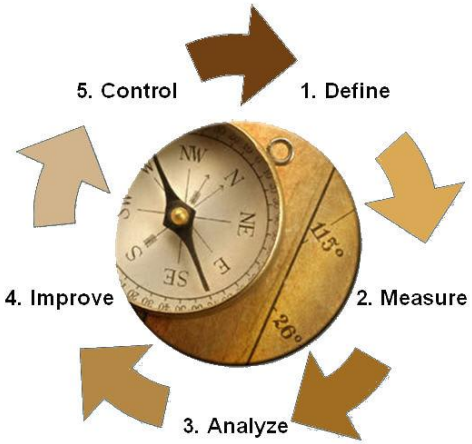

Application of Statistical Process Control to Demand Management Process

Charles Novak, CPIM

charles.novak@jaguar-aps.com

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Some of our clients….

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fgf brands
WALMARK
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Hanes
DORMA
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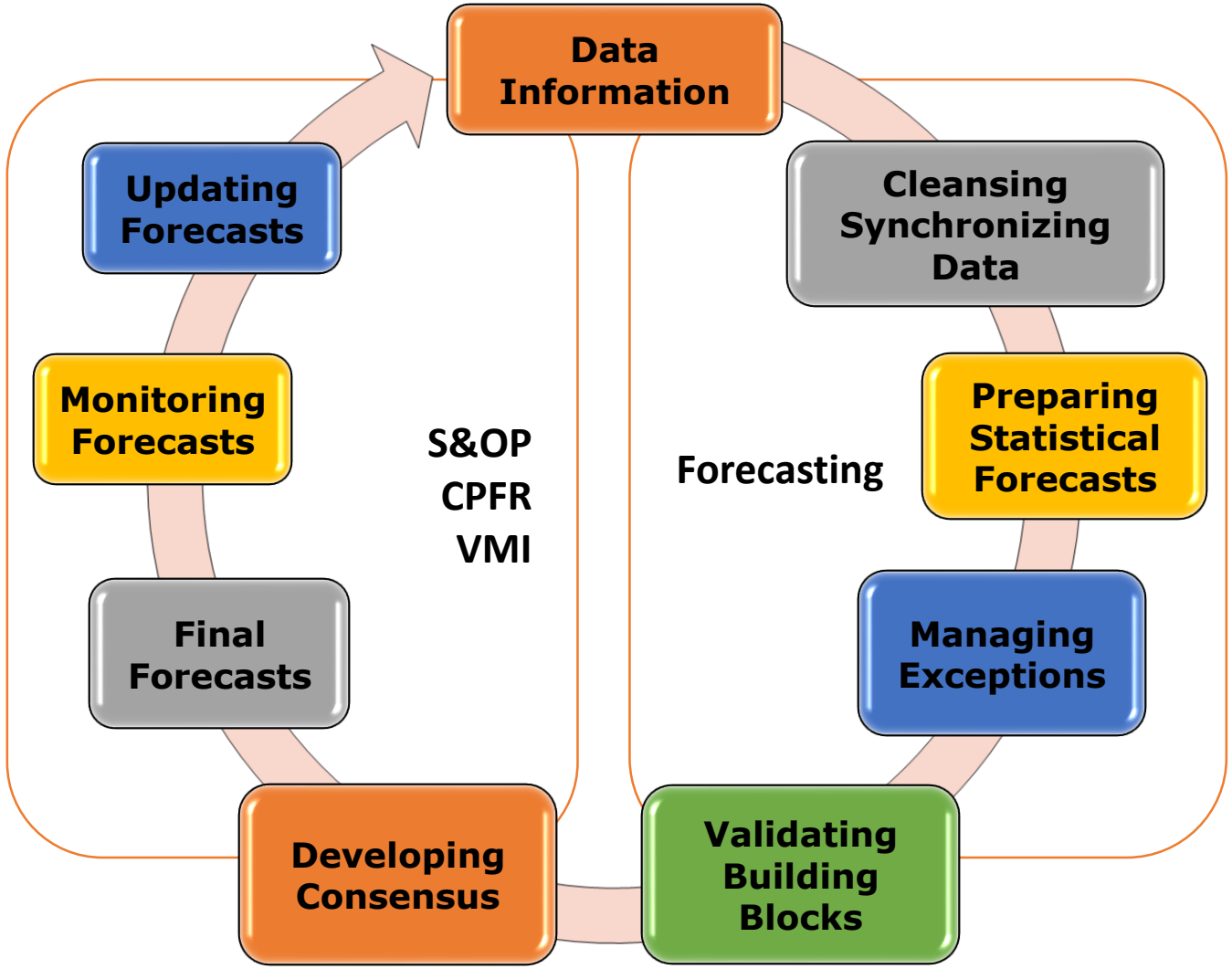
Agenda

- Forecast Process and Data
- Statistical Process Control (SPC)
- Overview
  - Attributes
  - Variables
  - Normal Distribution
- Application of SPC in Demand Forecasting
  - History
  - Forecast
  - Forecast Error
- Q&A

Forecast Process Design Factors



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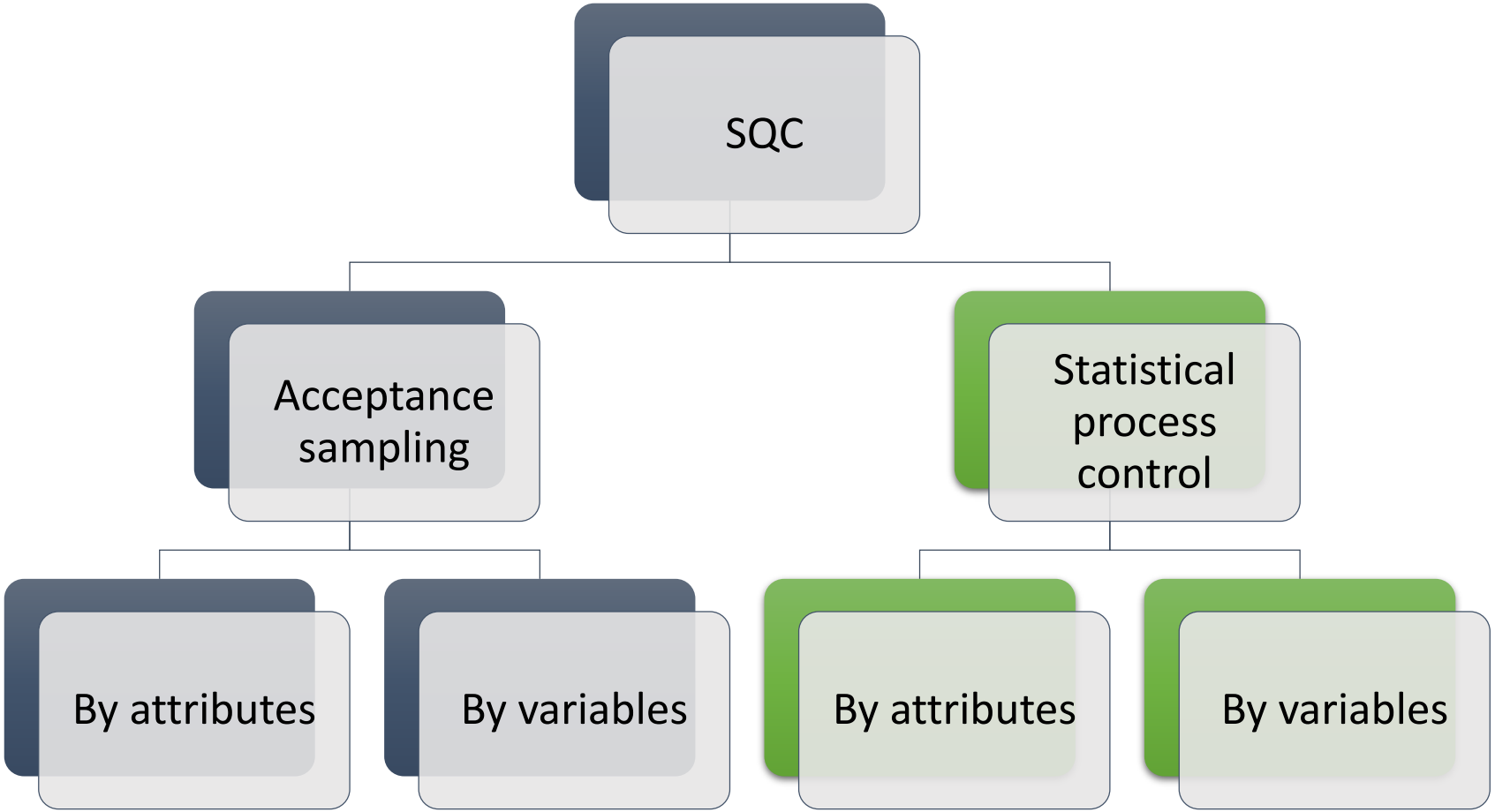
When Does the Data Need to Be Cleansed?

- Setting up a new forecasting software/system
  - Clean history stripped of variances and data segmentation based on attributes
- Monthly forecasting process
  - Validation of latest actual sales/demand and correction of recent issues, market/economy shifts
  - Validation of latest statistical forecasts and model adjustments where needed (i.e. trend or seasonal component adjustments)
- Setting up [meaningful] forecast error targets
  - Validation of error distribution from previous year
  - Application of Normal Distribution Curve to isolate explainable issues
  - Adjustments for past and future unusual activities

Statistical Quality Control (SQC)



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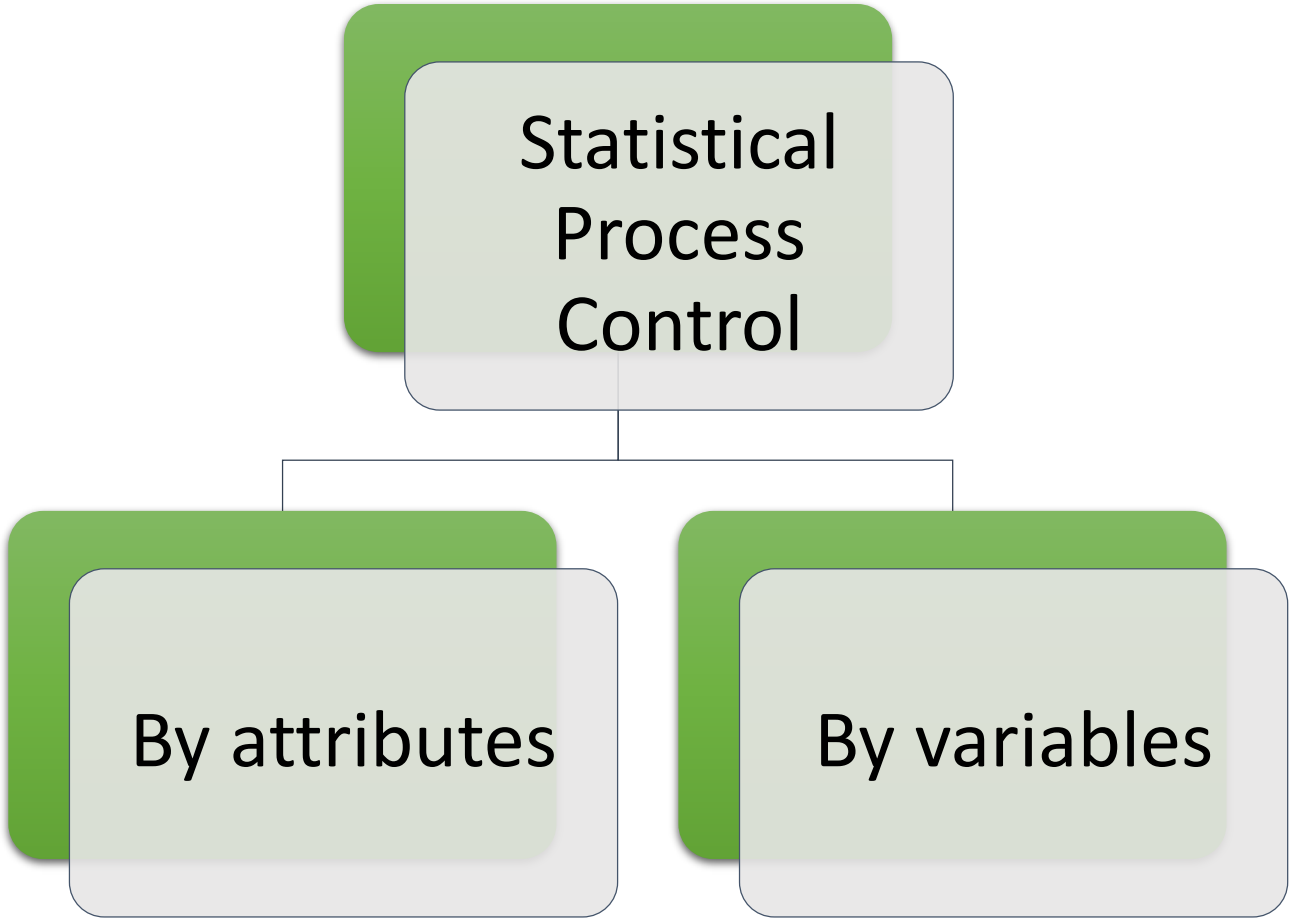
Statistical Process Control



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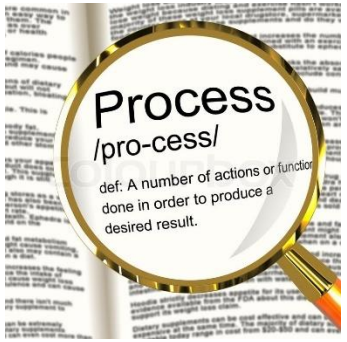
Process Definitions



Statistical Process Control

… the application of statistical methods to the measurement and analysis of variations in a process.

