More information will be available at

Lincolnshire Room (6th floor)

7:00pm-11:00pm

Monday September 14

(Also learn about the Bootstrap technique for testing validity of a model or method)

Insureware
Software Solutions and eConsulting for P & C Insurance

Economic (& Cost of) Capital for the Combined Reserve and Underwriting Risk across all Long Tail Lines of Business

Insureware
Software Solutions and eConsulting for P & C Insurance

Economic (& Cost of) Capital for the combined reserve and underwriting risk across all long tail lines of business

- How is Economic and Cost of Capital to be calculated on a company-wide level, for reserve and underwriting risks taking into account diverse LOBs?
- What is the difference between variability and uncertainty?
- How can volatility for a LOB be described succinctly?
- What are the different types of calendar year trends and how are they manifested?
- When should there be Total Reserve increases from year to year? By how much?
- How do we maintain consistent estimates of prior year ultimates from year to year?
- How do estimates of ultimates change conditional on next calendar year's paid losses? Equivalently, one year horizon.

Insureware
Software Solutions and eConsulting for P & C Insurance

- **Case Reserve Estimates versus Paid Losses. Should they be modelled separately? CREs often lag paid losses in respect of trends.**

- **What are the different types of correlations between LOBs and how are they manifested?**

- **How do we know if two LOBs have common drivers and accordingly are highly correlated?**

- **What is the impact of correlation on risk capital allocation?**

- **How much do different companies (in particular, Berkshire Hathaway, Swiss Re and The Hartford) have in common in the same LOB and between LOBs? Do they share volatility and correlations?**

We use real companies' data to answer these questions.

Insureware
Software Solutions and eConsulting for P & C Insurance

Economic Capital and Cost of Capital computations depend on VaR and or T-VaR calculations

- **VaR and T-VaR must based on an "accurate" distribution of aggregate reserves by LOB and correlations between them. Assumptions should be transparent and auditable**

- **Need to allocate risk capital by LOB and calendar year. Cost of capital is based on calendar year payment stream distributions. Therefore need to model paid losses.**

- **Rating agencies apply an additive risk charge for combined reserve and underwriting risk. Incorrect! Antithesis of basic principle of insurance.**

- **New business is mostly renewal business and affords additional risk diversification. This means that typically**

<u>Combined</u> reserve and underwriting risk charge

< <u>reserve</u> risk charge + <u>underwriting</u> risk charge, for any T-VaR

Three types of correlations

1. Process correlation (linear)
2. Parameter correlation (linear)
3. Reserve (and Ultimate) distribution correlations (not linear)

- Reserve distribution correlation is usually considerably less than process correlation.
- Segments of the same LOB such as 1. net of reinsurance and gross, 2. indemnity versus medical, 3. layers, for example, limited to 500K and limited to 1M, have common drivers and are highly correlated.
- Different LOBs very often do not have common drivers. That is, the trend structure (especially along calendar years) is not the same and process correlation is zero.

Insureware
Software Solutions and eConsulting for P & C Insurance

- The Mack method is a regression formulation (weighted average trend through the origin) of volume weighted average link ratios.

- It is important to check the weighted standardized residuals versus development period, accident period, calendar period and fitted values.

- Traditional actuarial methods, including the Mack method and bootstrapping*, often give grossly inaccurate assessment of risks. Yet they are regarded as "best practice" and are used by Fitch, S&P and Moody's. We illustrate this with real data Berkshire Hathaway PPA and Everest Re HO/FO.

- Traditional actuarial methods do not have descriptors of features (volatility) in the data- there is absence of a story!

- Inaccurate information on risk is at best misguided and at worst very dangerous

We use the bootstrap technique to test (validate) the model

Insureware
Software Solutions and eConsulting for P & C Insurance

Variability and Uncertainty

Variability and Uncertainty are different concepts; not interchangeable

"*Variability is a phenomenon in the physical*

world to be measured, analyzed and where appropriate explained.

***By contrast uncertainty is an aspect of knowledge*."**

Sir David Cox

Our knowledge (measurement) of variability has associated uncertainty

Insurance is the transfer of variability from one risk bearing entity to another

Insureware

Software Solutions and eConsulting for P & C Insurance

Example: Coin vs Roulette Wheel

Fair Coin

100 tosses *fair* coin (#*H*?)

Mean = 50

Std Dev = 5

CI [50,50]

In 95% of experiments with the coin the number of heads will be in interval [40,60].

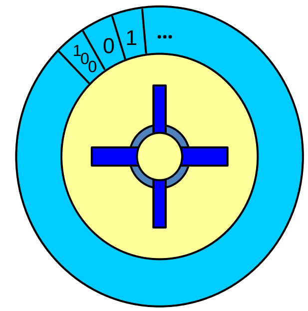
"Balanced Roulette Wheel"

No. 0,1, …, 100

Mean = 50

Std Dev = 29

CI [50,50]



In 95% of experiments with the wheel, observed number will be in interval [2, 97].

Where do you need more risk capital?

In each example there is no uncertainty in our knowledge about the variability. We know the whole probability distribution.

Introduce uncertainty into our knowledge - if coin or roulette wheel are mutilated then conclusions could be made only on the basis of observed data.

Insureware
Software Solutions and eConsulting for P & C Insurance

Basic Principles of Insurance

Risk diversification by pooling risks

$CV(X+Y) < W_1 CV(X) + W_2 CV(Y)$ provided X & Y>0, and correlation is not one, where W_1 and W_2 are weights proportional to the means

CV is a measure of % variability

Coefficient of Variation (CV)=SD/M

Mean (M) = average of outcomes weighted by the probabilities

Standard Deviation (SD)= (approx.) average distance of an outcome from the mean (M), weighted by the probabilities

Insureware
Software Solutions and eConsulting for P & C Insurance

Basic Principles of Insurance

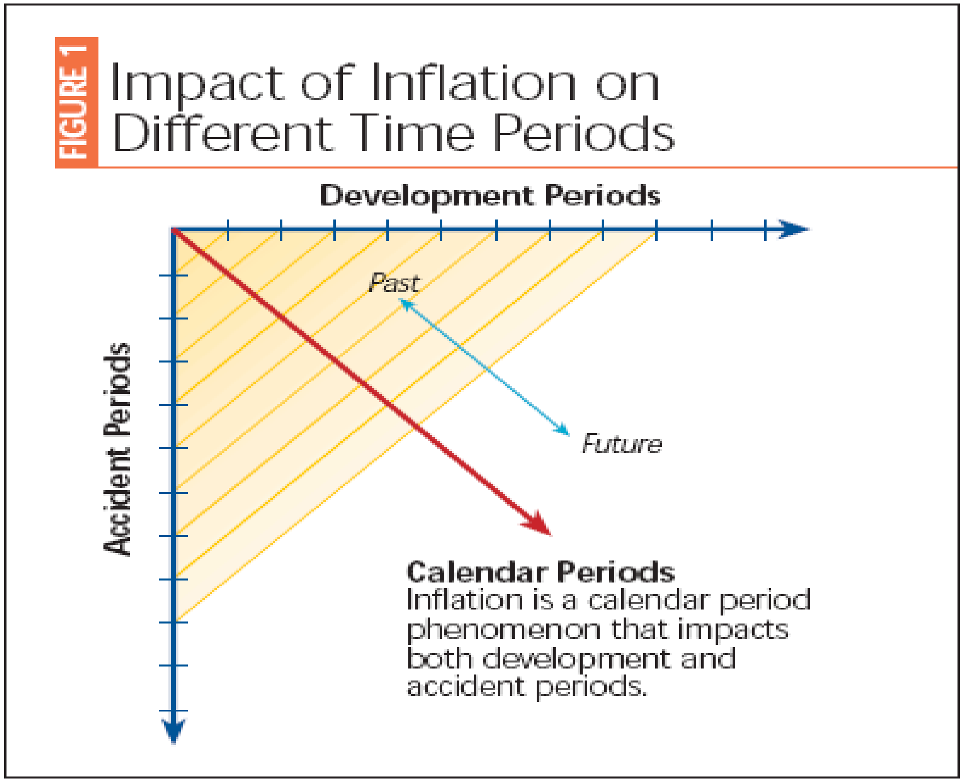
SD(Sum)<=Sum of SD's- basic principle of statistics

It is easier to forecast the sum of many numbers than the sum of fewer numbers

SD(Sum) = Sum of SDs if correlations are all 1

SD(Sum)<<Sum of SDs if correlation close to zero

The difference between SD(Sum) and the Sum of SDs is related to the correlations (degree of diversification)



Calendar year "effects" (trends and shifts)

(i)"Inflation" = social, economic or a legislative shock

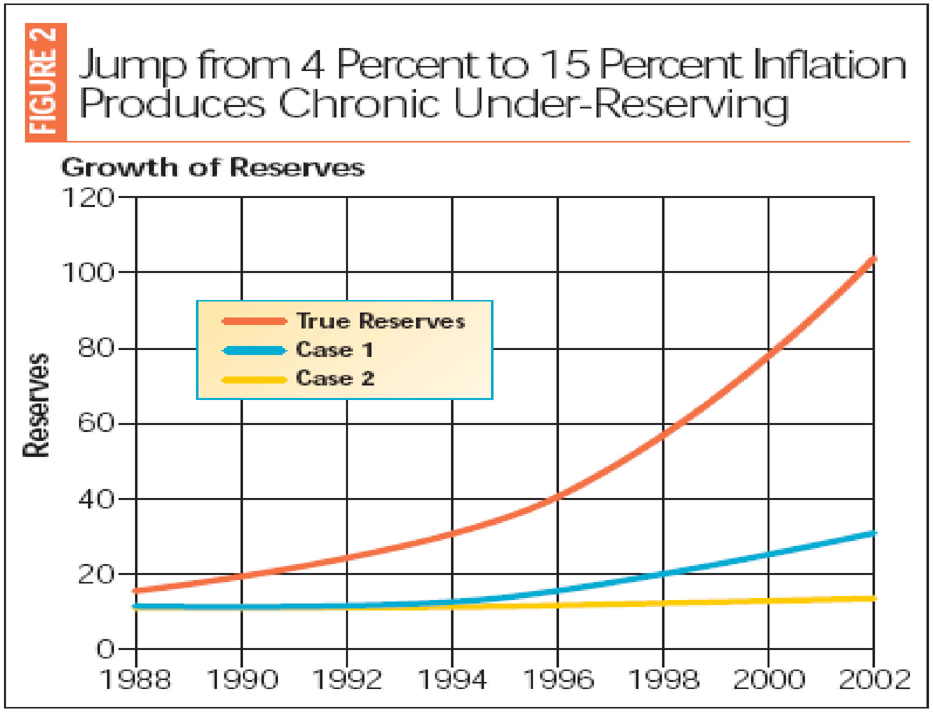
(ii)Mortgage insurance- defaults related to economic/financial variables. Are there leading indicators?

(iii) Legislative changes (shock)

Cannot immunize (insulate) against social inflation

When should there be Total Reserve increases from year to year? By how much?

Insureware
Software Solutions and eConsulting for P & C Insurance



Suppose true inflation prior 1998 is 4%, post 1998 is 15%.
True Reserves

Assume (falsely) 15% kicks in in 1994.
Case 1

Assume (falsely) paid losses continue to increase from 1998 only at 4%.
Case 2.

Unrecognized inflationary trends consume capital exponentially.

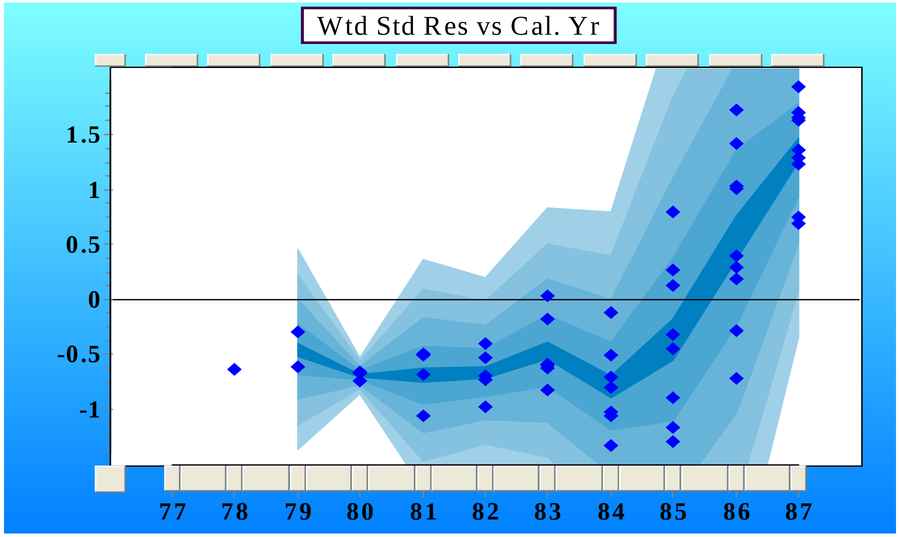
Insureware
Software Solutions and eConsulting for P & C Insurance

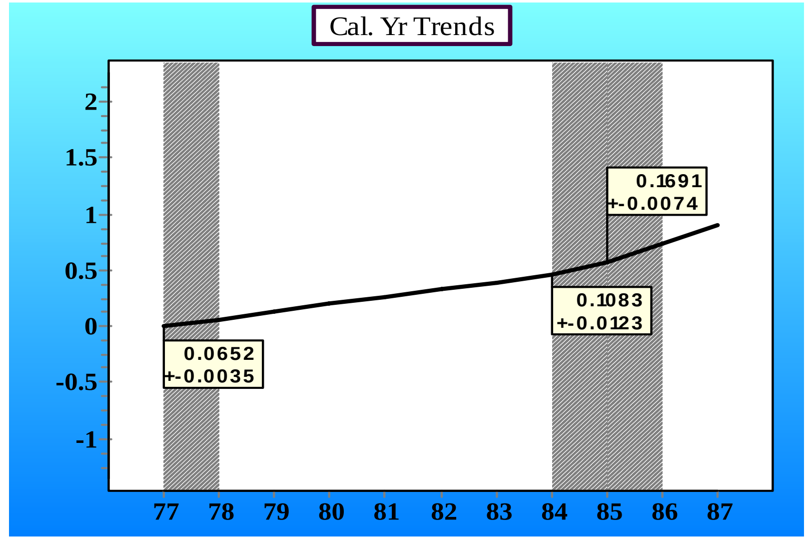
Total Reserve increases from year to year (with same exposure as previous year)

- What does a calendar year trend (inflation) of 15% imply in terms of loss reserves and underwriting each year? The following are simple arithmetic facts.
  - Each year the company needs to increase its total reserves by <u>at least</u> 15%.
  - The ultimates for prior accident years will remain consistent with each increase in <u>total</u> reserves. Indeed it is only by forecasting along the 15% trend that they would remain consistent.
  - Each year the company needs to increase its premium (price) by <u>at least</u> 15%.
  - Ultimates increase by <u>at least</u> 15% from one accident year to the next.
  - These are not reserve upgrades.
  - Mack and related methods give inconsistent ultimates from year to year on updating.

See discussion on one year horizon

Limitations of Mack Method when calendar trends are present



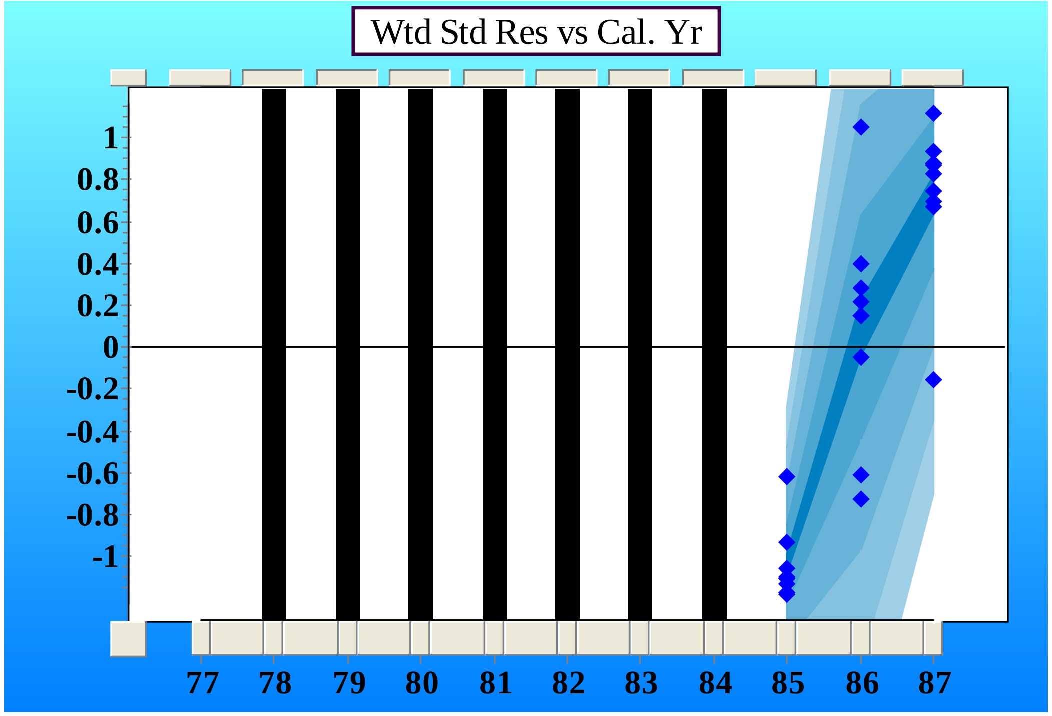


(Left) Residuals after applying Mack method to the loss array for company ABC. Note the sharp trend after 1984.

(Right) Probability Trend Family model picks up the change in trend structure in this direction. How can we improve Mack to deal with this?

Limitations of Mack Method when calendar trends are present

A natural way to try to deal with the foregoing problem is to omit the early years and keep only the last three years of data for which the inflation trend appears to be constant. Unfortunately this does not work as calendar trends are inherently invisible to link ratio based methods. Mack does not contain any sensible descriptors of the volatility in the data.



(Left) residuals after applying the Mack method with all but the last three years omitted from data. The sharp trend is still present.

Limitations of Mack Method when calendar trends are present

The best solution is to consider a modelling framework that possesses calendar year, development year and accident year (trend) parameters plus volatility about the trend structure.

