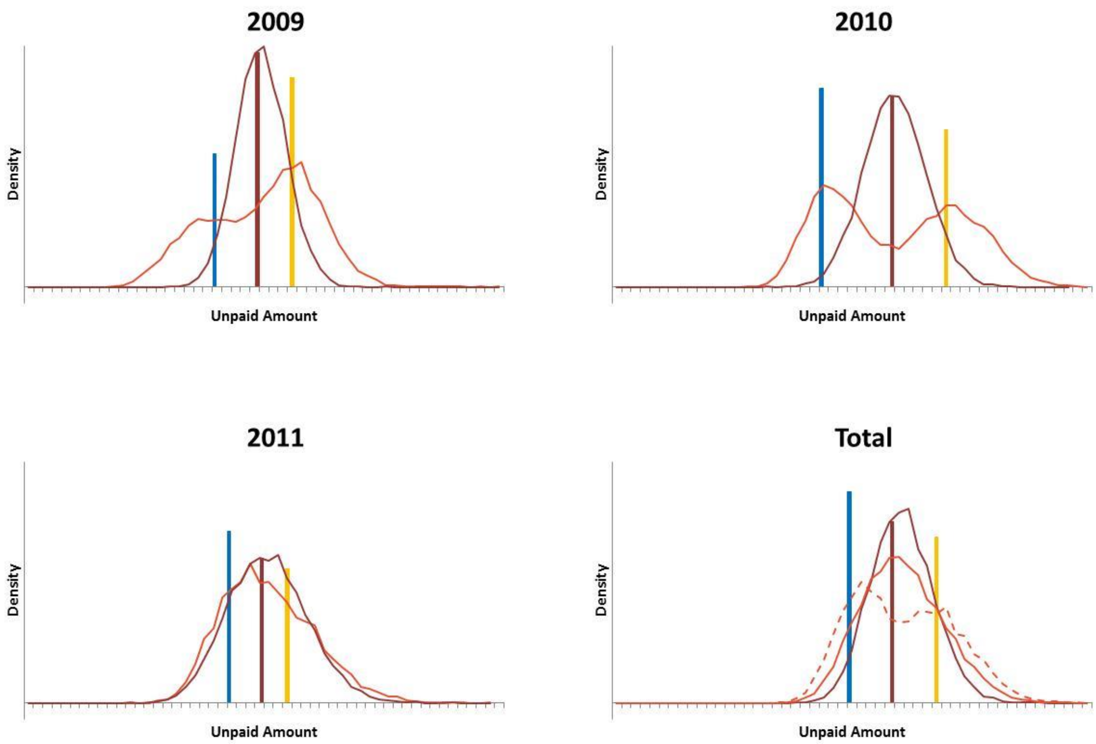
Uncertainty Summary: Comparison (CVs)

	Model A	Model B	Selected: Scaled	Selected: Wtd Sample (Rank Tying)	Selected: Wtd Sample (Model Tying)
2009	25.3%	11.0%	11.0%	23.9%	23.9%
2010	14.1%	11.4%	11.4%	25.0%	25.0%
2011	16.0%	17.0%	17.0%	19.6%	19.6%
Total	10.9%	9.1%	9.7%	14.3%	21.9%

As before, graphs assist in the interpretation and comparison of these results and the associated distributions. Such graphs corresponding to Figure A.9 can be viewed in Figure A.10. Please note:

- The blue and yellow columns represents the point estimate prediction from Models A and B
- The red column represents the selected central estimate
- The burgundy line represents the distribution around the selected central estimate using multiplicative scaling
- The red line represents the distribution around the selected central estimate using weighted sampling
- In the 'Total' graph, the distribution is shown around the total aggregate point estimate using:
    - Rank Tying (solid red line)
    - Model Tying (broken red line)
    - Scaling (solid burgundy line)

Figure A.10. Comparison of distributions using weighted sampling and scaling



Appendix B

In statistics, the Mean Squared Error (MSE) measures the difference between an estimate and what the true value is. Consider a random variable, y and a predicted variable, $\hat{y}$. The mean squared error (MSE) is:

$$E[(y-\hat{y})^2]$$

Expanding this term through additive properties yields:

$$E[(y-\hat{y})^2] = E[(y-\hat{y}+(E[y]-E[y])+(E[\hat{y}]-E[\hat{y}]))^2]$$

Reordering yields

$$= E\left[\left((y-E[y])-(\hat{y}-E[\hat{y}])+E[y]-E[\hat{y}]\right)^2\right]$$

A series of expanding terms and subsequent simplification yields,

$$\begin{aligned} = E\big[&(y-E[y])^2-(y-E[y])(\hat{y}-E[\hat{y}])+E[y](y-E[y])-E[\hat{y}](y-E[y])+(\hat{y}-E[\hat{y}])^2 \\ &-(y-E[y])(\hat{y}-E[\hat{y}])-E[y](\hat{y}-E[\hat{y}])+E[\hat{y}](\hat{y}-E[\hat{y}])+E[y]^2 \\ &+E[y](y-E[y])-E[y](\hat{y}-E[\hat{y}])-E[y]E[\hat{y}]+E[\hat{y}]^2-E[\hat{y}](y-E[y]) \\ &+E[\hat{y}](\hat{y}-E[\hat{y}])-E[y]E[\hat{y}]\big] \end{aligned}$$

$$\begin{aligned} = E[&(y-E[y])^2-2(y-E[y])(\hat{y}-E[\hat{y}])+2E[y](y-E[y])-2E[\hat{y}](y-E[y])+(\hat{y}-E[\hat{y}])^2 \\ &-2E[y](\hat{y}-E[\hat{y}])+2E[\hat{y}](\hat{y}-E[\hat{y}])+E[y]^2-2E[y]E[\hat{y}]+E[\hat{y}]^2] \end{aligned}$$

$$\begin{aligned} = E[&(y-E[y])^2-2y\hat{y}+2yE[\hat{y}]+2\hat{y}E[y]-2E[y]E[\hat{y}]+2yE[y]-2E[y]^2-2yE[\hat{y}] \\ &+2E[\hat{y}]E[y]+(\hat{y}-E[\hat{y}])^2-2\hat{y}E[y]+2E[y]E[\hat{y}]+2\hat{y}E[\hat{y}]-2E[\hat{y}]^2+E[y]^2 \\ &-2E[y]E[\hat{y}]+E[\hat{y}]^2] \end{aligned}$$

$$= E[(y-E[y])^2-2y\hat{y}+2yE[y]-E[y]^2+(\hat{y}-E[\hat{y}])^2+2\hat{y}E[\hat{y}]-E[\hat{y}]^2]$$

$$= E[(y-E[y])^2]-E[2y\hat{y}]+E\big[2yE[y]\big]-E[E[y]^2]+E[(\hat{y}-E[\hat{y}])^2]+E\big[2\hat{y}E[\hat{y}]\big]-E[E[\hat{y}]^2]$$

$$= E[(y-E[y])^2]-2E[y\hat{y}]+2E\big[yE[y]\big]-E[E[y]^2]+E[(\hat{y}-E[\hat{y}])^2]+2E\big[\hat{y}E[\hat{y}]\big]-E[E[\hat{y}]^2]$$

$$= E[(y-E[y])^2]-2E[y\hat{y}]+2E[y]E[y]-E[y]^2+E[(\hat{y}-E[\hat{y}])^2]+2E[\hat{y}]E[\hat{y}]-E[\hat{y}]^2$$

$$= E[(y-E[y])^2]-2E[y\hat{y}]+2E[y]^2-E[y]^2+E[(\hat{y}-E[\hat{y}])^2]+2E[\hat{y}]^2-E[\hat{y}]^2$$

$$= E[(y-E[y])^2]-2E[y\hat{y}]+E[y]^2+E[(\hat{y}-E[\hat{y}])^2]+E[\hat{y}]^2$$

If we assume y and $\hat{y}$ are independent, then $E[y\hat{y}] = E[y]E[\hat{y}]$ and

$$= E[(y-E[y])^2]-2E[y]E[\hat{y}]+E[y]^2+E[(\hat{y}-E[\hat{y}])^2]+E[\hat{y}]^2$$

Reordering yields,

$$= E[(y - E[y])^2] + E[(\hat{y} - E[\hat{y}])^2] + E[y]^2 - 2E[y]E[\hat{y}] + E[\hat{y}]^2$$

which simplifies to,

$$= E[(y - E[y])^2] + E[(\hat{y} - E[\hat{y}])^2] + (E[y] - E[\hat{y}])^2$$

Insurance 2.0: Insuring the Sharing Economy & Sharing the Insurance Economy

Dion Oryzak and Amit Verma

Abstract: The rise of the sharing economy (including firms such as Uber, Airbnb and TaskRabbit) has created new insurance challenges as assets traditionally insured under personal lines policies are being used by micropreneurs to generate income on a part-time, and often full-time, basis. The peer-to-peer nature of these unique risks is unprecedented as they have only recently been enabled by advances in mobile technology. The insurance industry has been extremely cautious about entering this space, even as regulators have increased calls for a solution bridging the insurance gaps between personal and commercial coverage. We believe this peer-to-peer trend will continue and could culminate in true peer-to-peer insurance, or risk transfer between individuals, with regulators constantly playing catch up and insurers either adapting or being displaced. In preparing this paper we interviewed executives from major players in the sharing economy and the insurance industry.

Keywords: sharing; collaborative consumption; ridesharing; homesharing; carsharing; peer-to-peer; peers; Uber; Lyft; Airbnb; Getaround; RelayRides; Lending Club; Farmers Insurance Group; Greenlight Re; James River Insurance Company

INTERVIEWEES

In preparing this paper we interviewed the following people.

- Joel Laucher, Deputy Commissioner, California Department of Insurance (CDI)
- Frank Chang, Lead Actuary, Uber
- John Clarke, Senior VP Marketing, James River Insurance Company
- Sam Zaid, CEO and Founder, Getaround
- Shelby Clark, Executive Director, peers.org, (also Founder and ex-CEO of RelayRides)
- Dave Cummings, Senior VP Personal Lines, ISO
- Mariel Devesa, Head of Innovation, Farmers Insurance Group
- Robert Passmore, Senior Director of Personal Lines Policy, Property Casualty Insurers Association of America (PCI)
- Jim McNichols, Chief Actuarial Officer, Greenlight Re
- Laura Maxwell, Consultant, Pinnacle Actuarial Resources
- Graeme Adams, Principal, Finity Consulting, Australia (and ex-Head of Product & Underwriting at IAG)
- Dr. Amy Gibbs, Digital Communications Manager, ANZIIF

The quotes attributed to each interviewee throughout this paper were spoken extemporaneously and do not necessarily represent the views of the organization they work for. We thank them immensely for their time, input and expertise.

PRESENTATION

There is a supplementary presentation that will be presented at the CAS Ratemaking & Product Management Seminar on March 10, 2015 and can be accessed at the following:

https://prezi.com/tktcfvgex_fb/insurance-20/

INSURING THE SHARING ECONOMY

Uberrima fides means "utmost good faith" or, more simply, "trust". Two-way trust lies at the heart of the business models of both the insurance industry and the sharing economy. 'Trust' uniquely binds the two. When policyholders pay a premium they trust that insurers will honor their promise to pay at claim time. Insurers trust that policyholders will truthfully disclose relevant information at the time of both underwriting and claim submission. When somebody rents out their home for a few days to a stranger using Airbnb, they trust that this stranger will look after their property. When somebody takes a ride downtown courtesy of Uber they trust that the driver will get them there safely and hassle-free. Both those providing and receiving the peer-to-peer service trust that the tech-based intermediary that matched them up has policies in place to effectively deal with things going wrong. Whether such events are tragic accidents or malicious, everyone trusts that the relevant party within the transaction has adequate insurance coverage and that lawmakers have adequately anticipated these risks and mandated beforehand which party should carry what kinds of coverage. Most of the time, this trust is well-placed and this new economy functions seamlessly. But when it does break down, it does so with unfortunate consequences.