… a technique that prevents defects from occurring while a product is being produced.

… instead of inspecting product dimensions at the point of delivery, responsibility for quality moves to an upstream [manufacturing] process.

… SPC informs customer that the supplier is monitoring and controlling key [manufacturing] processes.

… it is a first step to a long-term process of continuous improvement.

SPC in Forecasting

… the application of statistical methods to the measurement and analysis of variations in data.

… a technique that prevents future forecasts to be driven by problematic past.

… instead of trying to understand what happened after the fact, the accountability for final company results move to an upstream process (S&OP).

… good forecasting provides information and guidance to the whole business.

… it is a part of business process continuous improvement initiatives.

What is the Difference?

Statistical Process Control (SPC)

- **SPC is based on six ideas:**

1. Quality is conformance to specifications.
2. Processes cause products to vary.
3. Variation in processes and products can be measured.
4. Common cause variation produces measurements that follow a predictable pattern.
5. Special cause variation disrupts the predictable pattern.
6. Causes of variation can be isolated and identified.

Data Management and Forecasting

- **Forecasting …**

1. Quality starts with clean data … GIGO.
2. Demand variability causes data streams to vary (Bullwhip Effect, pushes, etc.).
3. Variation in data can be measured.
4. Common cause variation produces measurements that follow a predictable pattern.
5. Special cause variation disrupts the predictable pattern.
6. Causes of variation can be isolated and identified.

Objectives

SPC

- Process of creating a product and making sure the process does not produce defective parts.
- Achieved by examining attributes and variable data.
  - **Attributes data** – a measurement made when the characteristics being measured can take only certain specific values, such as color or condition
  - **Variable data** – a measurement made in cases where the characteristics being measured can take on any value

Forecasting

- Process of creating a demand plan that the company as a whole acts on until next updates are available.
- Achieved by examining attributes and variable data.
  - **Attributes data** – specific values: Level, Trend, Seasonality, Moving Holidays, Promotions, Competitive Activity, etc.
  - **Variable data** – any value: Out-of-Stock, Trend Intervention, Irregularly Scheduled Promotion, Competitive Activity, Economics, Financial Pushes, etc.

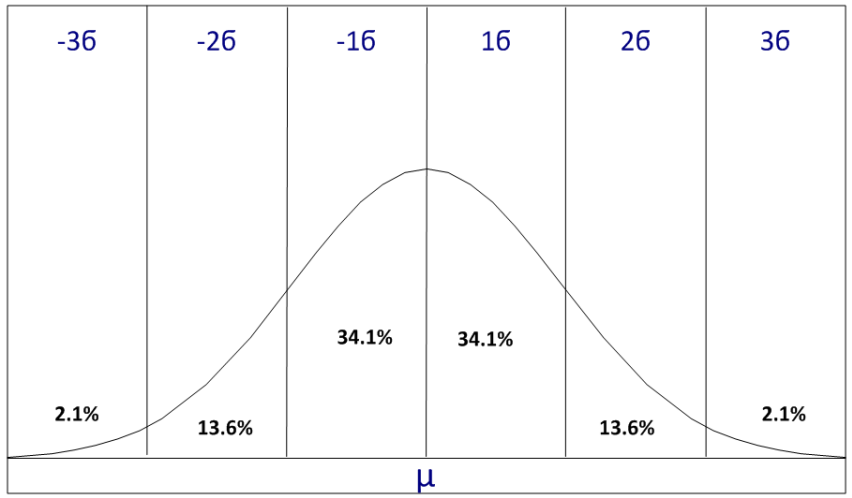
Normal Distribution

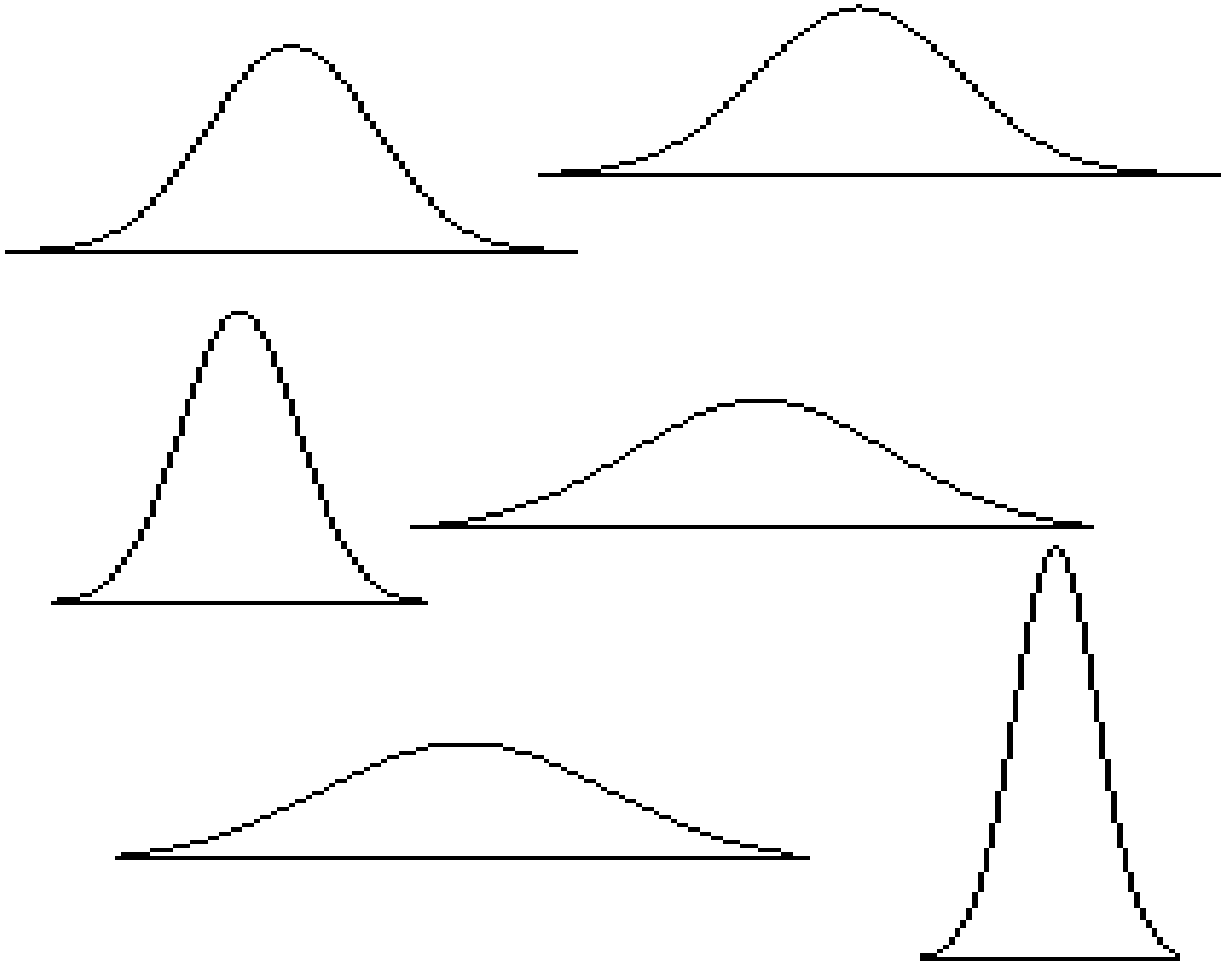
Family of distributions that have the same general shape (Bell Curve).

Symmetric with scores more concentrated in the middle that in the tails.

Normal distributions differ in how spread out they are. The area under each curve is the same.

Used in control charts to identify outliers





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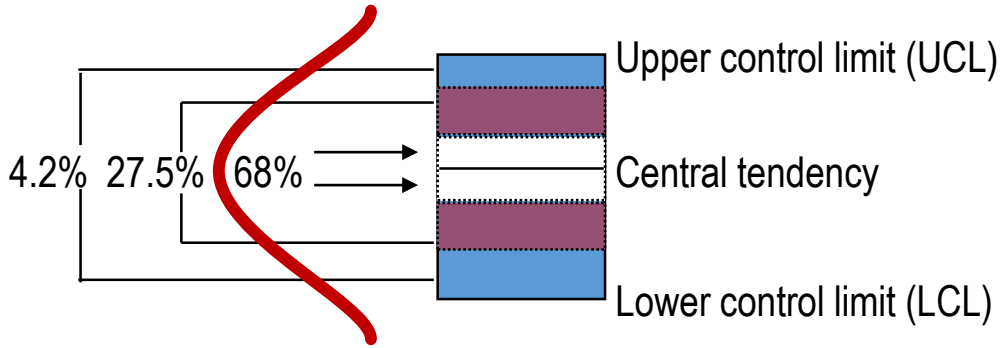
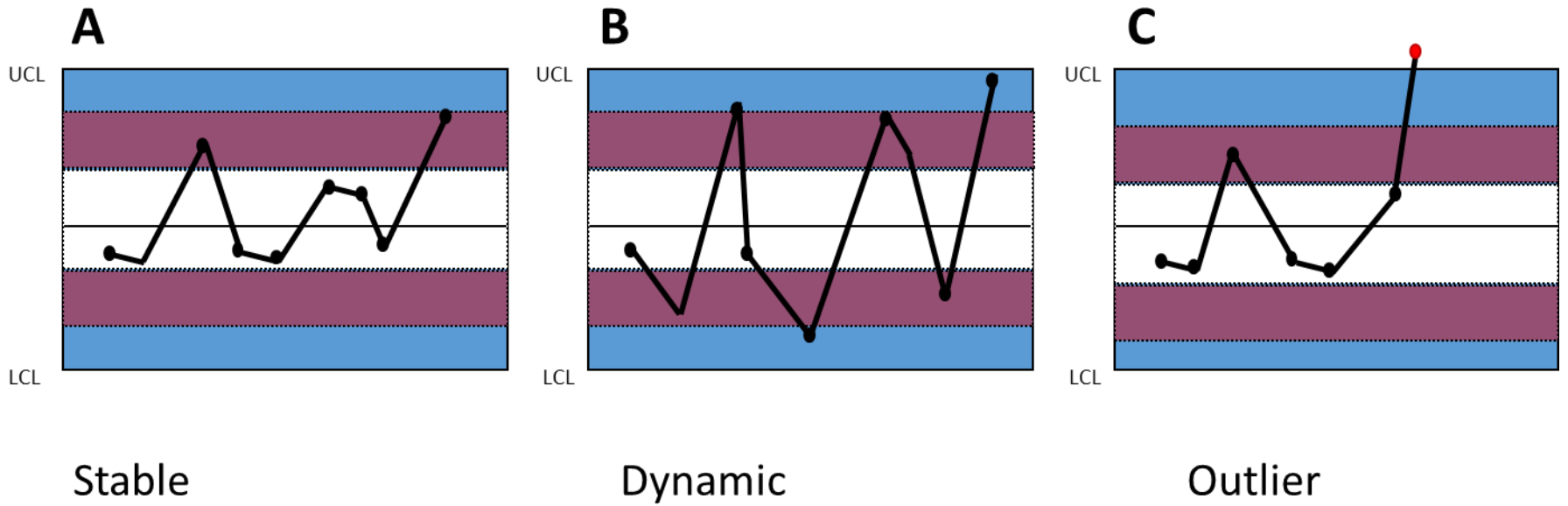
Interpreting SPC Control / Outlier Charts

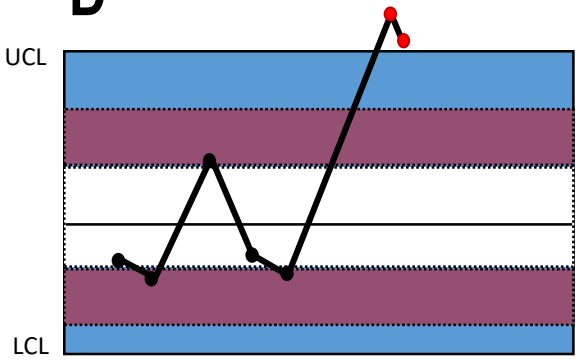
If the data is normally distributed, the dots representing period sales/orders should fall within the shaded regions with the frequencies shown.





