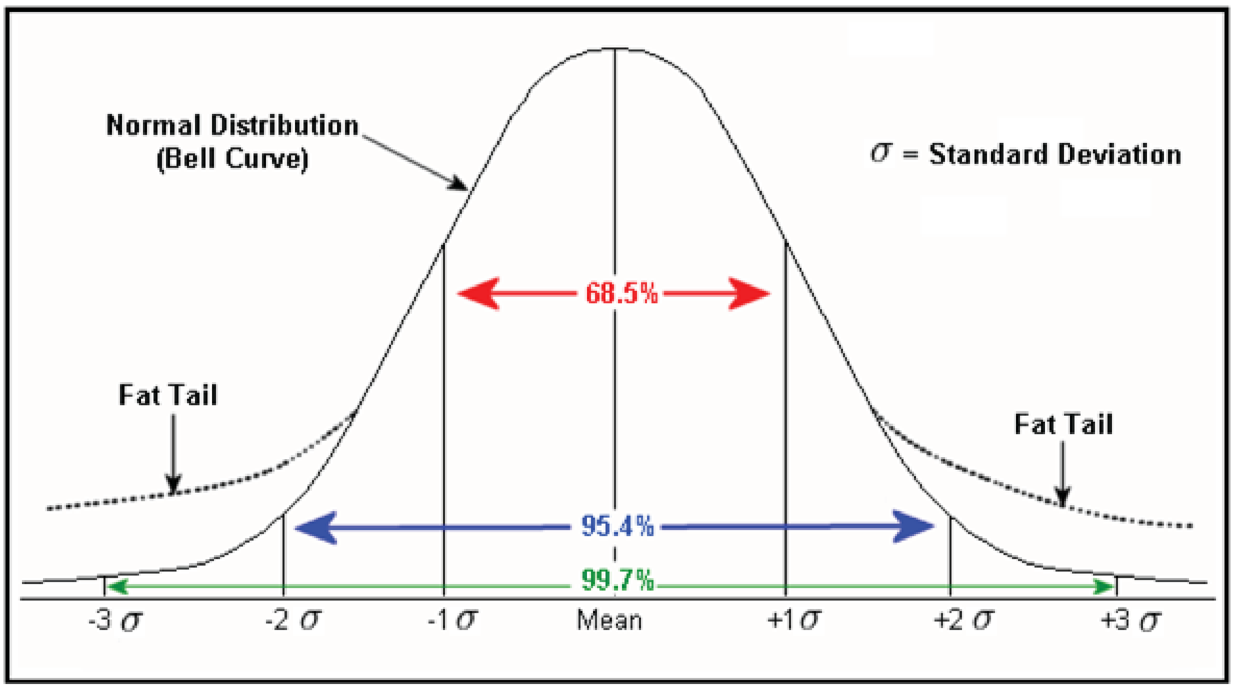
Developments on the Reserving Uncertainty Frontier

By Syed Danish Ali

'In reserving, are we swapping specific risk for systematic risk?'[1]

This is the key question that we ask here. The hypothesis that in normal market conditions, reserving results are kept at consistent levels and volatility of their results is reduced. The traditional approach requires precise figures (point estimates) and so leads to understatement of uncertainty. This keeps a comfort level for us but the hidden risk of uncertainty in our reserve estimates is hardly given the attention it merits. The uncertainty crops up from the rug it was shrugged under in stressed market conditions and reserves that are then systematically proven to be insufficient.

In other words, are we causing the fat tail problem[2] by our practices? What can be done to reduce the fatness of such tails and bring the hidden uncertainties onto the surface explicitly? [3]



A fat tail exhibits large skew and kurtosis and so there is a higher probability for large losses compared to other distributions like normal distributions. This higher loss tendency remains hidden under normal market conditions only to resurface in times of higher volatility.

