Institute and Faculty of Actuaries

Sensing and Responding to Signal vs. Noise

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04 October 2017

Agenda

A. BSRCH Goals

B. Actuarial Method Redefined

C. Extracting Signal From Noise

D. Statistical Philosophy

E. Use Cases

   a) Hypothesis A: Everything is Awesome

   b) Hypothesis B: There is Evidence of Change

   c) History Lesson

F. Philosophy in Action and Extension

G. Questions

A) Better Sensing and Responding to Change: Goals

If we have great models which deal with all the risks which are going on, then life is good and you don't need to go BSRC.

But, sometimes our models are incomplete or cannot handle change.

How Can We:

- Detect when risks are changing
- Evaluate if models are appropriate to deal with them
- Identify how to improve data or modelling to deal with the change?

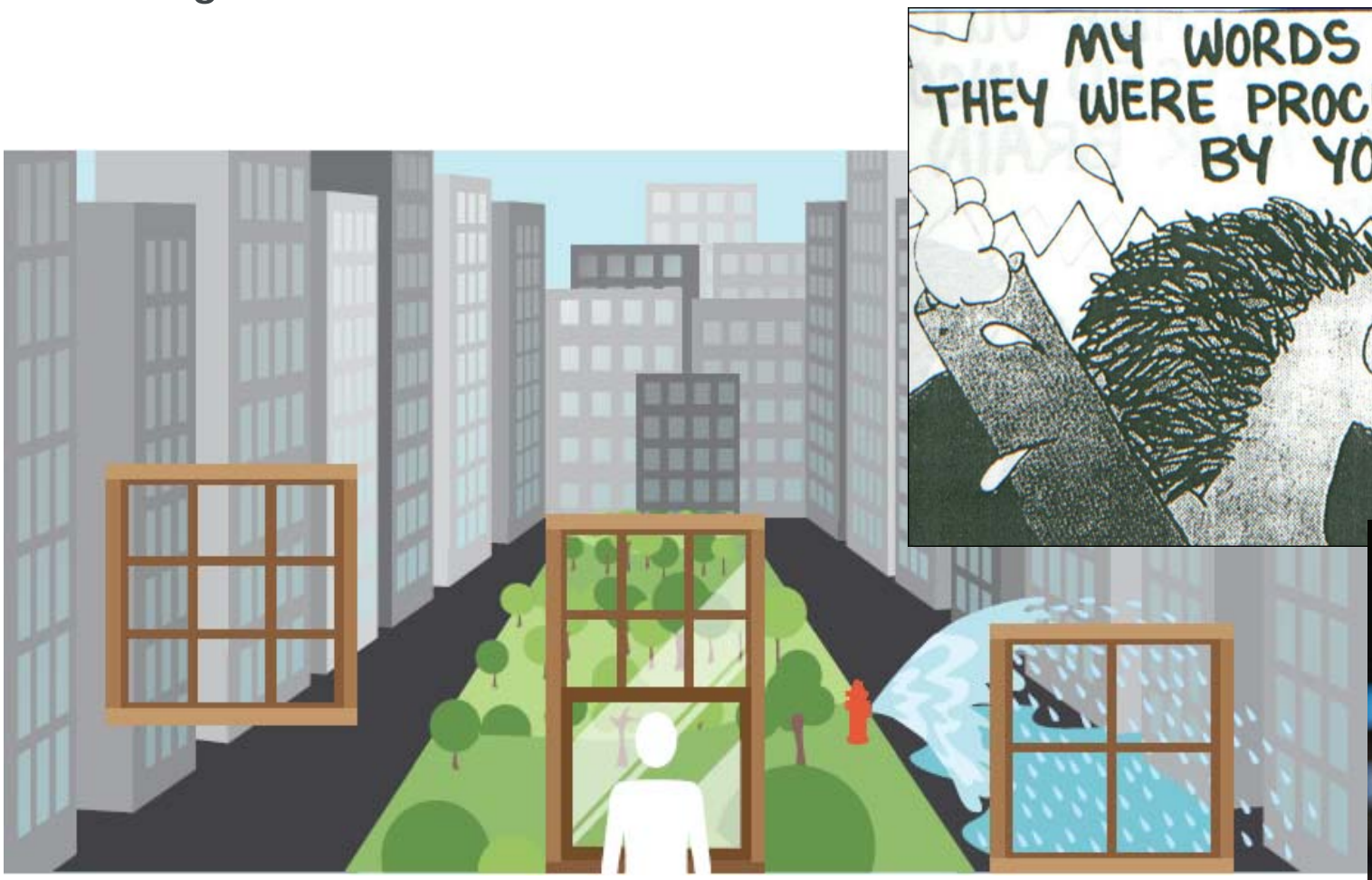
This requires Logical, Mathematical, Philosophical and Social: Tools AND Processes -*Which Actuaries Are Uniquely Qualified To Apply*