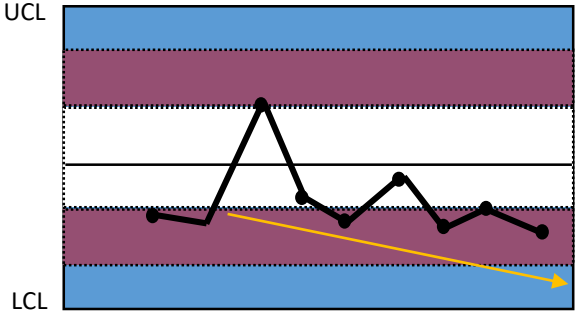
Interpreting SPC Control / Outlier Charts

D



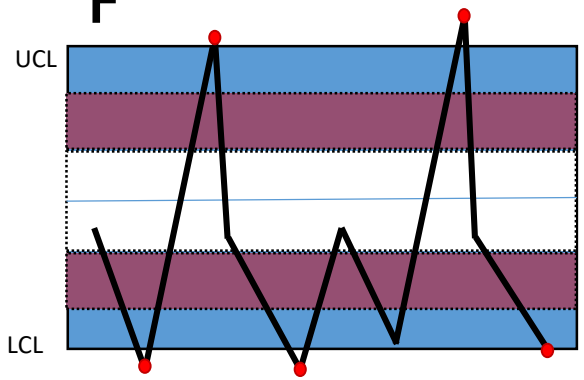
Outlier. Two consecutive samples are out outside of UCL

E



A downward trend is detected. Look for the cause of this "drift."

F



Seasonal pattern will often have peaks and valleys outside UCL and LCL.
Choose tighter limits to detect INLIERS – not normally distributed data within limits.

Bad Data

Weather impacted	Restated
Marketing impacted	Too much
Rapidly changing	Too little, too late
Intermittent	Wrong
Seasonal	Misaligned year-over-year
Financial push	Aggregated at the wrong level
Volatile	Incomplete
Short or no history	Missing
Extremes	Duplicate
Days in the month	Negative

Source: Trend Savants

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Events Can Be Different

Source: Trend Savants

One Time

- Transportation
  - Rail
  - Strikes
  - Earth
- Co
- We
- Marketing
  - Promotions

Get rid of it!

Treat it as missing

OR Build it into your model

Recurring

- Calendar
  - Easter
  - Chi
  - R
  - Business holidays
- Regional activity
- Marketing activity
  - Special pricing
  - Advertising
  - Promotions

Build it into your model

Sustained

- Strategic
  - R
  - Re
  - Acquisition
- Tech
- 9/1
- Product awareness campaigns
- Cor
- Price

Model that adapt

Restart the series

Save seasonality

Three Big Mistakes Forecasters Do

1. Expecting to roll poor forecast up into a good forecast

2. Tying forecast inputs to the general ledger or key reports

3. Incorporating irrelevant data or information

Source: Trend Savants

Seven Guiding Principles

Accept that data do not have to be perfect. Data only needs to predict the future.
Use the right amount of data.
Separate volatile data and associate risk with the volatility.
Recognize that definition used for corporate reporting may not be suitable for forecasting.
Identify which data are useful. Value observed evidence over judgement.
Make sure the data you use and the forecasts you create address the real problem/goal.
If you can measure it, you can improve it.

Source: Trend Savants

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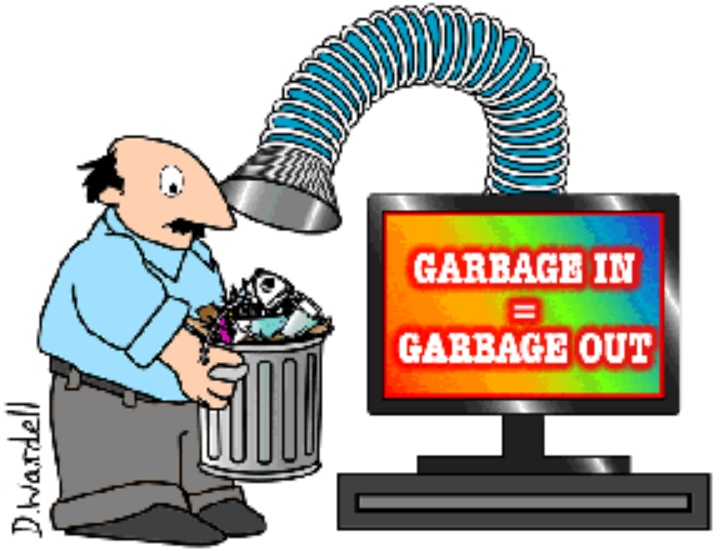
[Forecast]
Data Attributes and Variables



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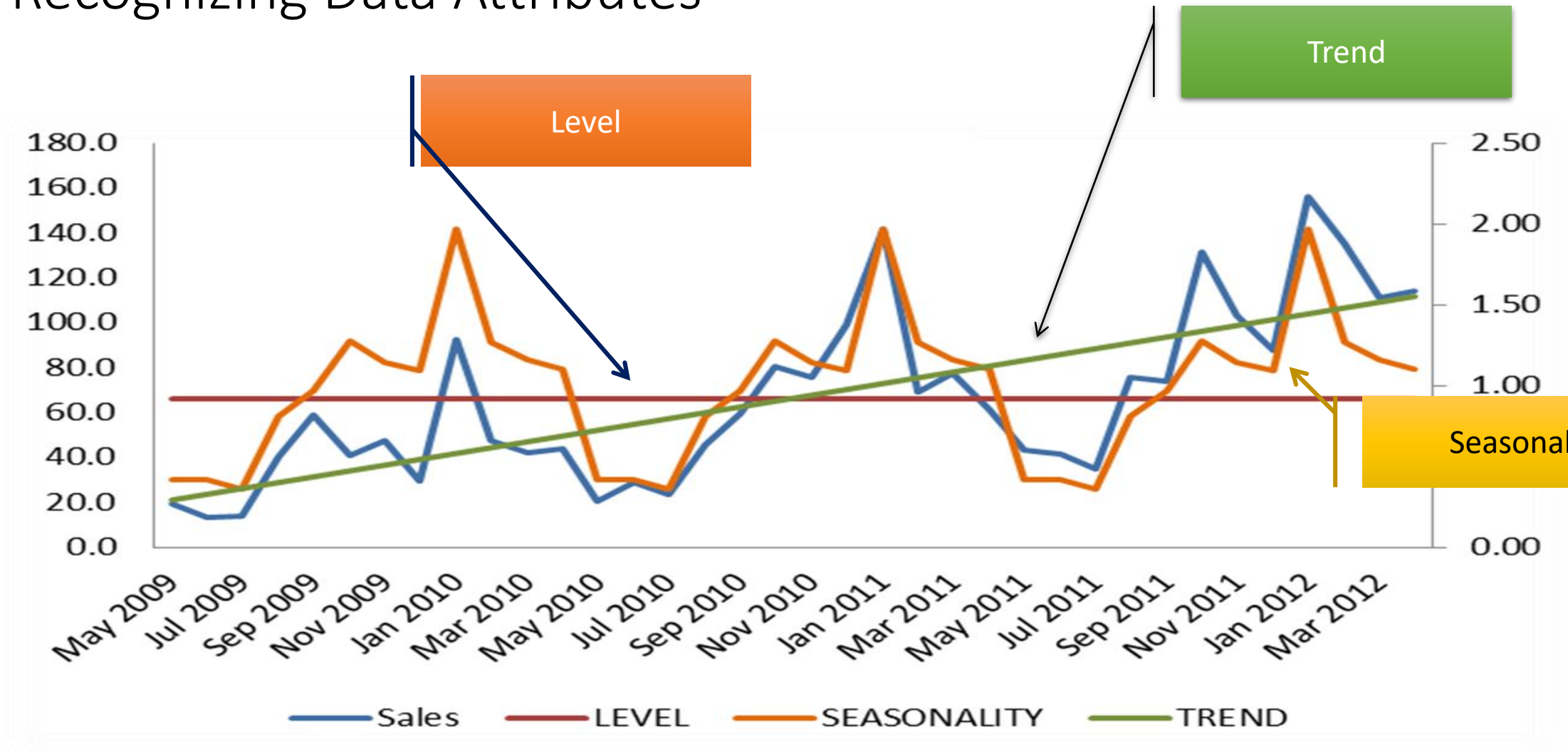
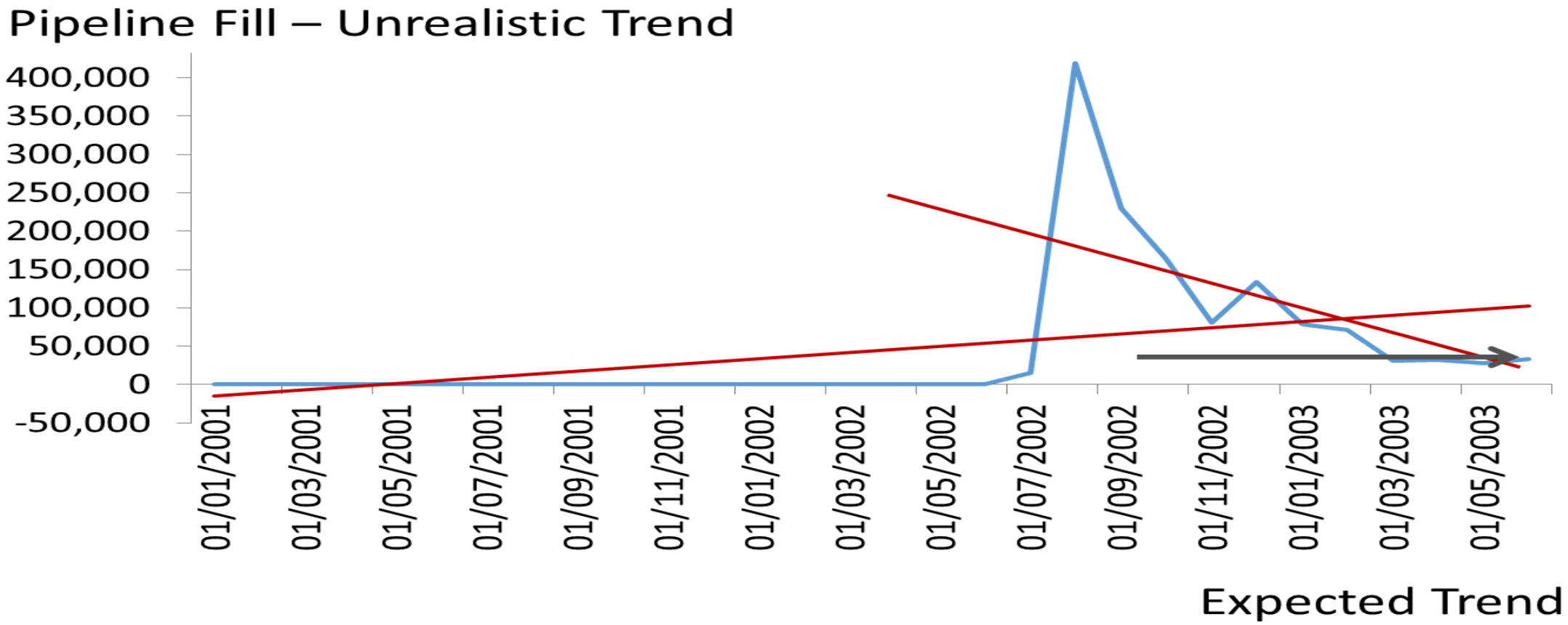
Recognizing Data Attributes