The Structure of this report can be highlighted as follows:

1. Establishing the context (PwC gold standard)
2. Measuring uncertainty (stochastic and CoV)

[1] Idea adapted from 'The Economist; In Plato's Cave; January 2009'.
[2] http://lexicon.ft.com/Term?term=fat-tails
[3] http://advisoranalyst.advisoranalystgr.netdna-cdn.com/wp-content/uploads/2014/10/bellcurve.png

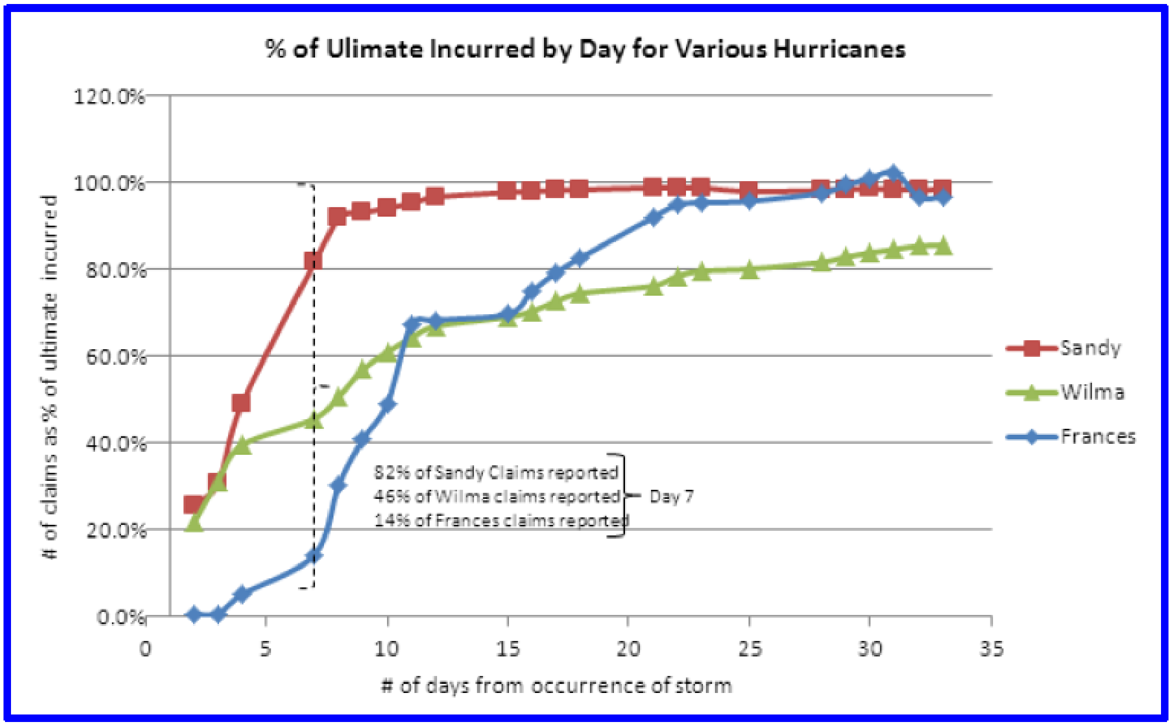
3. Alternative measures (triangle free reserving and data science)
4. Message to stakeholders

This report does not intended to give detailed explanation of each model it mentions. Rather, it will endeavor to provide intuition coverage of key ideas in the models that it covers in helping to shed more light on uncertainty of the reserving process and how to decrease the uncertainty. As it's a survey and evaluation of different methods for handling reserving uncertainty, it is advised that those models and measures described here that are not known to the reader can be explored further by reading the references given in this report.

Establishing the context

Reserving is not an isolated exercise in pure mathematics but is deeply embedded into the business context and practices prevalent in the company.