The "move fast and break things" mantra of Silicon Valley is at odds with the slow and cautious approach of the insurance industry. With traditional insurance you know what you're insuring, who is using it and why. For auto coverage you know the insured's age, address, vehicle and driving record, and you know if they will be using it for weekend drives or commuting to work. For homeowners coverage you know location, construction type, characteristics of the residents and that they will be living in the property most of the year. The fine rating details may vary from policy to policy, but the broad risk profile is consistent both over time and between policies. Even in commercial auto policies you know the fleet of vehicles being insured and possibly the pool of drivers, even if you can't know who will be driving at any point in time.

Those assumptions break down in the sharing economy, where individuals act as micropreneurs, switching their assets seamlessly between personal and commercial use. Risk in the sharing economy is somewhat similar to a landlord's policy or a home business endorsement on a homeowner's policy, where a traditionally personal lines asset is used for income generation. But even these personal-commercial hybrid risk profiles tend to be both standardized in their own right and constant over time. A rental property remains so throughout the year, with tenants changing at most once or twice a year and with standard risk mitigation measures in place, like reference checking and bond requirements. The same properties (or vehicles) entering the sharing economy can see personal and commercial uses being juggled day in, day out. This new breed of mixed use asset is being facilitated through the recent rise of the smartphone app and tech juggernauts acting as brokers that instantly match service seekers with service providers.

Hundreds of sharing economy startups have launched online in the past six years. The following are some of the better-known firms:

- **Homesharing:** Airbnb; VRBO, HomeAway, Wimdu
- **Transportation Network Companies (TNCs), aka Ridesharing:** Uber, Lyft, Sidecar, Hailo
- **Carsharing:** RelayRides, Getaround, FlightCar
- **Care**: DogVacay.com (dog care), care.com (child care, home care, senior care, pet care)
- **Other:** Taskrabbit (odd jobs and errands), SnapGoods (possession sharing), EatWith (dining with strangers)

Businesses like ZipCar and car2go offer essentially by-the-hour rental cars leased from a dedicated corporate entity and do not offer truly peer-to-peer services, so aren't included above.

Insuring the sharing (or peer-to-peer) economy requires a unique insurance product design that bridges personal and commercial insurance, as well as a pricing methodology that is responsive to the mix of personal and commercial exposure varying day-to-day or minute-to-minute. The unique risk profile of using personal assets for peer-to-peer income generation on a large scale, facilitated by a technological intermediary, gives rise to two different issues. Firstly, an insurance gap arises because personal lines policies generally won't pay claims if the asset was being used for income generation at the time a claim is incurred. A separate policy, probably a commercial lines one, would be required, which can be an expensive and onerous requirement for a micropreneur. Secondly, even where insurers are prepared to cover these periods of exposure, the question of how to price this coverage is tricky. Historical experience is little help as a pricing guide for the new and unique risks presented by the sharing economy.

Unique Risk Profiles

It is important to isolate the underlying reasons for why the risk exposure for each type of peer-to-peer business is different from that of a standard personal lines policy covering the same asset.

Homesharing

Homesharing services like Airbnb generally create a greater property risk than is priced into a traditional homeowner's policy, resulting in denial of claims arising from or because of a 'guest'. The increased risk mainly arises from having strangers occupy and use the property without the owner's supervision. The exact accommodation a guest may rent varies from the entire property to just a couch for the night. Guests may intentionally steal or destroy the property or simply act more carelessly than they would with their own property.

A 2011 incident[1] referred to as 'Ransackgate' involved a woman renting out her apartment in San Francisco's Mission district on Airbnb. The guests vandalized the property, burning much of her possessions to ash, as well as stealing birth certificates, social security numbers and credit cards that were kept in a safe on the premises. This prompted Airbnb to create its $50k (now $1m) Host Guarantee and offer it free of charge to hosts in the United States and now several other countries[2].

Transportation Network Companies (TNCs)

TNCs (or ridesharing companies) involve a taxi-like, or limousine-like, service where drivers respond to requests on their smartphone and transport passengers from one destination to another. The TNCs (such as Uber, Lyft or SideCar) sign on drivers as independent contractors and not employees of the TNC. The TNC provides the connection infrastructure, payment processing and branding that drivers rely on to attract passengers.

The increased risk for TNC drivers working for companies like Uber, Lyft and Sidecar arises for quite a different reason to that of homesharing. The guests in a TNC service are chauffeured rather than left unsupervised, so malicious damage to, or theft from, the vehicle is unlikely to be a problem. The increased auto risk simply arises from being on the road for a longer period of time (and proportional increase in liability and collision risk) when your job involves driving for much longer periods than would be the case under an equivalent purely personal use vehicle. There is also an increased risk from travelling through a greater variety of neighborhoods that the driver may not be familiar with.

There are many types of TNC drivers, from those who drive a 40-50 hour-per-week full-time job, to those who opportunistically offer rides occasionally when they happen to be travelling for personal reasons and check their app to see if they can pick up someone travelling in the same direction. The nature of risk exposure from TNC risks is not qualitatively different from that of a personal lines policy, only the duration (or distance travelled) for which they are exposed.

Carsharing

Carsharing services like Getaround and RelayRides involve an individual advertising their car on a

[1] http://mashable.com/2011/08/01/airbnb-ransackgate/

[2] https://www.Airbnb.com/guarantee

smartphone service, which can then be rented by other individuals on a short term basis. As a cross between Transportation Network Companies (without the chauffeur component) and homesharing services, carsharing services suffer from the problems of both groups. These vehicles are on the road for longer than pure personal vehicles are, and they are also in the possession of strangers, who may act maliciously or more carelessly than the owner would. A high demand vehicle in a city center location could have six different drivers per day...

When you rent out your vehicle under RelayRides and Getaround, your personal lines policy ceases to be exposed, with the RelayRides and Getaround commercial policy becoming primary with a Combined Single Limit of $1m. The insurance market had never seen this type of exposure before (outside of traditional rental car businesses), so even when insurance is offered it tends to be priced somewhat conservatively as if it were a commercial livery policy. More commonly, insurance is not obtainable at all.

Errands

The business model behind TaskRabbit is that when someone needs a quick errand run (such as picking up dry cleaning), they will advertise it on the app, with an individual (known as a Tasker) in the area bidding on it, such as offering to pick up your clothes and deliver them to your house for a $5 fee, while another person/Tasker beats that offer with a $4 bid. On the surface, an errand running service seems to have a less problematic business model than Airbnb or Uber. After all, they aren't leasing property, nor are they transporting people on public roads. However, if the Tasker is driving while running an errand, say to pick up your dry cleaning, then the personal lines auto insurer usually won't pay, since their vehicle is being used for income generation. Knowing this, it's much easier for a TaskRabbit courier to equivocate at claim time, saying they happened to be driving for personal use at just that time rather than running someone else's errand, than it is for an Uber driver or Airbnb host to similarly claim that damage arose purely from personal use. A larger risk exists for liability and vicarious liability if people/property are damaged during the course of a Tasker performing an errand.

Other

Peer-to-peer possession sharing, like that offered by SnapGoods, is probably the most problematic offering in the peer-to-peer economy from a risk pricing perspective. If one person lends another person a ladder for a fee and the ladder breaks, who is liable for the resulting damage? How can such a liability be priced in advance? When faced with the liability risk of one stranger lending another stranger any variety of household tools like a ladder, a drill, a corkscrew or a chainsaw in any possible state of repair or disrepair, other peer-to-peer arrangements like Airbnb and RelayRides start to look extremely standardized and predictable by comparison.

Current Insurance Arrangements

In one sense, many of the risks presented by the sharing economy have always existed. They have just been unknown and absorbed into the general risk pool. Joel Laucher (CDI) commented:

"It seems so new, and yet we know it has probably been going on for some time, so it's not brand new. I think it's just that size of the enterprise has grown to a point where it has vaulted into view. The exposure's been there and it has been absorbed without anyone noticing. There haven't been any awful consequences that we've heard about before the TNC activities hit the news as a result of accidents involving fatalities and injuries."

Robert Passmore (PCI) expressed similar sentiments:

> People have had vacation homes forever and rented them out part of the season and used them part of the season. Insurance products have been adapted to them…..Like being a handyman; TaskRabbit is providing a more formal marketplace for something that has always been available informally. The risk has always been there. If you're working as a handyman there's a possibility you could make a mistake and something bad could happen. I don't think that's changed. I think they could grow a lot more because of the ease of use of the marketplace. The smartphone is just a boon for this kind of stuff. Before you had to hear about a handyman by word of mouth.

In many of these instances, the admitted market won't even accept the risk, and coverage needs to be sought from the Excess and Surplus (E&S) market. In most states even accessing the E&S market first requires a licensed agent to conduct a due diligence search from admitted carriers in the state to try and accept the risks. Upon three rejections[3], the agent is allowed to access the E&S market via a surplus lines broker licensed in the state. John Clarke (James River) explains how critical the E&S market was to the fledgling sharing economy:

> The creation of coverage for the TNC industry (ridesharing coverage) is a great example of the surplus lines market at work. Last year, as the new industry saw a large amount of growth, they (the ridesharing companies) were deciding to buy, add or endorse coverage related to UM, UIM, expanding limits, changing from contingent to primary coverage and making all kinds of the other coverage changes. Frankly, you have to have the flexibility of surplus lines to keep up with something that's evolving this fast. We could make changes for them rapidly. The admitted market just doesn't have that flexibility, even if they wanted to do so.

These exposure types do have precedents from the old economy though. A pizza delivery driver using their own vehicle wouldn't be covered by their personal lines policy during work periods, so the pizza chain's commercial auto policy could cover these non-owned autos for the specific times

[3] Unless the type of insurance being sought is classified as an exportable item by the state. This does not require the due diligence search to be fulfilled before seeking coverage from the E&S market.

they are being used commercially. A landlord's policy or home business endorsements are other existing examples of personal/commercial lines hybrids.

Some of the ridesharing companies have an E&S policy covering their drivers whilst they are operating in a ridesharing capacity with a commercial liability limit typically of $1m. However, up until recently they were engaged in a disagreement with admitted insurers in most states on the risk profiles of their drivers and hence the price of the commercial coverage. TNCs argued that their full-time and part-time drivers have risk profiles more similar to that of a personal lines risk or a less active livery service. Insurers, however, argued that the ridesharing companies' drivers are more similar to taxis, requiring higher premiums than other types of livery, and much, much higher than a personal auto policy.

There have been reports in the news that TNC-related claims are probably still being reported as personal auto claims. Joel Laucher (CDI) commented:

> The personal auto carriers are probably paying some costs that they didn't account for in their pricing and are paying for coverage that they think they've excluded.