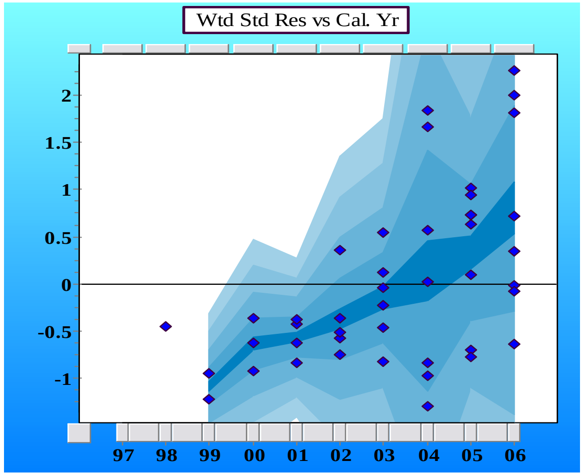
This involves four pictures that provide a story about the business

Assumptions about the future are explicit (transparent) and can be related to past experience

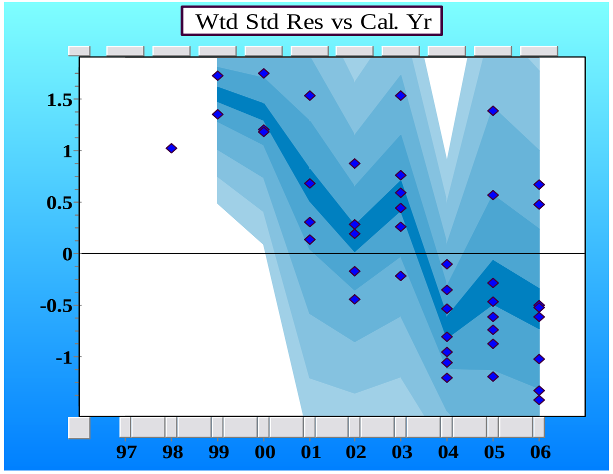
Require a modelling framework that can incorporate detailed business knowledge in the formulation and exploration of future scenarios including events that give rise to correlations

Mack method Berkshire Hathaway and Everest Re, Schedule P 2006

Mack ER HO/FO



Mack BH PPA



Here trend in method << trend in data

37,178T +_10,708T Much Too low!

Here trend in method >> trend in data

4,423,054T+_ 219,857T Too High!

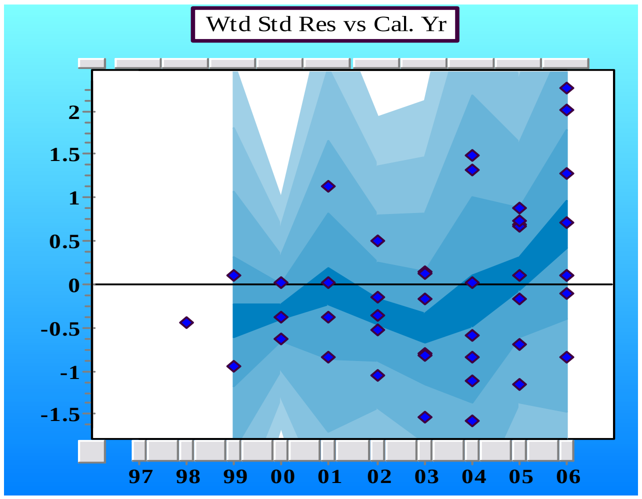
Residuals represent the difference of two trends

Residuals = trend in data - trend estimated by the method

Insureware
Software Solutions and eConsulting for P & C Insurance

Mack method Berkshire Hathaway and Everest Re, Schedule P 2006 Measuring 'average' calendar year trend

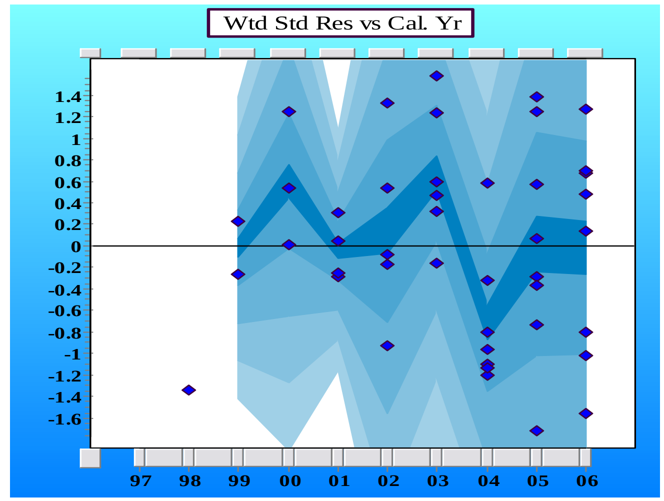
ER HO/FO



PTF with zero forward trend yields 52,311T+-14,656T versus Mack 37,178T+_10,708T

15M difference. Still much too low. If we continue the 40%+_ trend 03-06 to the entire forecast period we obtain 132,363T+_54,266T

BH PPA



PTF with identified 7%+_ forward trend yields 3,939,208T+_130,818T versus Mack 4,423,054T+_ 219,857T

500M difference!

Insureware
Software Solutions and eConsulting for P & C Insurance

TG LR HIGH

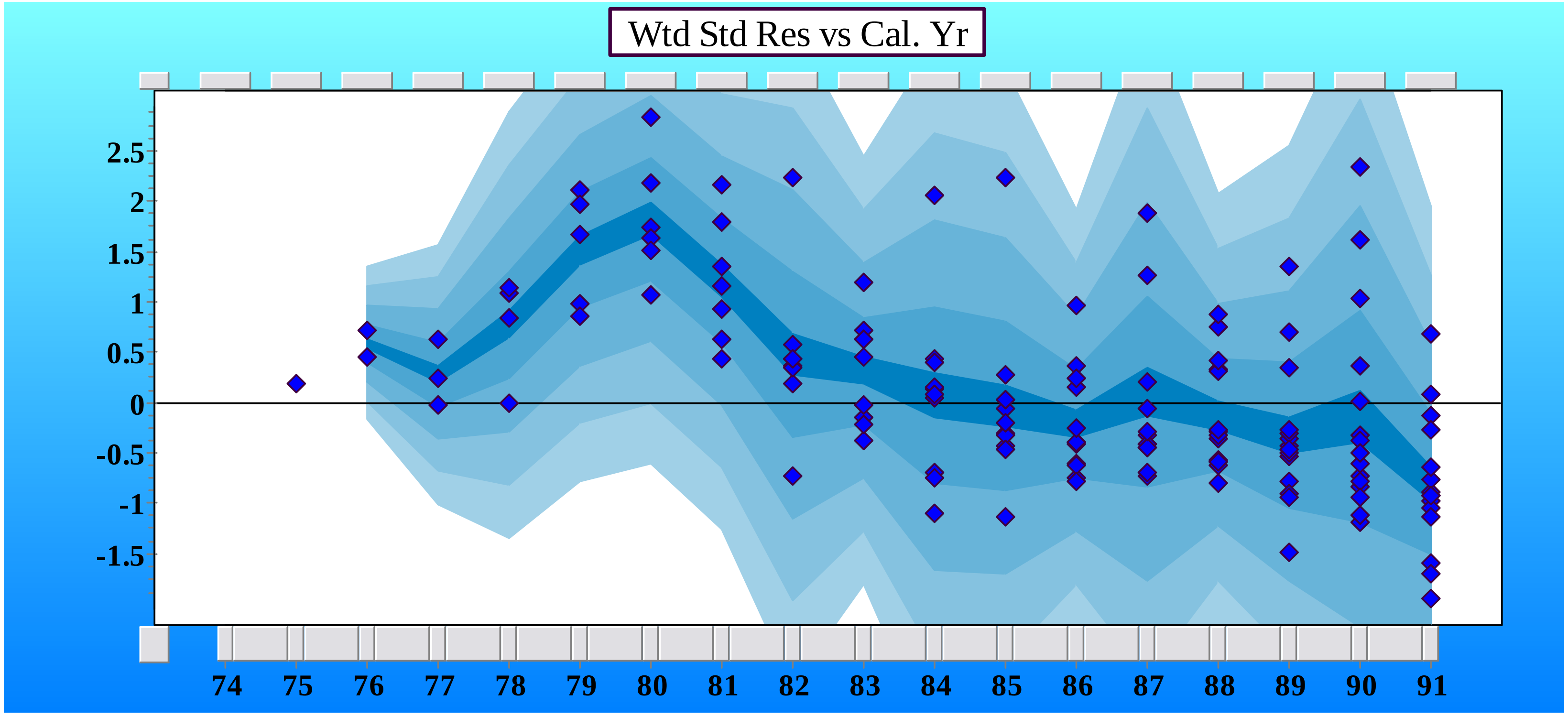
Mack can yield Reserve Mean much too high

ELRF- Mack

Trend estimated by method >> Trend in data

Mack= 896,133T +_104,117T

Arithmetic averages= 1,167,464T +- 234,466T

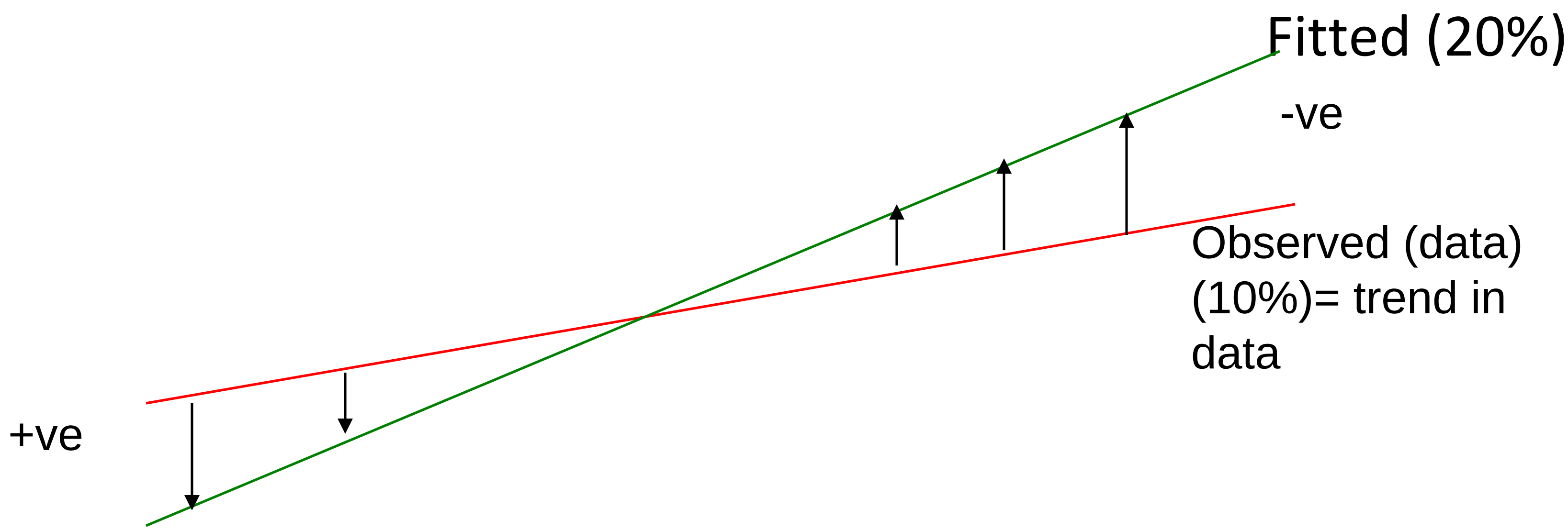


Insureware

Software Solutions and eConsulting for P & C Insurance

TG LR HIGH

Residuals= Trend in data- Trend estimated by method



Residual = Data trend –Fitted Trend

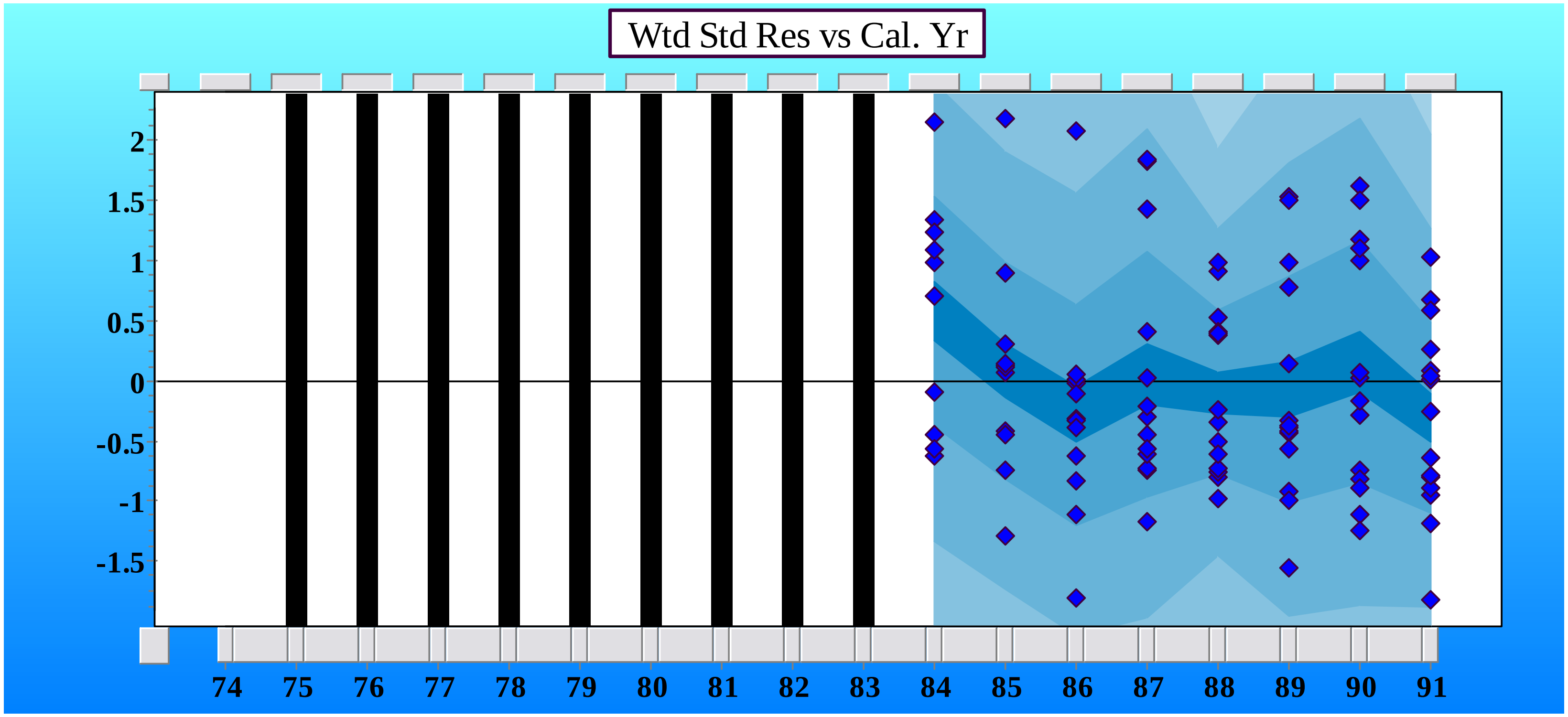
TG LR HIGH

Trend in data close to trend in method. Best ELRF model, link ratios =1, and still not very good. Trend assumption of method not known

468,439T+- 47,346T

Very different answer!

Mack= 896,133T +_104,117T



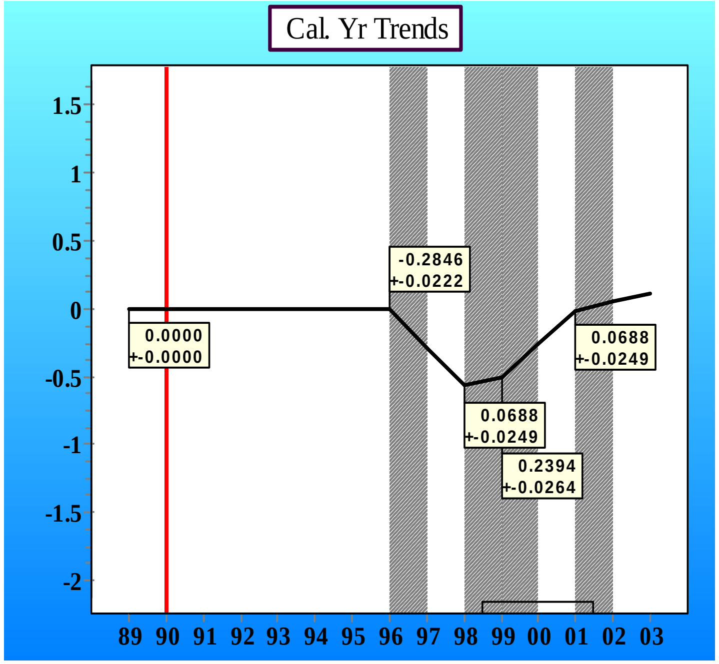
COMPANY XYZ

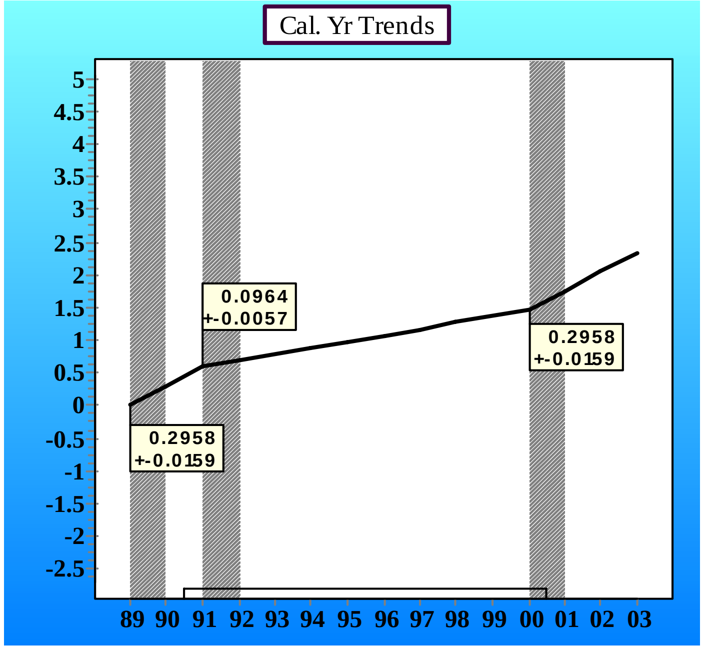
Modelling Incurred data does not yield distribution of calendar year payment streams and their correlations required for cost of capital calculations.

CREs usually lag paid losses in respect of trends

CREs versus Paids

When was the company sold?





A number of reinsurers lost a lot of money on the aggregate stop loss!

Insureware
Software Solutions and eConsulting for P & C Insurance

Correlations between LOBs

- Three types of correlations
  - Process correlation
  - Parameter (trend) correlation
  - Similar trend structure implying commonality in calendar year drivers

- Cannot measure these correlations unless LOB trend structure and process variability (volatility) modeled accurately

- Most important direction is the calendar year

- Reserve distribution correlation << Process correlation

- Highest Process correlation have seen is 0.6!

- Highest Reserve distribution correlation 0.2!

- **<u>Most long tail LOBs exhibit close to zero correlation</u>**

- **<u>Each company is different</u>**

Insureware
Software Solutions and eConsulting for P & C Insurance

Correlation and Linearity

Correlation, linearity, normality, weighted least squares, and linear regression are closely related concepts.

The idea of correlation arises naturally for two random variables that have a joint distribution that is bivariate normal. For each individual variable, two parameters a mean and standard deviation are sufficient to fully describe its probability distribution. For the joint distribution, a single additional parameter is required the correlation.

If *X* and *Y* have a bivariate normal distribution, the relationship between them is linear: the mean of *Y*, given *X*, is a linear function of *X* ie:

$$E(Y|X) = \alpha + \beta X$$

Insureware
Software Solutions and eConsulting for P&C Insurance

The slope β is determined by the correlation ρ, and the standard deviations and :

$$\beta = \rho\sigma_{\mathbf{Y}} / \sigma_{\mathbf{X}} ,$$

where $\rho = Cov(X,Y)/(\sigma_{\mathbf{X}}\sigma_{\mathbf{Y}}).$

The correlation between *Y* and *X* is zero if and only if the slope β is zero.