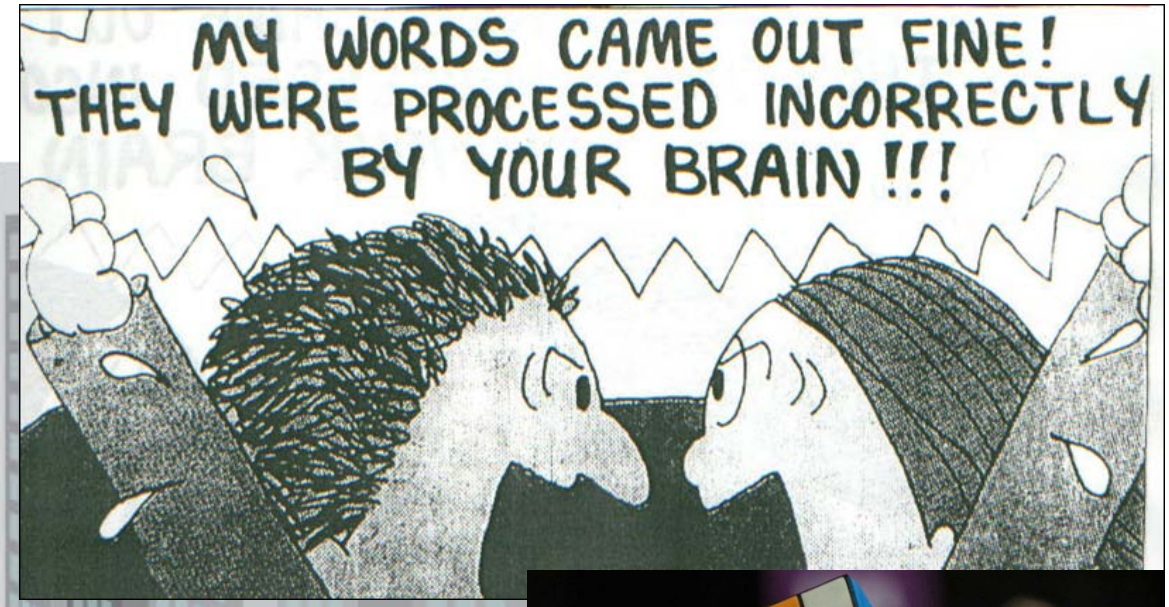
B) Actuarial Method Redefined

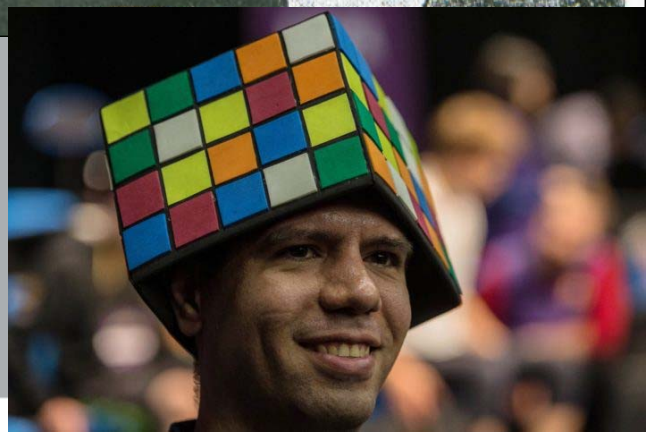
- We need to understand what makes an actuary an actuary in order to know how to be a better actuary
- The concepts of mental model and heuristics help greatly
- Knowing this helps us collaborate and compete better with wider professionals
- The BSRCH Approach is part of How We Do This

Mental Model Frames of Reference

Figure 3.1 What we perceive and how we interpret it depend on the frame through which we view the world around us.







Rational Heuristics –'logically sound' methods for discovery[1]

Example: THE INTERVENTION-FINDER HEURISTIC -aims to identify an intervention which maximizes the probability that a particular effect event will occur. ... ***In contrast to the Bayesian approach, this heuristic uses only a small amount of causal and statistical information to determine the best intervention point.*** This heuristic might help a boundedly rational agent ***when information is scarce, time pressure is high, or computational resources are limited***.[2]

[1]Anna Grandori. Heuristics as Methods: Validity, Reliability and Velocity. Springer International Publishing Switzerland 2015; Studies in Applied Philosophy, Epistemology and Rational Ethics Volume 16

[2]Meder, B., Gerstenberg, T., Hagmayer, Y. and Waldmann, M. (2010). Observing and Intervening: Rational and Heuristic Models of Causal Decision Making~!2009-08-27~!2010-01-07~!2010-07-13~!. The Open Psychology Journal, 3(2), pp.119-135.

Heuristic Play –The Imagination Tree

Actuarial Method

- Collaborative Engagement With Wider Professionals
- Founded in Insurance, Risk, Logical and Mathematical Knowledge
- Carried as Mental Models
- Converted Into Rational, Causal Heuristic Models
- Adapt as Circumstances Require Based on Feedback

BSRCH Approach

- Improve Challenge and Input From Wider Professionals ← Last Year
- Leverage Philosophy, Logic and Experience to Extend Knowledge
- Build Stronger Mental Models ← The Future?
- Continually Test and Refine Heuristic Models ← Current Focus
- Adapt as Circumstances Require Based on Feedback

"for the performance of these duties it is evident that not only a sound knowledge of mathematic principles is required, but also the practical application of financial judgement and experience" (IFoA Charter, 1884)

C) Extracting Signal When All Data Contains Noise

It’s like setting cruise control then plotting the movements of your fellow drivers.

1. Incremental Data
2. Select a mean benchmark -From recent own or a-priori data
3. Set Confidence Interval Bands -Ditto
4. Watch How The Series Evolves Relative To The Man And Confidence Interval

“Range” is the difference between the largest and smallest points in a group

1. Set Range Bands
2. Look for Variability Signals

Apply Nelson’s Rules

Shewart's Charts

- Control Charts in Manufacturing: Since 1927
  - Is my Process:
    - Predictable Or Unpredictable
    - In Conformance or Otherwise?
  - Should We Look for Assignable Causes For Unplanned Process Changes?
  - What Impact Did the Intervention Have?
  - Drove A Manufacturing Improvement Explosion
- Control Charts In Actuarial Science: Since 2017
  - How Predictable Is My Loss Data And Is It Sufficiently Stable For Projections?
  - Should We Look for Assignable Causes?
  - What Is The Impact of the Event?
  - A Brighter Future?

Energy vs. Insurance Sector Comparison

Energy	Insurance
Continuous Monitoring For External Effects / Breakdowns	Identifying Risk And Process Change Impacts
Scheduled Maintenance	Models Fit For Purpose And Reflective Of Current Conditions?
Inspection Deeper Dive On Critical Components: Corrosion; Known Weak Links,	Premium Reviews, Actual V Expected Analyses, Reinsurance Reviews, Try Out A New Premium Structure On A Sample Of Renewals
Emergency Shutdown And Pressure Relief	ORSA Triggers, Underwriting Review Mandate
External Factor Monitoring Of Kpi's, (Leading Indic.)	Ditto
Scenario Analysis / Back Testing At What Level Is It Broken?	Ditto + How Much Movement Would Be Statistically Significant
Intervention Impact Assessment	Ditto
Process Safety Performance Indicators (Pspis)	Model Adequacy Performance Indications

Basic Data Manipulation

Accident Year by Development Period

Incremental Actual

AY	0 - 3	3 - 6	6 - 9	9 - 12	12 - 15	15 - 18	18 - 21	21 - 24	24 - 27	27 - 30	30 - 33	33 - 36	36 - 39	39 - 42	42 - 45	45 - 48	48 - 51	51 - 54
2013	268	1,102	1,609	3,179	4,485	3,611	3,899	2,059	3,250	2,482	3,440	4,480	2,783	821	1,771	1,339	3,560	4,649
2014	619	1,967	3,046	4,035	4,688	4,121	5,125	4,629	4,336	4,893	3,343	3,319	1,886	3,199				
2015	636	1,681	2,254	3,241	4,504	3,253	4,170	4,029	4,015	6,584								
2016	511	1,294	2,225	2,850	3,557	3,895												
2017	575	1,827																