Personal auto insurers don't seem too concerned by the rise of ridesharing, with Joel Laucher further referring to conversations with carriers:

> I was surprised on the ridesharing part, that companies didn't come in and immediately strengthen their exclusions on the livery….No one's really told us, well our first question now during a claims investigation is "Are you driving for a TNC?" They have kind of said that they haven't really changed their practices. It doesn't really seem prudent, at least in these areas where you know there is a lot of activity.

Laura Maxwell (Pinnacle) reiterated this view:

> Insurance companies need to start working on their underwriting rules and policy exclusions. I don't see that happening.

The lack of proactivity, initiative or innovation by the insurance industry was a consistent theme that resonated through each interview. Dave Cummings (ISO) elaborates:

> From my point of view, [the insurance industry] has historically not been at the forefront of emerging technologies and changing conditions. Many new exposures are initially excluded and the sense of urgency is not immediately recognized. However, over the past few years, we are seeing some insurers addressing these issues differently and embracing change and innovation. This is a very encouraging trend for the entire industry.

The reluctance of carriers to take decisive action can probably be attributed to two things:

Firstly, lack of a clear opportunity, with both the small size of the potential premium pool and the high uncertainty around its size. Joel Laucher (CDI) elaborated on this:

> TNCs themselves play it pretty close to the vest in terms of how many drivers they have and so there's kind of a lack of information about how many exposures are out there. Insurers don't know how many TNC drivers they have on their books now. And they don't know if there are enough TNC drivers to make it a market that they want to get active in. I guess they don't know how much it might grow and if they are going to miss the boat if they don't get out there. Insurers really want to see something worth their time before they spend much energy on it.

Laura Maxwell (Pinnacle) made a similar observation about the observed to-date small size of the ridesharing opportunity, and by extension the additional risk, in a report for the Colorado DOI:

> [The report] looked at how many extra miles rideshare drivers are going to drive compared to how many miles are already in the personal auto system. And they came up with pretty much none. It is such a small percentage at this time.

Secondly, the elephant in the room is simply the difference in culture between the insurance industry and the tech startup industry, with Sam Zaid (Getaround) elaborating:

> I think insurance [culture] is very entrenched and slow moving. That's sort of the nature of something where you have a lot of risk. If something is risky and you iterate very quickly, odds are you are going to lose that game. If you have something that really works and covers all the risk, it can be scary to go in a new direction. Historically the rate at which industries formed and shaped has been a lot slower than it is today. Insurance companies are iterating at that previous pace.

In mitigating the risk of stepping into the unknown, the actuarial profession's default approach is to first amass data. The more data the better, and don't come back until you've got it. Dave Cummings (ISO) commented on ridesharing data collection:

> Personally, I'd love to have as much of the data as possible. The more data we have on the risk the more accurately we can price. There are opportunities in data here which could enable some very interesting pricing and could respond well to the types of exposures and risks. This data would be different than the data we traditionally collect. However, it may be data ridesharing companies are reluctant to share. The fundamental questions we want to answer regarding risk are; how often a driver is using their vehicle for personal use vs. ridesharing, how many miles are they driving, where are they driving when working and when are they driving for the ridesharing company? Understanding if a driver is operating in an urban environment at night versus daytime in a rural setting, gives us an opportunity to think about and analyze the risk holistically.

And on homesharing data collection:

> I'd like to see more data collection that speaks to the exposure, seeing as how the exposure is a little different that a traditional homeowner or renter exposure. A lot of data is being collected by other sources and relates to the home's usage and exposure. One useful piece of information would be a better understanding of the owner or renter to relate that to other aspects of the risk. Knowing who is hosting and who is occupying the space during could better define the aspects of risk, specifically to the individuals involved.

And touching on setting up a sharing economy central database:

> A central repository to identify those who are drivers for ridesharing, leasers of homesharing, or participants of carsharing could be beneficial across the entire industry. The individuals will benefit from receiving proper coverage and ensuring there are no gaps in the coverage. Insurers will benefit by better pricing and classifying the risks they choose to write. Creating a mechanism where insured and insurers are able to communicate openly about coverage would help ensure coverage exists from the insurer's side and adequate coverage is received by the insured.

Mariel Devesa (Farmers Insurance Group) also spoke on the challenges of pricing ridesharing in the absence of good quality data:

> Data is key for us to price appropriately. As this is a very new industry, we used available data to price. As we learn more, by gathering actual data about our specific drivers and start understanding our drivers' behaviors better, we'll be able to improve. With more data, everything will get better.

A catch-22 arises from the insurance industry's desire for data as a prerequisite to offering dedicated insurance products for the sharing economy. This has led to much frustration from entrepreneurs unable to launch their sharing economy ventures. Shelby Clark (peers.org) recounts his experience in launching RelayRides:

> When we were trying to launch RelayRides, [one carrier] strung us along for six months and then they said, 'We really want to write this policy but we just need some data so why don't you come back after six months of operations and we'd be happy to take a look at this.' For us, that was really not helpful at all and they should have told us this six months ago. How are we supposed to get the data if we can't operate without insurance? We didn't go back to them. If you don't take a chance you lose the business.

The RelayRides experience was far from unique. Sam Zaid (Getaround) also detailed the difficulties he faced securing an insurance arrangement before being able to launch his company's carsharing business:

> We talked to agents and brokers. Many of them told us they could help but all they offered us were off-the-shelf products. We resorted to calling VPs from different insurance companies directly—we probably reached out to between 50 and 100 different contacts,

> either through warm introductions or cold calls. One or two insurers came to the table but, still, we did not get a deal done. That process was probably about 12 months. I guess you could argue that a car owner's insurance would apply but that wasn't proven. Since the car owners themselves weren't driving, we felt we needed a group insurance solution to protect our community. Once we finally secured insurance, we launched.

Other startups haven't been so cautious, instead preferring to launch anyway, expecting (or hoping) their personal insurance policies would simply cover claims due to ambiguities in policy wording that meant, in many cases, sharing economy activities weren't explicitly excluded. With an industry that has been very slow to offer specialist coverage, or even tighten up exclusion ambiguities in existing personal lines coverage. The only real option for such startups has just been to launch and hope for the best, with the expectation that once enough data is collected, proper insurance solutions will be developed.

In October 2014, five and a half years after Uber was founded, Erie Insurance launched what they touted to be a first-of-its kind coverage specifically designed to protect TNC drivers[4]. As best we can tell from examining the publicly available filings, Erie have taken their personal auto business use endorsement, like that used by pizza delivery drivers, and removed the livery exclusion, while keeping the existing pricing structure in place. Their flat business use endorsement remains at 12% or 20%, depending on whether the annual number of miles driven is less than or greater than 12,500, but is not sensitive to the proportion of the driver's time that is split between personal driving and driving for hire.

Erie's effort was followed by Farmers Insurance Group launching a ridesharing specific endorsement to their personal auto policy in Colorado[5]. Available from February 2015, the Farmers endorsement extends personal lines coverage to Colorado's legally required limits when a ridesharing app is turned on but no passengers have yet been accepted (commonly referred to as Period 1). The endorsement ceases when a ride has been accepted, as the TNC's group commercial policy should then become primary. Press releases suggested the endorsement was priced at an average of 25% loading.

In early 2012, in response to 'Ransackgate', Airbnb started offering a Host Guarantee Policy to hosts living in qualified countries. The Host Guarantee Policy, underwritten by a Lloyds of London syndicate, provides a $1m limit. This only covers deliberate property damage by a guest and does not cover accidental property damage nor liability, applies in excess of any primary policy, applies only after seeking and failing to recover from the malicious guest himself and needs to be reported the

[4] http://www.propertycasualty360.com/2014/11/19/erie-insurance-offers-ridesharing-protection

[5] http://www.prnewswire.com/news-releases/farmers-insurance-one-of-colorados-top-insurers-enters-rideshare-insurance-market-with-introduction-of-new-option-for-colorado-drivers-300021370.html

sooner of 14 days after check out or at the start of the next rental[6]. This coverage could be considered pretty restrictive and possibly lead to an insurance gap problem. New York lawmakers have picked up on this, urging the State Superintendent in September 2014 to investigate[7].

In response to this gap in liability coverage, on 20th November 2014 Airbnb announced the introduction of Host Protection Insurance[8]. Effective 15th January 2015, it will automatically provide $1m liability coverage to hosts within the U.S. in excess of their primary coverage.

HomeAway (another homesharing service) offers primary commercial coverage to their members through a program called Assure that they write in partnership with P&C broker CBIZ Insurance Services.

Like Airbnb's Host Guarantee and Host Protection Insurance, most homesharing coverage developments have been initiated by the homesharing websites themselves. Insurers have been slower to address homesharing coverage gaps than they have been for ridesharing. Joel Laucher (CDI) commented:

> There's a big difference between homesharing and ridesharing. I think it's fair to assume that the insurers' intent was to not cover ridesharing exposure at all. On the homesharing side it's not that definitive that companies didn't want to write that coverage. There's an exclusion in the liability section that indicates 'We don't cover any rental of the home except on an occasional basis'. Because it is not an absolute exclusion, there's clearly some level of this exposure permitted, so the coverage issues will probably evolve a little more slowly.

This sentiment was mirrored by Dave Cummings (ISO):

> We are devoting more attention ourselves to the homesharing side of the issue. I think there's more to come there. The insurance side hasn't bubbled up in the same way as media or public awareness has when compared to ridesharing in the last year and a half. To some degree I think that might simply be driven by where public attention is going and where regulatory attention is going. Certainly ridesharing has been increasingly active. Homesharing hasn't been receiving that level of activity, at least not yet.

And by Robert Passmore (PCI):

> We haven't seen much regulation or legislation on the Airbnb's of the world. Most of the discussion about Airbnb has been around zoning and taxes, things like that that don't come so much into the insurance realm. Airbnb has taken a different approach. They've come along a little bit quicker, perhaps taking what's happened with the TNCs as a cautionary tale.

---

[6] https://www.Airbnb.com/terms/host_guarantee

[7] Lawmakers call for Airbnb investigation over misleading insurance claim

[8] http://blog.Airbnb.com/Airbnb-host-protection-insurance/

Joel Laucher (CDI) also elaborated on the greater difficulties home insurers have than auto insurers in even identifying that insured's assets are being used in the sharing economy:

> Auto of course has a high frequency of accidents so an insurer is more likely to find something out about its risk. Home insurance, unless something pretty bad goes wrong and there is an injury, nobody knows about the sharing activity. You're not going to have enough of the frequency to give you much of a signal to tell you something is going wrong. I think sharing-specific coverages or exclusions will be slower in developing – it may still be some time before insurers really get concerned or even figure out how to monitor exposure on the homesharing side. There's got to be enough frequency for them to catch on to the exposure. Until that happens, everything is just absorbed into the regular loss pool.

As of late 2014, four insurers offered a business owners policy (BOP) specifically for people offering their homes for short term rental on sites like Airbnb and HomeAway. Officially structured as a BOP, they are designed to replace the homeowners or renters policy that an occupant would normally have. To take one of these four as an example, Proper Insurance Services[9] offers $1m in commercial general liability, $1m in personal liability, building damage coverage, personal property coverage and lost income. One key difference between this coverage type and that of HomeAway's is that this coverage is offered at a flat premium (many multiples that of a pure personal lines policy) regardless of how often the property is rented, rendering it uneconomical for the very occasional host.

RelayRides and Getaround sought insurance on behalf of their pool of available vehicles from more traditional admitted carriers.