Also note that, when *Y* and *X* have a bivariate normal distribution, the conditional variance of *Y*, given *X*, is constant ie not a function of *X*:

$$Var(Y|X) = \sigma^2_{Y|X}$$

Insureware

Software Solutions and eConsulting for P&C Insurance

This is why, in the usual linear regression model

$$Y = \alpha + \beta X + \varepsilon$$

the variance of the "error" term ε does not depend on X.

However, not all variables are linearly related. Suppose we have two random variables related by the equation

$$S = T^2$$

where T is normally distributed with mean zero and variance 1.

What is the correlation between S and T ?

Linear correlation is a measure of how close two random variables are to being linearly related.

In fact, if we know that the linear correlation is +1 or -1, then there must be a deterministic linear relationship

$Y = \alpha + \beta X$ between Y and X (and vice versa).

If Y and X are linearly related, and ***f*** and ***g*** are functions, the relationship between ***f*(** Y **)** and ***g*(** X **)** is not necessarily linear, so we should not expect the linear correlation between ***f*(** Y **)** and ***g*(** X **)** to be the same as between Y and X.

(Answer to question on previous slide is zero)

Insureware

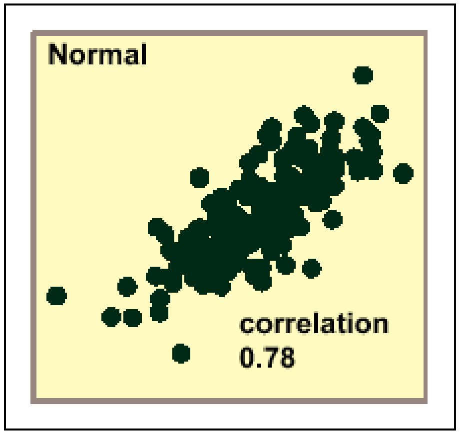
Software Solutions and eConsulting for P&C Insurance

A common misconception with correlated lognormals

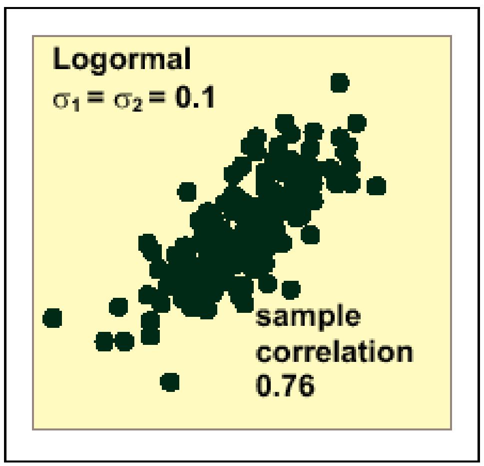
Actuaries frequently need to find covariances or correlations between variables such as when finding the variance of a sum of forecasts (for example in P&C reserving, when combining territories or lines of business, or computing the benefit from diversification).

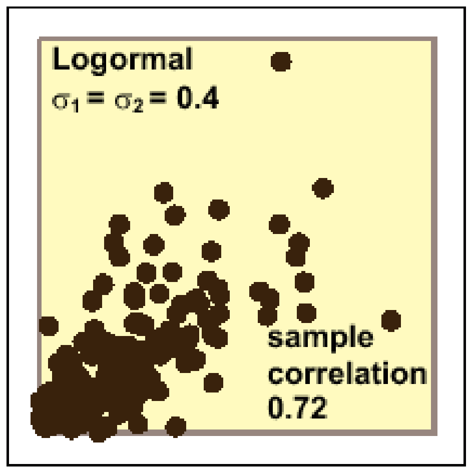
Correlated normal random variables are well understood. The usual multivariate distribution used for analysis of related normals is the multivariate normal, where correlated variables are linearly related. In this circumstance, the usual linear correlation (the *Pearson correlation*) makes sense.

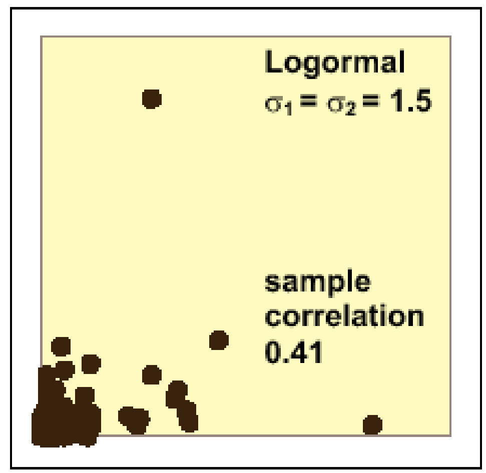
However, when dealing with lognormal random variables (whose logs are normally distributed), if the underlying normal variables are linearly correlated, then the correlation of lognormals changes as the variance parameters change, even though the correlation of the underlying normal does not.



All three lognormals below are based on normal variables with correlation 0.78, as shown left, but with different standard deviations.

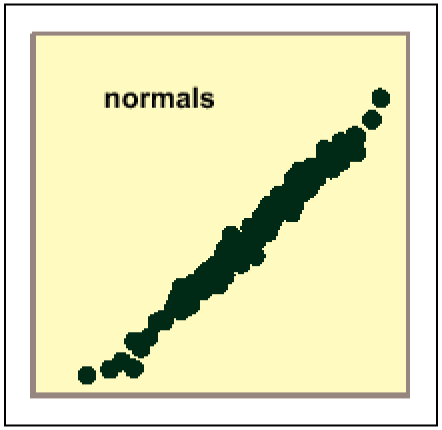


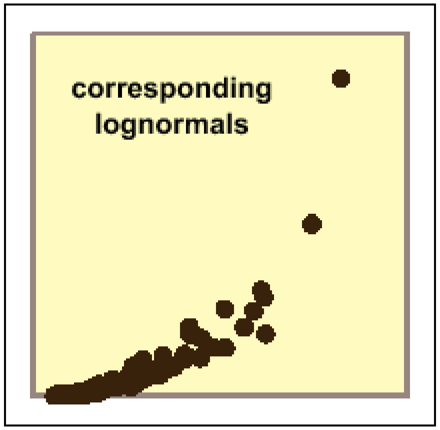




We cannot measure the correlation on the log-scale and apply that correlation directly to the dollar scale, because the correlation is not the same on that scale.

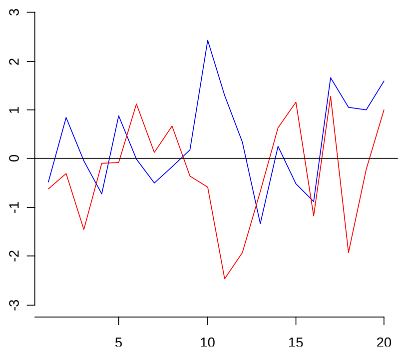
Additionally, if the relationship is linear on the log scale (the normal variables are multivariate normal) the relationship is no longer linear on the original scale, so the correlation is no longer linear correlation. The relationship between the variables in general becomes a curve:



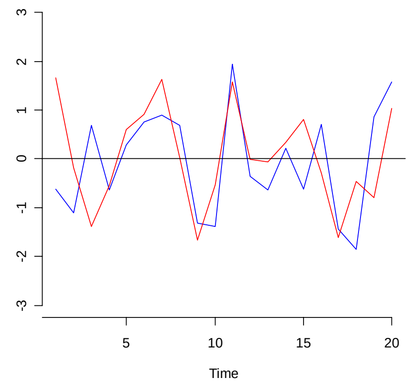


Insureware
Software Solutions and eConsulting for P&C Insurance

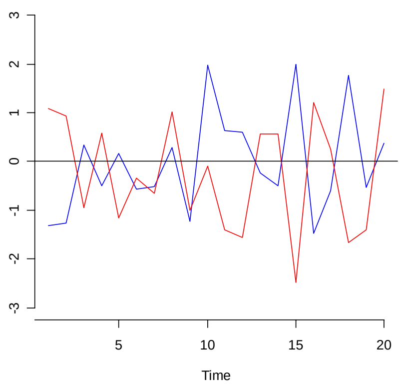
Correlation in time-series



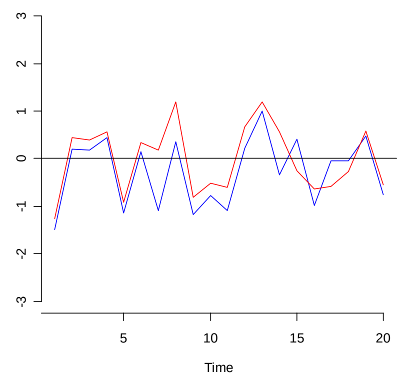
Series
corr. = 0



Series
corr. = 0.5



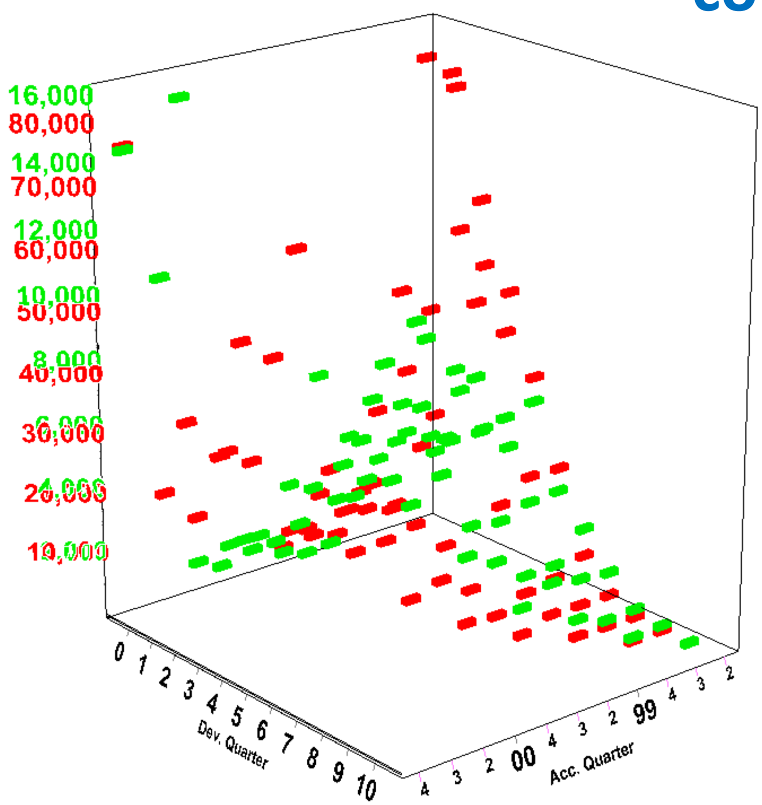
Series
corr. = -0.5



Series
corr. = 0.8

Insureware
Software Solutions and eConsulting for P & C Insurance

We call the correlation of the random component (after modeling the trend structure in the three directions) of two loss development arrays: process correlation



3D plot of data

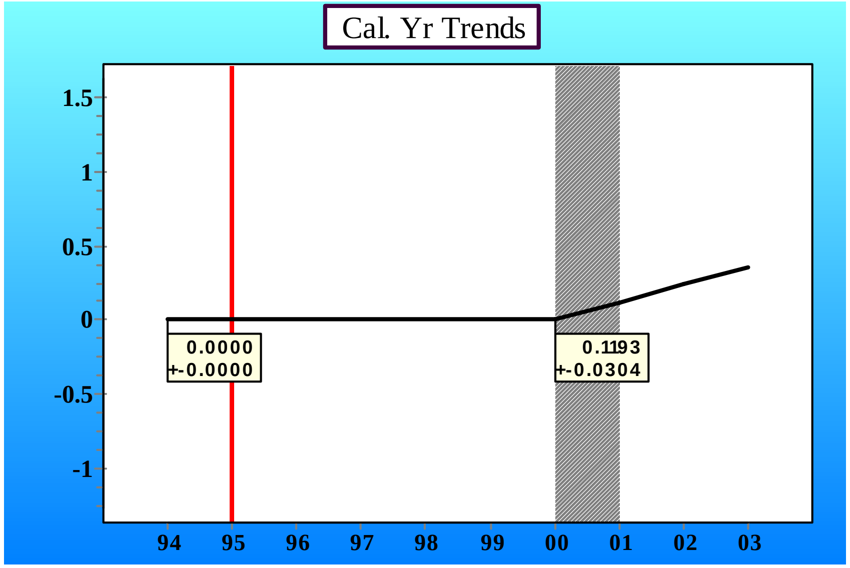
These two triangular loss arrays have process corr. = 0.9 after modelling their respective trend structures. Cannot detect from data plot.

Insureware
Software Solutions and eConsulting for P & C Insurance

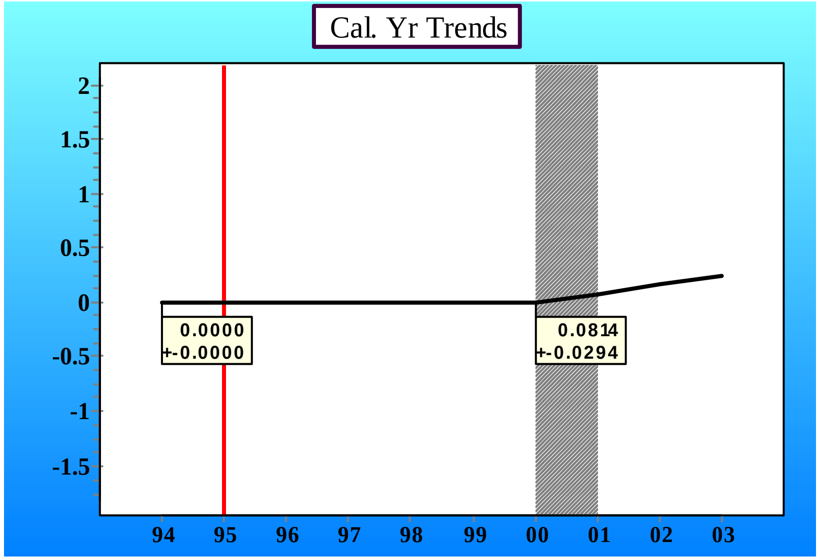
Two LOBs: LOB1 and LOB3

Actually same LOB different territories

LOB1



LOB3



Both LOBs have a calendar year trend change in 2000

That should be regarded as a concern!

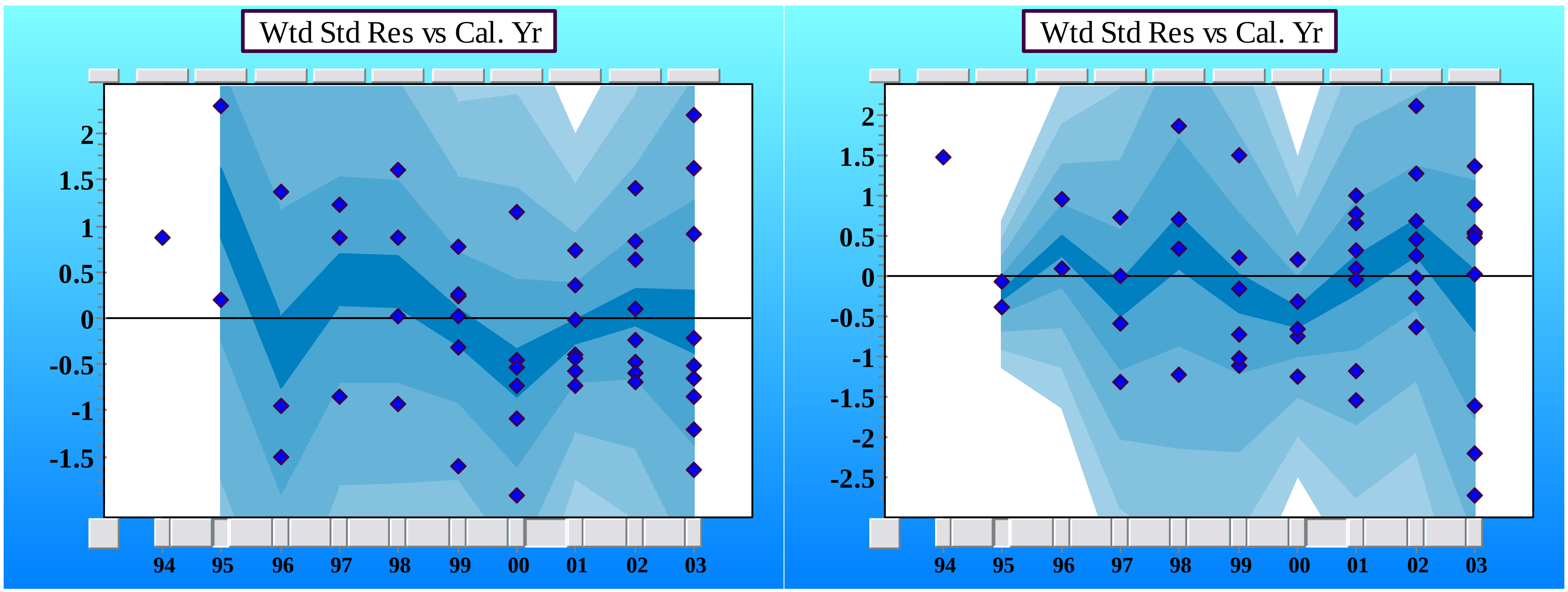
Insureware
Software Solutions and eConsulting for P & C Insurance

Two LOBs: LOB1 and LOB3

Actually same LOB different territories

Process correlation=0.35

LOB1 LOB3

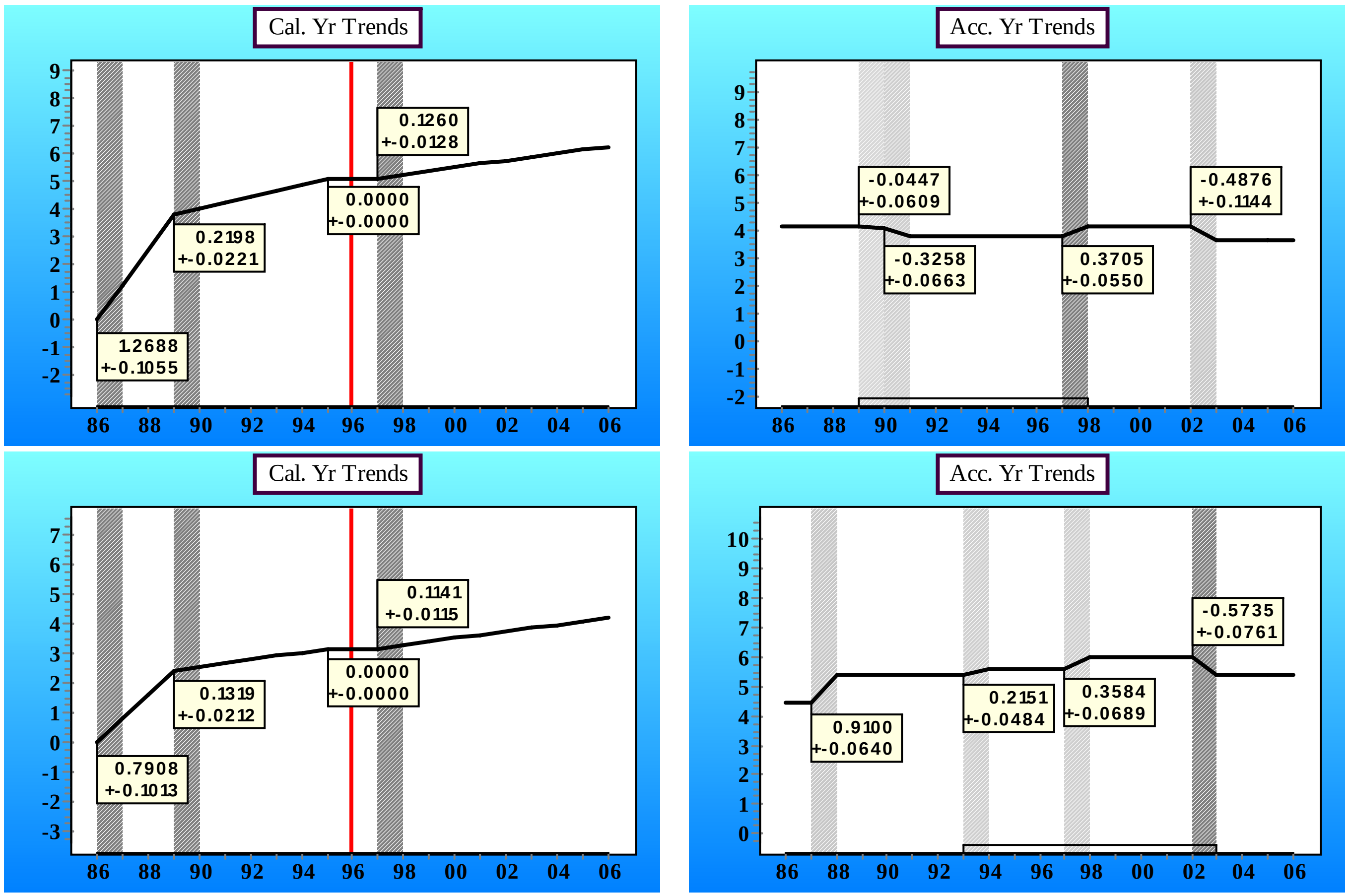


Note 98-00 slight negative trend, 00-02 slight positive trend and 02-03 zero trend LOB1 and slight negative trend LOB3.