Accident Year by Calendar Period

Incremental Actual

AY	Mar-13	Jun-13	Sep-13	Dec-13	Mar-14	Jun-14	Sep-14	Dec-14	Mar-15	Jun-15	Sep-15	Dec-15	Mar-16	Jun-16	Sep-16	Dec-16	Mar-17	Jun-17
2013	268	1,102	1,609	3,179	4,485	3,611	3,899	2,059	3,250	2,482	3,440	4,480	2,783	821	1,771	1,339	3,560	4,649
2014					619	1,967	3,046	4,035	4,688	4,121	5,125	4,629	4,336	4,893	3,343	3,319	1,886	3,199
2015									636	1,681	2,254	3,241	4,504	3,253	4,170	4,029	4,015	6,584
2016													511	1,294	2,225	2,850	3,557	3,895
2017																	575	1,827

Development Period by Calendar Period

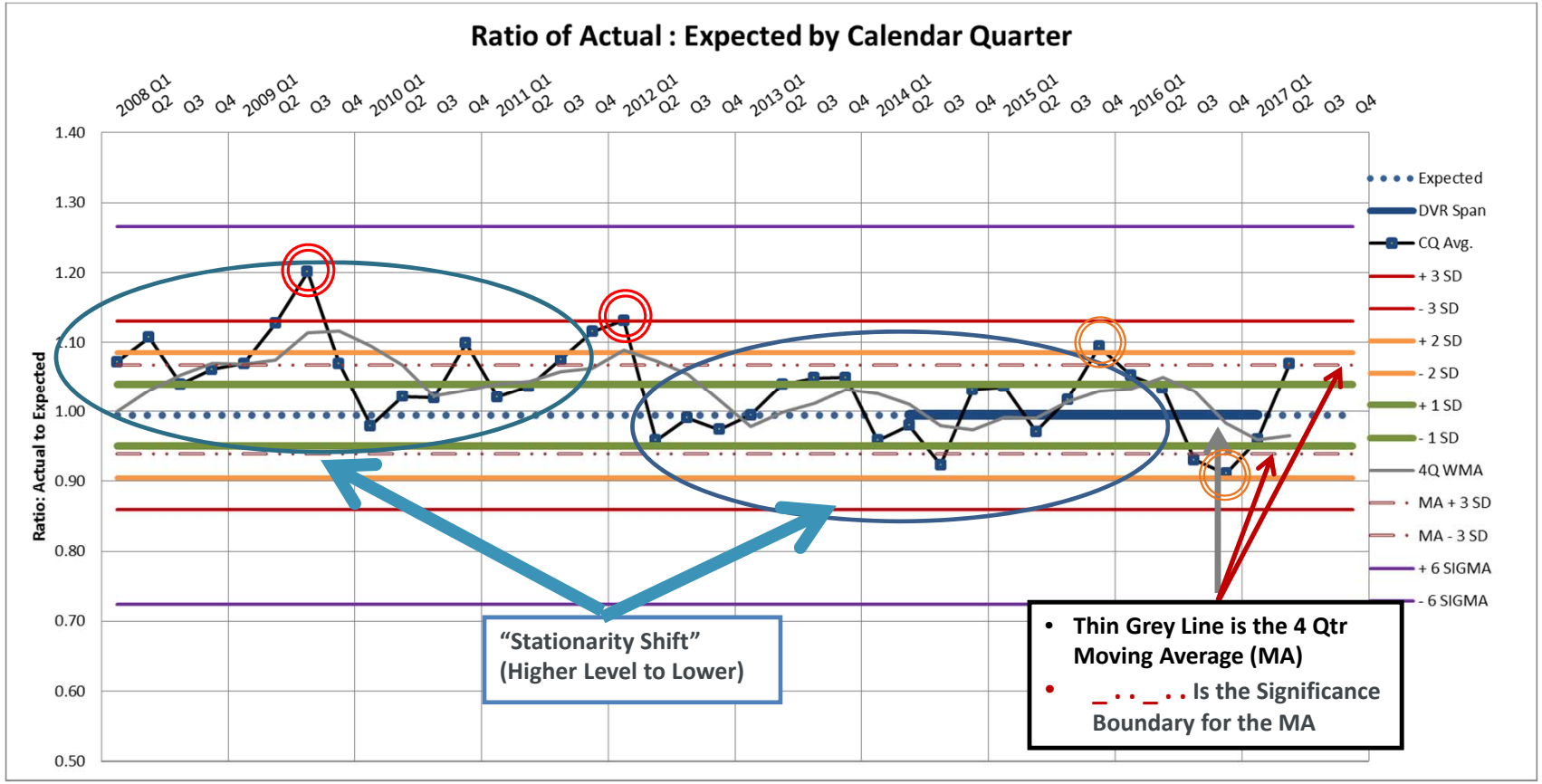
Incremental Actual

Dev	Mar-13	Jun-13	Sep-13	Dec-13	Mar-14	Jun-14	Sep-14	Dec-14	Mar-15	Jun-15	Sep-15	Dec-15	Mar-16	Jun-16	Sep-16	Dec-16	Mar-17	Jun-17
4 - 5 Yrs																	3,560	4,649
3 - 4 Yrs													2,783	821	1,771	1,339	1,886	3,199
2 - 3 Yrs									3,250	2,482	3,440	4,480	4,336	4,893	3,343	3,319	4,015	6,584
1 - 2 Yrs					4,485	3,611	3,899	2,059	4,688	4,121	5,125	4,629	4,504	3,253	4,170	4,029	3,557	3,895
0 - 1 Yrs	268	1,102	1,609	3,179	619	1,967	3,046	4,035	636	1,681	2,254	3,241	511	1,294	2,225	2,850	575	1,827