Recognizing Data Attributes

Recognizing Data Attributes



Recognizing Data Variables



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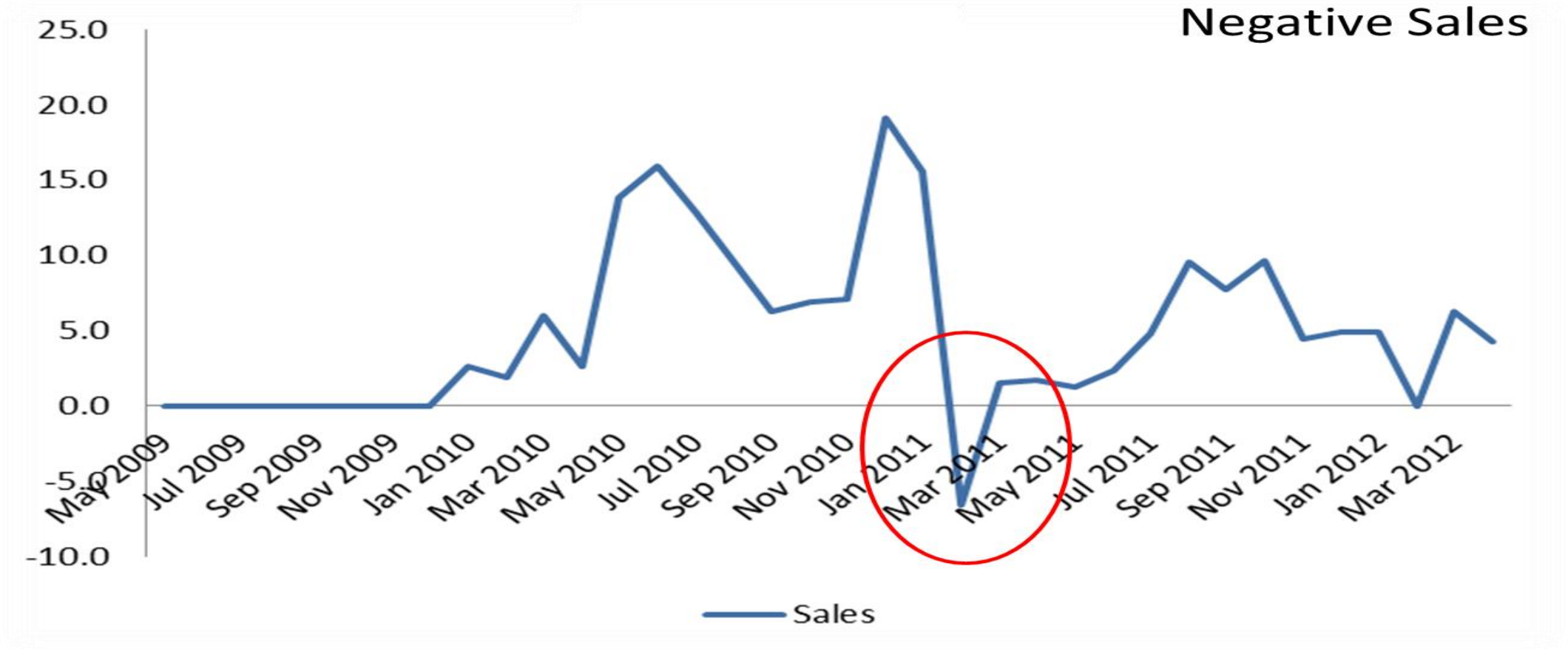

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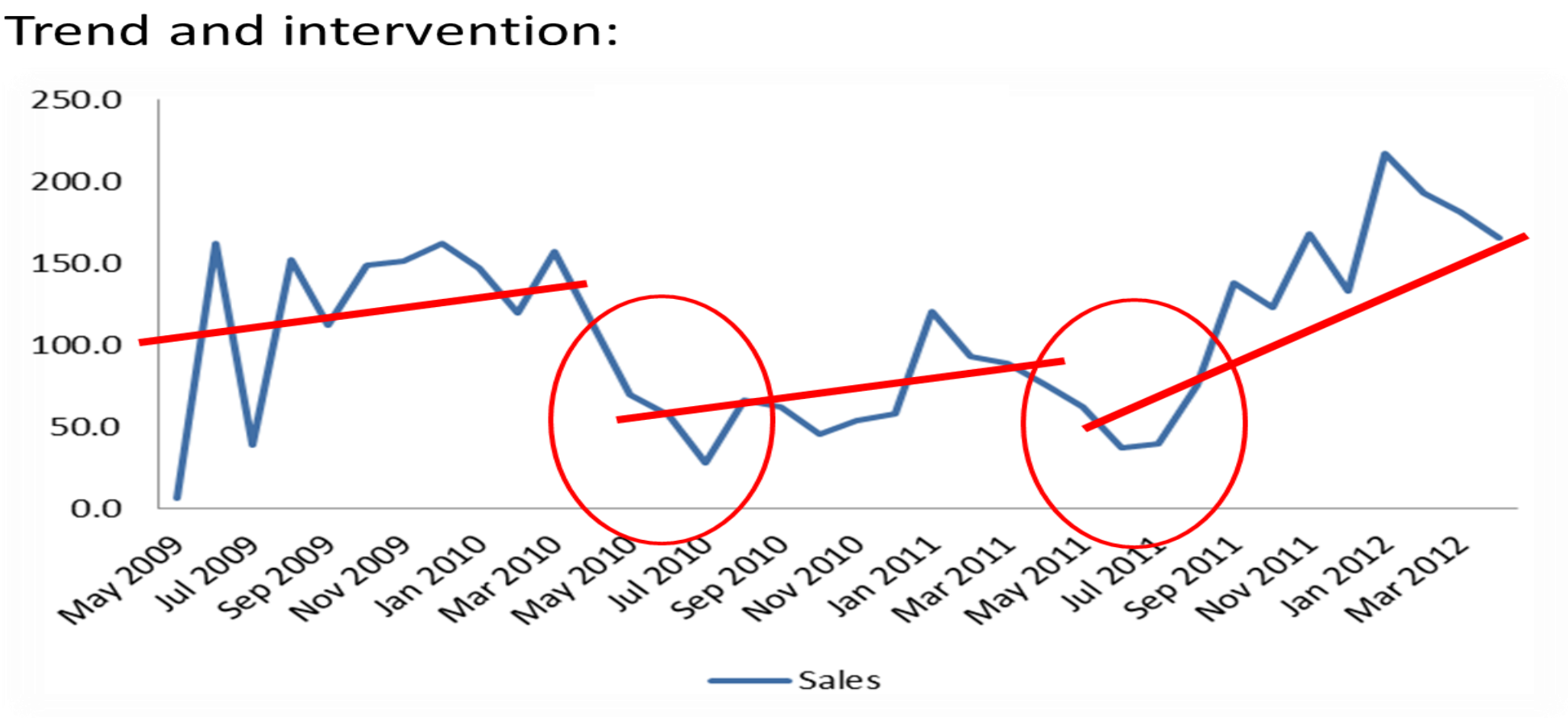

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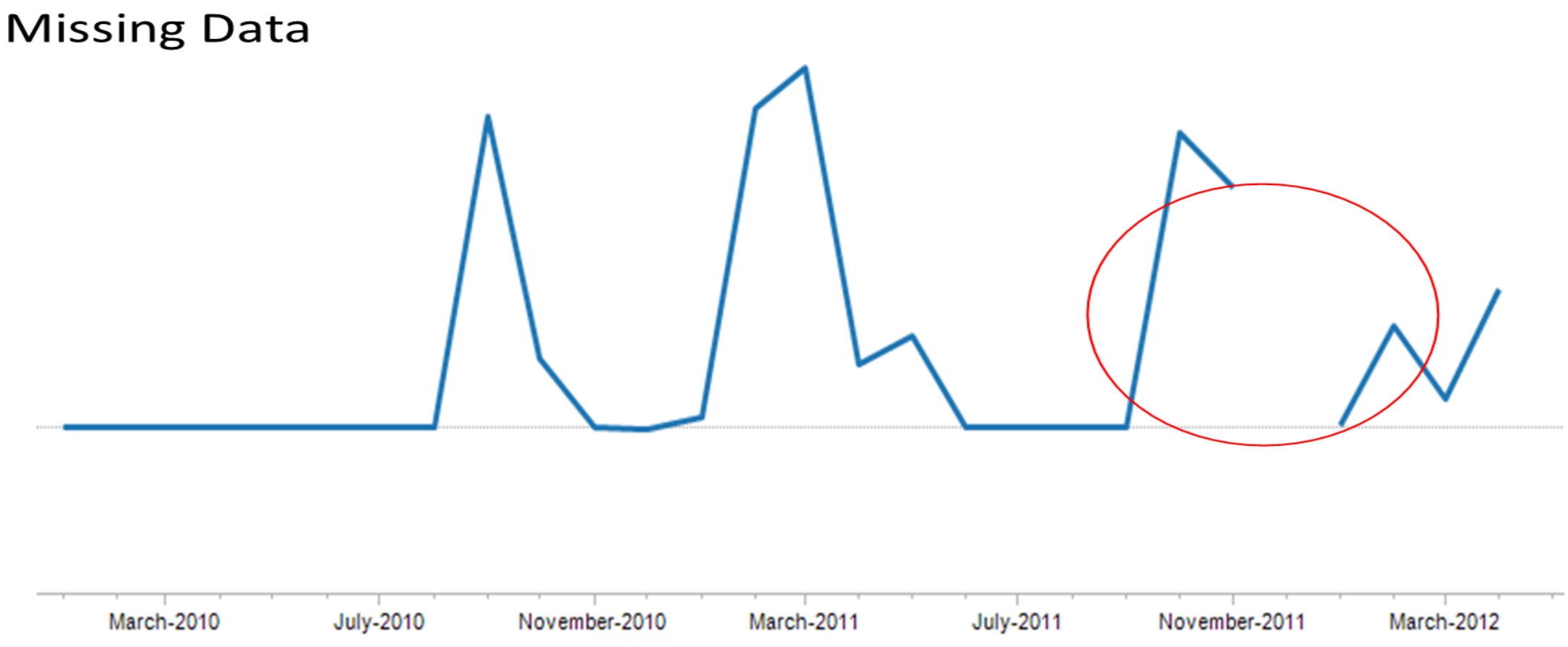

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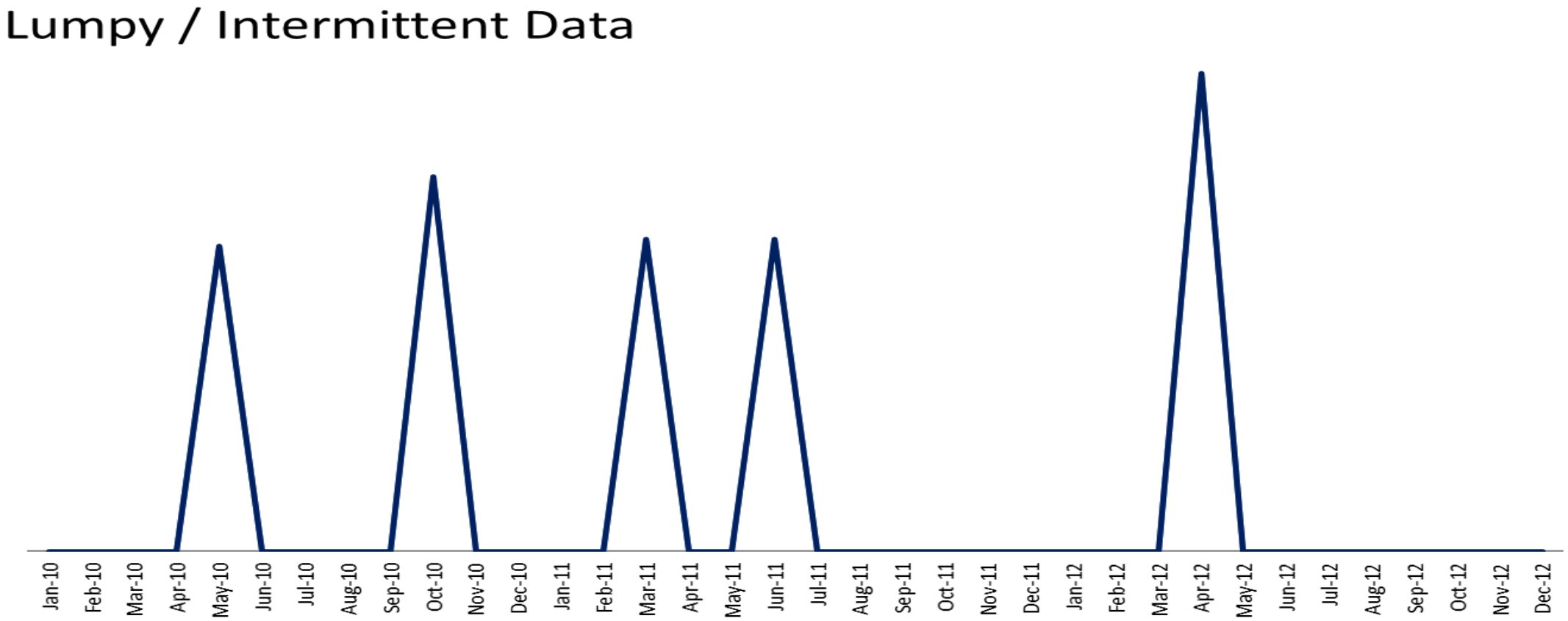