Insureware
Software Solutions and eConsulting for P & C Insurance

When do two LOBs (LOB A & LOB B) have common drivers?

When they have “same” trend structure and process correlation is high

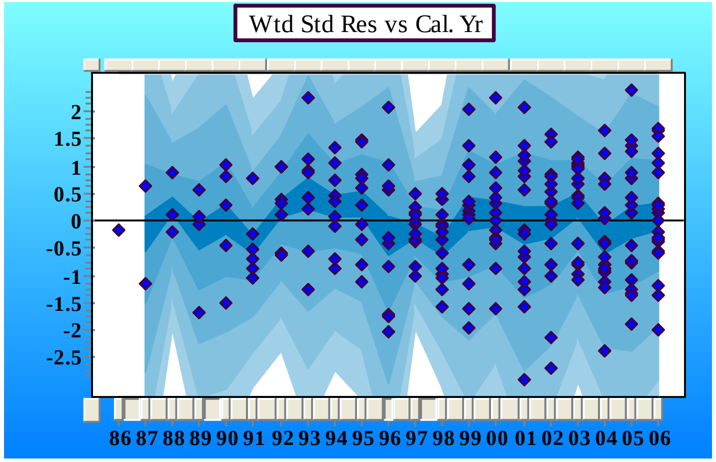


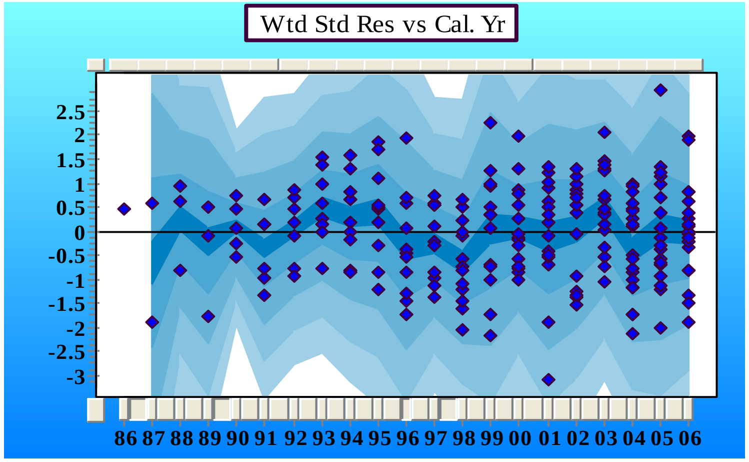
Calendar year 97-06 parameter correlation is 0.74.

Process correlation next slide is 0.84

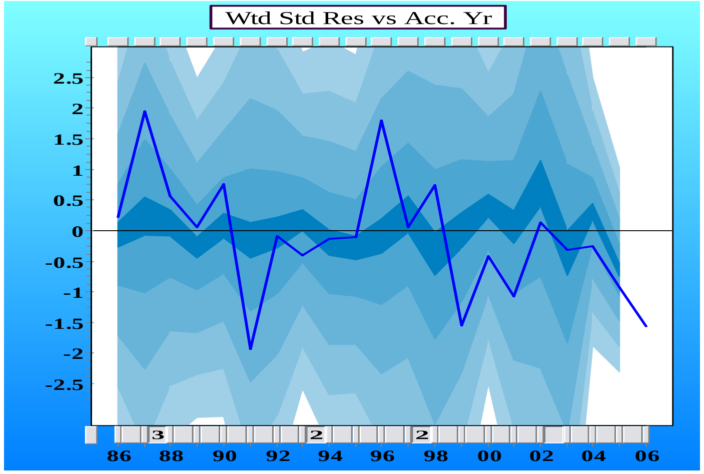
PTF Calendar trends and Accident levels, LOB A (left) LOB B (right) – close resemblance in placement of trend changes is evidence of common drivers.

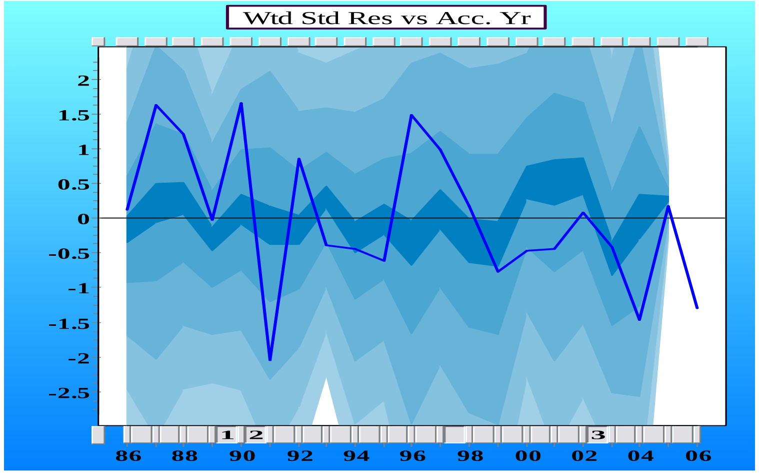
Insureware
Software Solutions and eConsulting for P & C Insurance





Residual plots by calendar year LOB A (left) LOB B (right)

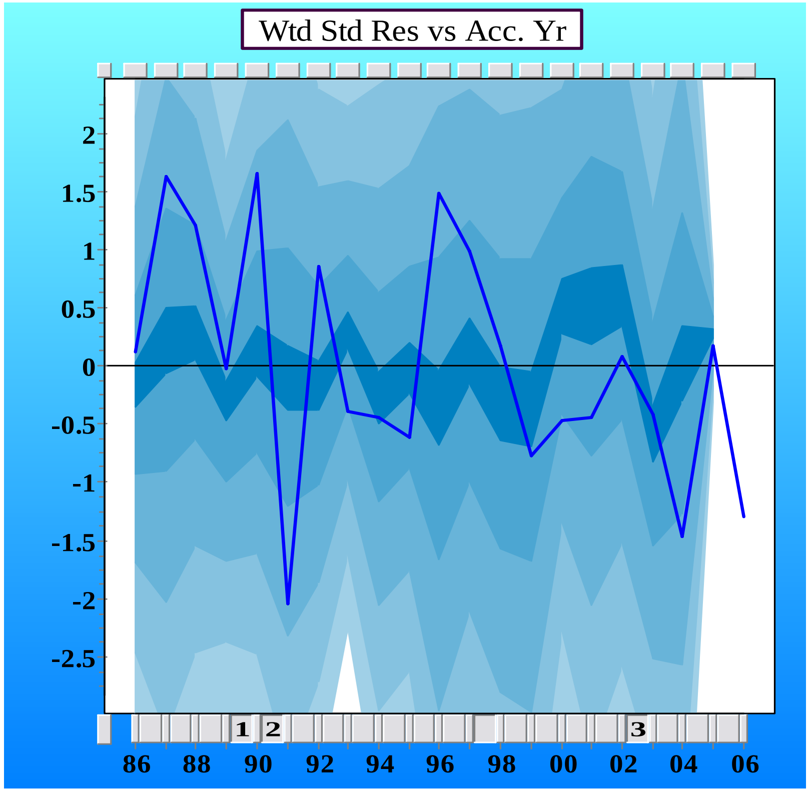


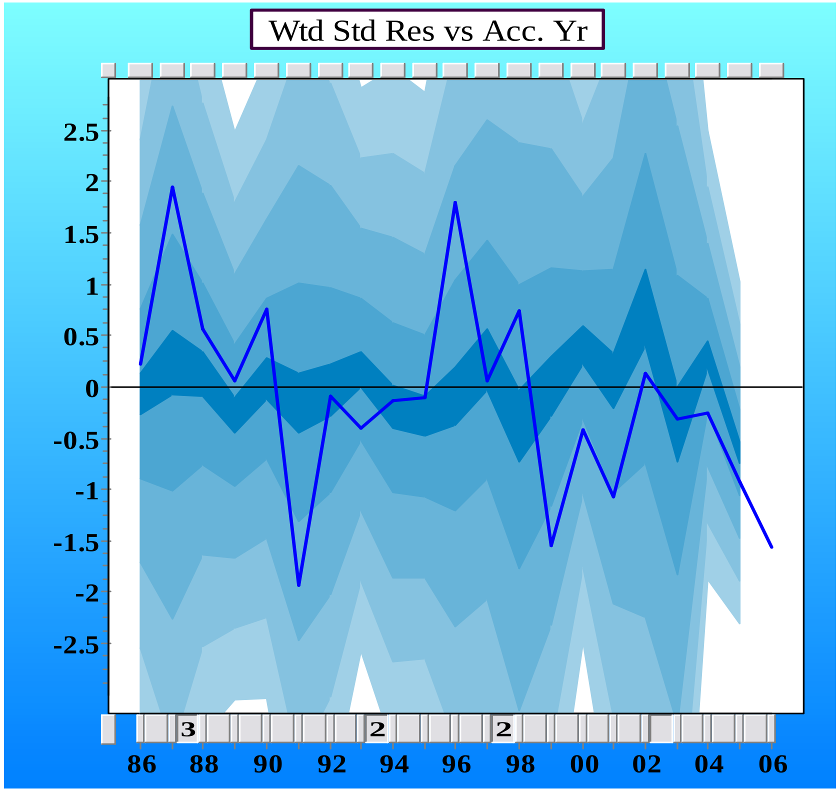


Blue line is trace (versus accident year) of (single) calendar year (2006)

Process Correlation = 0.85

Insureware
Software Solutions and eConsulting for P & C Insurance

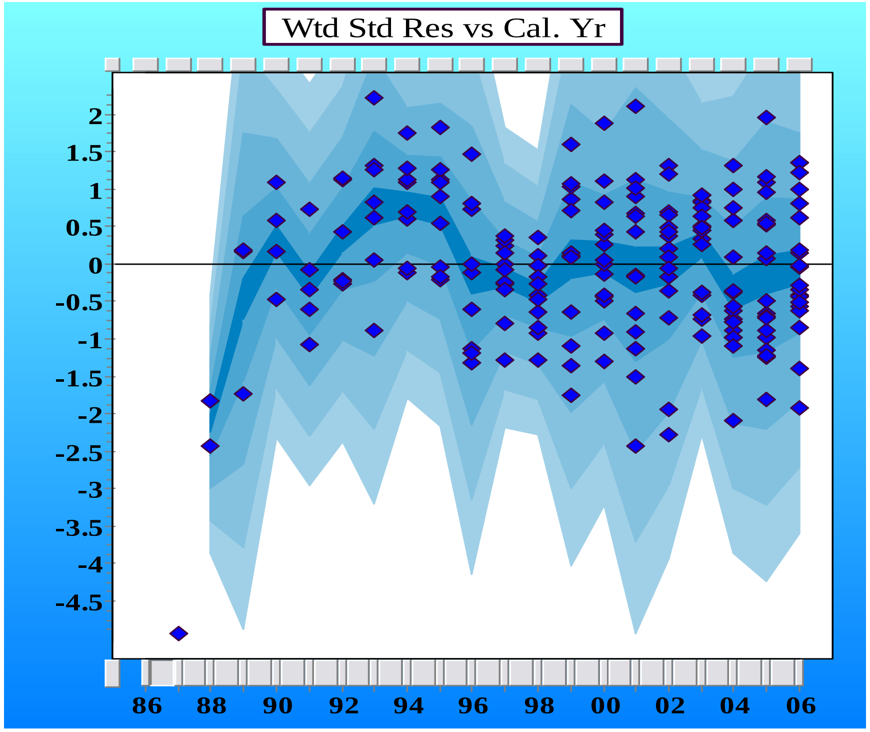


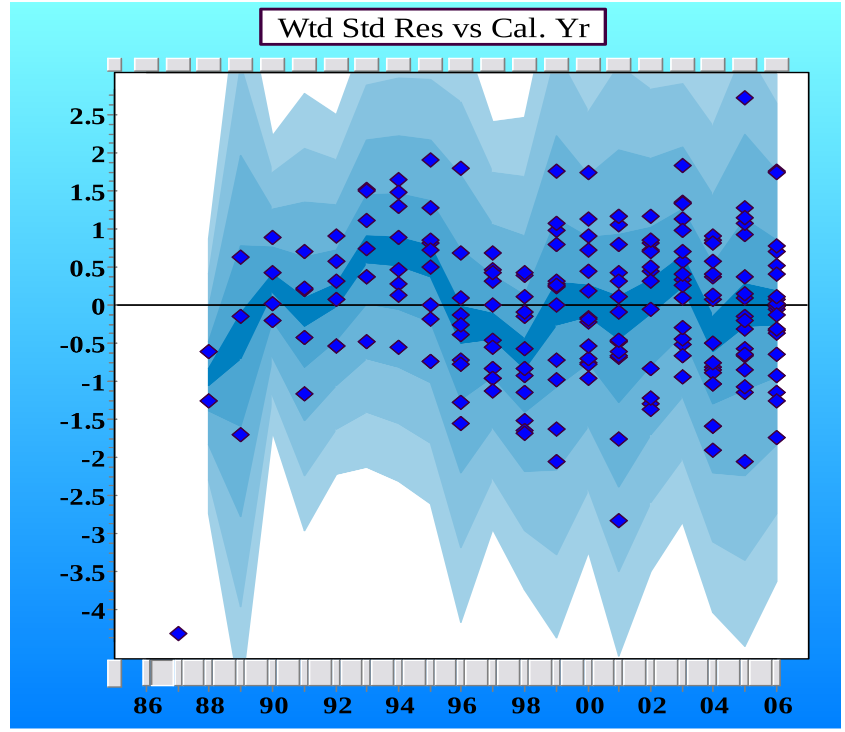


When do two LOBs (LOB A & LOB B) have common drivers?

- Two LOBs have “same” trend structure and high process correlation
- Visible in trace of calendar year 2006 versus accident years.
- Note high process correlation (of 0.85).

Insureware
Software Solutions and eConsulting for P & C Insurance





Residuals above are for data adjusted for development and accident period trends only.

Therefore correlations are trend + process.

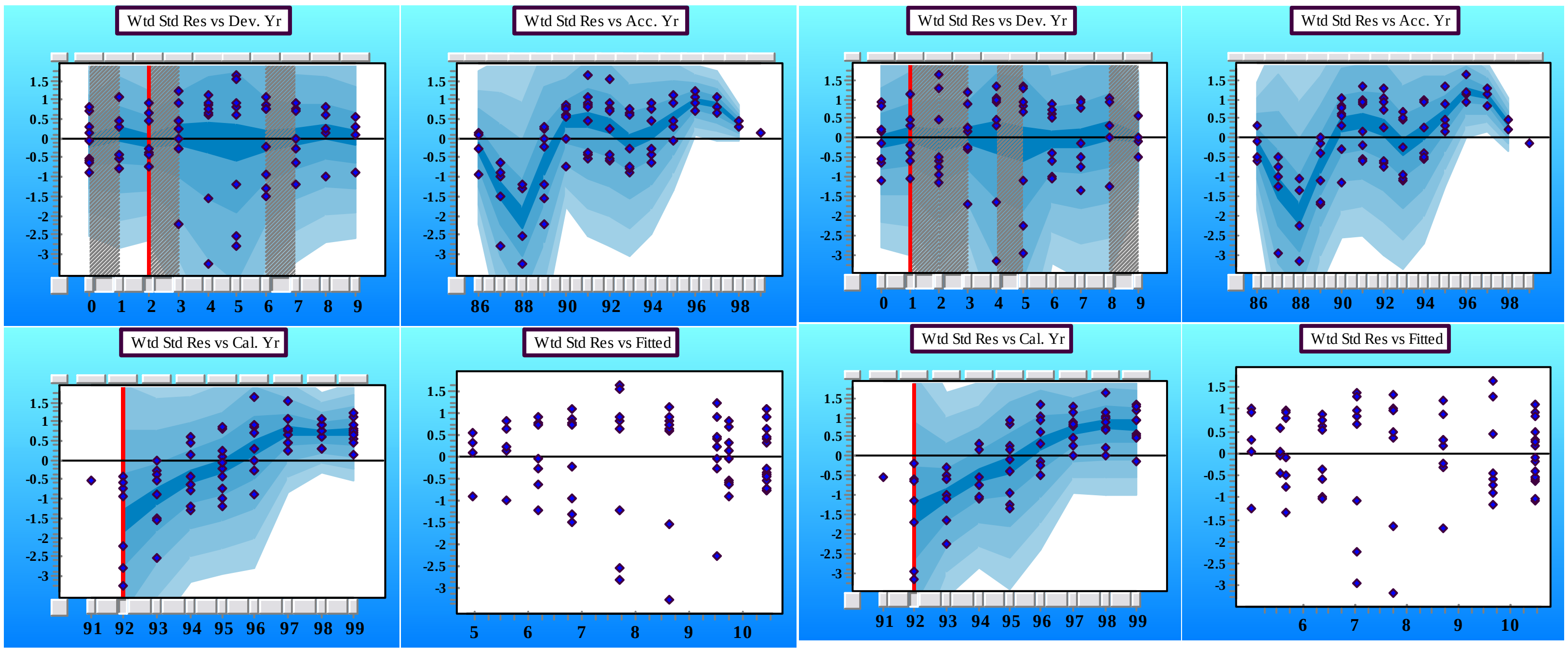
The two LOBs A & B are in fact gross and net of reinsurance paid losses that do share common drivers!