Ridesharing companies don't generally provide blanket commercial insurance coverage. Their business model becomes much simpler, and their liability much reduced, if they are facilitators or matchers of service seekers to service providers, not as providers themselves. If each micropreneur were responsible for their own insurance coverage, sharing companies would fall back to the much less risky position of being a tech company simply providing an online matching service. Insurance is a very complicated and compliance-driven area that falls outside their prime competency.

As described earlier, the first problem is disagreement between the peer-to-peer companies and insurers on whether the true risk profiles are more similar to that of personal lines policies or commercial policies. There isn't enough data to determine which view is closer to the truth. The second problem is that the part-time personal / part-time commercial nature of these risks makes it problematic to even determine when the asset has moved between these two states.

The ultimate solution may be a hybrid personal and commercial policy, switching between these

[9] https://www.properinsurance.co/

coverage types as appropriate. Determining where and when the pendulum should swing between these two bounds, and pricing it accordingly, is the challenge facing peer-to-peer networks, insurers and regulators.

Regulatory Response

Regulators have been more proactive in addressing sharing economy coverage gaps than insurers themselves have been. The California Commissioner, Dave Jones, has been active writing letters to the public utilities commission, holding hearings, moderating an educational event at a recent NAIC meeting and chairing a sharing economy working group. Joel Laucher (CDI) commented:

> Commissioner Jones is very interested because he sees a huge exposure, a chance for people to be injured and not compensated, when clearly these are exposures that should be covered. He wants to exert his influence as much as he can to see that the sharing economy industry is taking appropriate responsibility and that the insurance market is responding with relevant products. That's what insurance is all about. But I think we found that much of the industry is kind of sitting back and watching to see where this will go.

Amy Gibbs (ANZIIF) was more critical of this 'wait and see' approach:

> Sitting back and waiting to see what happens has not worked for other industries, neither has dismissing the technology as fad. Those that do embrace digital early will stand a good chance of becoming market leaders, so the potential benefit may outweigh the risk.

In October 2014, San Francisco passed a law, becoming effective February 2015, legalizing property rentals for less than 90 days for city residents renting out their property, but requiring the collection of hotel taxes and a minimum $500k liability insurance coverage. This law has been dubbed the 'Airbnb law' by competitors like HomeAway[10] because legalizing only rentals for resident hosts in the city disadvantages HomeAway's customer base that is weighted more toward out of town owners that list their San Francisco properties for short term rentals on a full-time basis.

In September 2013 the California Public Utilities Commission (CPUC) passed a law labelling ridesharing companies as 'Transportation Network Companies' (TNC) and that all drivers operating in California must carry $1m commercial liability insurance effective when the vehicle is operating as a livery vehicle. At that time, no guidance was given on when the personal lines coverage should give way to the commercial coverage or vice versa.

The ambiguity of coverage came to a head on 31st December 2013 when Syed Muzaffer, a 57 year old Uber driver, tragically hit and killed six year old Sophia Liu, as well as injuring her mother and brother in the Tenderloin neighborhood of San Francisco.

---

[10] http://techcrunch.com/2014/11/03/homeaway-sf-lawsuit/

The driver was not carrying a passenger, nor responding to a passenger request, but did have the Uber app turned on. The driver's personal lines insurer denied liability, arguing that the app being turned on was enough to classify the vehicle as being used for a commercial purpose at that time. Uber also denied liability, arguing that with the driver not carrying a passenger, nor responding to one, the fact that the app happened to be turned on was not enough for it to be classed as commercial use.

This insurance gap was picked up in the media and political discourse, with the CPUC mandated to devise a solution. The public dialogue of liability in the wake of Sophia Liu's death led to the formulation of a three period system promulgated by assembly bill AB 2293[11], which goes into effect July 2015:

- Period 1 - driver turns app on waiting for a passenger match;
- Period 2 - match accepted, driver en route but passenger not yet picked up; and
- Period 3 - passenger in the vehicle until passenger exits the vehicle.

The Sophia Liu incident occurred under a period 1 exposure, but the bill passed in September 2013 did not explicitly specify if the commercial insurance requirement was to apply under period 1 (or any other period). TNCs are generally in agreement that the commercial liability requirement applies for periods 2 and 3. Dave Jones, Insurance Commissioner for California, and Benjamin Lawsky, Superintendent for New York Department of Financial Services, told the press in January/February 2014 that they had concerns about the insurance gap in period 1.

Robert Passmore (PCI) observed that this incident led to a rapid closing of insurance gaps:

> The TNCs themselves went from offering little or nothing in the way of insurance coverage, and they've incrementally increased that over the last year and a half or so. The discussion has become more about a couple of narrow periods of time where there are gaps rather than no coverage whatsoever.

Robert Passmore (PCI) also opined that rather than overly prescriptive regulation, the best approach to further close insurance gaps is legislating simple, clearly defined requirements but leaving the 'how' up to industry innovation, combined with adequate disclosures to drivers:

> Our position is pretty simple. The best way to support innovation is to have some clear, very basic insurance rules that say when you're making yourselves available you need to have specific insurance coverage that applies. We want to leave the door open for insurance companies to innovate and offer a personal lines product with an endorsement to cover those kinds of exposures. You can leave the door open to all sorts of things, coverage purchased by the driver, coverage purchased by the TNC company or combinations thereof. ...People that sign up for the program need to get some information about here's the insurance that you

[11] http://www.leginfo.ca.gov/pub/13-14/bill/asm/ab_2251-2300/ab_2293_cfa_20140616_104829_sen_comm. html

> need to get or here's what we provide for you and here's some information about the personal lines policy as it is unlikely to provide coverage for you. We think some basic disclosure when you sign up is very important. That's when you need the information, when you're deciding to enter into this activity.

When we asked Frank Chang (Uber) what he wishes the insurance industry would do to make ridesharing more accessible, he responded:

> There's a huge opportunity for premium for the companies who can construct a seamless product for period 1.

On 14th March 2014 Uber announced that effective immediately they would provide $50k/$100k/$25k[12] of coverage during period 1. When it becomes effective in July 2015, AB 2293[13] will require a minimum $50k/$100k/$30k[14] of insurance coverage in period 1, while periods 2 and 3 remain at the $1m limit requirement. Further, the TNC coverage is to be primary.

For context, other CPUC mandated minimums include[15]:

- $15k/$30k/$5k for personal auto
- $750k commercial liability for up to seven passengers (charter-party)
- $1.5m liability for up to 15 passengers (charter-party)
- $5m liability for 16 or more passengers (charter-party)
- The California state minimums for taxicabs mirror that of personal auto (15/30/5). However, in California, cities and counties regulate taxis, not the CPUC, and each typically imposes their own higher minimums. San Francisco, for instance, imposes a $1m minimum.

Although California is leading the way on TNC regulation, and therefore has the most relevance for framing insurance product development, other states are making similar strides. Colorado has passed SB 14-125[16] and other municipalities are following Colorado's lead. These cities & states are likely to adopt regulation similar to, if not identical to, AB 2293 in California, with period 1 requiring a limit greater than normal personal lines coverage but not quite as onerous as that required for periods 2 and 3. It will be up to personal lines insurers whether they want to cover or exclude that period 1 exposure.

Robert Passmore (PCI) said that the city-by-city patchwork of insurance requirements is a

---

[12] $50,000 for death and personal injury, $100,000 for death or injury of two or more persons, and $25,000 for property damage (50/100/25), all per incident. https://blog.uber.com/uberXridesharinginsurance

[13] http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB2293

[14] $50,000 for death and personal injury, $100,000 for death or injury of two or more persons, and $30,000 for property damage (50/100/30), all per incident. (Vehicle Code § 16500).

[15] Public Utilities Code § 1040, General Order 115-F

[16] http://www.naic.org/documents/cipr_events_140819_colorado_sb.pdf

challenge for the industry, but is ultimately a public policy issue:

> The TNCs say they are not a taxi service, but what they do very closely resembles what taxis and limos do. If you look at insurance requirements for those kinds of services, they are all over the map, partially because they are set sometimes to the local level. Some places you don't have to have limits that are any higher than personal auto has. Other places it is as high as $5m. The consensus in the industry is that that's a public policy issue for the individual states to decide how much they want to require. We don't take a position on how much. We take a position on what is primary and specific so it doesn't leave any gaps between what the driver would have on their personal policy and what the TNC-specific insurance is providing.

In the next 18 months the National Association of Insurance Commissioners (NAIC) is likely to adopt model laws for all the states to subscribe to, making the TNC category a described line of insurance alongside taxis, livery and charter parties.

This period-based approach, where each of the TNCs hold their own excess policies, is complicated by the fact that drivers can have multiple apps turned on at once (e.g. Uber, Lyft and SideCar apps all active on the smartphone), with drivers wanting to access the largest pool of potential passengers they can, rather than limiting themselves to one brand. Which TNC's coverage would apply in this case, with multiple apps active but no specific passenger having been accepted? The more entities that are potentially liable, the more likely that none will ultimately be held liable because each can convincingly argue that 'someone else' is. This is the 'diffusion of responsibility' principle at play.

Cities in the U.S. and around the world such as Omaha and Berlin are trying to make it illegal for TNCs to operate. This is partly due to the insurance gap problem, and partly successful lobbying from the taxi industries trying to address a competitive threat.

The NAIC has formed a sharing economy working group. Some of the aims of the group are to create a common language around the TNC exposure, for example about what the periods are, and share developments in terms of the coverage requirements that the states have developed. Joel Laucher (CDI) commented about the objectives of the working group:

> I think a lot of it will be about the sharing of information about what is going on in the states on the legislative or regulatory fronts, identifying and clarifying the exposures involved and the coverage gaps, communicating with the industry and consumer representatives that are there about these new exposures and getting input about how to address them. Our commissioner really wanted there to be a forum to address these issues in a more orderly and comprehensive way.

The TNCs themselves have a very strong incentive to work with the regulatory and legislative process, if only to achieve uniformity of coverage across jurisdictions. Joel Laucher (CDI) commented:

> I'm pretty sure the TNCs will want to have some level of consistency across the country so that they don't have 40 different policies at different underlying limits in different states. They would probably like to have a national coverage policy that has the same underlying coverage by period. They were very engaged here in California and Colorado, and the period 1 underlying limits are the same in both states.

Crafting regulation pertaining to how insurers can act towards policyholders and members of the public who choose to participate in the sharing economy is a good first step, but then education and enforcement is required. Sam Zaid (Getaround) said:

> We continue to see a few cases where a car owner's insurance company refuses to renew their personal auto policy. This is usually pretty straight-forward to resolve although we often have to contact their insurance provider and educate them. The consistent response we receive is that they are unclear on policy and regulation. A lot of it is just an education process. Insurance is such a distributed and decentralized industry that you always have agents that are unclear on their own carrier's official policies.

Often overlooked, operational growing pains rarely grab headlines the way regulatory and product design challenges do, but they are no less real, as explained by John Clarke (James River):

> The TNC auto coverage has been a challenge simply because of the sheer amount of industry growth. We have people 24 hours-a-day setting up new ridesharing claims. We've established large teams in Scottsdale, Arizona as well as our home base in Richmond, Virginia to deal with the claim volume. The growth in those teams is not stopping any time soon. The growth of these businesses and the numbers of rides, the number of drivers and the number of miles these firms are rolling every day far exceeds what they could have guessed what they were going to do a year ago and certainly two years ago. This is a frequency driven business. There are the occasional large losses that generate headlines but the quiet headline is the sheer volume of very small claims as you would expect in an urban environment. Most may be small claims but there are a lot of them, and we have to be able to meet the service demands of these clients.