A/E Statistics

Incremental Actual																				
Dev	###	###	###	###	###	###	###	###	###	###	####	####	Mar-16	Jun-16	Sep-16	Dec-16	Mar-17	Jun-17	Sep-17	Dec-17
4 - 5 Yrs																	3,560	4,649		
3 - 4 Yrs													2,783	821	1,771	1,339	1,886	3,199		
2 - 3 Yrs									###	###	####	####	4,336	4,893	3,343	3,319	4,015	6,584		
1 - 2 Yrs					###	###	###	###	###	###	####	####	4,504	3,253	4,170	4,029	3,557	3,895		
0 - 1 Yrs	###	###	###	###	###	###	###	###	###	###	####	####	511	1,294	2,225	2,850	575	1,827		
										Total:			**12,134**	**10,261**	**11,509**	**11,538**	**13,594**	**20,154**		
										Nose: 0-2 Yrs			5,015	4,548	6,395	6,880	4,132	5,722		
										Tail: 2+ Years			7,119	5,714	5,114	4,658	9,462	14,432		
Incremental Expected																				
4 - 5 Yrs																	1,940	1,967	1,900	1,721
3 - 4 Yrs													3,012	2,373	3,049	3,139	3,759	2,961	3,806	3,917
2 - 3 Yrs									###	###	####	####	4,094	3,818	3,399	4,194	3,718	3,468	3,088	3,810
1 - 2 Yrs					###	###	###	###	###	###	####	####	2,959	2,509	3,378	3,478	3,395	2,880	3,876	3,991
0 - 1 Yrs	###	###	###	###	###	###	###	###	###	###	####	####	612	1,828	2,535	3,142	665	1,987	2,755	3,415
										Total:			**10,676**	**10,529**	**12,361**	**13,953**	**13,477**	**13,263**	**15,425**	**16,854**
										Nose: 0-2 Yrs			3,570	4,338	5,912	6,620	4,060	4,867	6,631	7,406
										Tail: 2+ Years			7,106	6,191	6,449	7,333	9,417	8,396	8,793	9,448
Incremental Actual / Expected																				
4 - 5 Yrs																	183.5%	236.4%		
3 - 4 Yrs													92.4%	34.6%	58.1%	42.7%	50.2%	108.0%		
2 - 3 Yrs									###	###	####	####	105.9%	128.2%	98.3%	79.1%	108.0%	189.8%		
1 - 2 Yrs					###	###	###	###	###	###	####	####	152.2%	129.6%	123.5%	115.9%	104.7%	135.2%		
0 - 1 Yrs	###	###	###	###	###	###	###	###	###	###	####	####	83.4%	70.8%	87.8%	90.7%	86.5%	91.9%		
										Total:			**113.7%**	**97.5%**	**93.1%**	**82.7%**	**100.9%**	**152.0%**	**0.0%**	**0.0%**
										Nose: 0-2 Yrs			140.5%	104.8%	108.2%	103.9%	101.8%	117.6%	0.0%	0.0%
										Tail: 2+ Years			100.2%	92.3%	79.3%	63.5%	100.5%	171.9%	0.0%	0.0%