Insureware
Software Solutions and eConsulting for P & C Insurance

Two segments of WC

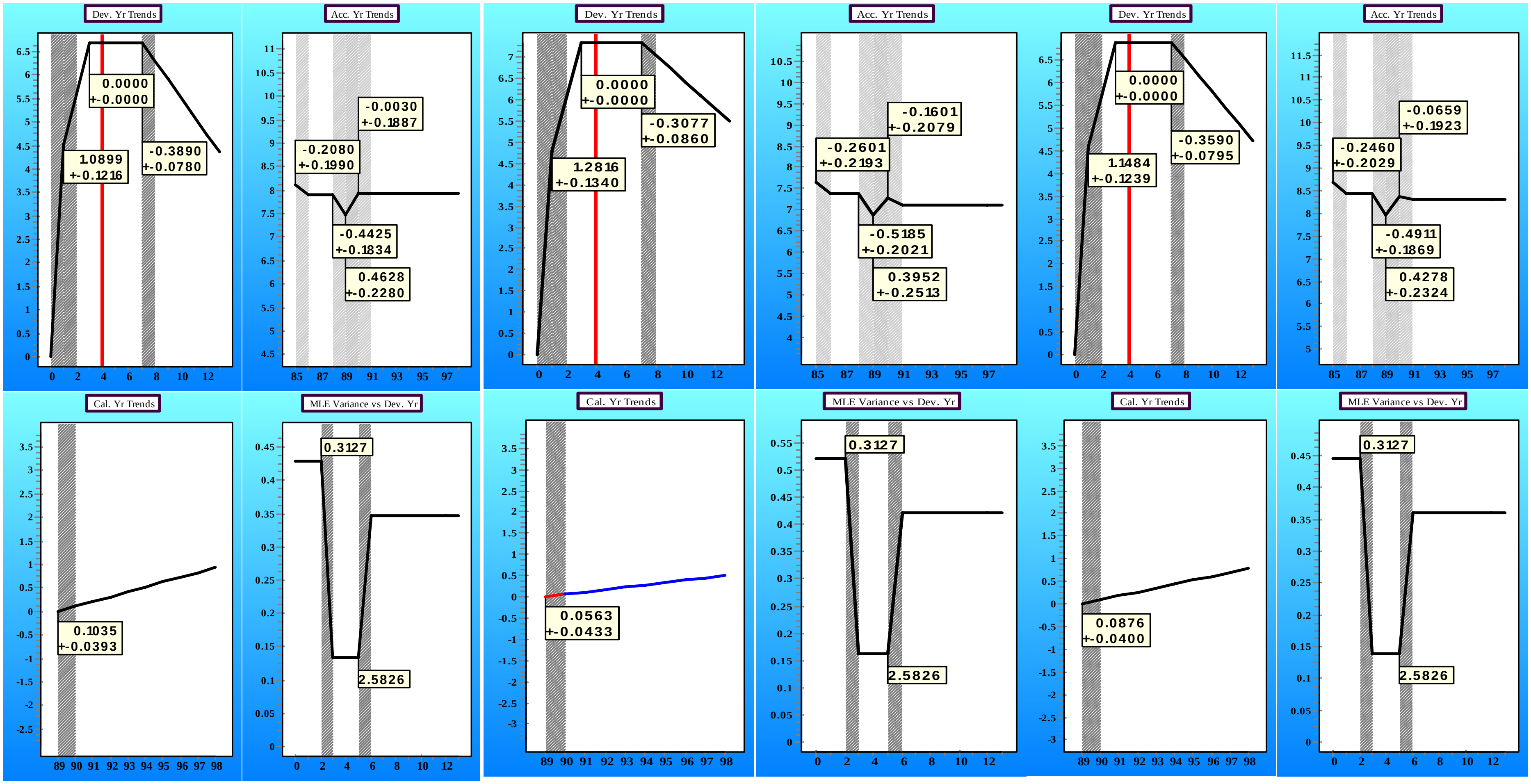
Each segment only adjusted for development year trends

Accident year parameter correlations equal 1 after modelling accident years- major implications also for future underwriting years, where correlation in distributions of ultimates exceed 0.99



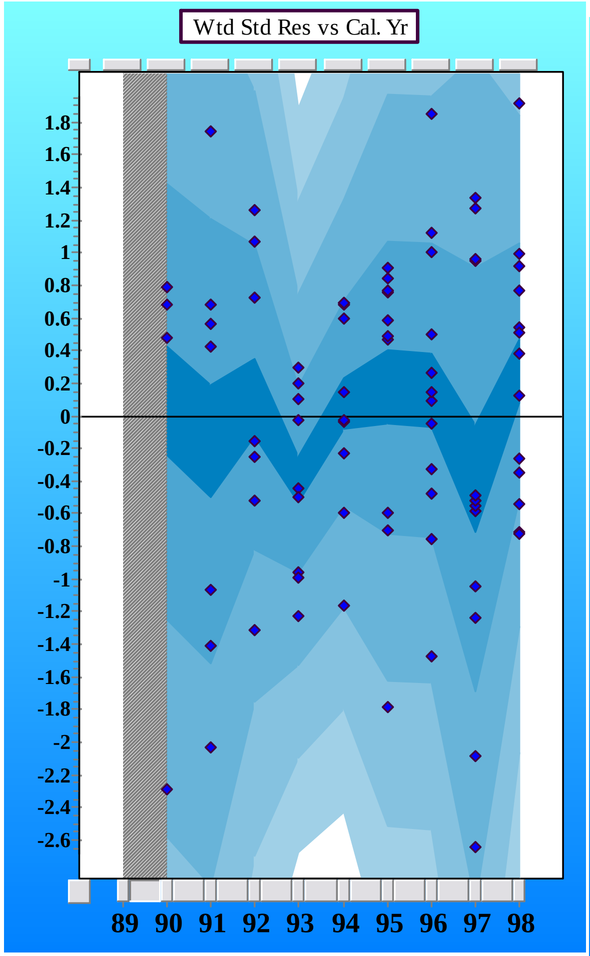
Insureware
Software Solutions and eConsulting for P & C Insurance

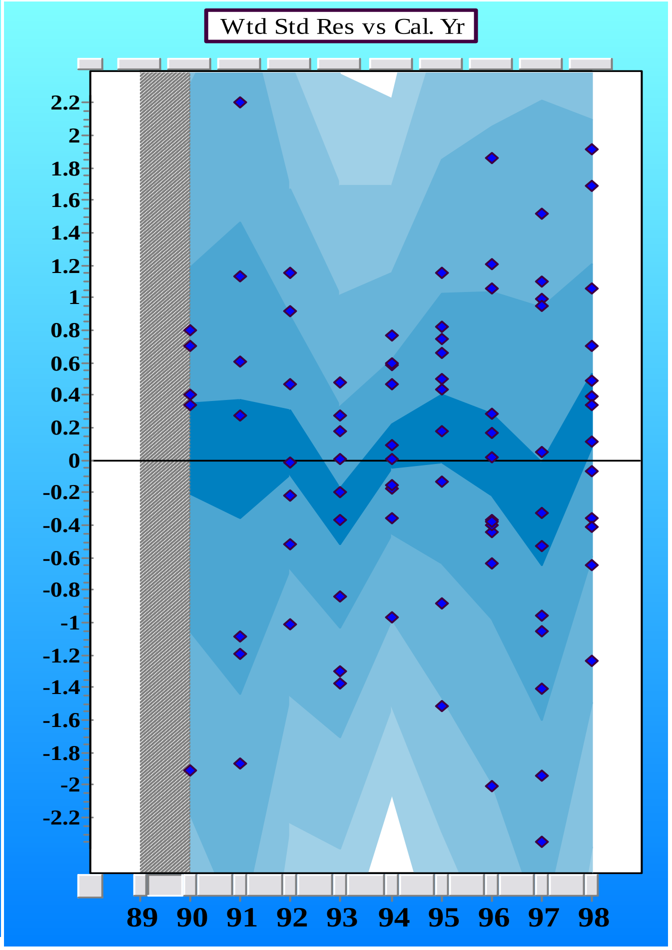
Layers Lim1M, Lim2M and 1Mxs1M
Lim2M=Lim1M+1Mxs1M
The trend structure is the same for each layer
(Left to right 1M, 1Mxs1M, 2M)

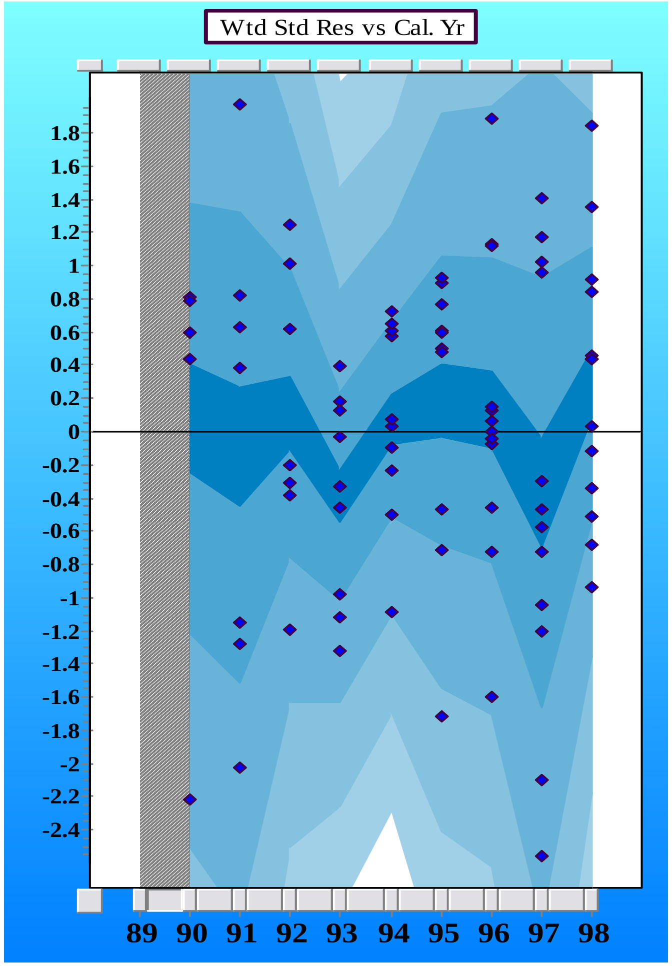


Insureware
Software Solutions and eConsulting for P & C Insurance

Layers Lim1M, Lim2M and 1Mxs1M
Lim2M=Lim1M+1Mxs1M
Very high process correlations
(Left to right 1M, 1Mxs1M, 2M)







Insureware
Software Solutions and eConsulting for P & C Insurance

Layers Lim1M, Lim2M and 1Mxs1M
Lim2M=Lim1M+1Mxs1M
Tables of process correlations (linear) and calendar year parameter correlations (linear)

This type of equivalent trend structure and high parameter and process correlations has not been observed for two LOBs

All | Gammas | Alphas | Iotas

Iota Correlations

		Lim1M:PL(I)	1Mxs1M:PL(I)	Lim2M:PL(I)
Dataset	Period	1989~1998	1989~1998	1989~1998
Lim1M:PL(I)	1989~1998	1	0.945646	0.992496
1Mxs1M:PL(I)	1989~1998	0.945646	1	0.977333
Lim2M:PL(I)	1989~1998	0.992496	0.977333	1

Final Weighted Residual Correlations Between Datasets

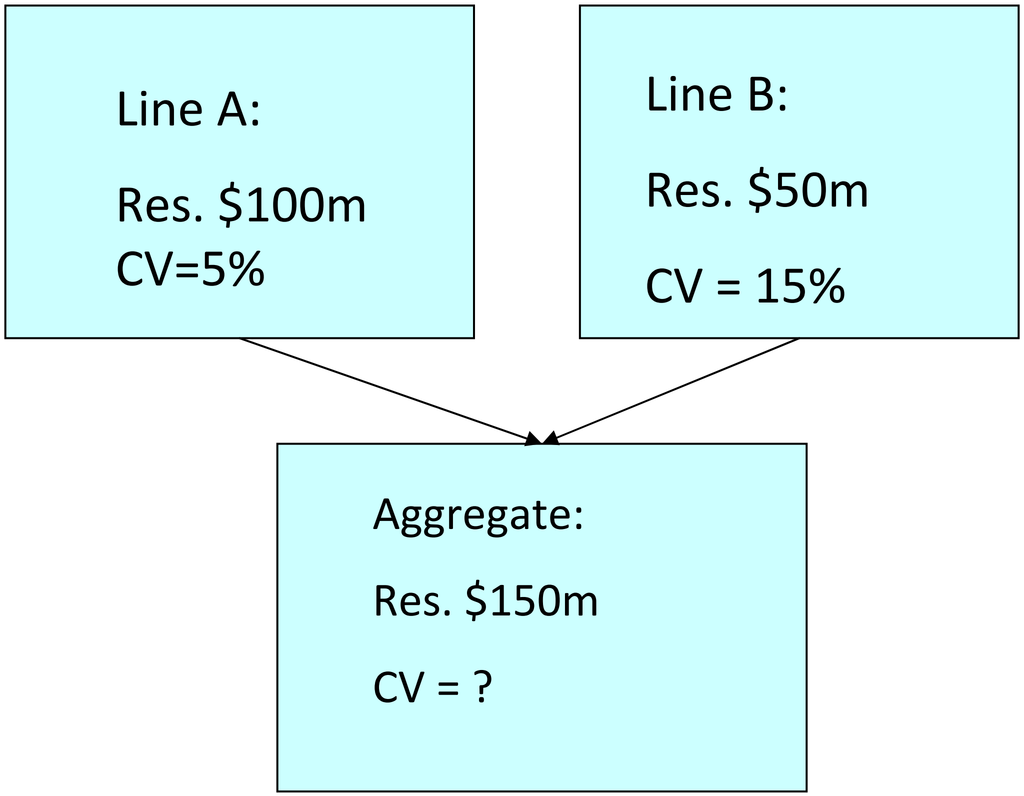
	Lim1M:PL(I)	1Mxs1M:PL(I)	Lim2M:PL(I)
Lim1M:PL(I)	1	0.945646	0.992496
1Mxs1M:PL(I)	0.945646	1	0.977333
Lim2M:PL(I)	0.992496	0.977333	1

Reserve distribution correlations between two distinct LOBs- a very different story

- Highest process correlation observed between two different LOBs is about 0.6 (in our experience)
- But Reserve distribution correlation is typically lower.
- Trend structures for two LOBs typically different
- Parameter correlations low or zero
- See Private Passenger Automobile (PPA) versus Commercial Auto Liability (CAL)for Berkshire Hathawy below, for example

Insureware
Software Solutions and eConsulting for P & C Insurance

Risk Capital Allocation



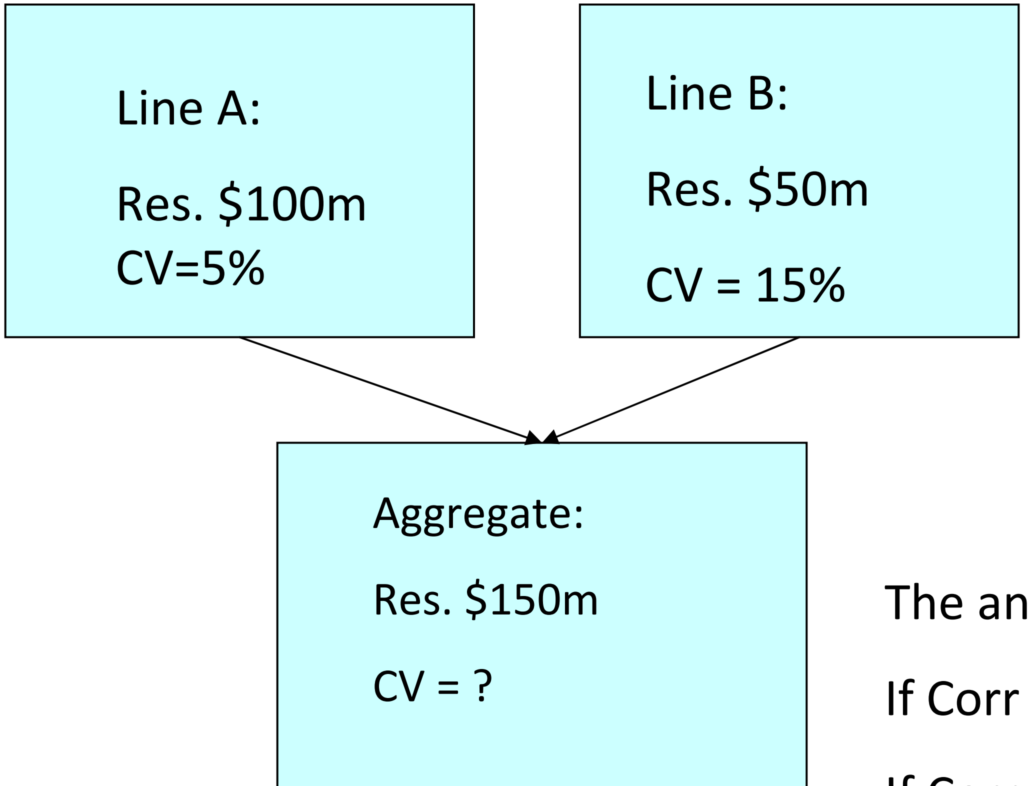
Assume Risk Capital at 98th percentile = 2 Standard Deviations

Risk Capital for Line A = $10m

Risk Capital for Line B = $15m

Aggregate Risk Capital (ARC) = $25m ?

Risk Capital Allocation



Assume Risk Capital at 98th percentile = 2 Standard Deviations

Risk Capital for Line A = $10m

Risk Capital for Line B = $15m

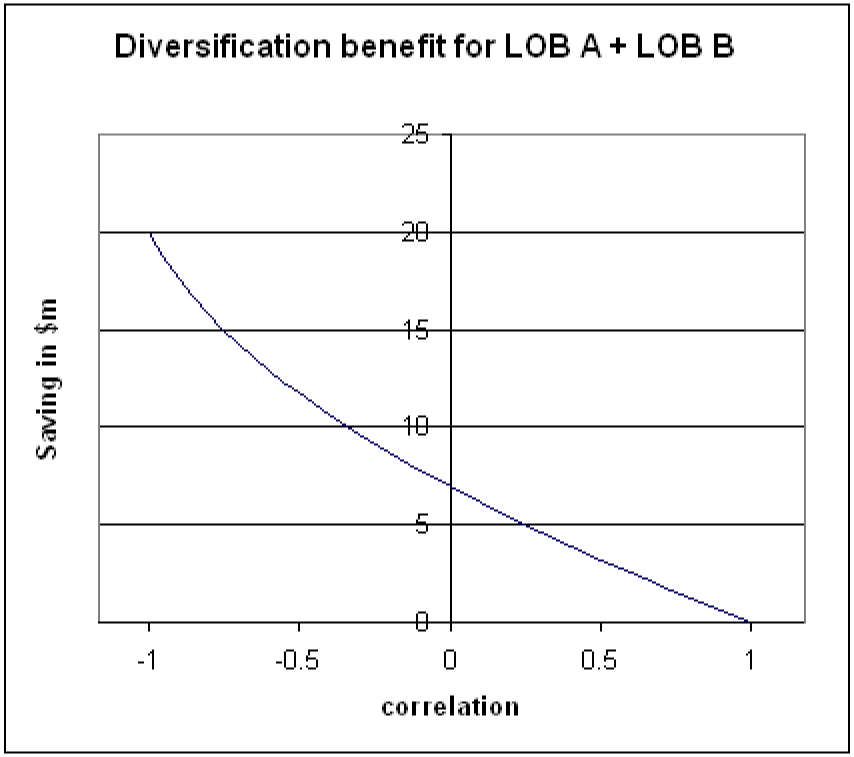
Aggregate Risk Capital (ARC) = $25m ?