Solutions

These new types of risks will necessitate a new type of insurance coverage. Tweaking some policy wording or trying to retrofit an existing insurance product just won't be enough. In insurance, as in everything, necessity is the mother of invention. Sam Zaid (Getaround) opined on this:

> Insurance is typically supporting the business so it subtends many other industries. Insurance usually follows something—there's this new risk so insurance fills a gap. All this innovation is being driven by disruption of industries that have said, 'We have a new risk profile and the insurance products that exist don't cut the mustard.

The industry has not reached a consensus on TNC insurance product design. Some are advocating modeling it on personal auto, whilst others are advocating a commercial auto approach. Laura Maxwell (Pinnacle) explains:

> I think personal auto can rate so much better than if you rate it as commercial auto. You can just get so much more detail from personal auto.

Mariel Devesa (Farmers Insurance Group) also argues that personal auto provides a better template for ridesharing coverage:

> We looked at the underlying usage of the vehicle, what it is being used for, and how consumers are interacting with the TNCs. What we are seeing is that the majority of the time drivers are using their personal vehicles for personal use. Our position, currently, is that period 1 is an extension of that personal use and therefore would fall under a personal use policy.

Dave Cummings (ISO) agrees that the sharing economy isn't going away, nor the insurance gaps that attend it:

> I believe the sharing economy will continue to grow. It's a new business model that, to some degree, blurs the distinction between personal and commercial exposures. As a result, there's a big insurance coverage issue that needs to be handled and addressed. Personal lines insurers will need to be part of the solution and need to accommodate in some way. I believe that we're only seeing the tip of the iceberg of what these issues may become. What we are seeing is a pattern where technology and connectedness are enabling an entrepreneurial model that wasn't previously possible. Other innovations are likely beyond the sharing economy. There's likely to be additional innovations where you see interactions and people thinking of ways they can commercialize their assets, their belongings, and their time in ways that are going to create a different type of business model again. This could produce different types of insurance exposures that we need to be ready to adapt to. We are currently writing coverage so that the industry as a whole continues to grow and address and enable these economic developments quickly and effectively.

Our view is that the distinction between personal auto and commercial auto is artificial and unnecessary. While it has been historically convenient to treat them separately, that notion is becoming outdated with the sudden ubiquity of peer-to-peer services that blur the line between commercial and personal. With separate customer bases and different drivers of claim experience, it has historically been convenient for carriers to separate product management, pricing and distribution networks into personal and commercial streams. Any middle ground between the two streams, such as personal vehicles being used for occasional commercial use (e.g. evening pizza delivery), has carried such little exposure that it wasn't worth deviating from the binary personal/commercial structural split. It was easier to just add an endorsement to either the personal or commercial policy templates to cater for these infrequent edge cases. With TNCs now a growing segment firmly occupying that middle ground between personal and commercial, it makes sense to break free of the binary product template that has been a convenient way to segment the auto insurance market for so long. After all, there's no inherent reason why you can't segment commercial auto as granularly as personal auto. It just hasn't historically been convenient to do so. Those edge cases are now becoming so common that the old binary split is now best thought of as a continuum.

We believe one of the simpler solutions to insuring TNC drivers is to adopt a usage-based insurance (UBI) philosophy priced with a personal lines rate plan and then applied to commercial or hybrid usage. First, the characteristics of the driver and the vehicle (age, sex, zip code, credit score etc.) would be used to compute the premium as if it were a plain vanilla personal lines auto policy and then broken down to cost per-mile. In addition to the standard personal auto premium, this cost per-mile is charged to each driver on a quarterly basis based on the number of miles they are actually driving in their capacity as a TNC driver over and above their personal driving. Depending on the jurisdiction, and the resulting limit requirements, this cost per-mile can be scaled up by the increased limit factors appropriate to the limit that applies to the period in which that 'TNC mile' falls, all automatically recorded by the app and reported by the TNC to the insurer. This places the cost of insurance back on the driver, while ensuring the TNC itself is complicit in accurately recording and reporting each driver's risk exposure.

As a simple example, if based on driver and vehicle characteristics the personal auto premium is $500, assuming an average of 10,000 miles and minimum personal auto limits, then the effective cost per 'personal mile' is 5 cents. If the increased limit factor to meet mandated limits when driving in a TNC capacity (defined as being when the app is turned on, say) is 2.0, then the cost per 'TNC mile' is 10 cents. The total premium for that driver then becomes $500 plus 10 cents times the number of miles driven while the app is turned on, the mile count being automatically reported by the TNC to the insurer.

This per-mile pricing would require the insurer to have a relationship with the TNC. It would be very difficult for an insurer to unilaterally insure a TNC driver, hoping to differentiate pricing periods between TNC miles and personal use miles and identify if a particular claim occurred on TNC time or personal time. It would, however, also directly address the 'insurance fraud' argument made by the taxi industry against TNCs that drivers have an incentive to leave their apps turned on even when having no intention of picking up passengers because of the benefit from increased insurance coverage. Paying per-mile for the increased coverage would disincentivize drivers from triggering the app unnecessarily.

We would also expect such product innovations to incorporate other developments like Pay How

You Drive (PHYD) telematics, social media-based rating and transitioning from agent-based distribution to the pure-play online distribution increasingly expected by the millennial generation, but we won't dwell on these developments in this paper as they are not specific to insuring the sharing economy.

On January 28, 2015 Dave Jones, the California Insurance Commissioner, announced approval of a new insurance endorsement for UberX drivers that have their vehicles insured by Metromile (a per-mile personal auto insurance MGA) to obtain period 1 coverage.[17]

> Metromile is leading the way to expand the insurance coverage available to UberX drivers and passengers… We encourage other insurance companies to offer insurance coverage to California drivers who drive for UberX and other transportation network companies.

Frank Chang (Uber) had this to say on the proactivity of personal lines insurance carriers and UBI:

> There has been response from a limited number of players who are set up to build ridesharing insurance products. In the news, Metromile, U.S.AA and Farmers have products for period 1. There is a Virginia filing from GEICO that covers all three periods. Definitely UBI is the best solution, so we're glad for the partnership with Metromile.

Dave Cummings (ISO) framed the opportunities around using apps for data capture:

> Due to the advances in the technology, the apps on our phone that we are already using, provides an opportunity for us to leverage new data that wasn't available even five years ago. This will further help us seek risk based pricing by getting more and better data about the true exposure and risk.

There are many opportunities like determining how many miles are being driven, where ridesharing drivers are operating their vehicle. Again, this will shed light not only on how they are driving, but what driving conditions they are operating. Are they in rush hour traffic? Are they driving in a snow storm? These are just some questions we can seek to answer with technology advances."

Mandating the capture of detailed usage data like this will facilitate, in the long term, better pricing models specifically for TNC usage, ending the debate over whether TNC miles are closer in risk to personal use, limousine use or taxi use.

This approach also solves the problem of coverage questions when drivers have multiple apps turned on at once. By passing the responsibility of coverage back from TNCs to the driver, the

---

[17] http://www.insurance.ca.gov/0400-news/0100-press-releases/2015/release009-15.cfm

driver's own insurer will be liable regardless of how many apps happen to be turned on at the time of an incident. To avoid being double or triple charged this 'per-mile' premium for each 'TNC mile' driven with multiple apps turned on, the TNCs will just need to ensure that they report the exact time periods the app was on so that the insurer can identify and remove any potential double counting across TNCs. TNCs operating in California are already required to maintain "waybills", which are records of all trips taken by each driver, which can be inspected by the CPUC on demand.

While usage-based insurance may be an ideal structure for ridesharing, for other sharing economy business models like carsharing, it is a virtual necessity. Sam Zaid (Getaround) relates his experience in finding a workable insurance solution at the dawn of the carsharing economy:

> We need usage-based insurance for our model as we can't control when an owner makes their car available for rent. We also require a group policy format so that one policy could cover two different sets of parties; drivers and owners. It's kind of a hybrid commercial/personal model. Because we were creating this novel thing that is also priced in a different way, folks had to get their heads around a lot of different things. If you didn't have the right senior people at the table, it was just never going to happen. You need to rate things differently and think about things a little differently. Once you've made the initial investment to figure it out, it's not so bad. You've got that foundation and you can start to really explore new things. But you have to find a carrier willing to innovate—not many carriers are willing to do that.

Sam Zaid (Getaround) also elaborated on another insurance model that would structurally align with the carsharing model perfectly, where coverage is purchased by and follows the driver, not the vehicle:

> It would make a lot of sense if insurance followed the driver and was all usage-based because, structurally, that aligns with our business and probably all the new TNCs. Any person with a driver's license should have an insurance rating factor and when they hop in a car, you combine the car's rating factor to compute the base insurance rate they pay. If you're a risky driver then it's higher. If you're driving in San Francisco vs New York then the rate changes.

The difficulty of pricing for homesharing within the framework of existing homeowners policy endorsements is quite problematic, with Joel Laucher (CDI) commenting:

> In auto there's a structure to get separate charges for this type of activity through a class plan. Homeowners isn't really set up pricing-wise generally to allow for special events or circumstances like occasional renting. But there are always answers or similar situations out there once you start looking around. Vacation rentals and special events aren't new concepts.

Airbnb's Host Guarantee and Host Protection Insurance aren't without their critics, but we believe these are significant steps in the right direction. Including this coverage automatically, and embedding the cost in Airbnb's listing fee, ensures that even occasional hosts can be covered at a reasonable cost. Contrast this against the Proper Insurance approach, and those like it, which are sold direct to hosts and have a fixed annual rate that is insensitive to how much time the property is rented as opposed to occupied by the primary resident. The Proper Insurance pricing structure is understandable since the alternative would be to somehow price a usage-based insurance product with commensurate administrative overhead, but can be cost-prohibitive for part-time hosts.

The Global Sharing Economy

Much of the discussion about the sharing economy to date has been very U.S.-focused. Some of the major sharing economy players such as Uber and Airbnb have expanded globally, offering much the same service model, and met with as varied a reaction as they have in the U.S.. Some countries have outright banned them, while some have accepted them and regulated them. But the common problem in every country faced with sharing economy entrants is dealing with newly created gaps in insurance coverage.

An international view on insuring the sharing economy provides a fresh perspective on how possible solutions could be approached in the U.S.. Graeme Adams (Finity Australia) commented on how Australia has embraced carsharing:

> Here we've got GoGet, which is renting a car by the hour [similar to ZipCar]. It's been embraced by local councils. Local councils now are providing locations on street corners for shared cars. Developers are now doing deals with councils so that the design of a block of units would include spaces for shared cars. Clearly it's in the interests for the developer because one developer that's developing a development here called Central Park, they've allowed 44 spaces for GoGet. That means they don't have to provide one or two car spaces per unit, so it's actually good for the developer. We've even got the state government using GoGet or shared cars rather than having their own state fleet.