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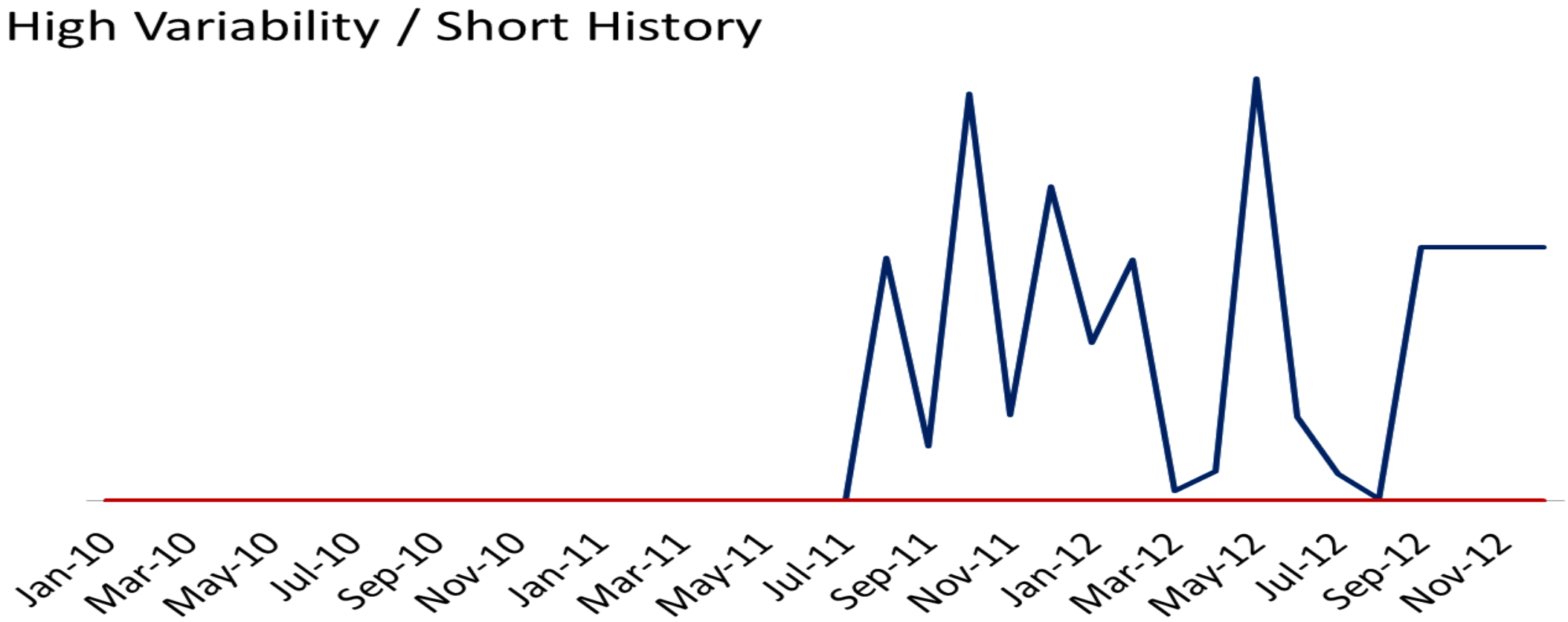

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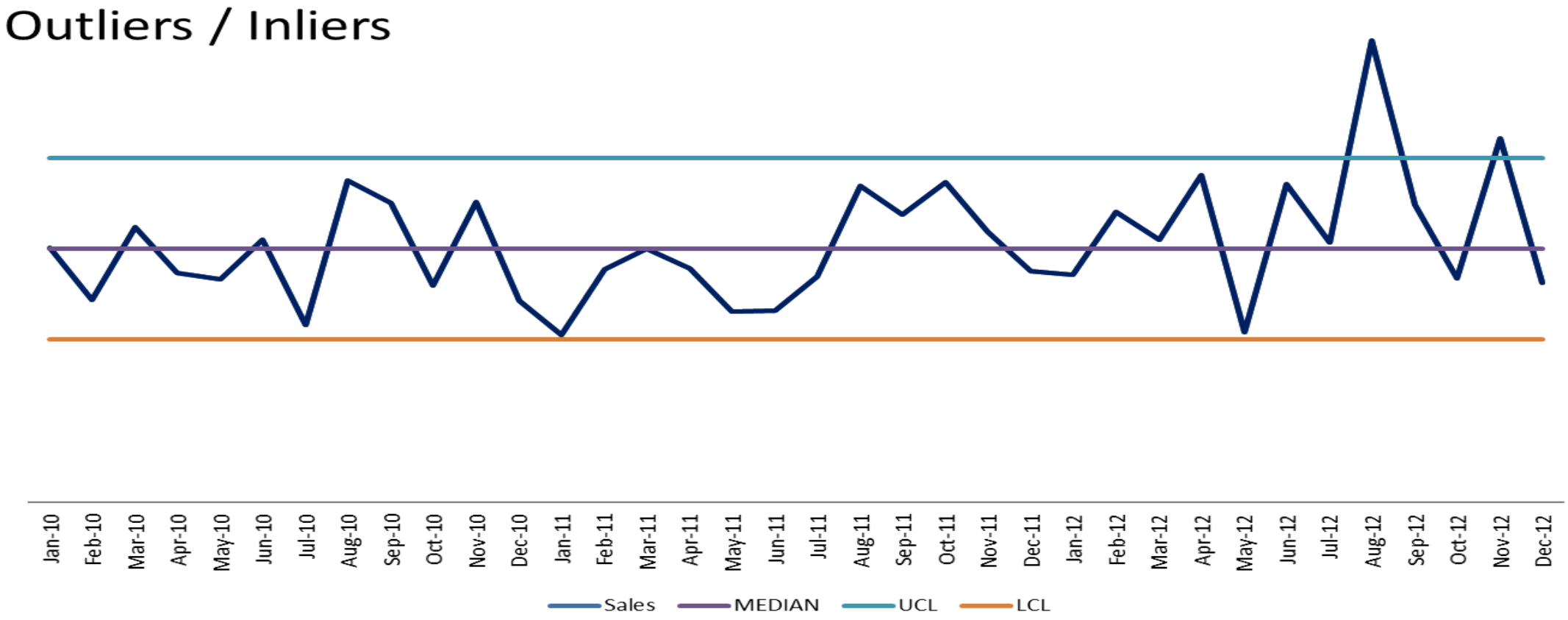

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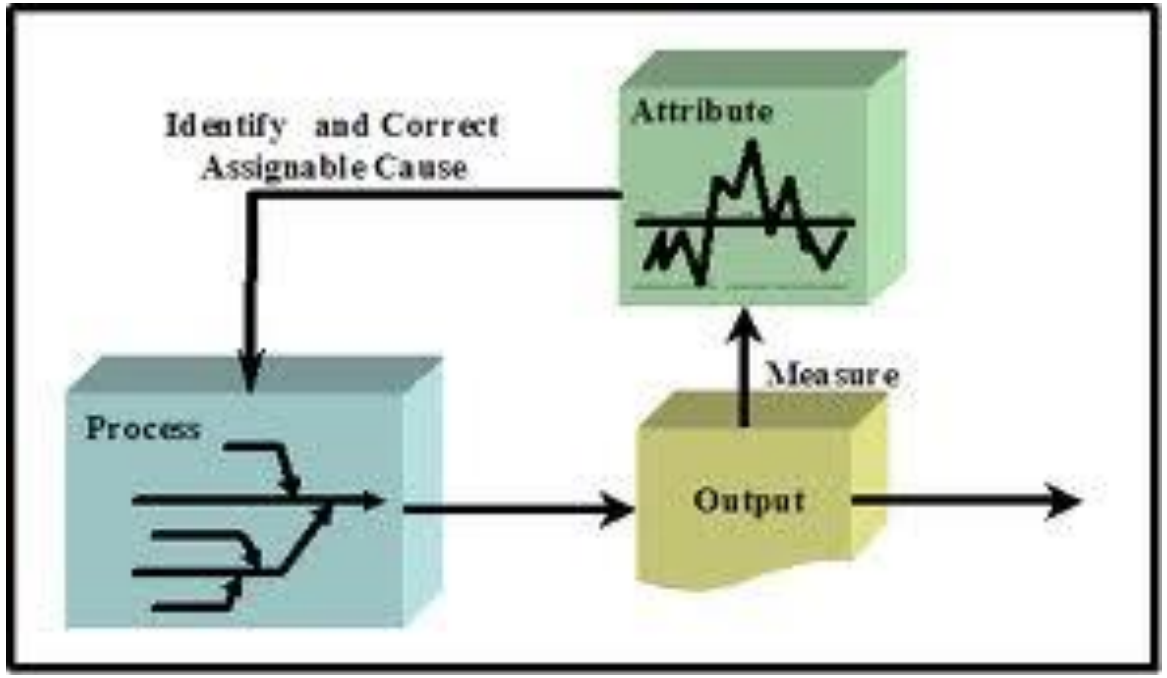
SPC in Action



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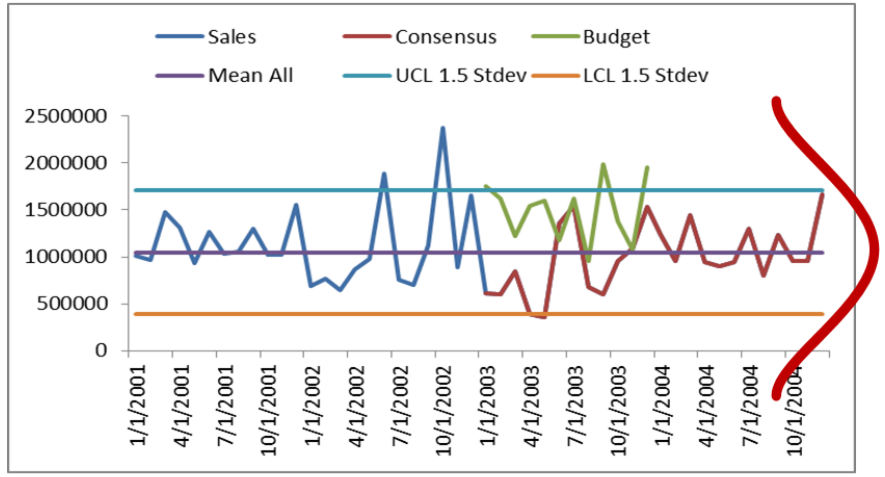
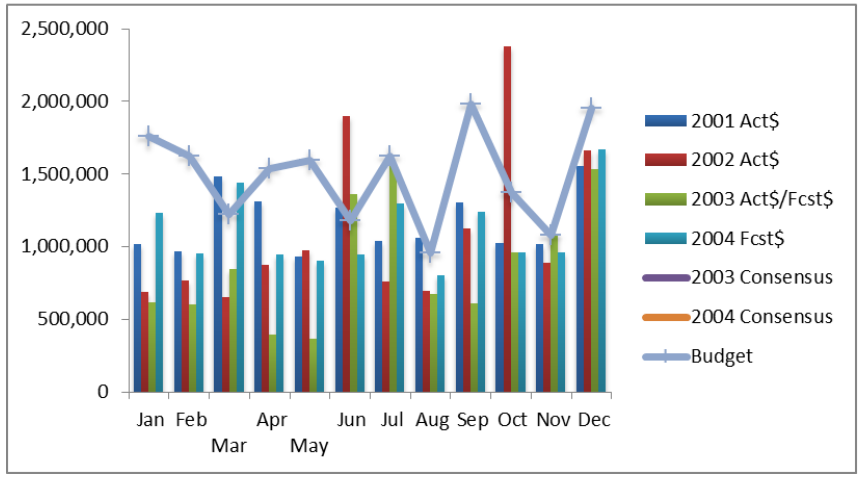
Data Patterns

Year	2001	2002	2003	2003	2004	2004	2003
Type	Act$	Act$	Act$/Fcst$	Consensus	Fcst$	Consensus	Budget
Jan	1,016,248	688,596	617,283		1,231,152		1,757,142
Feb	966,865	766,446	602,750		950,984		1,623,203
Mar	1,481,853	648,596	847,051		1,439,245		1,225,868
Apr	1,306,460	872,160	391,643		943,672		1,541,599
May	932,225	973,835	362,336		901,445		1,595,019
Jun	1,263,743	1,893,099	1,359,610		943,668		1,180,014
Jul	1,034,062	756,173	1,549,700		1,297,940		1,624,785
Aug	1,056,382	697,192	674,853		797,941		960,231
Sep	1,302,315	1,123,005	605,022		1,236,824		1,984,361
Oct	1,020,060	2,377,383	959,899		958,369		1,372,795
Nov	1,017,760	888,744	1,086,717		958,370		1,077,998
Dec	1,554,614	1,657,032	1,528,386		1,669,997		1,956,904
Q1	3,464,966	2,103,638	2,067,084	2,067,084	3,621,381	3,621,381	4,606,213
Q2	3,502,428	3,739,094	2,113,589	2,113,589	2,788,785	2,788,785	4,316,632
Q3	3,392,759	2,576,370	2,829,575	2,829,575	3,332,705	3,332,705	4,569,377
Q4	3,592,434	4,923,159	3,575,002	3,575,002	3,586,736	3,586,736	4,407,697
TOTAL	13,952,587	13,342,261	10,585,250	10,585,250	13,329,607	13,329,607	17,899,919





Is this product seasonal?