The answer depends on the correlation.

If Corr = +1.0, ARC = $25m

If Corr = 0.0 ARC = $18m

Risk Capital Allocation: Diversification benefit



Benefit =

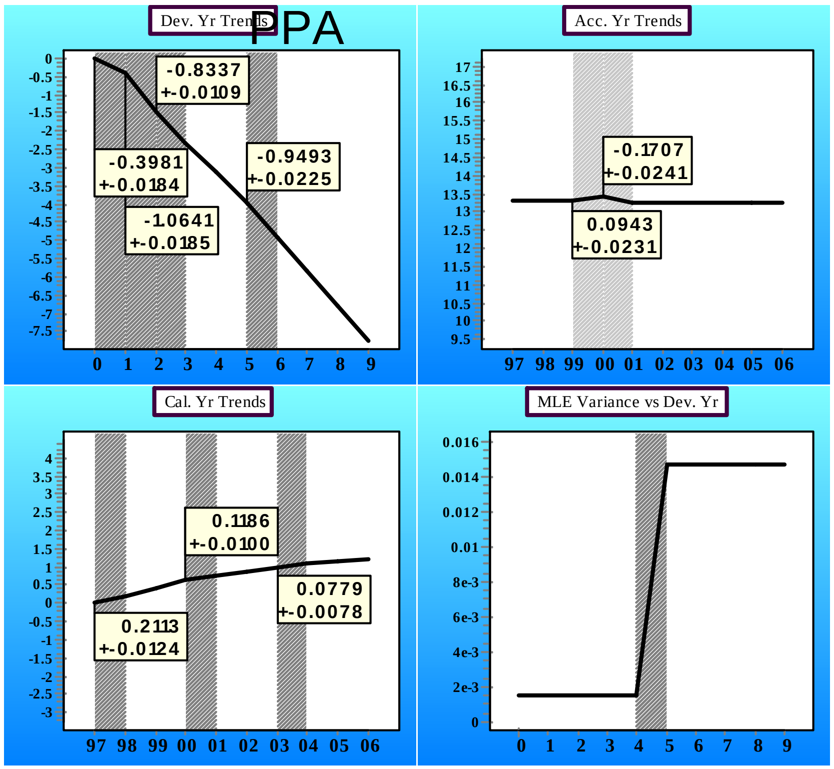
Sum of individual risk capital assessments – aggregate risk capital assessment from *joint distribution* of the two (correlated) lines.

Insureware
Software Solutions and eConsulting for P & C Insurance

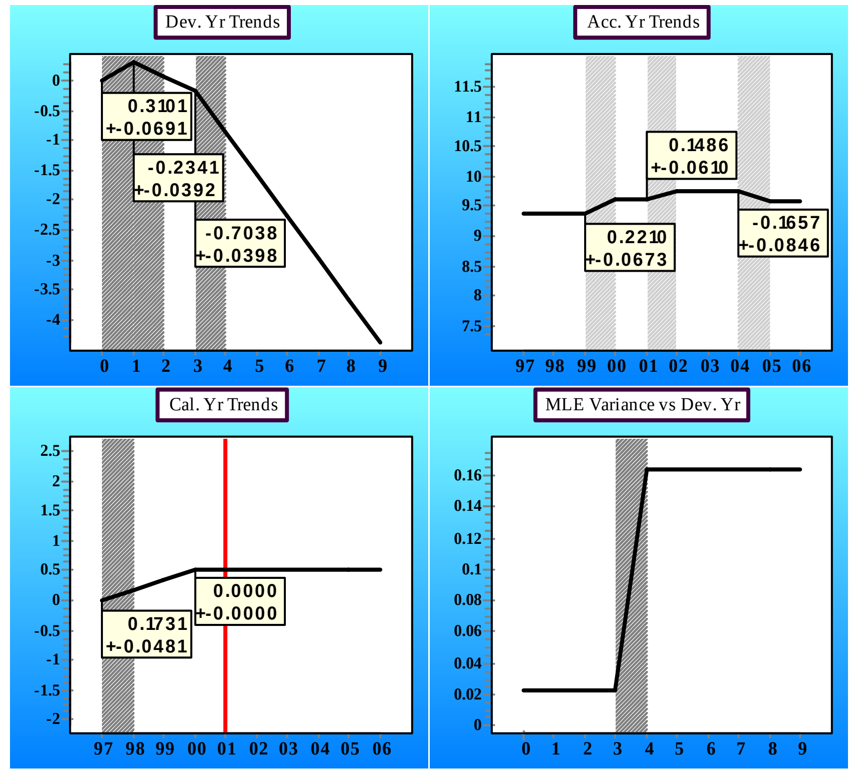
Berkshire Hathaway Schedule P 2006

No LOBs have the "same" tend structure and most LOBs have zero process correlation. Consider Private Passenger Automobile and Commercial Auto Liability

LOB PPA



LOB CAL

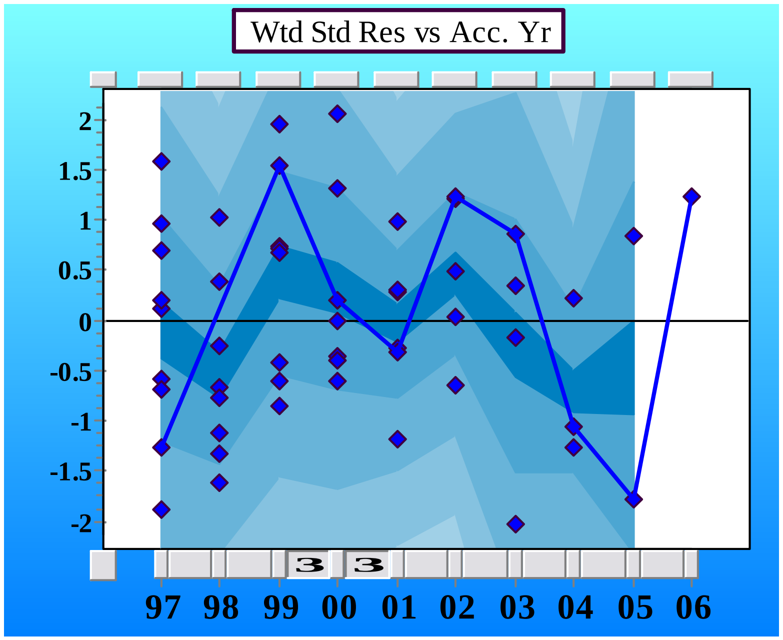


Note LOBs have very different trend structure and process variance

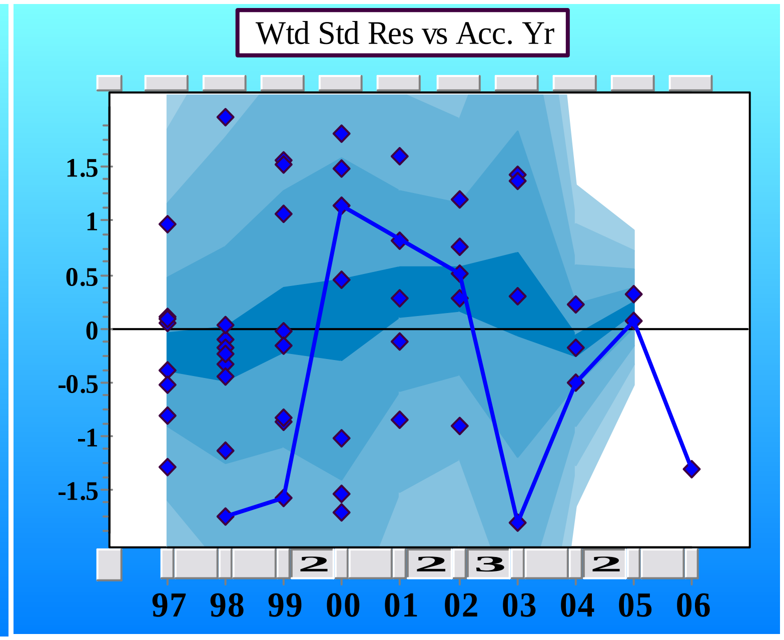
Insureware
Software Solutions and eConsulting for P & C Insurance

Berkshire Hathaway Schedule P 2006

LOB PPA



LOB CAL



Note zero process correlation. Blue lines represent trace of calendar year 2006

Insureware
Software Solutions and eConsulting for P & C Insurance

Forecast lognormal distributions (and their correlations) for each future cell for each LOB based on an explicit forecast scenario

2003	3,202,436	1,525,975	1,107,844	413,244	194,092	104,193	56,317	2
	3,225,785	1,514,680	1,022,987	418,588	200,477	4,986	7,268	
2004	3,443,730	1,649,599	1,197,652	446,766	239,812	128,758	69,606	3
	3,362,493	1,663,027	1,139,227	428,201	11,242	7,137	9,282	
2005	3,714,166	1,783,347	1,294,820	552,022	296,359	159,145	86,048	4
	3,734,136	1,840,895	1,207,194	26,731	16,318	10,359	11,954	
2006	4,011,063	1,928,056	1,599,904	682,204	366,309	196,740	106,393	5
	4,008,908	2,020,277	79,001	38,777	23,877	14,966	15,494	
	Total Fitted/Paid		2007	2008	2009	2010	2011	
Cal. Per.	25,980,855		2,571,638	1,199,857	639,334	337,281	173,651	8
Total	25,966,538		97,713	55,991	37,506	25,695	19,419	1

1 Unit = $1,000

Blue is observed, black is mean of lognormal and red is standard deviation of lognormal

Berkshire Hathaway Schedule P 2006
One Year Time Horizon- “Change” in Ultimates conditional on next year’s paid losses?

Related Question:

When do estimates of prior year ultimates stay consistent on updating (next valuation period) ?

No need for simulations! Why?

ummary | Risk Capital Allocation | Correlations | Correlations (logs)

Accident Yr Summary

Acc. Yr	Mean		Standard	CV		Cond. on Next Cal. Per.	
	Outstanding	Ultimate	Dev.	Outstanding	Ultimate	Std.Dev.|Data	+-Ult|Data
1999	404,928	7,341,745	96,942	0.24	0.01	54,108	80,437
2000	694,421	7,694,760	138,848	0.20	0.02	81,066	112,725
2001	1,169,064	8,854,561	187,454	0.16	0.02	113,677	149,051
2002	1,726,108	8,062,073	239,837	0.14	0.03	180,697	157,704
2003	2,012,700	7,324,906	245,950	0.12	0.03	190,312	155,797
2004	2,967,607	8,370,560	311,555	0.10	0.04	240,509	198,045
2005	4,895,219	10,343,879	509,057	0.10	0.05	336,132	382,302
2006	9,616,003	11,863,381	1,374,676	0.14	0.12	711,682	1,176,113
Total	23,898,022	80,529,585	2,040,345	0.09	0.03	1,172,221	1,670,001

1 Unit = $1,000

Which risk characteristics of the data do calendar year payment stream distributions depend on?

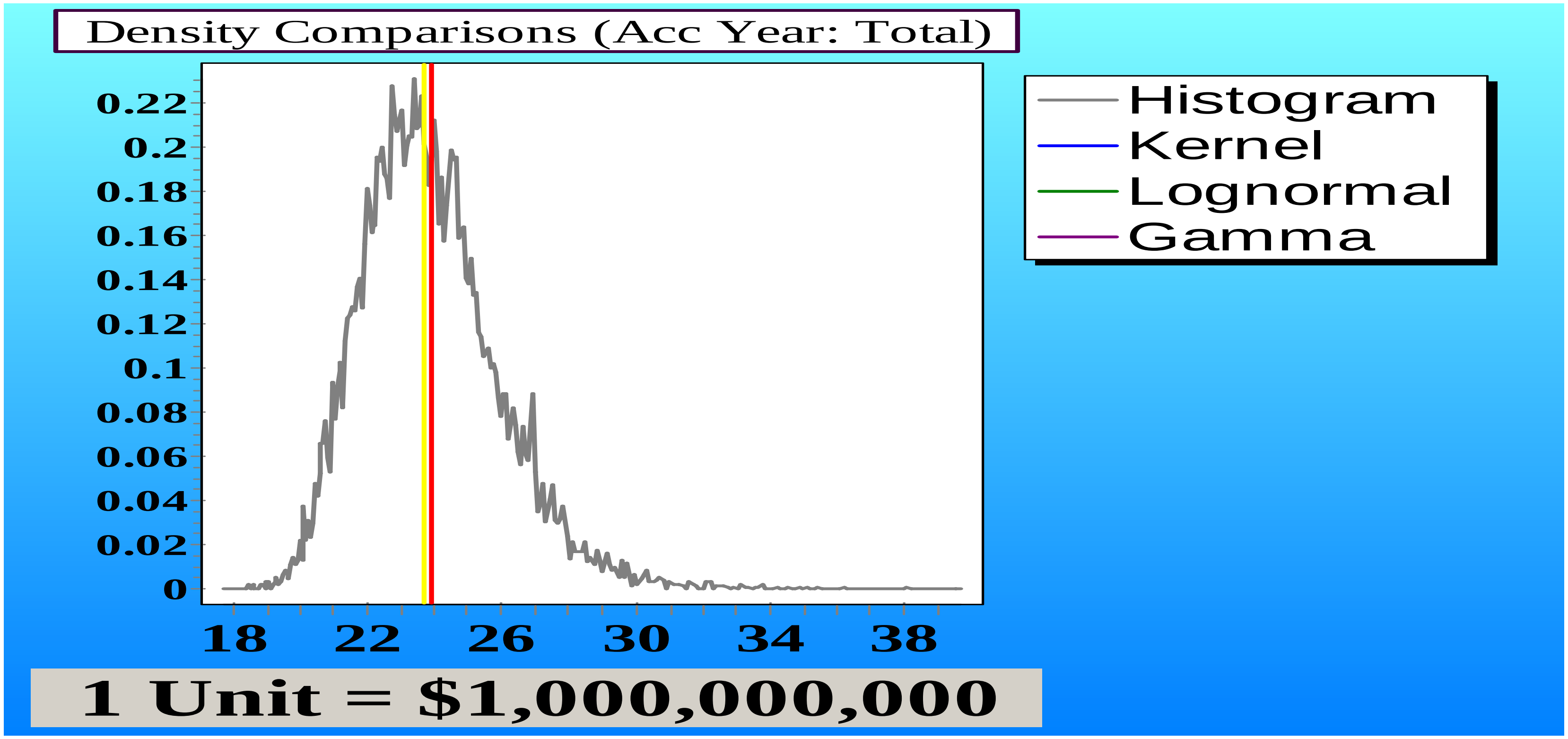
1. Base development period trends, and
2. Calendar year trend assumptions for the future

Calendar Yr Summary

Calendar Yr	Mean Outstanding	Standard Dev.	CV Outstanding	Cum. Payment as % of total
2007	7,622,060	1,088,629	0.14	31.89
2008	5,017,532	615,907	0.12	52.89
2009	3,488,650	393,684	0.11	67.49
2010	2,466,501	292,625	0.12	77.81
2011	1,733,841	236,258	0.14	85.06
2012	1,202,056	192,478	0.16	90.09
2013	757,950	139,015	0.18	93.27
2014	505,861	107,567	0.21	95.38
2015	351,572	85,873	0.24	96.85
2016	250,232	67,960	0.27	97.90
2017	182,100	56,547	0.31	98.66
2018	127,726	43,378	0.34	99.20

1 Unit = $1,000

Distribution of Aggregate Reserves=Sum of all lognormals for each future cell for each LOB



Note skewness (even) of aggregate distribution.
Mean=23.9B, VaR at 95%=3.6B and T-VaR at 95%=5B

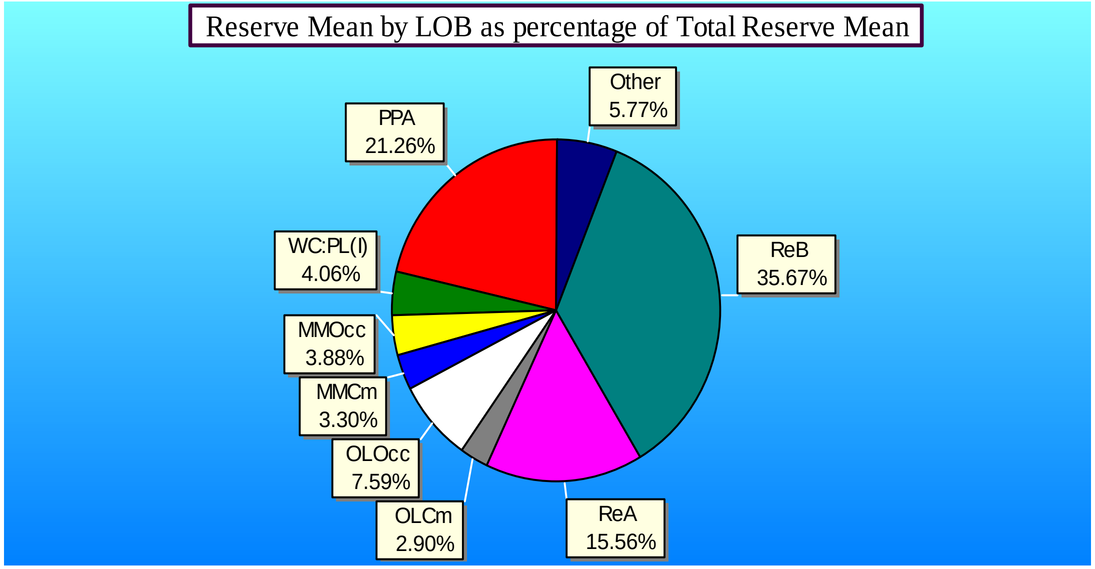
Insureware
Software Solutions and eConsulting for P & C Insurance

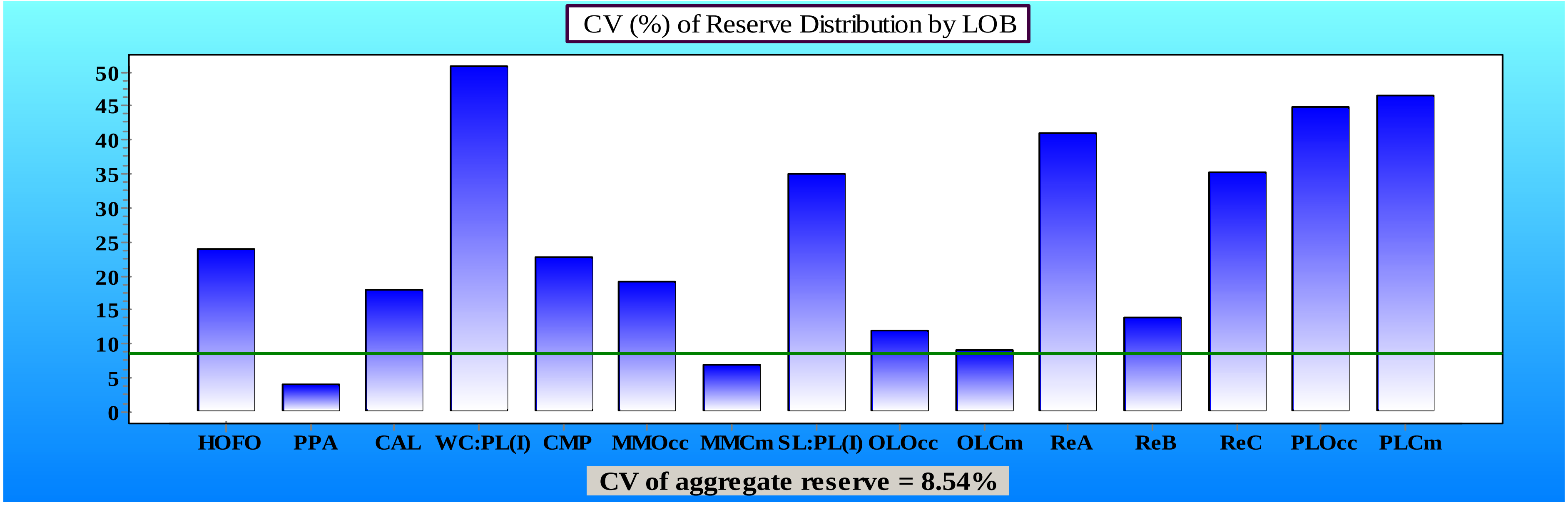
Mean Reserve as a % of Total Reserve, and Reserve CV of aggregate versus CV for each LOB.