The insurance regulatory regime in countries like the UK and Australia is quite different from that of U.S. states. Insurance product design and pricing in these countries can be modified and iterated with the same freedom as most other industries, with mainly reserving and solvency requirements of insurers being heavily regulated. For most classes; product design, forms and pricing changes don't need to be filed and approved. The ability for insurers to change their products and pricing structures in response to external stimuli such as the rise of ridesharing and homesharing means that, as long as the sharing service itself abides by applicable regulations, the idea that there could be any systemic coverage gap in a competitive and responsive insurance market is seen as a quaint notion. Graeme Adams (Finity Australia) explains:

> Have you given the insurance company what they need to understand the risk they want to take on? Have you declared that you are a ridersharer? When you take out insurance you

> need to declare if it's going to be for a business purpose or private use. If you say business purpose then they'll say, 'Well what's your business, plumber or electrician?' 'Well, no I do rideshare'. Then they should say 'well how many times a week?', 'how many kilometres?' etc and they should have a premium for it. Now in some cases they may not. They may just have a standard uplift of 20% because it's business use. It depends on how sophisticated they are. If you have said 'yep, that's fine' and paid your additional premium I don't see what the problem is because the insurer has properly assessed the risk and there's been an appropriate premium struck between the insurer and the insured. So it's not a problem.

The same goes with homesharing. Have you advised your insurer that you want to have others that you don't know living in your house for a time? The insurer might say 'that's fine we'll hit you with another premium'. They might say, 'Look, we're going to offer you a landlord's policy for three months while you have Airbnb clients staying'. Again I don't see a problem with that because the insured and insurer have discussed the appropriate risk and they've struck an appropriate premium and they have an opportunity to buy an appropriate product for the insured or landlord."

Jim McNichols (Greenlight Re) provided a forward-looking insight into the direction insurance is taking and the cultural challenges it poses:

> I firmly believe, no, I know, that bitcoin, driverless cars, electric cars, drones, they're coming! We will have synthetic currency. We will have driverless cars. I can tell you that, as a certainty it will happen. The ultimate question is when will the regulatory environment allow it and when will society and insurance catch up with them?
>
> I am from the baby boom generation and we own our cars, homes, albums, CD's and highend electronics. If you contrast the way that I approach my work and view the economic landscape with how millennials do, it may as well be medieval versus modern. Millennials avoid ownership but do require efficient access (to cars, homes, music, equipment, etc…). Much of this change is going to be forced by the new generation of consumers by not only expecting it to be this way but rather demanding it be this way. As a baby boomer, my mindset is that the efficiencies of the sharing economy may not make much difference on the margins, whereas a millennial is going to think 'Look, this is the only way it should be done.' There are four generations currently obtaining homeowners and auto insurance with very different perspectives as to what it is and how it is supposed to perform.

Many of the innovations and cultural clashes touched on by Jim McNichols will inevitably have to be addressed by the insurance industry as new risk exposures and business models that are today inconceivable eventually become commonplace. In the next section we explore how the insurance business model itself becomes one such arena, with well-funded disruptors clashing with incumbents on the battleground of peer-to-peer insurance.

SHARING THE INSURANCE ECONOMY

So far we've discussed the rise of new peer-to-peer micro-commercial insurance risks. These may disrupt the industries they are attempting to displace (like taxis or hotels) but, apart from necessitating rewording of some policy documents, they don't impact the insurance business model itself. Since insurers are free to accept or reject these risks depending on their confidence in being able to price or underwrite them there isn't any existential risk to insurers. However, true peer-to-peer insurance, which we have not yet seen, could disrupt the insurance industry as forcefully as TNCs have disrupted the taxi industry. But is peer-to-peer insurance even possible?

Many startups are styling themselves as "peer-to-peer insurance". Friendsurance[18], was founded in Germany in 2010. Similar models launched in the UK include Bought By Many[19] launched in 2012 and Guevera[20] launched in 2014. These models are more a form of insurance 'group buying', like Groupon in the U.S., or One Big Switch in Australia, than a true peer-to-peer business. In these models the risks arising from groups of 'friends' are transferred to insurance carriers with whom Friendsurance, Guevara or Bought By Many have partnered on favorable terms. These models differ from traditional insurance in that customers are placed into risk pools of 'like' customers, with 'No Claim Discounts' or rebates then earned at the pool level, rather than the individual policy level. The defining characteristic of peer-to-peer models like ridesharing or homesharing is that there are micropreneurs earning an income by providing a service (such as livery or accommodation) to customers. There are no micropreneurs in the Friendsurance, Guevara and Bought By Many business models. There are only passive pools of customers who are somewhat affected by the claims experience of other customers in their pool. Hence we would argue that the 'peer-to-peer insurance' label attributed to these companies is a misnomer.

The closest we have come to seeing a genuine large scale peer-to-peer risk transfer arrangement isn't insurance related at all, but is actually peer-to-peer lending, pioneered by Zopa in the UK and today dominated by Lending Club in the U.S.. Lending Club listed on the NYSE to much fanfare on 11th December 2014 with a valuation of $9 billion. The service connects 'investors' or lenders with borrowers directly, effectively disintermediating banks[21]. At the date of its IPO, Lending Club was licensed to lend to individuals in 45 states and accept investors in 27 states[22]. The listing was a major milestone in the maturation of peer-to-peer lending, having previously been dominated by

[18] http://www.friendsurance.com/
[19] http://www.boughtbymany.com
[20] http://www.heyguevara.com
[21] Lending Club uses WebBank, a Utah-chartered Industrial Bank, to facilitate the transactions, so while the bank's balance sheet has been (mostly) disintermediated, the bank is still required operationally
[22] http://www.lendingclub.com/

startups, in the same way that Facebook's IPO in 2012 legitimized the social media business model. Lending Club's growth has validated its inherent advantage over the "legacy infrastructure" and "incumbent inertia" of large banks. Marc Jacobs, the founder of OnDeck, a competitor to Lending Club, summed up the opportunity quite succinctly[23]:

> It sounds retro to say the Internet has arrived. But financial services are really the last massive market that is technology-based but remains rooted in systems from the 1980s and 1990s, before the Internet disrupted everything.

In many ways, peer-to-peer insurance is a natural extension of peer-to-peer lending. Let's now speculate how a genuine peer-to-peer insurance arrangement might work, where one individual directly insures another individual (or more likely a group of individuals insures another individual) without using the traditional insurance corporation as the intermediary. In the following discussion we make very little reference to specific federal and state laws, for two reasons. Firstly, laws affecting the sharing economy are malleable and constantly in flux. Secondly, we don't want this document to be construed in any way as legal advice. It is far more useful and readable to stick to a general discussion of the business model than to delve into such specifics as how the Gramm-Leach-Bliley Act (as currently applied) impacts privacy policy or how registration requirements of the Securities Act would impact the process of securitizing insurance-backed notes.

So in that spirit, in the middle you would have an entity (the 'central entity') that provides the electronic infrastructure in the form of apps, a large database, an online interface and a payment clearing house. As with other brokering models, like Uber or Airbnb, it doesn't directly provide the service it advertises but is a facilitator of this service, matching an individual service provider with an individual service seeker. The central entity (probably) takes no risk onto its own balance sheet, but takes a fee on each transaction it facilitates. Joel Laucher (CDI) agreed with this view, stating:

"The first thing we would be concerned about is who is controlling the funds? Maybe you would need a licensed administrator. Maybe the peers are just signing a pledge or a surety to offer up the funds when a participant has a loss. Is that money really readily available? It's all about their fiduciary responsibilities. And you'd have to have a group big enough or fund large enough to pay out a major claim and still exist after it had one loss."

On one side of this central entity are the risks to be insured. Similar to online insurance quoting today, customers would enter their details into an online interface provided by the central entity and receive a quoted premium. In a reverse auction arrangement, the individual might bid the premium they are prepared to pay, which can be accepted or rejected by individual underwriters on the other

[23] http://www.latimes.com/business/la-fi-lending-club-ipo-20141212-story.html

side of the transaction. It is these individual underwriters who are the micropreneurs, the insurance equivalent of an Uber driver. Although Lending Club's pricing model involves setting interest rates for particular credit tranches in advance, its competitor Prosper, started with an auction pricing approach, where an applicant's interest rate falls as lenders bid to invest in that loan. This, like other aspects of their business model, subsequently evolved into one more closely resembling Lending Club's. A reverse auction pricing model would be impossible under all U.S. states' pricing regulation, but could be a viable model overseas.

Like Lending Club's lenders, these underwriters would be akin to amateur or semi-professional financial derivatives traders. They would lodge capital with the central entity, like an initial margin, and then determine what risks they are prepared to take onto their personal 'balance sheet'. Like amateur derivatives traders moving into and out of positions based on technical or fundamental indicators, they would monitor their portfolio of auto, home and other P&C risks, growing in desired market segments and running off others. Like current day employed insurance portfolio managers, these underwriters would earn premium in proportion to the risks they are exposed to and suffer claim losses accordingly. They would decide what lines of business they want to 'dabble' in and how best to structure their own portfolio to achieve suitable diversification. The key difference is that their personal capital is at risk.

To achieve sufficient diversification, each of these underwriters would only ever be able to take small slivers of any individual risk (like 0.01% of a home insurance risk). Due to this small exposure an underwriter would have to any individual risk, it probably wouldn't be possible for each underwriter to manually inspect the profile of all risks they absorb onto their balance sheet. Maintaining the privacy of the insureds could prevent this from ever happening.

The underwriters would probably address this information limitation in one of two ways: rule based acceptance; or syndicate based acceptance. Under rule based acceptance the underwriter specifies some predetermined risk acceptance rules, with acceptance/rejection then being automatic. For instance, they might specify that they will accept 0.01% of any auto risk from people with clean driving records, capped at 100,000 policies per city, say, to achieve geographic diversification.

Syndicate based underwriting would follow the Lloyds of London model, where a group of individual underwriters follow (or appoint) a lead underwriter. The lead underwriter spends more time manually inspecting each risk and then has the power to bind all the individual underwriters in that syndicate to those risks they deem acceptable. In return for the extra effort selecting and managing the portfolio, they take a larger, but pre-specified, cut of the profit from that syndicate.

Underwriters would need to be able to sell their risk portfolios to other underwriters, either to withdraw their capital, to limit their own risk exposure or for regulatory and solvency reasons.

Underwriters' positions would need to be valued as frequently as possible (at least daily), both for the purpose of determining a fair transfer price between underwriters (even if only advisory) and for determining individual solvency. With traditional financial traders, determining a P&L, solvency and hence margin requirements at any point in time is relatively easy through marking to market, however, for peer-to-peer insurance a very sophisticated, and largely automated, valuation and capital model would be necessary. Conceivably, this could use existing actuarial reserving and DFA models but be much more automated with the use of sophisticated machine learning. New techniques would inevitably need to be developed to cope with both the new business model and the extremely short time frames required, i.e. even just moving from a quarterly reserving basis to a daily one would be problematic for most actuarial reserving techniques. One could imagine requiring a very large correlation matrix, capturing every risk in the system to determine and allocate appropriate diversification benefits to each underwriter. The diversification benefit would be different for each underwriter based on their own mix of risks by geography, line of business and other factors.

Just like present day insurers, individual underwriters would also need to select the asset mix in which capital, lodged to back their liabilities, is to be invested. This need be no more complex than the process employees go through today with their 401(k) plans, allocating their fund mix between cash, domestic equities, international equities, listed property etc. In the interests of simplicity, to ensure that underwriters focus more on the liability side than playing the asset side, let's assume that the platform offers only two options, a risk free cash account and an S&P 500 index fund, where the allocation between these two must sum to 100%. Any fluctuations in the S&P 500 fund should be marked to market in real time and reflected in the underwriter's P&L. Similarly, asset volatility would need to form part of the capital requirements model.