Is this product trended?

Is this product stable or dynamic?

Are there any issues we need to correct?

Are there any changes in data that we need to build in the forecast?

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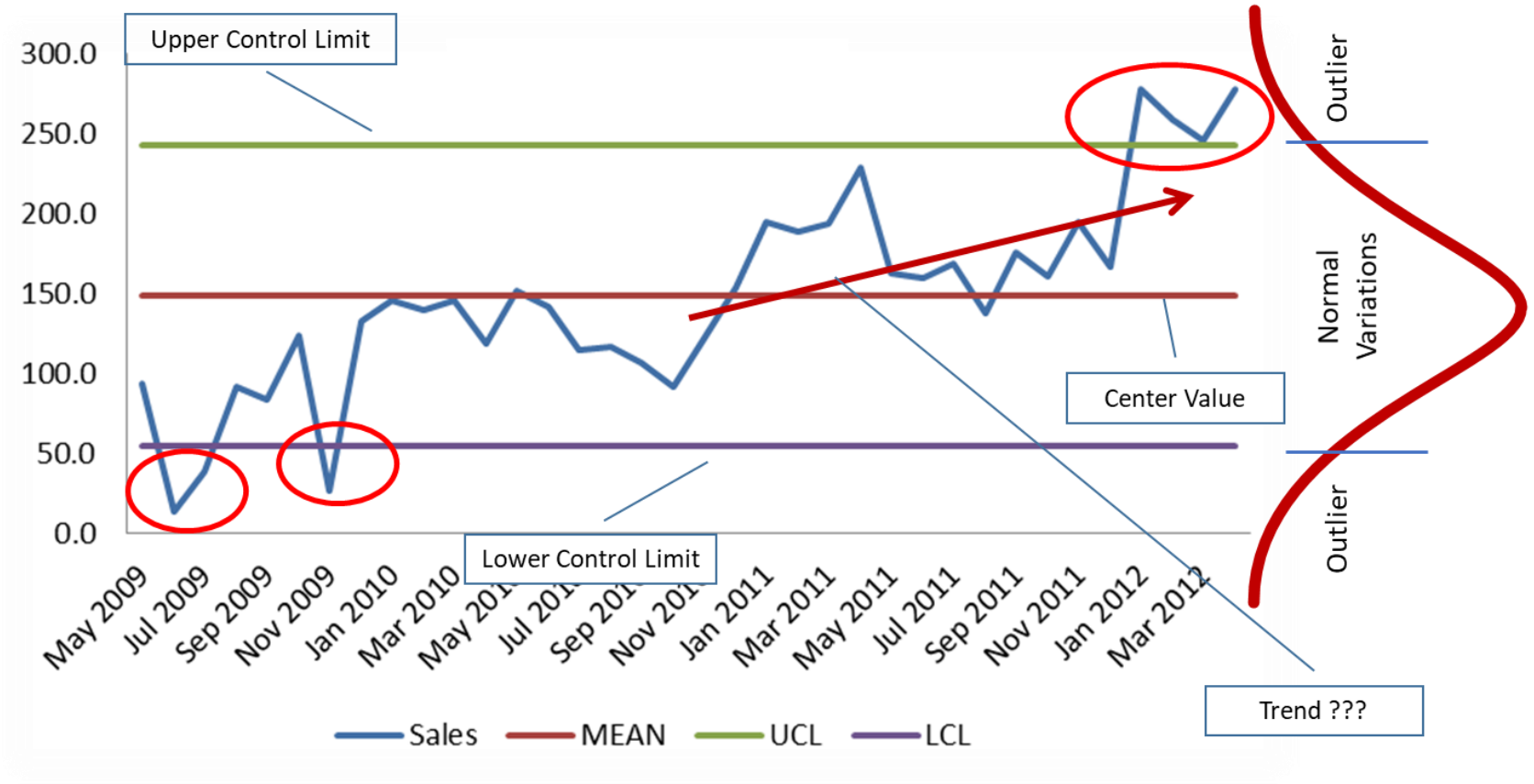
SPC Control Chart: Identifying Patterns & Variables



Center value and UCL/LCL definitions: There is a difference between Mean and Median, 1σ and 3 σ, … ***Rule of thumb – start with Mean 18 Months and 1.5 σ***

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Forecast Error and SPC

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Period End Forecast Error Reporting

DIVISION	(All)
CATEGORY	(All)
BRAND	NTT GUM
SUB-BRAND	(All)
PROMOTED GROUP	(All)

Data

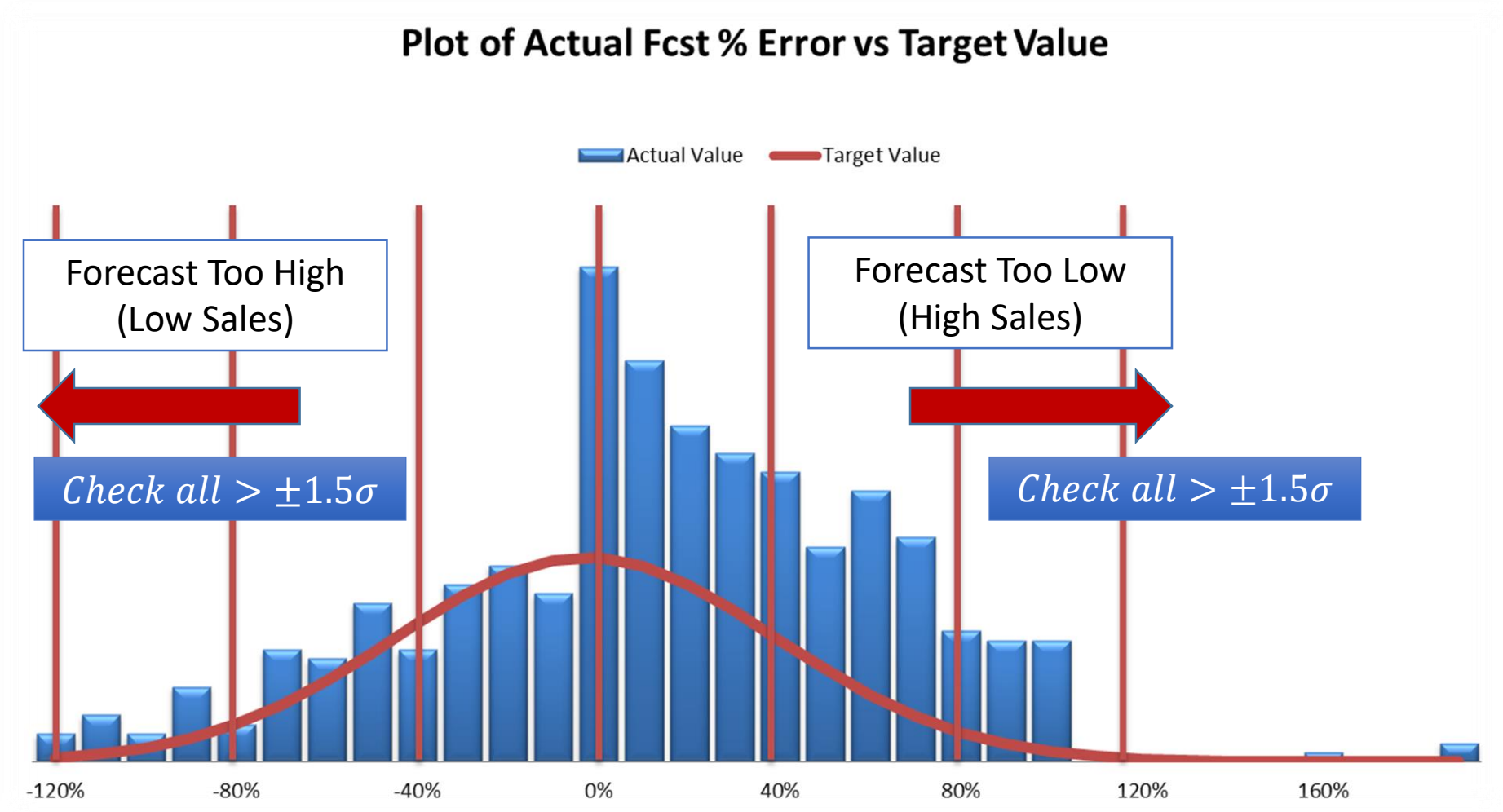
PLANNER	TYPE	SKU2	ACT 08 P7	FCST 200807	Bias 08 P7	Bias L3	Bias YTD	%Bias 08 P7	%Bias L3	%Bias YTD	%Bias L12	ABS 08 P7	ABS L3	ABS YTD	ABS L12	ABS%ERROR 08 P7	ABS%ERROR L3	ABS%ERROR YTD	ABS%ERROR L12	MAPE L12	TS1	TS2	TS3	TS4	WEIGHTED TS	WEIGHTED BIAS	DMD VAR	STDEV
PETER	BASE	36706	0	0	0	-1	-1	0%	100%	100%	100%	0	1	1	1	0%	0%	0%	0%	0%	0.000	-1.000	-1.000	-1.000	0.000	0%	-346%	0
		36744	941	1200	-259	-7	295	-28%	0%	4%	18%	259	1051	2025	5190	28%	29%	26%	30%	29%	0.769	0.577	0.488	0.234	0.398	2%	36%	510
		36747	0	0	0	0	-8	0%	0%	100%	100%	0	0	8	8	0%	0%	0%	0%	0%	-1.000	-1.000	-1.000	-1.000	-1.000	0%	-242%	2
		36748	468	522	-54	142	-449	-12%	8%	-12%	5%	54	250	937	2244	12%	14%	25%	28%	28%	0.115	0.202	-0.001	-0.228	-0.082	1%	36%	238
		36754	707	500	207	1240	733	29%	50%	13%	20%	207	1240	1955	3450	29%	50%	35%	31%	34%	0.447	0.420	0.529	0.504	0.498	34%	26%	240
		36758	326	220	106	188	-130	33%	17%	-5%	2%	106	188	506	1035	33%	17%	20%	20%	21%	-0.093	-0.306	-0.284	-0.063	-0.157	11%	30%	130
		39875	104	123	-19	-43	-27	-18%	-12%	-3%	1%	19	43	247	443	18%	12%	31%	29%	29%	0.135	0.173	-0.157	-0.119	-0.076	-9%	33%	42
		39877	235	478	-243	-145	103	-103%	-11%	3%	-2%	243	341	903	1754	103%	27%	29%	30%	34%	0.032	0.242	0.189	-0.185	-0.008	-16%	29%	144
		39879	50	99	-49	-90	-52	-98%	-47%	-9%	-17%	49	90	198	322	98%	47%	33%	32%	38%	-0.371	-0.351	-0.373	-0.469	-0.419	-38%	31%	26
		39881	162	153	9	98	83	6%	17%	7%	0%	9	98	317	549	6%	17%	27%	23%	26%	-0.211	0.041	0.149	0.028	0.042	11%	29%	56
	CLUB	36738	0	2	-2	4	3	0%	40%	17%	56%	2	8	19	47	0%	80%	106%	98%	58%	0.590	0.543	0.467	0.467	0.487	0%	101%	4
		36740	0	2	-2	-3	-24	0%	-100%	600%	-129%	2	3	24	44	0%	100%	0%	314%	67%	-0.366	-0.278	-0.533	-0.786	-0.617	0%	294%	3
		94020	0	0	0	0	0	0%	0%	0%	0%	0	0	0	0	0%	0%	0%	0%	0%	0.000	0.000	0.000	0.000	0.000	0%	346%	16
		95413	0	0	0	0	0	0%	0%	0%	300%	0	0	0	15	0%	0%	0%	0%	0%	-1.000	-1.000	-1.000	0.000	0.000	0%	-346%	1
		95421	0	0	0	0	0	0%	0%	0%	457%	0	0	0	32	0%	0%	0%	0%	0%	-1.000	-1.000	-1.000	-1.000	-1.000	0%	-346%	2
		95671	164	202	-38	-186	-407	-23%	-38%	-42%	-11%	38	186	407	824	23%	38%	42%	39%	59%	-0.075	-0.246	-0.212	-0.315	-0.253	-32%	51%	89
		95672	89	66	23	17	81	26%	7%	13%	14%	23	45	109	229	26%	19%	17%	20%	19%	0.739	0.671	0.694	0.824	0.761	12%	19%	18
	NP	39747	84	124	-40	-110	-107	-48%	-33%	-12%	-15%	40	152	437	1148	48%	46%	50%	58%	182%	-0.193	-0.291	-0.514	-0.629	-0.517	-27%	112%	184
		39748	283	377	-94	477	170	-33%	41%	7%	13%	94	665	972	1627	33%	58%	38%	30%	33%	0.254	0.364	0.441	0.226	0.307	21%	69%	312
		39749	75	98	-23	-71	-110	-31%	-28%	-18%	-12%	23	71	118	403	31%	28%	19%	29%	32%	-0.295	-0.276	-0.384	-0.969	-0.657	-23%	79%	91
		95515	0	0	0	0	0	0%	0%	0%	100%	0	0	0	54	0%	0%	0%	100%	100%	1.000	1.000	1.000	1.000	1.000	0%	346%	16
		95525	283	381	-98	-134	-230	-35%	-17%	-12%	-12%	98	142	310	761	35%	18%	16%	19%	19%	-0.538	-0.506	-0.832	-0.829	-0.769	-16%	30%	99
		95527	166	225	-59	-62	-240	-36%	-9%	-16%	-1%	59	144	336	649	36%	21%	22%	19%	20%	0.030	0.239	-0.255	-0.536	-0.318	-12%	33%	94
		95529	162	268	-106	-193	-319	-65%	-35%	-23%	-2%	106	193	347	674	65%	35%	25%	23%	23%	0.301	0.254	0.156	-0.047	0.079	-29%	40%	98
		95531	114	140	-26	-90	-317	-23%	-21%	-32%	-19%	26	90	317	516	23%	21%	32%	25%	29%	-0.723	-0.810	-1.000	-1.000	-0.953	-23%	30%	52
		95598	0	0	0	50	347	0%	100%	100%	100%	0	50	347	347	0%	100%	100%	100%	100%	1.000	1.000	1.000	1.000	1.000	0%	251%	73