Reserving estimates are embedded in a host of external conditions. The case study of different claim lags for Progressive Insurance Company for same natural catastrophe of Hurricanes highlights the complex contingencies in action prominently[4]:



For Super-storm Sandy, there was early re-entry into the affected areas by the policyholders which resulted in early reporting of claims. For Wilma, the flood waters caused by the Hurricane retreated fairly quickly, allowing policyholders to report claims within a reasonable time period. Frances Hurricane occurred on Labor Day weekend which resulted in significant delays in reporting of claims. This shows that how risk events can manifest in different ways despite belonging to the same hazard of 'hurricane'.

Due to such inherent uncertainty levels, corporate governance of improving and monitoring processes and controls enveloping the reserving exercises is vital. The key controls for processes can be described as follows[5]:

- Involvement of board and senior management as reserves compose the largest liability on an insurer's balance sheet.
- Adequate staffing and skills of actuaries including external actuaries
- Ensuring reasonable data capturing, quality and reliability

[4] Progressive corporation: Report on loss reserving practices; Aug 2014
[5] PwC: The Gold Standard; Assessment of the property-casualty actuarial reserving process. July 2010

- Following reserving approach and methodologies as endorsed by actuarial societies and regulations as well as its documentation
- Accurate and valid disclosure of financial statements

Emerging lines of business like insurance relating to genetics, nanotechnology and cybercrime as well as long tailed classes like asbestos have higher inherent uncertainty in reserves and require greater input from judgment of experts. Risk culture is important as experts in some culture might be systematically conservative while others systematically optimistic in other cultures and companies. Culture also impacts controls and checks in place with regards to the underwriting cycle. The company should avoid the situation where controls feed undue optimism in times of growth and undue conservatism in depressed times ('feeding greed in greedy times and fear in fearful times'[6]).

It is also crucial to synchronize key assumptions and reserving approach throughout various branches of a global insurer as well as throughout other departments like claims and underwriting.

There is no shortage of actuarial methods when it comes to reserving. From chain ladder, double chain ladder, Bornheutter Ferguson, Cape Cod to stochastic models, a diverse variety of models are available each with their own biases in capturing reserving realities. Employing a number of models at the same time and choosing the results that best fit a pre-determined criteria like expert judgment termed as 'Algorithmic democracy' (Panning) is important for reserving as there are many different methods to calculate the reserves. Each method has its own strengths and weaknesses and a number of simultaneous modeling helps to establish further corroboration than a single model. A parsimonious (not too many-not too low) number of methods can be applied to see what reserves they bring fourth. This can help us see some aspects that might have been ignored from focusing on one or two methods.

Algorithmic democracy of running multiple models simultaneously can be useful as some models might highlight some parts of the fail tail and other models might expose other parts of the fat tail as their results, percentiles and residual errors are different even over the same data.

1. **Measuring uncertainty:**
    a. **Stochastic Reserving**

A standard approach in quantifying uncertainty revolving around the reserving point estimate is stochastic reserving. Stochastic methods for reserving are used in capital modeling exercises but deterministic methods like BF and Chain Ladder dominate the reserving landscape[7].

The bootstrap method breaks development factors into two important areas; random noise and the underlying historical pattern. While underlying historical pattern is constant, random noise is shuffled across the triangles for a number of simulations to create probability distribution of IBNR results. In this process, random noise is assumed to lie uniformly at every point in the triangle.

Mack Method facilities claims data in telling the story as it is distribution-free for claim amounts. Instead of tagging any distribution to the claim amounts, normal distribution is applied onto the mean and lognormal onto the standard deviation of the claims so as to generate a full distribution of ultimate claims.

[6] The Economist; Wild-animal spirits; January 2009
[7] Actuarial Post: Making uncertainty explicit-stochastic modeling

Stochastic methods are important in preventing and exposing fat tails because randomness and simulations allow us a greater access then what we do from learning from history and extrapolating it to the future. Instead of placing all of our hedges on history being a reliable indicator of the future, stochastic measures uncover greater possibilities than history has shown us to shed greater light on fat tails and how they can manifest.