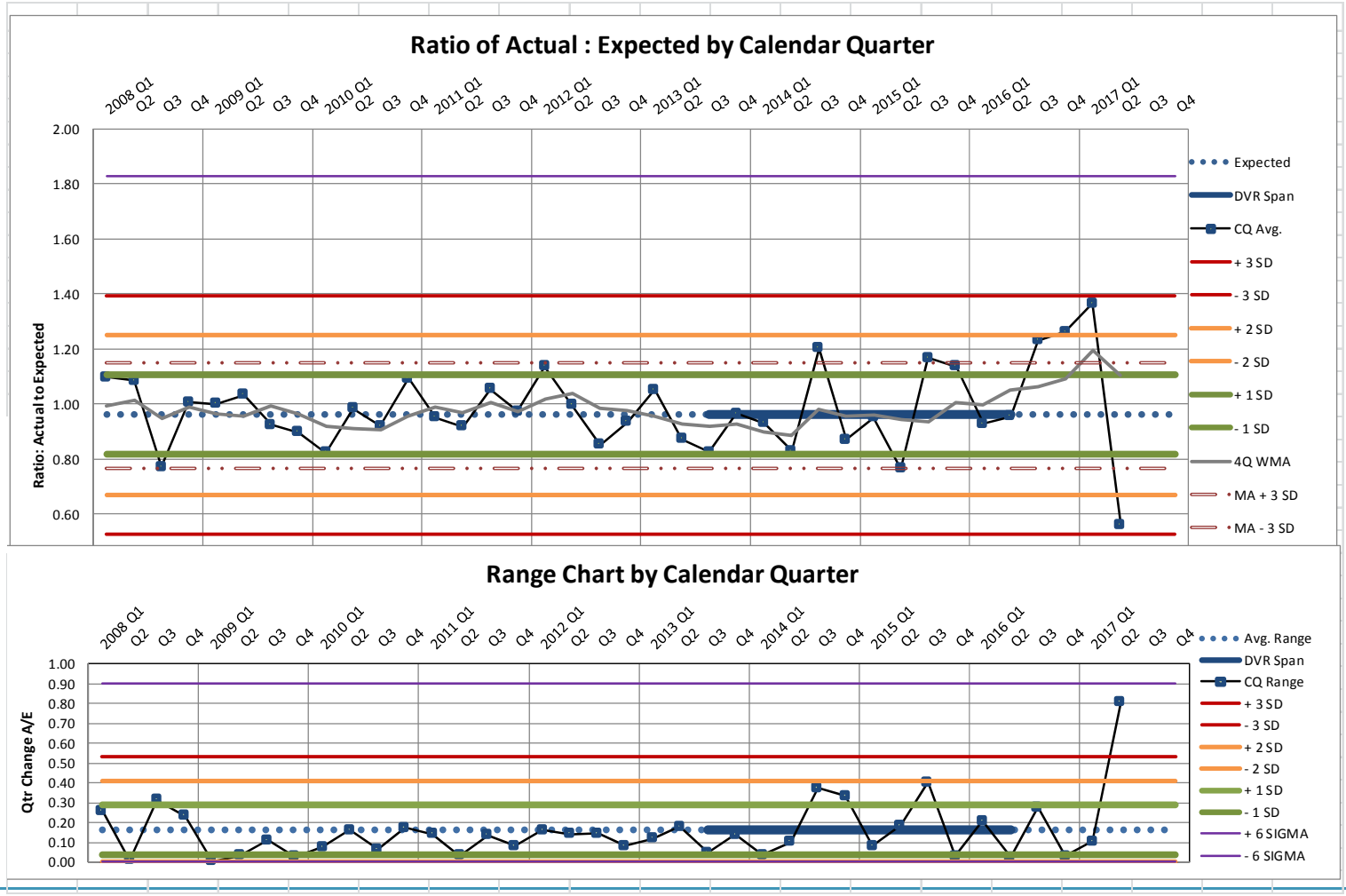
Control Charts



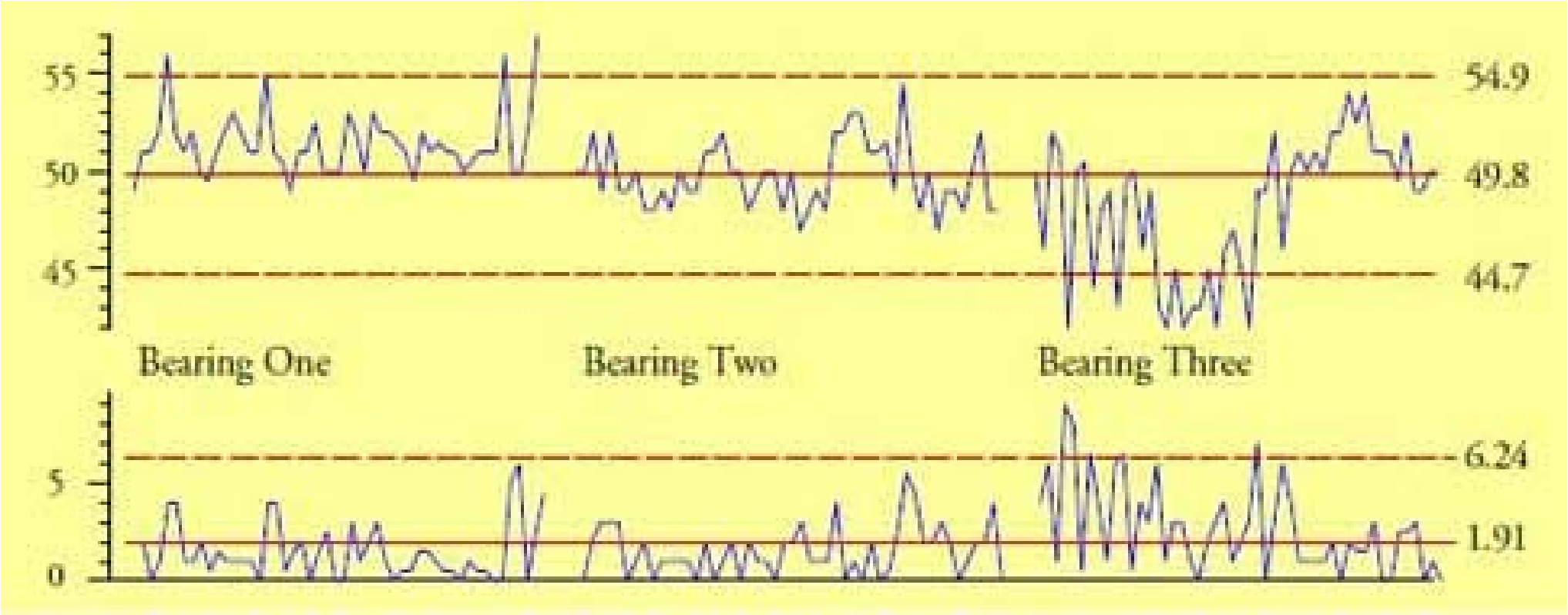
Three Standard Deviations are Statistically Significant