Red highlights – greater than 30% error – is it all you need to know?

– is there more to look at?

– how can one get to it?

Forecast Error Distribution – Exception Management



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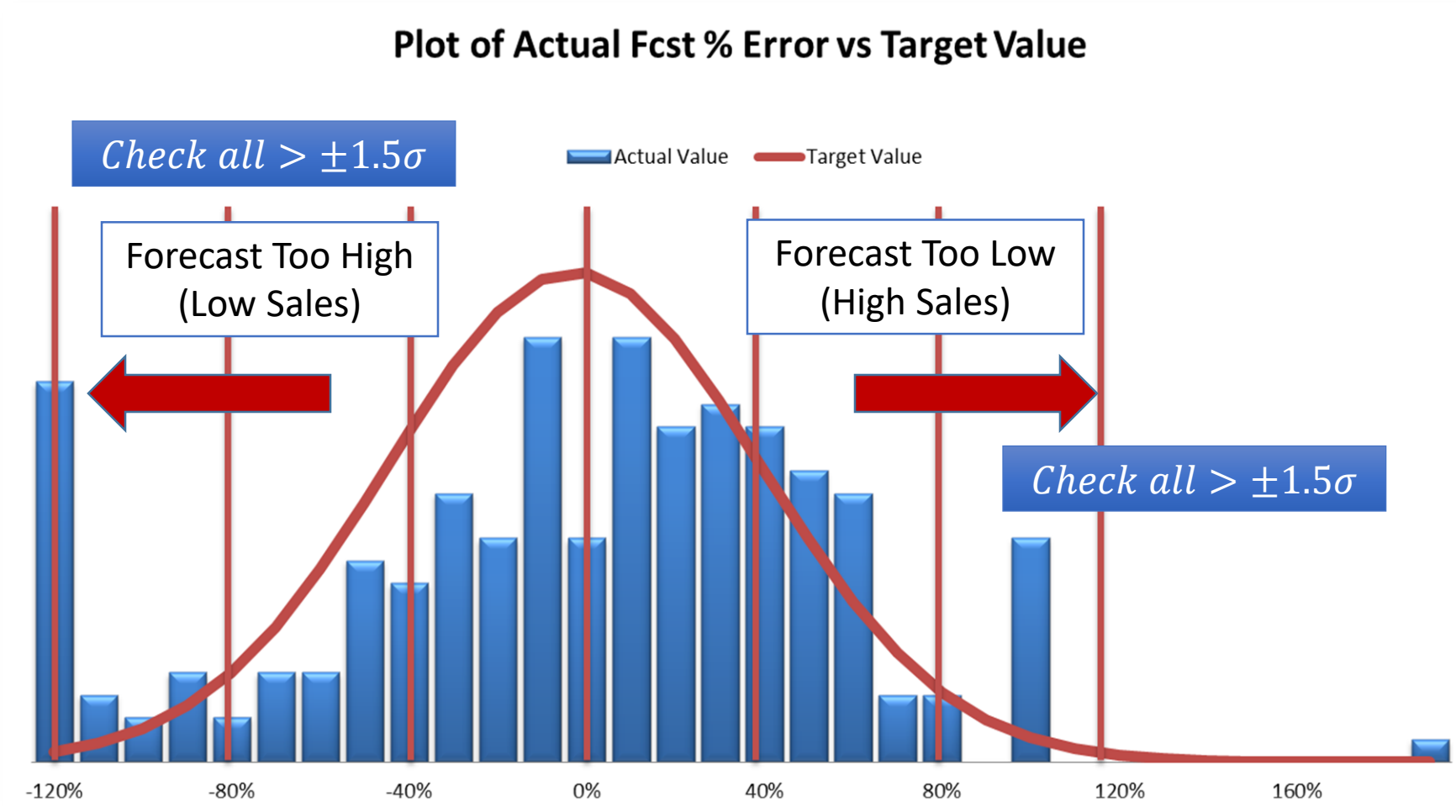
Forecast Error Distribution – Exception Management



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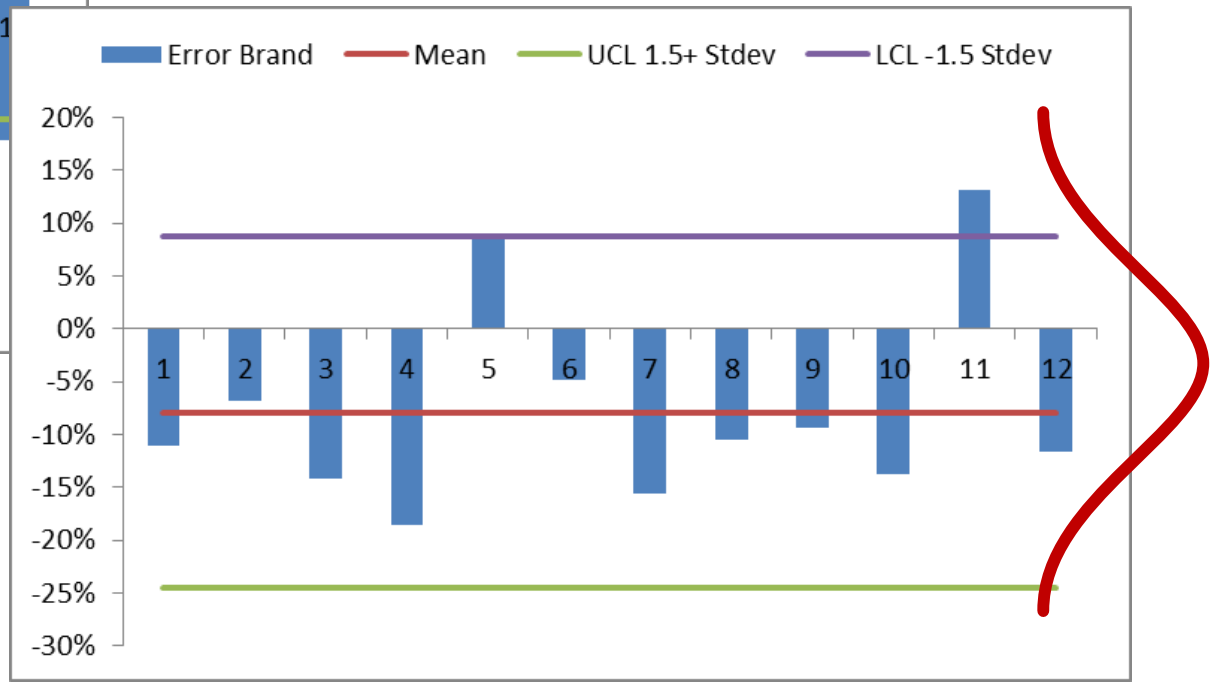
Forecast Error Tracking – Exception Management

Is the forecast performance in control or not?



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Forecast Error Tracking – Exception Management

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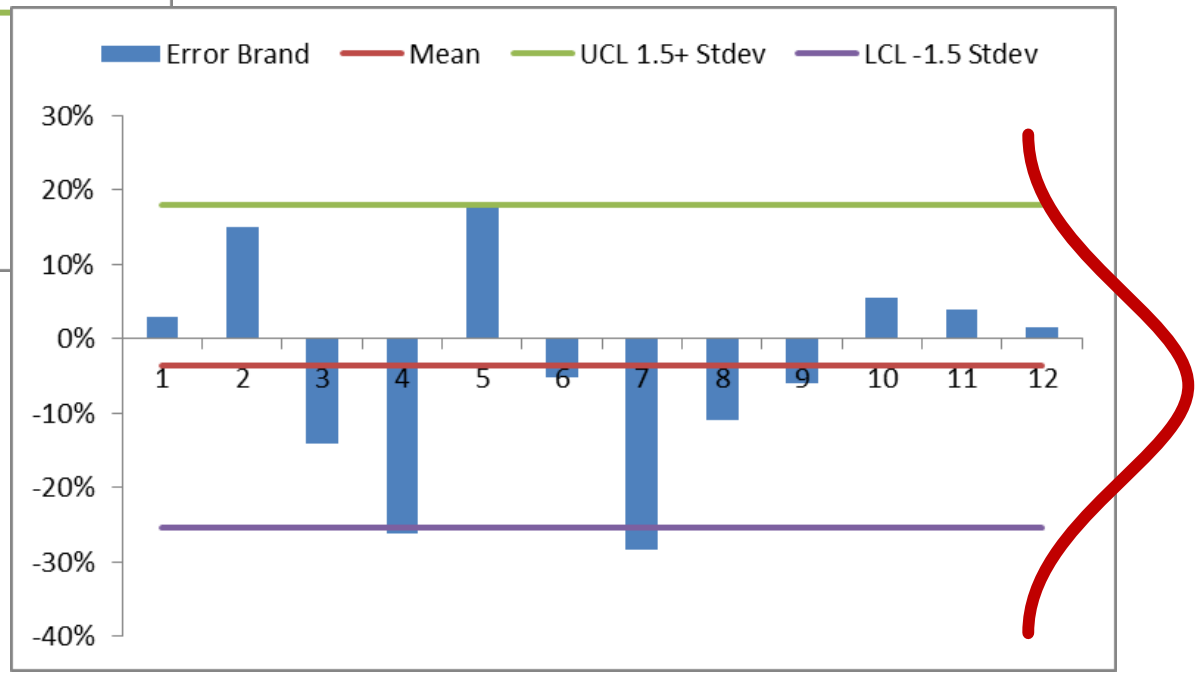