Although we would expect these micropreneur underwriters to be more technically savvy than the average person, understanding the complex relationships between their underwriting decisions, asset allocation, diversification measures and their capital requirements will be challenging. How many professional underwriters today have a thorough understanding of how each decision they make impacts their carrier's capital requirements? Communicated effectively, the capital model would convey to each underwriter what their 'risk budget' is and allow them to 'allocate' that budget accordingly. Taking risk in one area (say underwriting risk) eats into their risk budget, limiting their capacity to take risk in another area (say asset risk). Derivative traders today face a slightly simpler version of this mechanism where their margin requirements change dynamically as they open and close positions and as market prices shift.

Anyone following along with this description of what is effectively an online trading platform provided by a central entity might see similarities with the defunct Enron Online (EOL)[24], an online energy trading platform provided by the Enron Corporation. In brief, EOL allowed commodity traders (particularly natural gas traders) to trade directly with Enron as the market maker. This utilized a one-to-many trading model, as opposed to the many-to-many model used by the NYSE for instance. This first-of-its-kind platform quickly dominated the commodity trading market with its ease of use, with the EOL platform claiming a 60% share of the world's natural gas trading volumes. This model was riddled with problems. The FERC investigation into Enron after its collapse concluded[25] that 'like a casino, Enron had the "house" advantage by trading on EOL in energy markets', that 'Simply put, the use of EOL enabled Enron to post any price it wanted', 'The overall evidence supports the conclusion that trading abuses and manipulation occurred on EOL'.

There are a lot of learnings from Enron Online that should to be applied to any web based peer-to-peer insurance platform. Some of these are of the 'What did they do right?' variety but many more are 'What did they do wrong?' Some learnings include:

- **Don't allow the exchange to trade on its own account.** Uber and Airbnb don't compete with their own partners (drivers or hosts) by operating ridesharing cars or buying properties to rent out. They act purely as a many-to-many exchange, which limits conflicts of interest. This doesn't mean that the platform can't participate in the risks and profits too. In fact the originate-to-distribute mortgage securitization model, where originators have 'no skin in the game', disincentivizes prudent risk selection (to the extent that the platform manages or influences this). The separation of writer and ultimate financial bearer of risk leads to its own conflict and in fact was one of the leading causes of the '07-'08 financial crisis. Some form of risk retention or risk sharing by the platform would probably be desirable. However this is structured, the key philosophy is that the peer-to-peer platform be a partner to its micropreneur underwriters, not counterparty to them.
- **Disincentivize trading and speculation.** Since the purpose of the platform is to allow individuals with capital to absorb real world auto and home risks of other individuals, there shouldn't be any need to trade or speculate. Trading should really only be necessary to manage or withdraw capital. Uber and Airbnb don't allow individuals to buy up large blocks of ridesharing or homesharing time in the hope of reselling it later for a profit (like the business model of hotels.com for example).
- **Ensure only simple, liquid, well known asset classes are allowed.** Part of Enron's dubious accounting practices involved marking to market 'washed' illiquid assets to manipulate paper profit[26]. Allowing only very simple, liquid and transparent asset classes (like a cash account

[24] http://www.lieffcabraser.com/Media-Center/Articles/The-Rise-and-Fall-of-Enron-s-One-to-Many-Trading-Platform.pdf

[25] The Federal Energy Regulatory Commission ("FERC") Final Report on EnronOnline p.VII-14

[26] 'Washing' is simultaneously buying and selling an exchange traded asset at the same price. No financial risk is taken, but a new 'market price' is established. When combined with mark to market accounting, washing helps manipulate reported profits.

and an S&P 500 index fund) for underwriters to park their capital limits the ability for any party to manipulate their financial position through trading and washing.

- **The valuation and capital requirements models should be as transparent as possible.** Ideally the regulator would have full view of the inner workings of the model, but the parameters and capital requirement formula should also be transparent enough to the public for a knowledgeable individual underwriter to approximately reproduce their imposed liability valuation and capital requirement from information they know about their own portfolio.
- **Strong whistleblower protections.** Whistleblowing was critical in uncovering the Enron fraud. In practice, protections for whistleblowers are often inconsistently applied[27]. If you're going to encourage whisteblowing (a la "If you see something, say something"), don't send mixed messages by vilifying whistleblowers.

The rise of peer-to-peer insurance would see a reversal of industry consolidation taking place over the past couple of decades. Dave Cummings (ISO) suggested:

> The trend in the industry over the past 20 years, particularly in personal lines insurance, has been to consolidate. In personal auto there are far fewer insurers in the market today than there were even 10 years back. Companies have continued to grow organically in addition to the consolidation. If peer-to-peer insurance really breaks into the market, there is potential to reversing of that trend. If this market were to grow, it could take back some of the market share the largest insurers have been able to consolidate. If so, it would be a change to the balance and competitiveness of the market.

Hurdles to Implementation

We believe there are five main obstacles to the above business model becoming a reality: technical; consumer acceptance; privacy; regulation; and industry inertia.

Technical

Current peer-to-peer arrangements are technologically quite simple (compared to an insurance operation). Airbnb, Uber and eBay are just sophisticated online bulletin boards, with payment processing and a feedback rating system to keep participants (mostly) honest when dealing with strangers.

Lending Club's platform provides a good starting point for thinking about the peer-to-peer insurance platform. Lending Club pulls credit reports, summarizes information about prospective borrowers for investors to review and has a messaging capability to enable investors to ask borrowers specific questions about their financial position. Once loans are issued, each investor is able to track

---

[27] At one extreme, whistleblowing that embarrasses the government tends to result in persecution, vilification and self-imposed exile for the whistleblower (i.e. Edward Snowden, Chelsea Manning and Julian Assange). At the other extreme, whistleblowing beneficial to the government tends to be well protected and even lucrative, such as the $104 million payout by the IRS in September 2012 to one whistleblower for revealing instances of large scale tax evasion.

payments and defaults from borrowers in their portfolio.

The technical hurdles for true peer-to-peer insurance are much, much greater than other peer-to-peer services, even that of peer-to-peer lending. Any large scale external event, from hurricanes to terrorist attacks, needs to be reflected in claim valuations in real time. Just automatically valuing each insurance risk each moment, determining diversification benefits and capital requirements would necessitate automating reserving, catastrophe and capital models while maintaining at least as much accuracy as their currently labour intensive versions today.

From this point of view, you could almost say that automating away the entire actuarial services industry is a prerequisite for the viability of true peer-to-peer insurance. However, you'd still need actuaries to build and review the models being used and explain their workings to regulators. The fact that they would operate automatically day to day, or minute to minute, isn't too far removed from current practice where reserving spreadsheets are automatically updated each quarter with new input data. This update cycle would just need to be shrunk from quarters to seconds. Even if large scale machine learning infrastructure that is able to accommodate processing this volume of information in such tight timeframes isn't quite there today, it certainly will be in the near future.

Pricing without any experience to draw on presents a technical hurdle, albeit one not at all unique to the peer-to-peer business model. Dave Cummings (ISO) suggests:

"Pricing without prior experience is a significant hurdle. New carriers will need to acquire data and insurance knowledge related to the risks they plan to take on. However, without older legacy systems holding them back, they get the opportunity to start with more sophisticated pricing models and more granular, data driven underwriting. Additionally, they have the opportunity to embrace technology and enable them to do more with fundamental pricing, underwriting and claims handling. A significant portion of the segment invasion comes from this flexibility."

Consumer acceptance

Dave Cummings (ISO) suggested that financial stability would weigh foremost when prospective policyholders consider peer-to-peer insurance:

> I would expect many people would first want to ensure that the peer-to-peer insurance has the financial backing it needs to cover policies. It's hard to know how much that enters into people's minds. I do wonder how many tech-savvy consumers are aware of or concerned with the financial stability of their insurer. I'm guessing that they may not place as much emphasis, so it's something that may or may not be an issue that consumers think about. If they are comfortable with the financial stability and claims handling process, then I would expect that there would be many who would embrace this concept. It's an attractive business model in many ways. It is something that seems to speak to some of the sentiments in the consumer base about insurance companies, and it does have a startup entrepreneurial feel to

> it that many consumers would look on positively as long as that basic threshold of meeting the expectation of financial and claims handling is going to be met.

Amy Gibbs (ANZIIF) further opined:

> We know from the digital disruption of other industries, such as with the entertainment industry, that the underlying technology is attractive to consumers who want to take more control and circumvent systems they see as being unfair or overly costly. Once the systems have been worked out in a technical sense, such as with Friendsurance or Peercover, the conversation changes, not to whether customers will use the new technology, but which provider of the new technology to use, and then more traditional evaluation comes into play - which provider is trustworthy, works the best or simply survives or outperforms the others. While Napster might have been shut down, its closure did not protect the music industry from countless other groups providing the same technology to consumers. When it comes to insurance, the idea of avoiding traditional insurance companies with their less than positive reputation (whether fairly or unfairly earned) is going to remain attractive to consumers.

While there are definitely technical hurdles for peer-to-peer insurance to cross, I think that it will be the social and cultural ones that will prove more difficult. With many insurers hesitating to even dip a toe in the water, it will be entrepreneurs from outside the industry that pave the way technologically speaking, and these groups won't have the wealth of knowledge - and safeguards - that the established insurance industry has.

Peer-to-peer lending and crowd sourcing technology already show that people are willing to take on the risk of trusting relatively new technology when it comes to their finances. Removing the alleged bad guy from an equation - be that big business, banks or insurers - is a powerful incentive for people and small business who want a fair go. For smaller insurance needs I think people will be very interested, particularly if it means they can afford to insure things they would not normally insure, or would deliberately underinsure for financial reasons. Equally, peer-to-peer insurance will open the door to niche insurance possibilities that consumers simply cannot get access to or afford, such as 'Bought by Many'."

Privacy

The privacy implications are very different between using a peer-to-peer service for transport, accommodation or errands as opposed to using one for insurance. When you use Uber, Airbnb or Taskrabbit you provide your name, address, email, phone number and pay with a credit card. You are revealing about as much about yourself as you do when you buy a book off Amazon, so privacy isn't a prime consideration. But when you buy insurance you need to reveal a raft of personal information including criminal history, credit score and even biometric information in the case of health insurance. We may accept giving this information to a large faceless corporation with no personal agenda beyond taking our money and making a profit, but when the person on the other side of the transaction is a micropreneur underwriter (or many, many micropreneurs if each takes only 0.01% of your risk), then privacy becomes much more of an issue. Although de-identified, the micropreneur reviewing your insurance application might be your neighbor, your boss, your mother-in-law or your parole officer.

The peer-to-peer lending model has already tackled this privacy issue. Individuals apply for loans on the online platform, where they input their credit score, income, financial position and intended use of the borrowed funds. The platform assigns a risk profile, which investors can review and then either lend or not based on criteria the investor chooses to screen for or against. Lenders and borrowers converse with each other to discuss financial position, but personally identifiable information is not (or should not) be shared.

Alternatively, if privacy concerns become such that amateur underwriters can't view and analyze insured's information at all how can they underwrite the risk?