Two Standard Deviations are "Warning Level", but may be False Positives

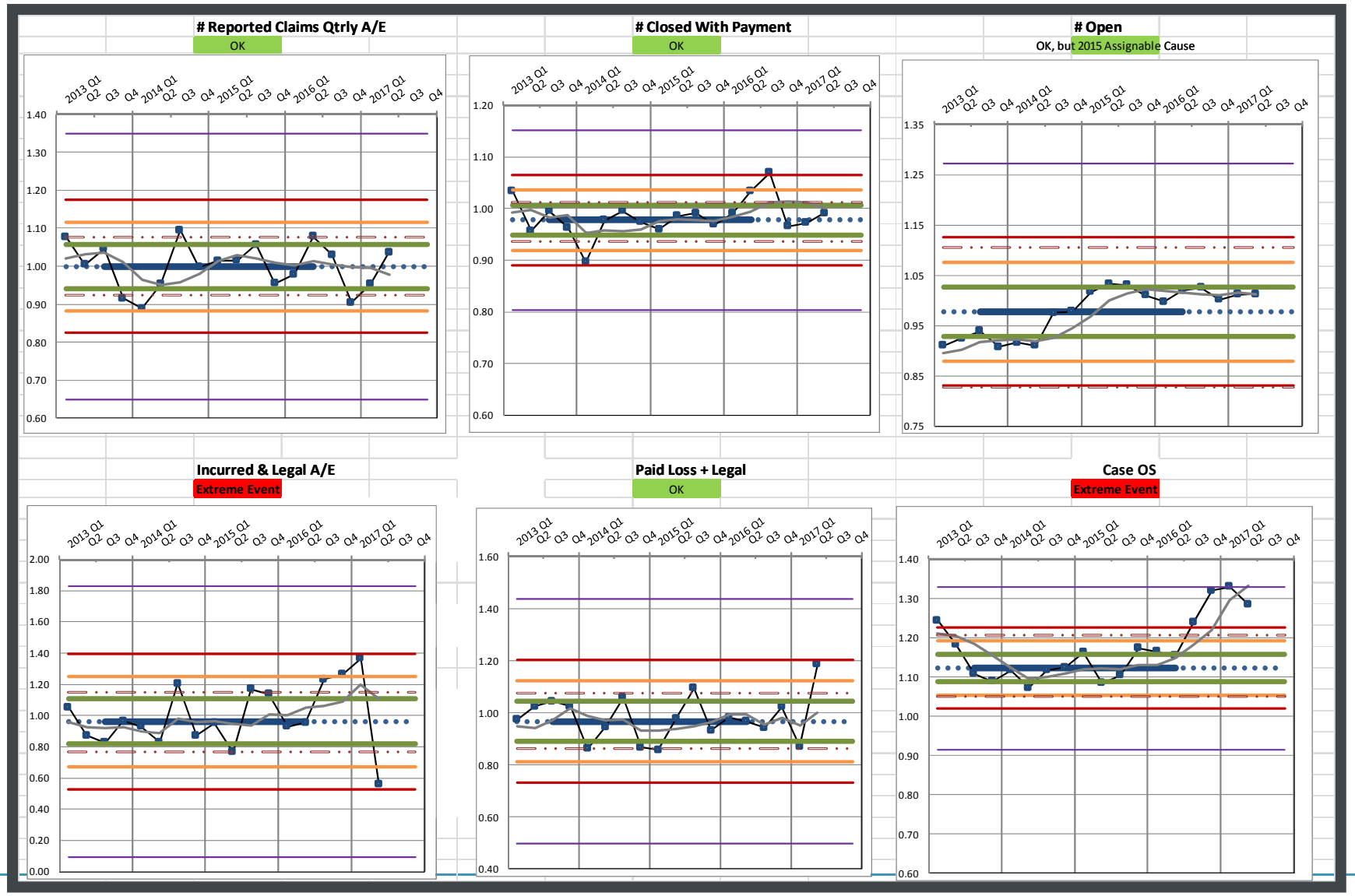
Range Chart: Increasing Volatility



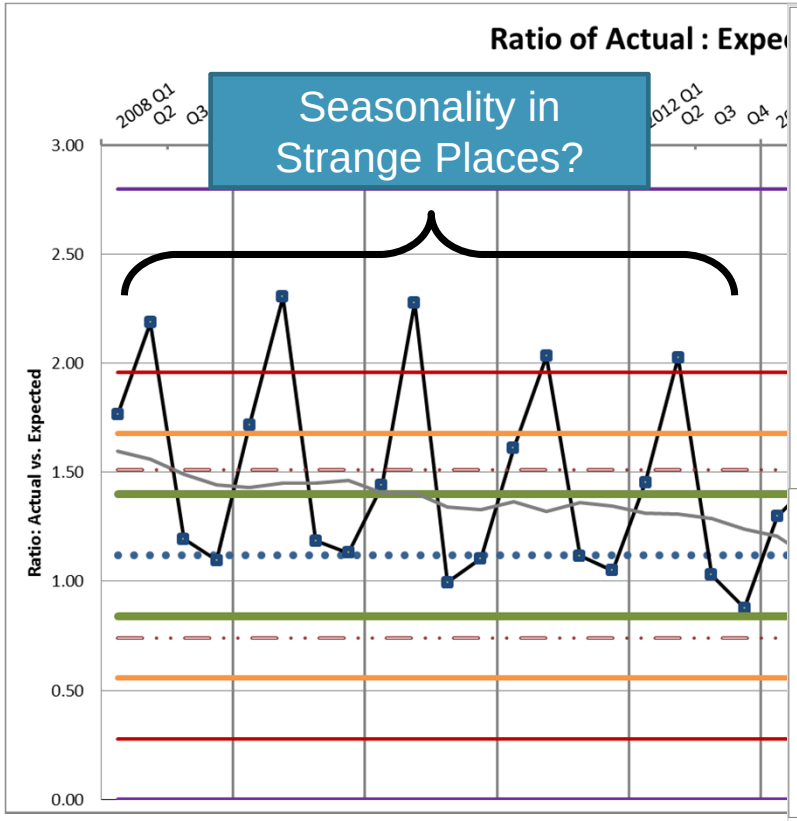
Looking at Things in Sequence

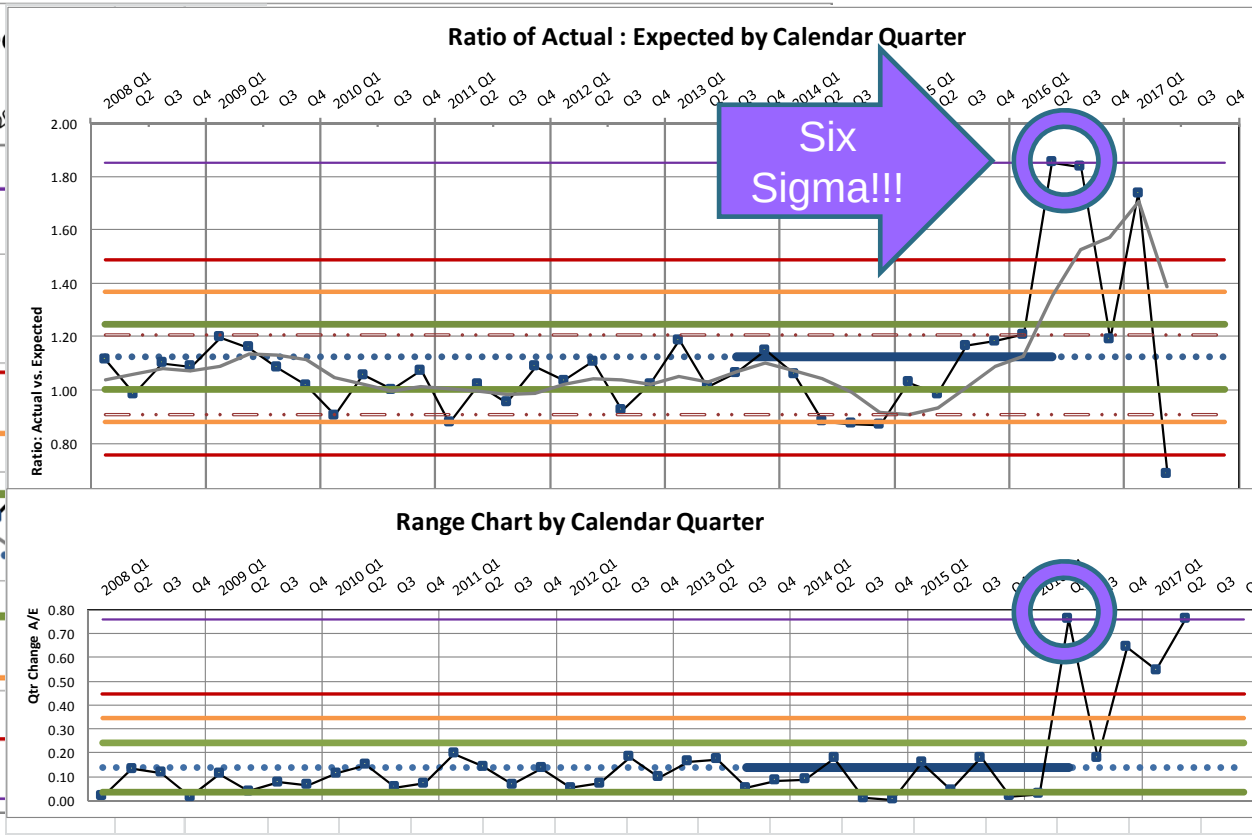


Storyboard View



Strange Things in Normal Data

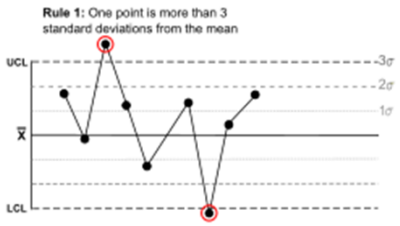
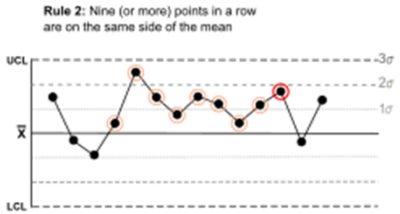
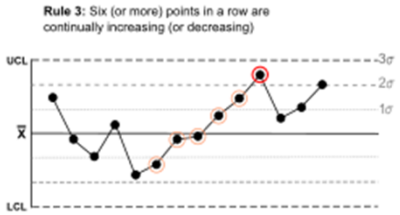


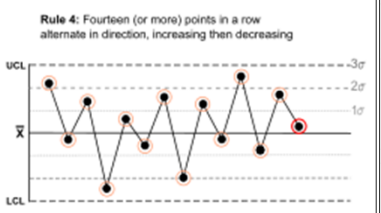
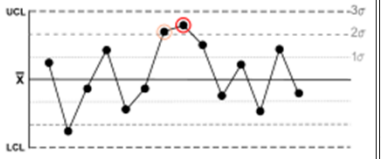
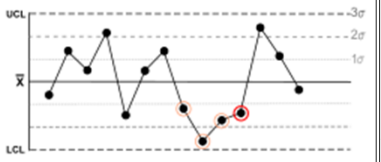