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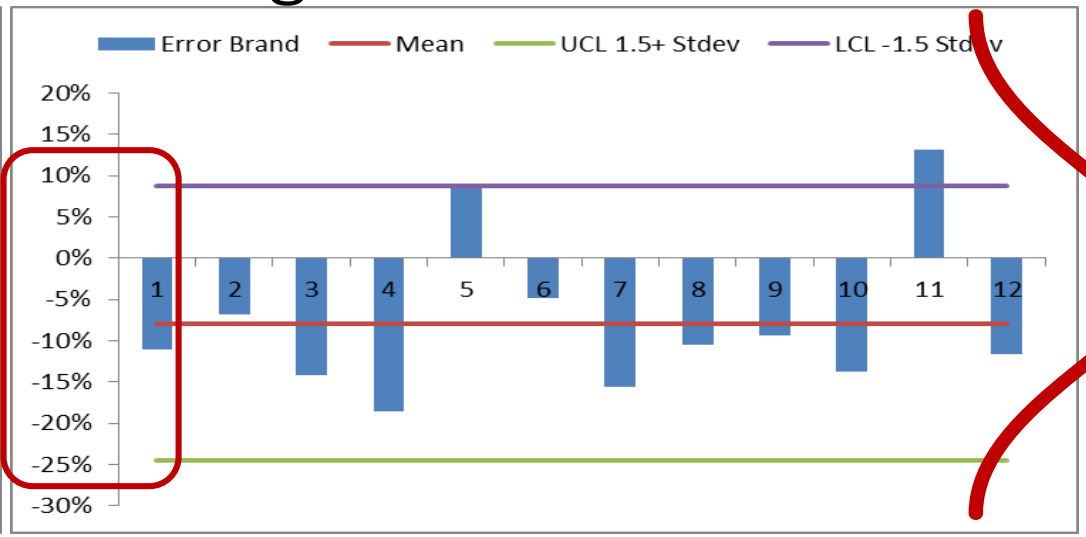
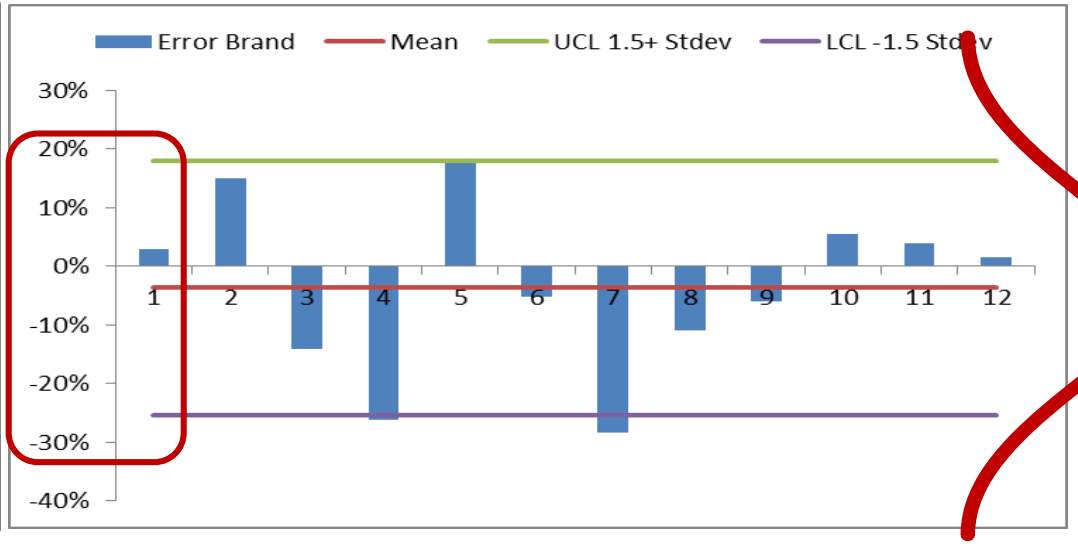
How would you define the error target?

Forecast Error Tracking – Target Setting



A target set to +/- 10%



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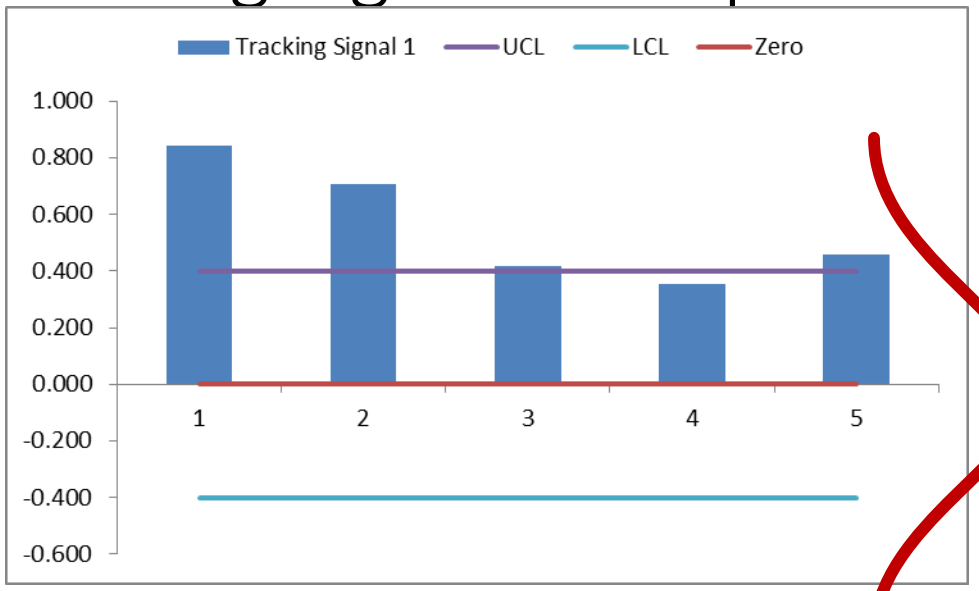
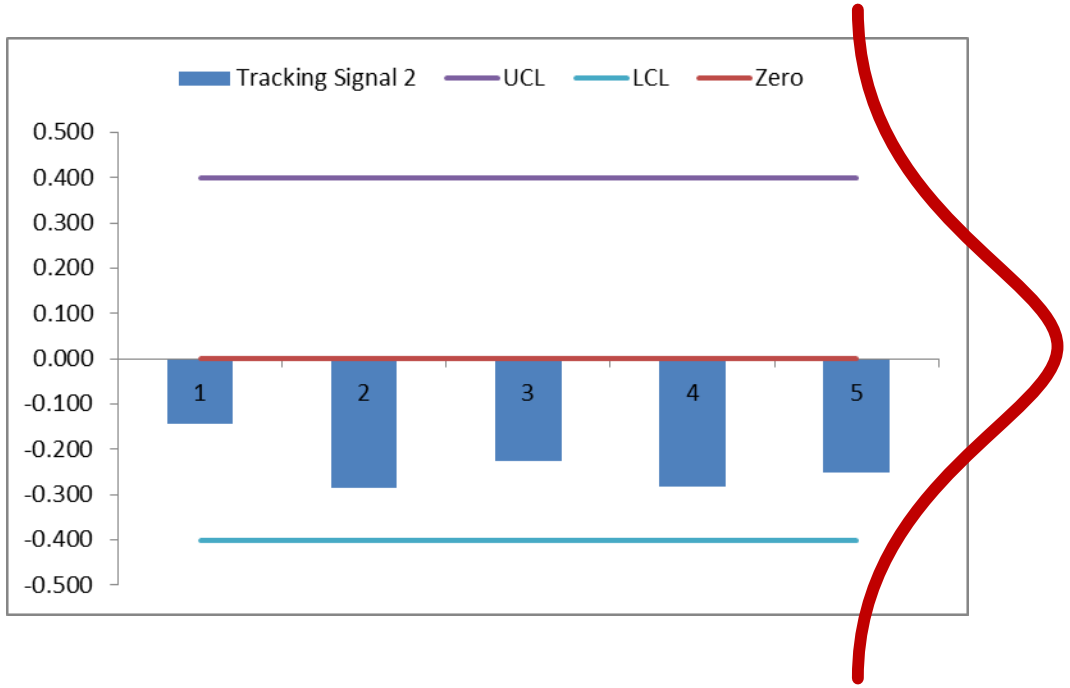
Tracking Signal - Exception Management



Limits: +/-1
Trigger Value: +/- 0.4
Positive Values:
Sales/Demand > Forecast
Negative Values:
Sales/Demand < Forecast



Many Statistical Forecasting software packages/systems use Tracking Signal logic to Auto Correct forecast model.

$$TS = \frac{Average\ Error_n}{Average\ Absolute\ Error_n}$$

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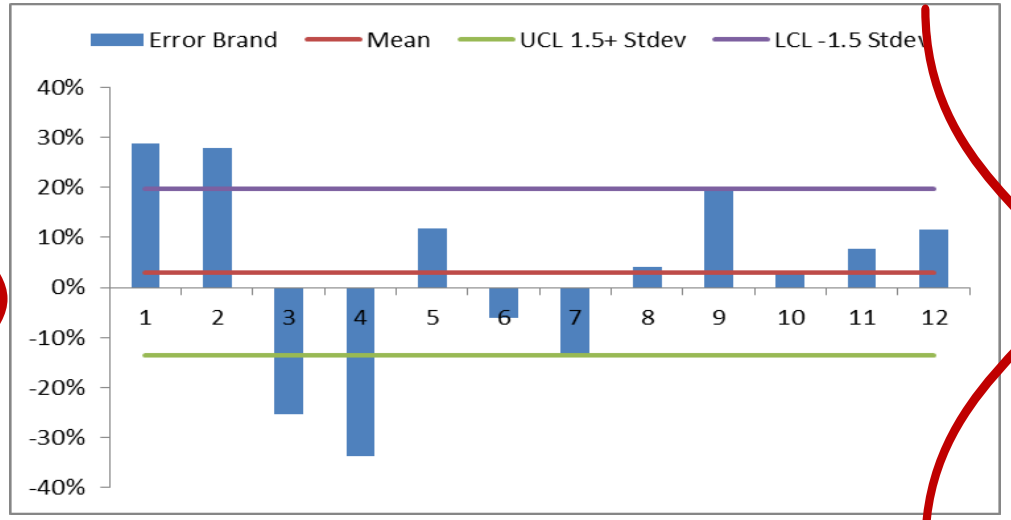
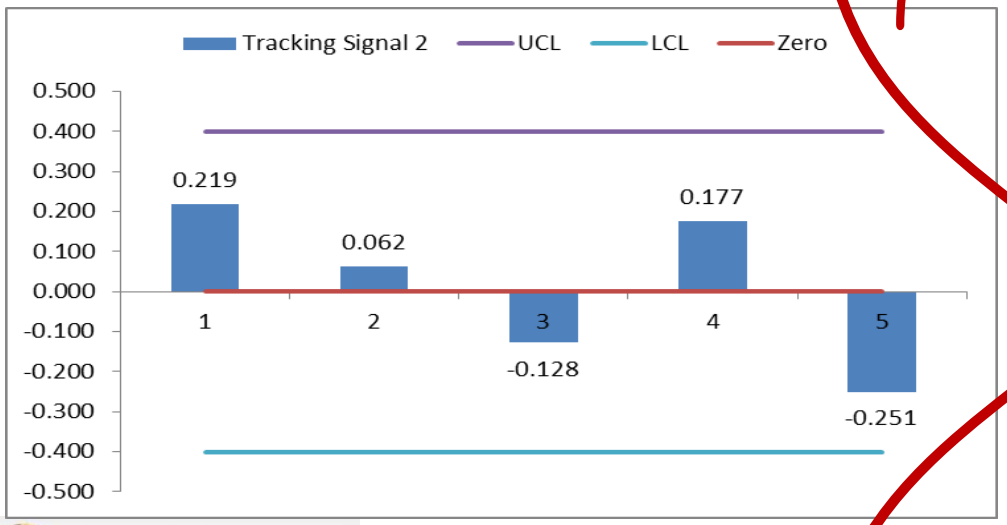
Tracking Signal - Exception Management





Well performing forecast…

What do you think?

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The end…

… or it is just a beginning?

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