The two broad answers, mentioned earlier, involve:

- De-identifying and aggregating the information to allow underwriters to analyze the aggregated data and then formulate their own rule based approach to underwriting, such as accepting no one with a credit score below 600; and/or
- Joining a syndicate and allowing a lead underwriter to manage the risk selection for you. The lead underwriter would act like underwriters today, being similarly licensed and bound by privacy requirements, so that they would have access to enough personal information to evaluate the risk of each applicant, but no more.

With appropriate limitations and licensing in place, we don't think this privacy hurdle, even today, is a showstopper for this peer-to-peer insurance model.

Regulation

Like all new forms of peer-to-peer business models, industry-specific regulation would need to be rewritten to accommodate this new business model. It's impossible to determine in advance how this regulation would apply, especially considering the process of writing regulations is itself the result of industry consultation, political compromise and a hearty dose of lobbying. The evolution of regulation in the face of similar business models, however, provides a good guide to how regulation of peer-to-peer insurance would evolve.

Dave Cummings (ISO) suggests that startup entrepreneurs considering entering this space shouldn't underestimate the regulatory hurdles:

> I would expect that they need to go through similar regulatory and licensing processes, which are significant. That's going to be a challenge and far from trivial. More generally, it seems there are a few things this sharing economy has highlighted. The companies going forward based on an interesting technology or business model may be slower to recognize the impact

> of regulation on insurance. It's something that they need to be aware of and they need to address early. I'd say generally regulators are supportive of new companies entering the market. [Startups] have that on their side as long as they have the right structure in place like financial stability, as well as understanding rate and market conduct regulation.

The two main groups of parties to the peer-to-peer insurance transaction are the underwriters and the insureds. Relationships with underwriters, essentially being individual investors, would most likely be regulated by the SEC, while relationships with insureds would likely be governed by each state's existing Insurance Departments. Like lenders and borrowers in the Lending Club model, the pool of underwriters and insureds would likely span many states on both sides of the transaction. In fact the principle of geographic risk diversification would make this many-to-many relationship by state desirable even as it makes it much more complex to regulate.

The underwriters would be in a very similar position to the lenders in the Lending Club model. In fact Lending Club investors can inspect individual applications for loans, ask each prospective borrower questions about their financial position and then decide on a case by case basis which loans to invest in. Lending Club CEO Randolph Laplanche described their regulatory framework:

> In our case we are selling an investment to an investor, so it's regulated by the SEC [Securities and Exchange Commission]. The investment isn't guaranteed. The investors can ask Lending Club for their money back and get it on the normal monetization schedule of the loan. There's no risk of a run on Lending Club like there is risk of a run on a bank. For that reason there is not FDIC [Federal Deposit Insurance Corporation]-imposed reserve requirements.

Assuming the underwriter's funds also would not be 'at call' we speculate a similar regulatory framework to that governing Lending Club's investors would apply[28]. Underwriters would only be able to withdraw funds once their claims backed by their funds had sufficiently run off or their liabilities were sold to another party.

We see no reason why the regulation governing the insured's interest in peer-to-peer risk transfer be different to that governing their relationship with insurance carriers today. First and foremost, reserves sufficient to pay claims need to be held. It goes without saying that the threat of a bad review on an eBay-style feedback rating system won't be enough to entice micropreneurs to turn over all their worldly assets in the event that their initial 'margin' proves insufficient.

You would need to have fairly stringent up-front capital requirements equal to, say, the 99th percentile of the expected claims distribution after an allocated diversification benefit (analogous to

---

[28] One of the most comprehensive summaries of the regulatory framework for peer-to-peer lending services that we could find freely available online is: http://www.aba.com/Tools/Offers/Documents/Chapman_Regulation_of_Peer-to-Peer_Lending_0414.pdf

margin requirements in derivatives trading, say) to mitigate default risk, combined with mandatory catastrophe reinsurance. As long as these parameters were set appropriately, there is no reason the risk of default need be greater under a peer-to-peer arrangement than under a traditional insurance arrangement.

Dave Cummings (ISO) suggests:

> I think there are obviously some issues that need to be addressed. Starting an insurance company in your basement is a very different thing. We need to ensure that as the company or program develops that they have the financial resources necessary, which is different from being able to develop a cool app. We need to make sure, as they grow, they've got the right expertise and information to make sure they are prepared to bear the risk that they are going to take on.

Amy Gibbs (ANZIIF) commented on the evolution of consumer protection legislation in peer-to-peer insurance:

> It will also be hard for regulatory bodies and national law to accommodate new technology. Consumer protection under these circumstances will prove hard. It's one thing to peer network your music downloads, but quite another when both your money and assets are at risk. That said, regulation will (eventually) have to keep up with the use of the people. Whether it will do that in time to avoid a potential financial disaster remains to be seen.

The second area for regulators interested in consumer protection to consider would be pricing. To be viable, consumers would need to, on average at least, pay less for insurance under a peer-to-peer arrangement than under traditional channels. Cost savings are a common theme in peer-to-peer business models. Just compare TNC vs taxi pricing and Airbnb vs hotel pricing. The best indicator for the cost savings that would likely arise from peer-to-peer insurance again stems from Lending Club's experience. Their ratio of expenses to loan value is less than 2 percent compared to banks' ratio of between 5 to 7 percent[29], largely due to Lending Club having more automated and streamlined processes than banks and not needing to maintain a branch network. We strongly believe a similar efficiency dividend would be realized in the insurance market, particularly when comparing agent-based distribution to a pure-play online distribution.

Industry Inertia

As a broad generalization, technological innovations originate (or are at least first commercialized) in the U.S. and are subsequently exported to other countries, eg Uber, Airbnb, Apple, Google and Microsoft. The opposite usually occurs in financial services, with U.S. innovation generally lagging

[29] http://www.cnet.com/news/with-rising-revenues-lending-club-ceo-plans-expansion-q-a/

that of other countries[30].

In the U.S., tech companies tend to be fast moving and agile, while insurance companies tend to be risk averse and compliance driven. What happens when you have a new world tech-based solution encroaching into an old world industry? It's a case of an unstoppable force meeting an immovable object.

The insurance industry's default course of action of sitting back and waiting to see what happens has not worked well for other industries disrupted by peer-to-peer technology, such as the music and entertainment industry. We believe this could go one of two ways. Just as the hotel industry, through the Hotel Trades Council, has preferred to let regulators wage war on Airbnb rather than expending energy doing so itself, so too would the insurance industry find this an effective first line of defense. As peer-to-peer insurance would represent a true existential threat to the insurance industry, lobbying of regulators by the industry to maintain the status quo could easily kill peer-to-peer insurance in the U.S. before it can even start.

The second possibility, which would become increasingly likely if the default response to neutralize the threat fails, is that the industry pivots, embracing the peer-to-peer model, positioning itself for lead underwriter roles in 'peer-to-peer' insurance syndicates (as described earlier) and hence taking on members of the public merely as passive investors. The composition of Lending Club's 'investors' followed this trajectory. Initially the funding base consisted of individuals lending as little as $25, but now only one third of funds are from individuals investors, with the rest coming from mutual funds and institutional investors who don't micromanage every loan application.

Many other peer-to-peer businesses have become dominated by large established players once the opportunity (or threat to their legacy business model) was recognized[31]. Avis acquired ZipCar in 2010, effectively a by-the-hour self-serve rental car service using cars conveniently scattered throughout participating cities. Mercedes-owned Daimler expanded its car2go service in 2009 which allows users to hop very short distances in a car without needing to return the car to its original location, effectively being a cross between Zipcar and the bike share infrastructure appearing around the world. In 2011 General Motors even invested $3 million in RelayRides. This model is analogous

---

[30] Examples of overseas innovations that were slow to be adopted, or haven't yet been adopted, in the U.S. in insurance include property level homeowners pricing, common use of GLMs, demand modeling, price optimization and the widespread transition from agent-based to direct online transactions. Similar examples of the U.S. being a late adopter in banking include free overnight peer-to-peer fund transfers between any bank, chips in credit and debit cards to prevent fraud, contactless payment and the abolition of paper checks. Even U.S. payment innovations like PayPal and the contactless 'Apple Pay' were essentially non-banking workarounds developed to provide the same payment functionality that had already existed for over a decade in personal banking in many countries outside the U.S., such as direct transfer and PayPass.

[31] http://www.forbes.com/sites/tomiogeron/2013/01/23/Airbnb-and-the-unstoppable-rise-of-the-share-economy

to creating a platform for crowd funded startup insurance trusts to operate, with the role of traditional insurance carriers morphing into that of managing these startup trusts.

So, is peer-to-peer risk transfer feasible? Could "insuring the sharing economy" really give way to "sharing the insurance economy"? We suspect asking the insurance industry this question would be like asking the Taxi Federation five years ago if they thought app-based ridesharing was feasible. The safest prediction we can make is that any entrants into this market will following in the footsteps of other disruptors, possibly asking forgiveness, but never asking permission.

Global Perspectives on Peer-to-Peer Insurance

Taking an international perspective on peer-to-peer insurance can be useful in understanding if, or how, it could be implemented in the U.S.. The entire value proposition of peer-to-peer is that price savings can be achieved by disintermediating an inefficient, legacy-driven middleman. Ironically, the biggest force that could see peer-to-peer insurance thrive in the U.S., could be the very force keeping it out of overseas markets. We are referring to relaxing regulation and letting competitive forces drive product design and pricing. While U.S. auto expense ratios are typically around 25%-30%, competitive forces in Australia, for instance, had driven expense ratios down to 10% decades ago. This has been achieved by significant automation and the dominance of online direct sales. In an already lean environment it is hard to see how a peer-to-peer platform could gain a cost advantage over existing players. Graeme Adams (Finity Australia) explains:

> The industry in Australia has been direct for a long, long time. They switched into internet channels and electronic commerce. Branches and even telephone centres are a thing of the past. The leading car insurer has an expense ratio on their car insurance of around 10% but they also have massive buying power so they can get cars fixed cheaper than most other insurers, let alone an individual. So if you have peer-to-peer insurance on car insurance, how could that beat an expense ratio of 10%? What is the real saving they get in terms of the premium they pay? There is a cost to manage the enormous complexity when 200-300 people are effectively paying the claim.

There has, however, been somewhat of a resurgence in mutuals and buying groups overseas. Graeme Adams (Finity Australia) explains:

> Buying groups are getting quite a leg up here. One Big Switch has got 630,000 members now from a standing start three years ago. That's a lot. Another, Capricorn, is a discretionary mutual. They don't provide insurance, they provide what they call 'protection'. The thing with a discretionary mutual is they are not obligated to pay out a claim under a policy. It's at their discretion that they pay a claim. Maybe there could well be a resurgence in mutuals because they have cheaper capital and don't have to make a commercial profit. It's particularly an issue as insurance becomes more expensive here. It's becoming more expensive for a whole host of reasons. It's on more of a sustainable footing now. Also we

> understand the risk better. We understand flood particularly, earthquake, other natural peril risks are well reflected in premiums down to individual properties.

Dave Cummings (ISO) agrees with this comparison:

> In many ways it's a reinvention or an older concept. This could be analogous to mutual insurance, as it started years ago. The idea of groups coming together to self-identify and to start to provide means for insurance. It's interesting to see how we are resurrecting an idea that originated over 100 years ago due to modern circumstances.

From this perspective, peer-to-peer insurance isn't anything new. It's really just a resurgence of mutuals that have been with us since the dawn of the insurance industry, only this time with a flashy new app.