LDF Interpolation Needs a Rethink

For Practical Reasons Cap at +/- 6 Sigma

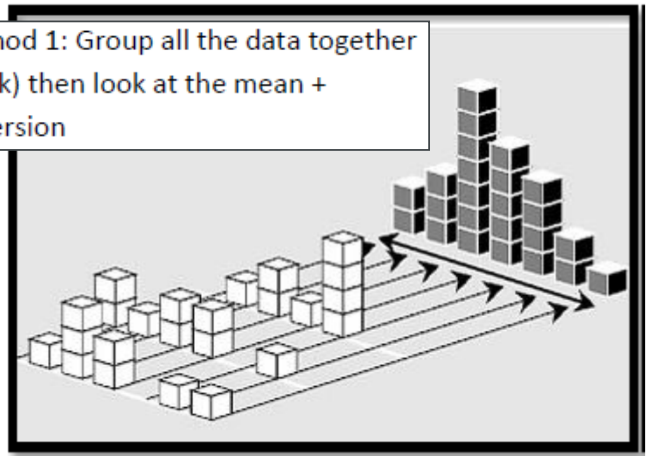
Nelson's Rules (https://en.wikipedia.org/wiki/Nelson_rules)

Rule	Description	Chart Example	Problem Indicated
Rule 1	One point is more than 3 standard deviations from the mean.		One sample (two shown in this case) is grossly out of control.
Rule 2	Nine (or more) points in a row are on the same side of the mean.		Some prolonged bias exists.
Rule 3	Six (or more) points in a row are continually increasing (or decreasing).		A trend exists.

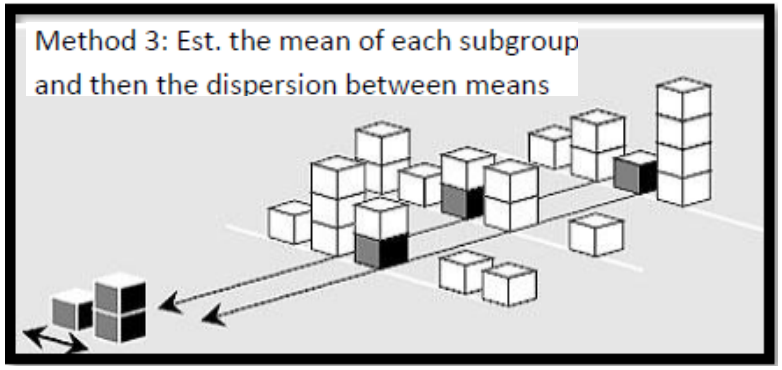
Rule	Description	Chart Example	Problem Indicated
Rule 4	Fourteen (or more) points in a row alternate in direction, increasing then decreasing.		This much oscillation is beyond noise. Note that the rule is concerned with directionality only. The position of the mean and the size of the standard deviation have no bearing.
Rule 5	Two (or three) out of three points in a row are more than 2 standard deviations from the mean in the same direction.		There is a medium tendency for samples to be mediumly out of control. The side of the mean for the third point is unspecified.
Rule 6	Four (or five) out of five points in a row are more than 1 standard deviation from the mean in the same direction.		There is a strong tendency for samples to be slightly out of control. The side of the mean for the fifth point is unspecified.

D) Statistical Philosophy –Grouping Strategy (1-3 from DJ Wheeler. Advanced Topics in Statistical Process Control. 2nd Ed 2004 SPC Press)

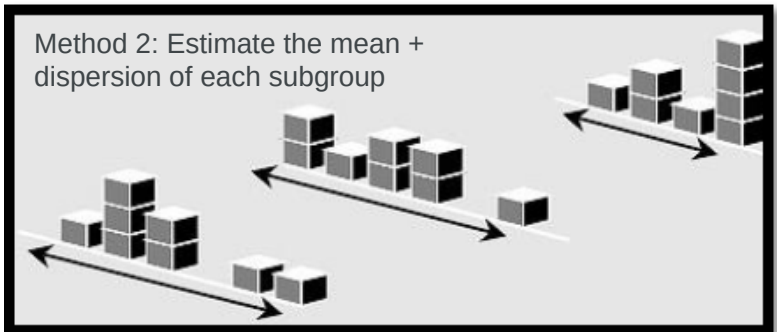
Method 1: Group all the data together (black) then look at the mean + dispersion



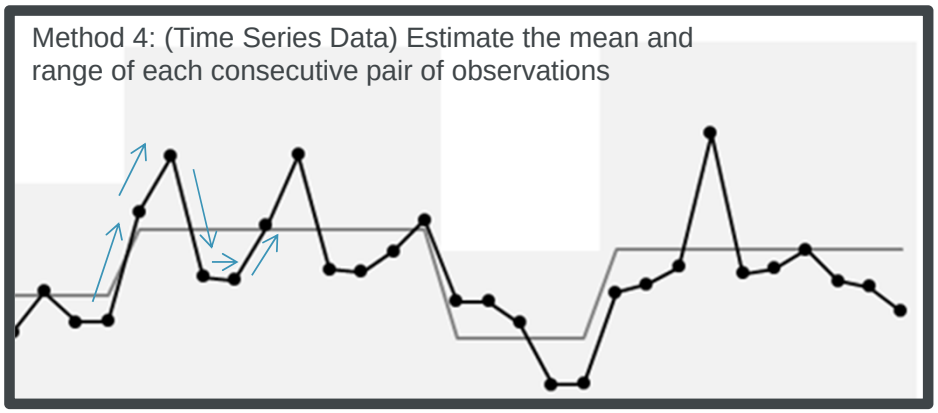
Method 3: Est. the mean of each subgroup and then the dispersion between means



Method 2: Estimate the mean + dispersion of each subgroup



Method 4: (Time Series Data) Estimate the mean and range of each consecutive pair of observations



Statistical Philosophy –Variability Estimation

(Wheeler)

We have many SD(X) computational choices once we decide how to group:

1. Mean or Median
2. Range or Root Mean Square
3. Biased or Unbiased

And we can look at the variability of SD(X) with similar choice

	Estimators for $SD(X)$		Estimators for $V(X)$	
Name of Estimator	**Biased**	**Unbiased**	**Biased**	**Unbiased**
Average Range	$\frac{\bar{R}}{d_2^*}$	$\frac{\bar{R}}{d_2}$	$\left(\frac{\bar{R}}{d_2}\right)^2$	$\left(\frac{\bar{R}}{d_2^*}\right)^2$
Median Range	----	$\frac{\tilde{R}}{d_4}$	$\left(\frac{\tilde{R}}{d_4}\right)^2$	----
Average Moving Range	$\frac{\bar{R}}{1.414}$	$\frac{\bar{R}}{1.128}$	$\left(\frac{\bar{R}}{1.128}\right)^2$	$\left(\frac{\bar{R}}{1.414}\right)^2$
Median Moving Range	----	$\frac{\tilde{R}}{0.954}$	$\left(\frac{\tilde{R}}{0.954}\right)^2$	----
Average Root Mean Square Dev.	$\bar{s}_n$	$\frac{\bar{s}_n}{c_2}$	$(\bar{s}_n)^2$	----
Median Root Mean Square Dev.	$\tilde{s}_n$	$\frac{\tilde{s}_n}{c_1}$	$(\tilde{s}_n)^2$	----
Average Standard Deviation	$\bar{s}$	$\frac{\bar{s}}{c_4}$	$(\bar{s})^2$	----
Median Standard Deviation	$\tilde{s}$	$\frac{\tilde{s}}{c_6}$	$(\tilde{s})^2$	----
Pooled Variance	$\sqrt{\bar{s^2}}$	$\frac{\sqrt{\bar{s^2}}}{c_4'}$	----	$\bar{s^2}$