2. Measuring Uncertainty

b. Coefficient of Variation

Coefficient of variation (CoV) is quite simply the ratio of the standard deviation σ to the mean μ. In actuarial terms it implies standard deviation of the estimated reserve as a percentage of estimated reserve which is the mean reserve calculated by the actuary[8].

Panning takes CoV as a yardstick for measuring uncertainty in reserves. Linear regression is applied onto a dependent variable Y (such as paid losses) with other independent variable(s) X. Panning charters a way out of key limitations of linear regression like homoskedasticity, correlated disturbances, bias and so on through a number of important modifications in the application of the linear regression.

The linear regression is then fitted and forecasted paid losses are generated. Standard deviation of these forecasts is calculated and both are put together in the CoV ratio. Model diagnostics such as analysis of standardized residuals is followed at the same time to ensure accuracy of applying the CoV method.

Apart from being an accurate measure of loss reserve uncertainty it is also simple to understand and implement using spreadsheets which actuaries use very often. Moreover, the CoV is comparable across different lines of business as well. It is recommended that CoV be utilized as a first and credible step towards systematically recognizing uncertainty in loss reserving by actuaries.

3. Alternative measures;

a. Triangle free reserving

The main problem with triangulation as per Parodi is that of information compression. By compacting information into a small triangle (only claims paid/claims incurred amounts by accident date/reported date/paid date) , a huge amount of information regarding claim statistics is lost and cannot be taken into account sufficiently, no matter how creative we get in engineering and tweaking the triangle itself. Triangle can be satisfactory for reaching a point estimate, but it gets very difficult to figure out the uncertainty revolving around this estimate when determining distribution of the reserves due to significant information lost in making of compact triangles[9]. Thus we need modeling that takes in higher dimensions of more factors that are available in the data instead of utilizing only two-dimensional triangles.

The paper goes on to argue that an alternative triangle free reserving is possible. Date of loss and date of reporting are very important for tis triangle free reserving framework. A frequency model of the IBNR claim count based upon lag (between reporting and loss date) distribution is developed on weighted basis so as to avoid biases towards any particular lags. This lag distribution is also used to produce kernel severity model for individual losses. These frequency and severity models can be combined through Monte Carlo simulation to produce an aggregate model for reserves. All the while we still retain high dimensions and each IBNR figure can be seen on a transactional level.

Parodi argues that this triangle-free approach has a number of advantages over triangulation. These are:

- Higher accuracy and predictive power than triangle based approaches.

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[8] William Panning: Measuring loss reserve uncertainty

[9] Pietro Parodi: Triangle free reserving; a non traditional framework for estimating reserves and reserve uncertainty: 4 Feb 2013

- Any further information on risk can be easily taken into account by this framework. For instance, a different model for losses above a given threshold such as Value at Risk threshold can be made on market statistics as company data might be too sparse.
- Calculation of tail factor can be done more systematically and rigorously than the heuristic fashion adopted in triangle based approaches.
- The results and approach does not become un-credible as easily as triangle based approaches when data is small.

However, it is important not to go overboard with this. Too many variables in data can mean colinearity and multilinearity can be present so Principal Component Analysis and other methods should be applied on variable selection to get parsimonious variables.

Triangle free reserving is important and worth consideration because it does not compressed information and utilizes a number of other parameters included in the data which can be analyzed for their impact upon IBNR on a transactional basis to reduce uncertainty in the reserving process.

3. **<u>Alternative measures:</u>**
    b. **<u>Data Science</u>**

While KPIs ratios are used frequently like ranges, changes in ultimate losses between analyses, evaluation of loss-ratio trends, IBNR-to-case ratios, etc, data science is not applied as much by actuaries for reserving purposes.

We argue that what was perceived as uncertain can now be made less uncertain with data science. Also the uncertainty should be captured from where it was partly generated like risky classes were underwritten which later lead to greater reserving uncertainty and so on.