WC has largest CV but is not smallest LOB by Mean Reserve

ReA has large CV and is not so large proportion of total business.

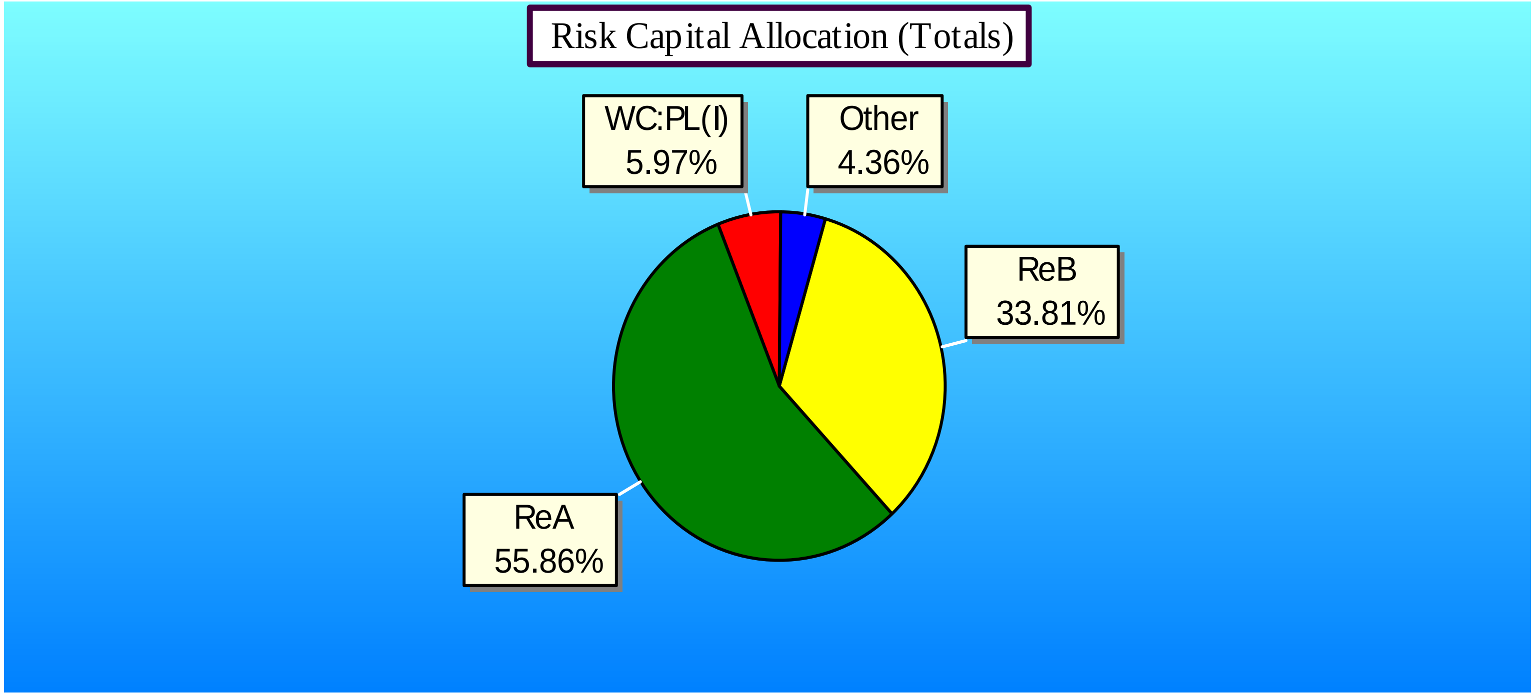
Reserve distribution correlations essentially zero!



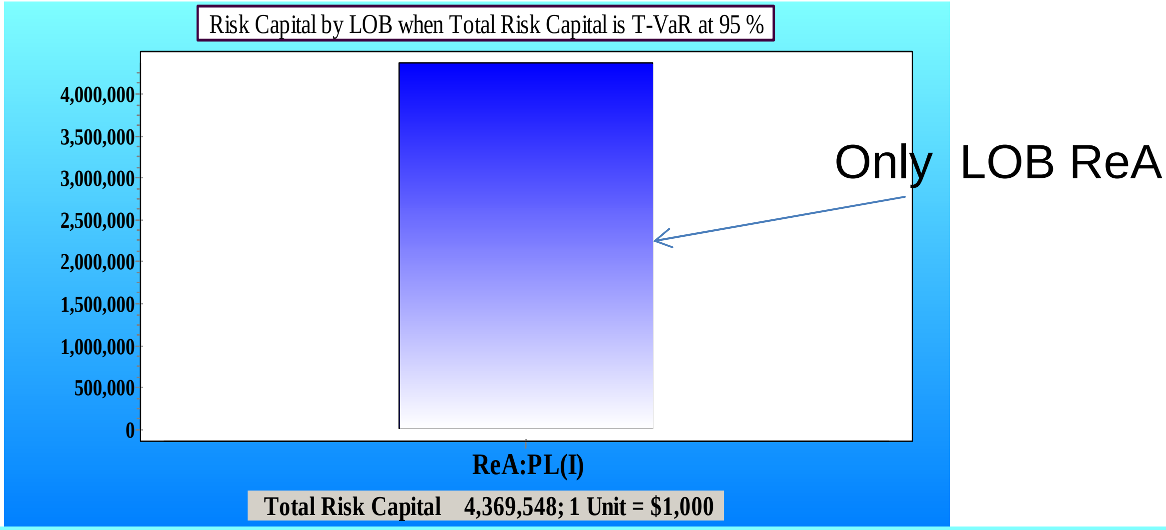


CV of aggregate less than most CVs

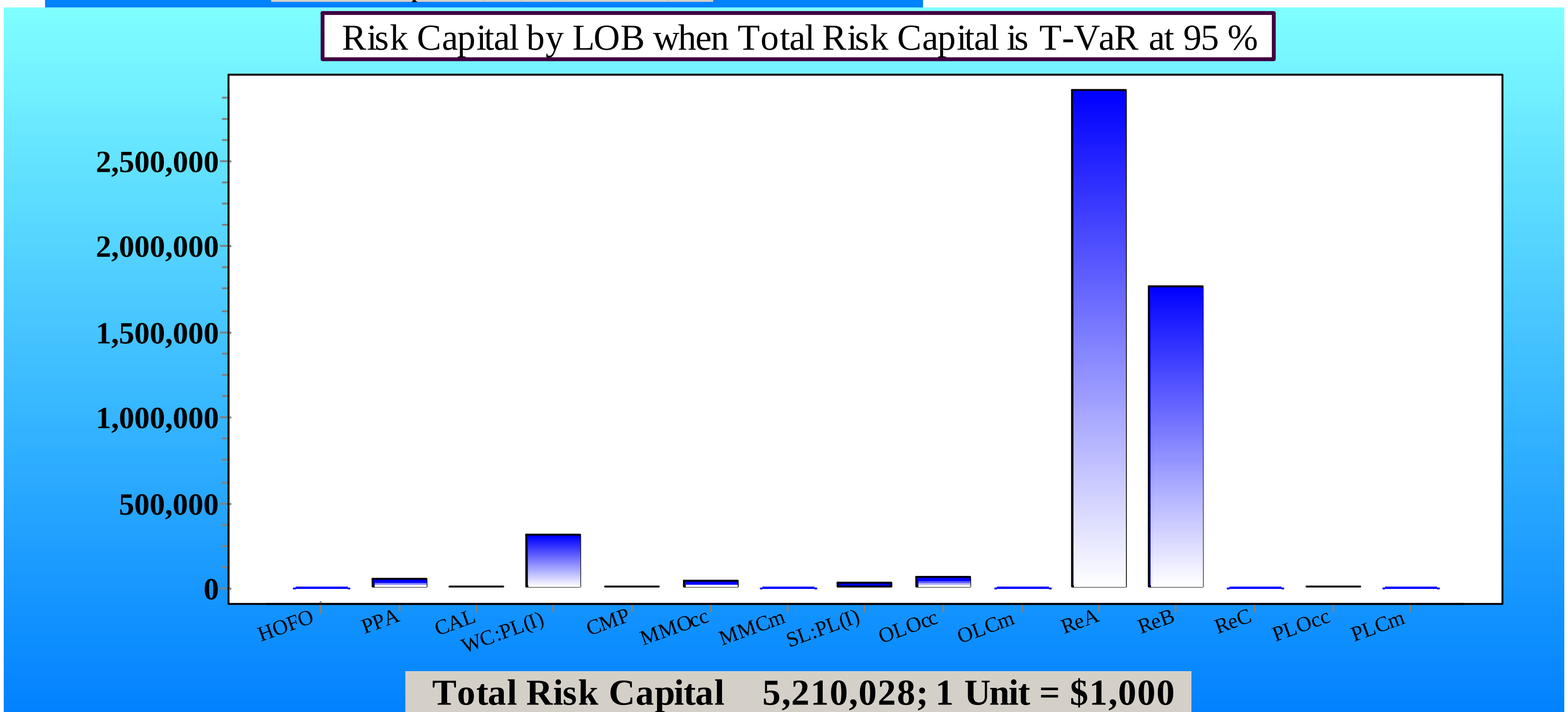
Risk allocation based on a variance/covariance formula



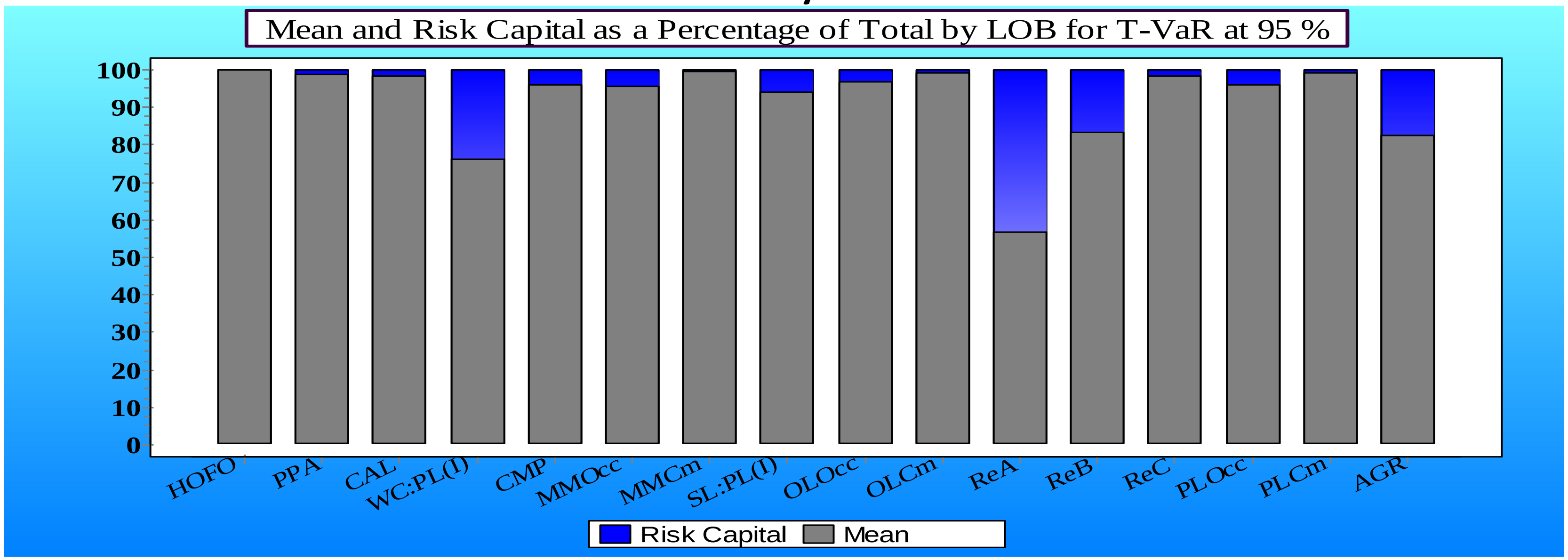
Insureware
Software Solutions and eConsulting for P & C Insurance

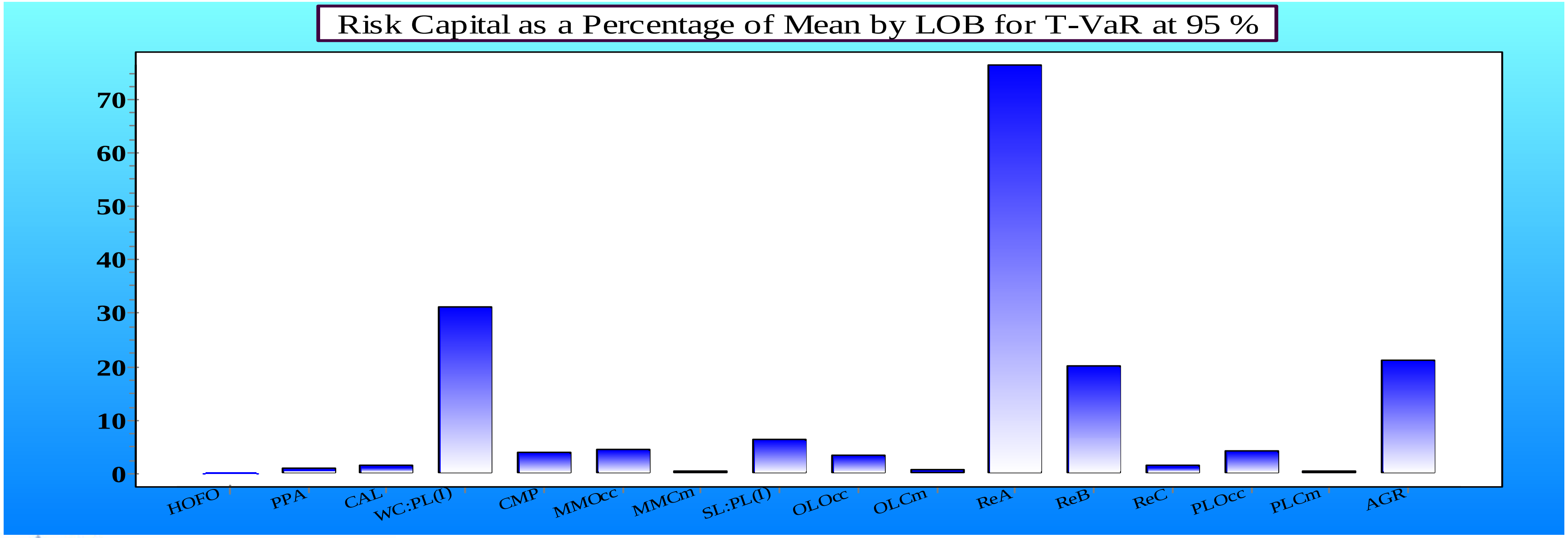


Risk capital for ReA if this is the only line written is not much less than risk capital for aggregate of all 15 LOBs! Much credit for risk diversification by writing the other LOBs that are essentially uncorrelated