Statistical Philosophy
–Choosing The Best of Many Options

Why use Root Mean Square vs. Range; Mean vs. Median; Biased vs. Unbiased?

- Root Mean Square Emphasizes Extreme Points
- Range Tends To Give Tighter Confidence Interval Bands –Useful For Detection
- Median Is A Bit Less Sensitive To Signal, But Has Much More Efficient Algorithms
- Bias Corrections Add Conservatism Not Accuracy
- **Rational Subgrouping Is More Important Than The Subgroup Size!!!**

–Unhappy Moments?

- Need Orders of Magnitude More Data to Estimate
- Not Generally Useful for Signal Detection
- Better When Philosophy Driven?

E) Use Cases

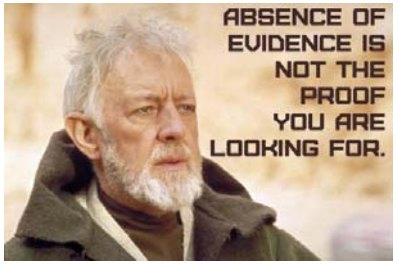
Hypothesis A:

Everything is better when we stick together side by side

Does the Chain Make Sense?

- Reported through Closed and Remaining Open
- Count and Amount
- Different Aggregations:
  - Overall,
  - Newer Claims;
  - In the Tail

Hypothesis B: There is Evidence of Change



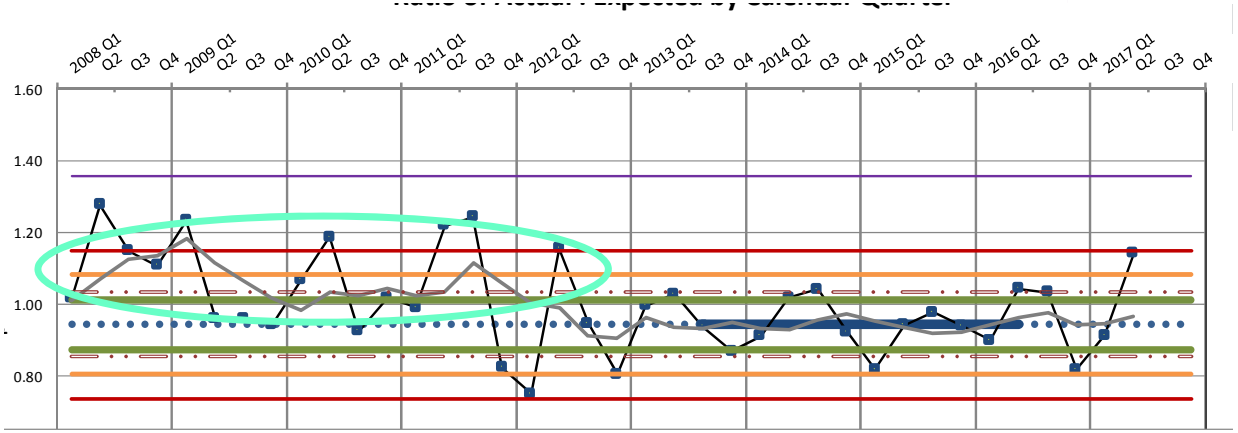
- Where Would You Look For Evidence First?
- What Else Should Move In The Same/Opposite Direction?
- Look At Triangles in Different Dimensions:
  - Accident Year
  - Report Year
  - Closing Year
  - Runoff Year
  - Hybrid (AY by Report Lag; RY by AY Lag;
- Deep Dive Data

History Lesson

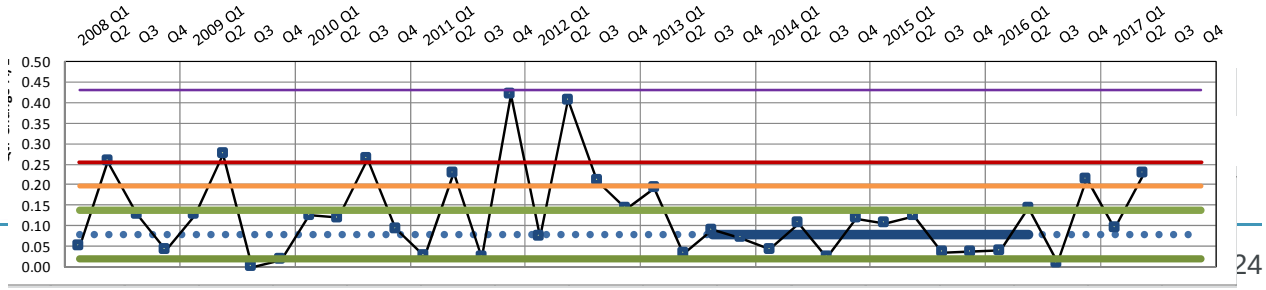
- How did you get where you are now?
- What does that tell you about where you might soon go?
- How can you take advantage of that?

- Statistical Variation is Only

  a Small Part of the Story



- We need to Build in for
  - Stationarity Shifts Somehow
  - And Volatility Changes



F) Philosophy in Action and Extension

- Some Live Examples
- Research Opportunities
  - Better Capital Modelling
  - World of Calendar Period Statistics + Automatically Screened
  - Better Communication of Uncertainty
  - Structural Drivers
- Actuarial Opportunities
  - Value Focus
  - Myth Debunking
  - Heuristic Refinement
  - Self Serve/Automatic Monitoring For Our Clients
  - Variance Reduction

Wrap-Up: Agile Actuarial Thinking

- We have Professional skills and an understanding of how insurance works.
- We carry this as mental models.
- We translate these into logic using heuristic models (which correspond to those mental models) where math and statistics can go play.
- If our heuristic models or mental models are wrong, we get poor answers
- We are agile if Control Charts/ Diagnostics help us quickly generate good questions and adjust our heuristic and underlying mental models.

Questions

Comments