The core idea here is that instead of compressing information on a triangle, it is time to widen up our sphere of analytics to more sources of information. This is crucial as reserving is not an isolated exercise but is deeply impacted by various business practices and areas of the insurance company as well. Data science can help us capture and analyze more information so as to directly reduce uncertainty inherent (veracity) in those data. It is very important as the higher uncertainties within the data, the higher uncertainty in reserving especially for specialized lines, long tailed or newly commercial lines. When widening our analytical sphere, we can discover previously unrecognized correlation among different factors as well.

With regards to loss uncertainty, data science can help in a number of ways:

- Exploring our data
- Predictive modeling
- Unstructured data and text mining

<u>Exploring our data</u>

Decision trees such as hidden decision trees or random forests can allow us to see the map and the critical paths upon which the data is proceeding. Thus, the trend and nature of even huge datasets can be understood through decision trees[10]. Decision trees are unsupervised methods of learning which means that they expose the trends within the data without relying only on what the analyst is interested in querying.

Clustering especially KNN means clustering is an imperative algorithm that exposes different clusters operating within a given data[11]. This can tell us the groupings within claim registers and premium registers like one cluster can be bodily injuries are associated with third parties that are associated with non-luxury vehicles that are commercial and so on.

Time series decomposition: There are R codes available for running this decomposition algorithm. Basically decomposition of time series takes a real-data time series and breaks it down into 1) trend (long term), 2) seasonal (medium term) and 3) random movements[12]. Such decomposition can have huge potential in understanding trends in data. For instance, claims data have trend that follow an underwriting cycle and mimics the economic cycle closely. An instance for seasonal trend can be higher sales of travel insurance in spring break and summer breaks and so on.

Predictive modeling

Aside from exploring the data various uncertain elements of risks can be captured for predictive modeling as well.

Generalized Linear Models (GLMs) using Over-Dispersed Poisson can be applied to arrive at distribution of reserves as part of stochastic reserving process[13].The Chain ladder package in R developed by Markus Gussman is readily usable and tells us the mean error around the mean reserve as well.

GLMM is a natural extension to GLM models as the linear predictor now contains random effects as well to incorporate fuzziness and give a stochastic feel for enhanced reserving.[14]

Predictive modeling using GLMs and GLMMs can also be assigned to categorize a particular policy into its proper risk category like into predictive risk for claim likelihood for a particular policy and so on (unacceptable risk, high risk, medium risk, low risk etc). Separate triangles can then be done for each major risk category so as to expose greater insight into the reserving process[15]. The results from the separate triangles can act as a feedback loop to the risk and underwriting categories of how valid and reliable are these categories and promote greater cooperation between underwriting function and the claim/reserving function which is vital to generating adequate risk-adjusted returns.

Unstructured data and text mining

It is well known that 80% of data is unstructured. Unstructured data is the messy stuff every quantitative analyst tries to traditionally stay away from. It can include images of accidents, text notes of loss adjusters, social media comments, claim documents and review of medical doctors etc. Unstructured data has massive potential but has never been traditionally considered as a source of insight before. The traditional relational

[10] HR Varian, 2014; The Journal of Economic Perspectives –JSTOR. "Big Data: New tricks for econometrics".
[11] Liu, D. R , Shih, Y.Y, 2005: The Journal of Systems and Software 77 (2005) 181–191."Hybrid approaches to product recommendation based on customer lifetime value and purchase preferences"
[12] Zucchini and Nenadic; R Vignette: Time Series analysis with R-Part I;
[13] Markus Gesmann: R Vignette: The 'Chain Ladder' package-insurance claims reserving in R.
[14] University College London; Introduction to GLMM
[15] Breton and Moore; SOA 14; Predictive modeling for actuaries: predictive modeling techniques in insurance

databases use rows and columns in handling data but NoSQL (Not-Only-SQL) uses a number of other components such as giving unique key or hash tagging to every item in the data. Insurance companies can utilize NoSQL databases like MongoDB and Hadoop because it captures so many elements of reserving that were deemed belonging to the domain of uncertainty before as they were too messy and qualitative[16].