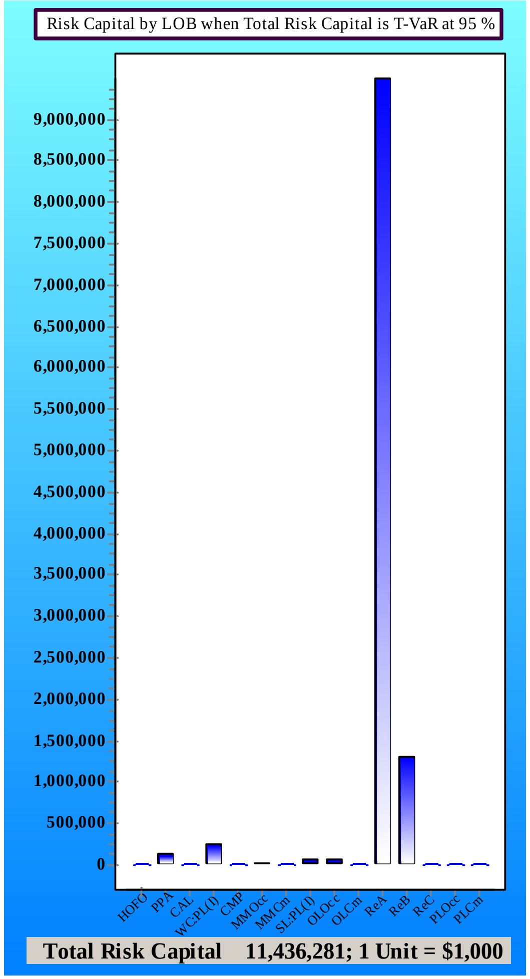
Berkshire Hathaway Schedule P 2006



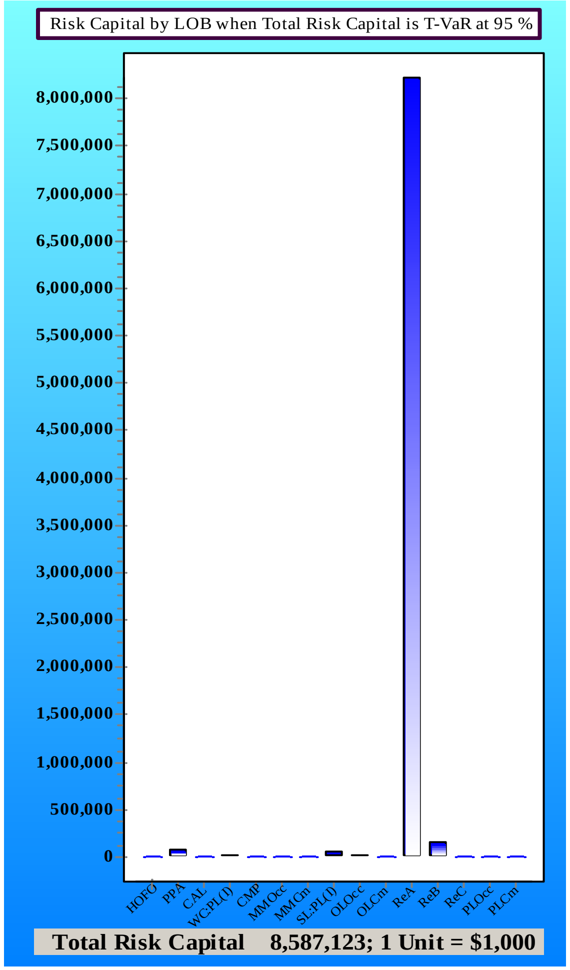


Insureware
Software Solutions and eConsulting for P & C Insurance

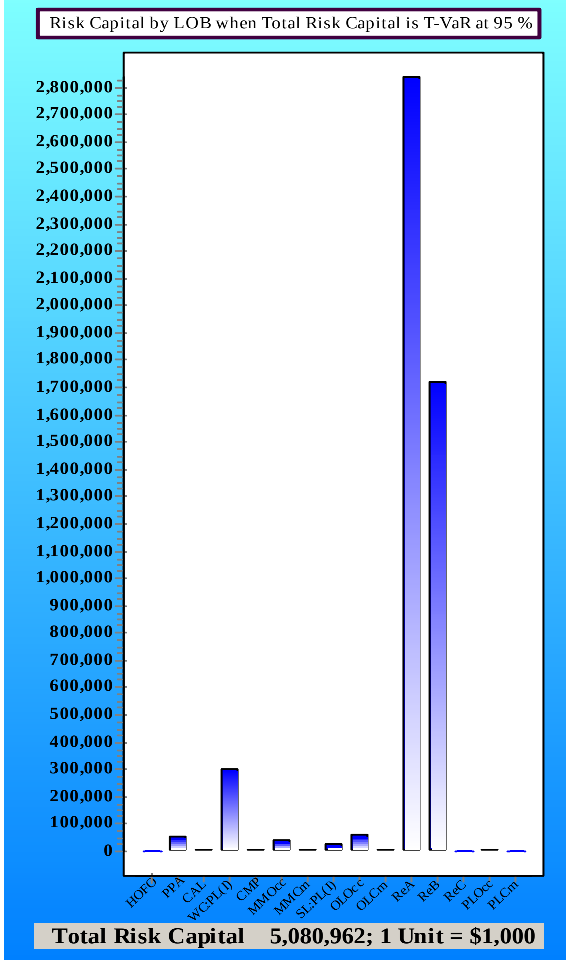
Combined risk charge < underwriting risk charge + reserve risk charge, for any T-VaR . Why?



Combined



Underwriting



Reserve

Insureware
Software Solutions and eConsulting for P & C Insurance

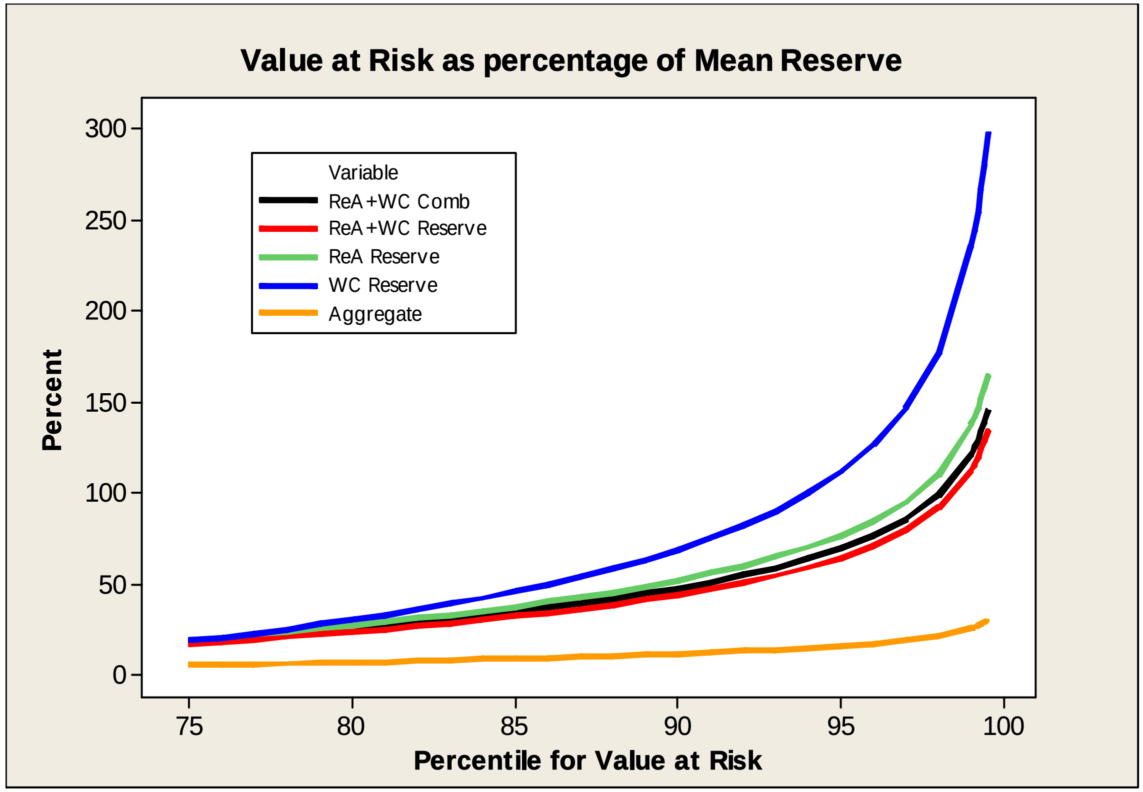
Berkshire Hathaway – Diversification Effects

This graph compares risk capital, calculated as Value at Risk and expressed as a percentage of the Forecast Mean Reserve. Only WC and ReA, two of the high CV lines are shown.

Blue = WC and **Green** = ReA
Red = WC+ReA

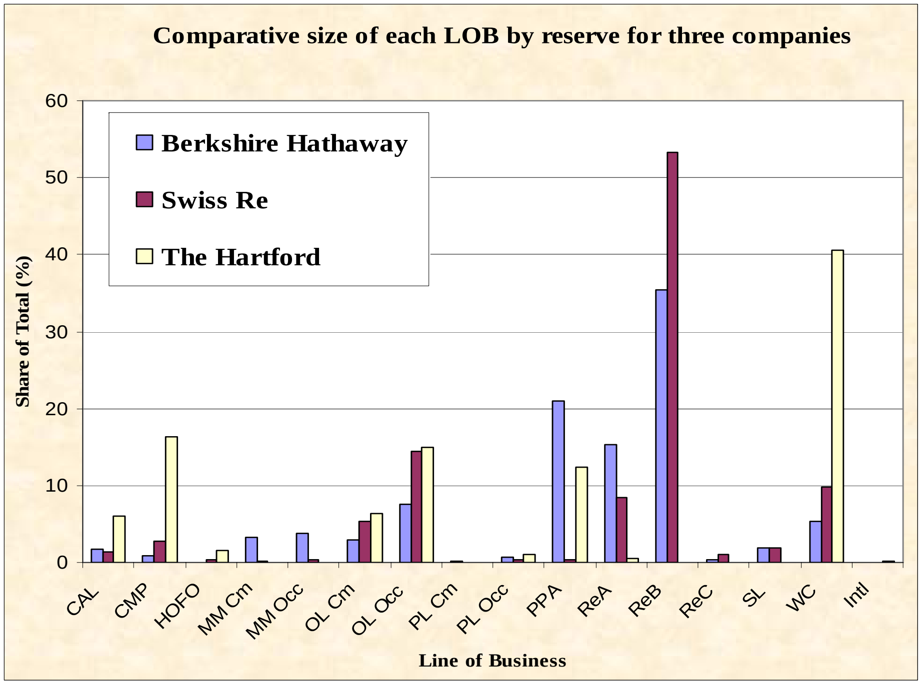
Black = WC+ReA including next underwriting year.

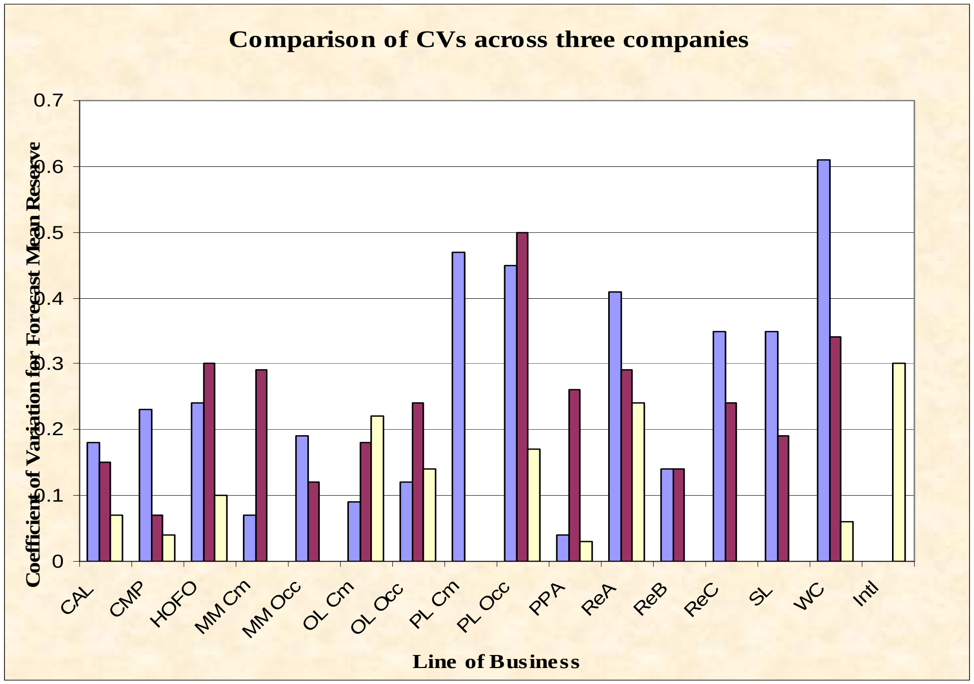
Orange = Aggregate of all BH lines.



Insureware
Software Solutions and eConsulting for P & C Insurance

Berkshire Hathaway, Swiss Re and The Hartford, comparison by Line of Business





Higher Mean does not necessarily mean lower CV

For PPA , BH Mean>HF Mean, and CV BH> CV HF

For OLOcc,Mean Hart> Mean Swiss Re > Mean BH & CV Hart>CV Swiss Re >CV BH

Insureware

Software Solutions and eConsulting for P & C Insurance

WC for BH versus SR reserve distributions by calendar year

ummary | Risk Capital Allocation | Correlations | Correlations (logs)

Calendar Yr Summary

alendar Yr	Mean Outstanding	Standard Dev.	CV Outstanding	Cum. Payment as % of total
2007	159,884	32,398	0.20	16.46
2008	118,214	30,173	0.26	28.64
2009	93,152	28,529	0.31	38.23
2010	80,409	31,904	0.40	46.51
2011	76,096	39,128	0.51	54.35
2012	78,181	49,850	0.64	62.40
2013	68,736	47,445	0.69	69.48
2014	64,214	50,166	0.78	76.09
2015	57,252	49,542	0.87	81.99
2016	46,566	43,194	0.93	86.78
2017	39,796	40,247	1.01	90.88
2018	29,327	30,856	1.05	93.90
2019	26,004	30,693	1.18	96.58

1 Unit = $1,000

Summary | Risk Capital Allocation | Correlations | Correlations (logs)

Calendar Yr Summary

Calendar Yr	Mean Outstanding	Standard Dev.	CV Outstanding	Cum. Payment as % of total
2007	276,458	77,839	0.28	21.92
2008	221,292	77,816	0.35	39.47
2009	177,917	75,607	0.42	53.58
2010	143,055	71,663	0.50	64.92
2011	115,136	67,018	0.58	74.05
2012	92,834	62,235	0.67	81.41
2013	74,857	57,561	0.77	87.35
2014	55,040	45,666	0.83	91.71
2015	39,108	35,277	0.90	94.81
2016	26,129	25,878	0.99	96.88
2017	17,101	18,737	1.10	98.24
2018	10,828	13,282	1.23	99.10
2019	6,479	9,085	1.40	99.61

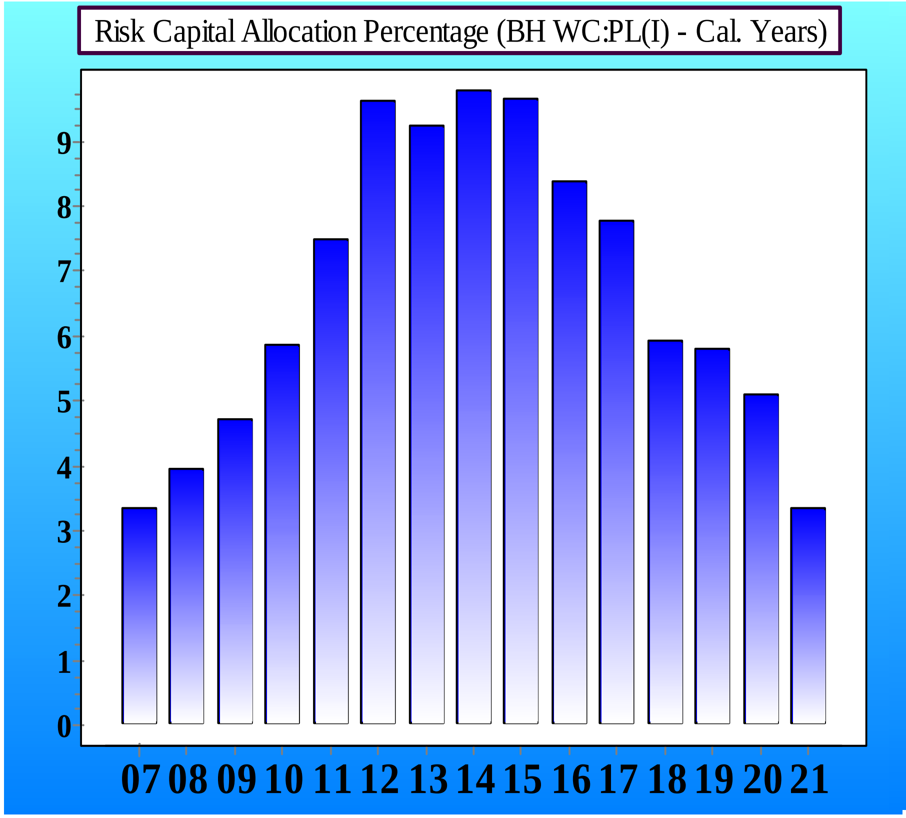
1 Unit = $1,000

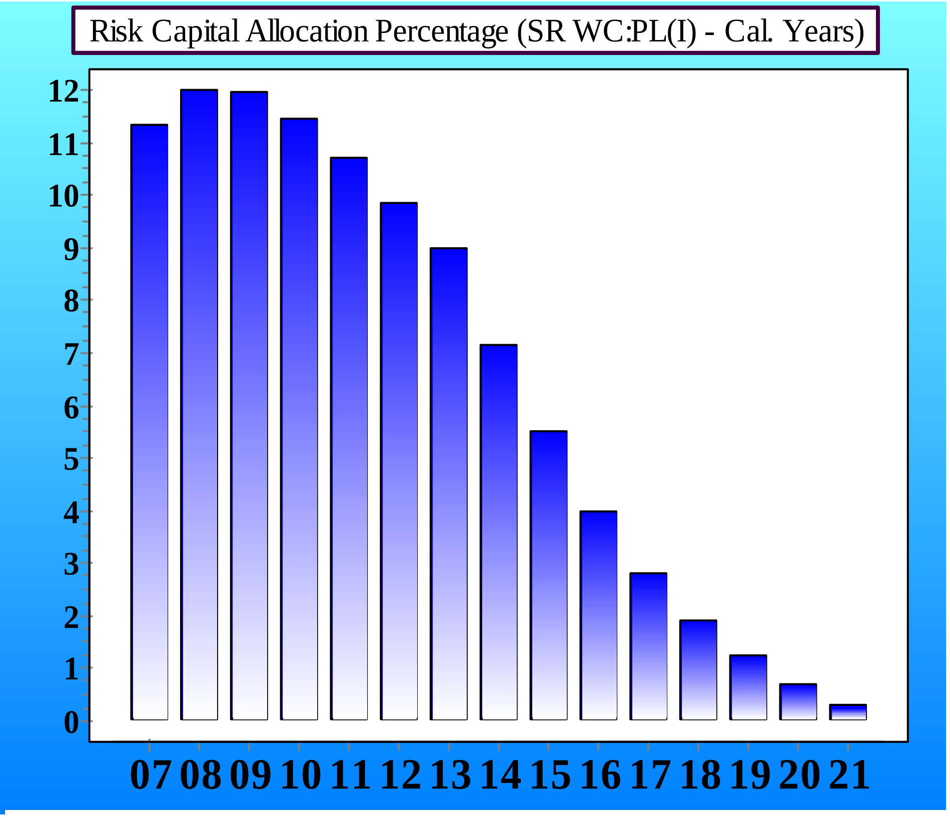
Distributions of payment streams by calendar year are different

These depend on the base development period trends and the assumed forecast scenario calendar year trends.

Insureware
Software Solutions and eConsulting for P & C Insurance

Risk capital allocation (%) by calendar year for WC, BH versus SR





% allocation very different. It is based on a variance/covariance formula that is a function of three factors. 1. The future calendar year trend (mean and standard deviation thereof) assumption, 2. Development period trends and 3. process variance.

Insureware
Software Solutions and eConsulting for P & C Insurance

Summary

•All companies are different and no company is the same as the industry.

•Consistent estimates of prior year ultimates on updating can only be maintained within a sound modelling framework that incorporates calendar year parameters and assumptions about the future are explicit and auditable. The assumptions can easily be monitored on updating.

•Reserve distribution correlation is usually considerably less than process correlation.

•Segments of the same LOB such as 1. net of reinsurance and gross, 2. indemnity versus medical, 3. layers, for example, limited to 500K and limited to 1M; have common drivers and are highly correlated.

•Different LOBs very often do not have common drivers. That is, the trend structure (especially along calendar years) is not the same and process correlation is zero.

• A sound measurement of volatility and correlations (from the data) is essential to calculate risk capital allocation by LOB and calendar year, irrespective of capital risk measure.

Insureware
Software Solutions and eConsulting for P & C Insurance

Summary

- Combined reserve and underwriting risk charge < reserve risk charge + underwriting risk
- Mack and related methods can give answers that are wildly too low or too high and cannot capture the volatility in the data.

More information will be available at

Lincolnshire Room (6th floor)

7:00pm-11:00pm

Monday September 14

(Also learn about the Bootstrap technique for testing validity of a model or method)

Insureware
Software Solutions and eConsulting for P & C Insurance