Text mining utilizes a number of algorithms to make linguistic and contextual sense of the data. The usual techniques are text parsing, tagging, flagging and natural language processing.[17] There is a correlation between unstructured data and text mining as many unstructured data is qualitative free text like loss adjusters' notes, notes in medical claims, underwriters' notes, and critical remarks by claim administration on particular claims and so on. For instance, a sudden surge in homeowners' claims in a particular area might remain a mystery but through text analytics, it can be seen that they are due to rapid growth in mold in those areas. Another useful instance is utilizing text analytics when lines have little data or are newly introduced[18].

Sentiment analysis/opinion mining over expert judgment on level of uncertainty in reserves can also prove fruitful. Natural Language Processing (such as in Stanford CoreNLP software available free for download[19]) is a powerful source of making sense out of the texts.

As highlighted earlier, Data science (exploratory, predictive modeling and text mining) can help us capture and analyze more information so as to directly reduce reserving uncertainty inherent (veracity) in those data.

[16] IBM White paper2013 : Harnessing the power of big data and analytics for insurance
[17] Stanford Natural Language Processing Group; available at: http://nlp.stanford.edu/software/
[18] CAS Ellingsworth and Balakrishnan: 2008. Practical text mining in insurance
[19] Stanford Natural Language Processing Group; available at: http://nlp.stanford.edu/software/

4. Message to stakeholders

Measuring-reserving-uncertainty has been immensely helpful in shifting the focus from result orientation to process orientation. Process oriented approach allows us to separate efforts from results which might not positively correlate for quite a time. External and complex as well as random factors with their interconnections continue to dominate the space between efforts and results. That is why many external risks black swans (black swans have very low frequency but Olympic-ally high consequences) like financial contagion to natural catastrophes can potentially bring ruin in Loss reserving results of companies despite our best efforts.

We can recognize that though we cannot predict black swans but reserving uncertainty exercises can be a character building experience where we train to be better evolvers rather than better predictors alone.

Reserving might also be 'perceived' as more technical then it actually is due to communication gaps and barriers within different stakeholders involved. To provide more common ground for mutual understanding, we actuaries have to build trust with management over how to overhaul the company's reserving processes[20]. We can highlight that while recognizing facts (in form of quantitative analysis), it seems as if we only tend to scratch its surface as data, on its own, highlights results; whereas there are plenty of processes that culminate in data generation as well as modeling methodology in the first place. There is an incredible depth once when we start looking beyond the facts into fact-making itself; and this is where expert judgment can prove invaluable to guide the reserving exercise.

One of the most contentious debates is over the level of complexity to be adopted in reserving between the technical and business sides of the operations. Actuaries advocate higher sophistication (especially in stochastic reserving) whereas managements usually prefer modeling that is understandable to them and where they can make their expert-judgment impact as well[21].

Both sides have their own merits. Each side is expressing a different perspective of a difficult problem. Triangle-based deterministic methods introduce a powerful simplicity in the calculations of reserving which renders it easier to narrow the communication gap between the management and the technical specialists. However, stochastic reserving, data science applications and triangle-free reserving can better exposure underlying variability in reserve estimates.

The Risk culture is foremost for any reserving exercise because financial and insurance sector is not solely run by quantitative numbers, but by the underlying human psychology as well. It is up to the risk culture to not antagonize in binary opposites like complex/simple, good/bad etc, but to reach the middle ground to converge communication and mentalities between different stakeholders.

In conclusion, by measuring and exposing areas of uncertainty, we can reduce our chances of swapping specific risk by systematic risk in our reserving procedures and lessen fatness of the tails. It is hoped that this report is able to generate further discussions and research into how to measure reserving uncertainty.

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[20] Actuarial Post: Making uncertainty explicit-stochastic modeling
[21] Ibid