

Six Sigma – Week 12

John Fico, Adjunct Professor
Fall 2020

Agenda

- Week 12
 - (11/5): Multiple linear regression – work on homework in class
 - (11/7): Binary logistic regression; start process capability
- Week 13
 - (11/12): Work on Case Study 2
 - (11/14): Case Study 2 presentations
- Week 14
 - (11/19): Process capability and control charts
 - (11/21): Process capability and control charts, work on final team projects
- Week 15
 - (11/26): Final team project presentations
 - (11/28): No class – Happy Thanksgiving
- Week 16
 - (12/3): Topic review (last day of class)
- Final Exam Week
 - (12/10): Final exam – 6:30pm-8:30pm – IST 1065

LS Text: $Y = f(X_1 \dots X_n)$

		X Data	
		Attribute	Continuous
Y Data	Attribute	Chi-Square	Logistic Regression
	Continuous	ANOVA Means/ Medians Tests	Regression

Binary logistic regression:
Example: One attribute Y, one attribute X,
one continuous X

Understanding the statistical significance of relationship between the Y and X(s) is key to finding root causes of problems in Six Sigma projects. Tool use depends on type of data we have.

LSSM Text: Binary Logistic Regression

- Output of a process is measured in attribute data such as Pass/Fail or Yes/No
- Example:
 - *Quality Approval status of a call center and the average Wrap-up Time (per call) are critical inputs in generating Customer Satisfaction (process output) across a number of call centers.*
 - *Customer satisfaction has been measured in a survey as Low or High.*
 - *Analyze data from Minitab worksheet (data in columns representing variables).*

LSSM Text: Binary Logistic Regression

Variable	Value	Count
Customer Satisfaction	Low	70 (Event)
	High	22
	Total	92

70 Low results out of 92 customers. Low defined as reference event

Deviance Table

Source	DF	Adj Dev	Adj Mean	Chi-Square	P-Value
Regression	2	7.574	3.787	7.57	0.023
Average Wrap Up Time (seconds)	1	4.629	4.629	4.63	0.031
Quality Approved	1	4.737	4.737	4.74	0.030
Error	89	93.640	1.052		
Total	91	101.214			

Wrap-up Time & Quality Approved status have significant effect on Customer Satisfaction

Coefficients

Term	Coef	SE Coef	VIF
Constant	-1.99	1.68	
Average Wrap Up Time (seconds)	0.0250	0.0123	1.12
Quality Approved Yes	-1.193	0.553	1.12

Coef. Of 0.025 indicates as wrap-up times increase, chances of **lower Customer Satisfaction** increase

Coef of -1.193 indicates call centers that are Quality Approved tend to have **higher Customer Satisfaction**. Coef is negative – as Quality Approved changes from No to Yes, Customer Satisfaction tends to move away from the reference (Low to High)

Odds Ratios for Continuous Predictors

	Odds Ratio	95% CI
Average Wrap Up Time (seconds)	1.0253	(1.0010, 1.0503)

Odds Ratios for Categorical Predictors

Level A	Level B	Odds Ratio	95% CI
Quality Approved Yes	No	0.3033	(0.1026, 0.8966)

Odds ratio for level A relative to level B

Odds ratio of 0.30 indicates odds of a **Quality Approved** call center having **Low Customer Satisfaction** are 30% of the odds of a **Non-Quality Approved** call center having **Low Customer Satisfaction**

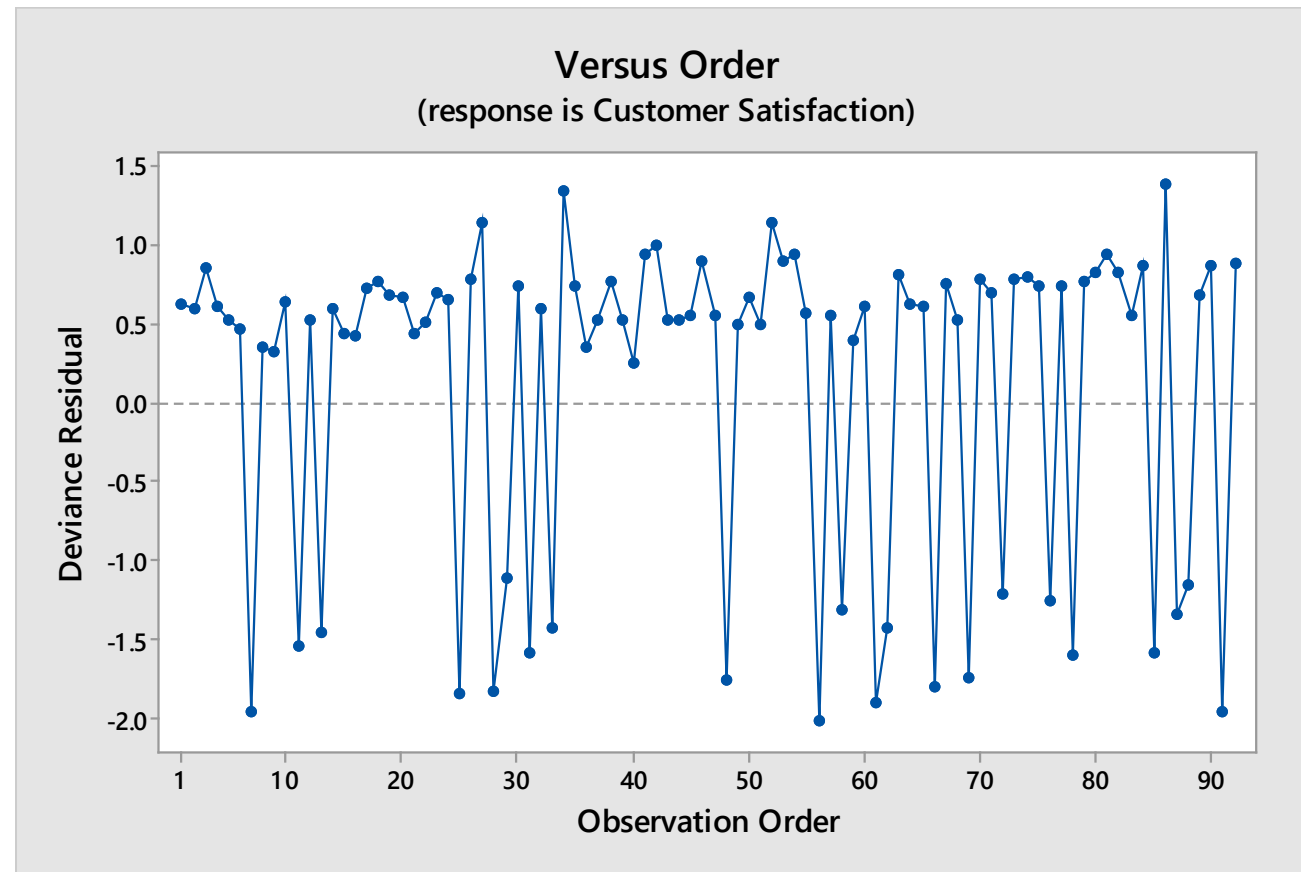
Goodness-of-Fit Tests

Test	DF	Chi-Square	P-Value
Deviance	89	93.64	0.348
Pearson	89	88.63	0.491
Hosmer-Lemeshow	8	4.75	0.784

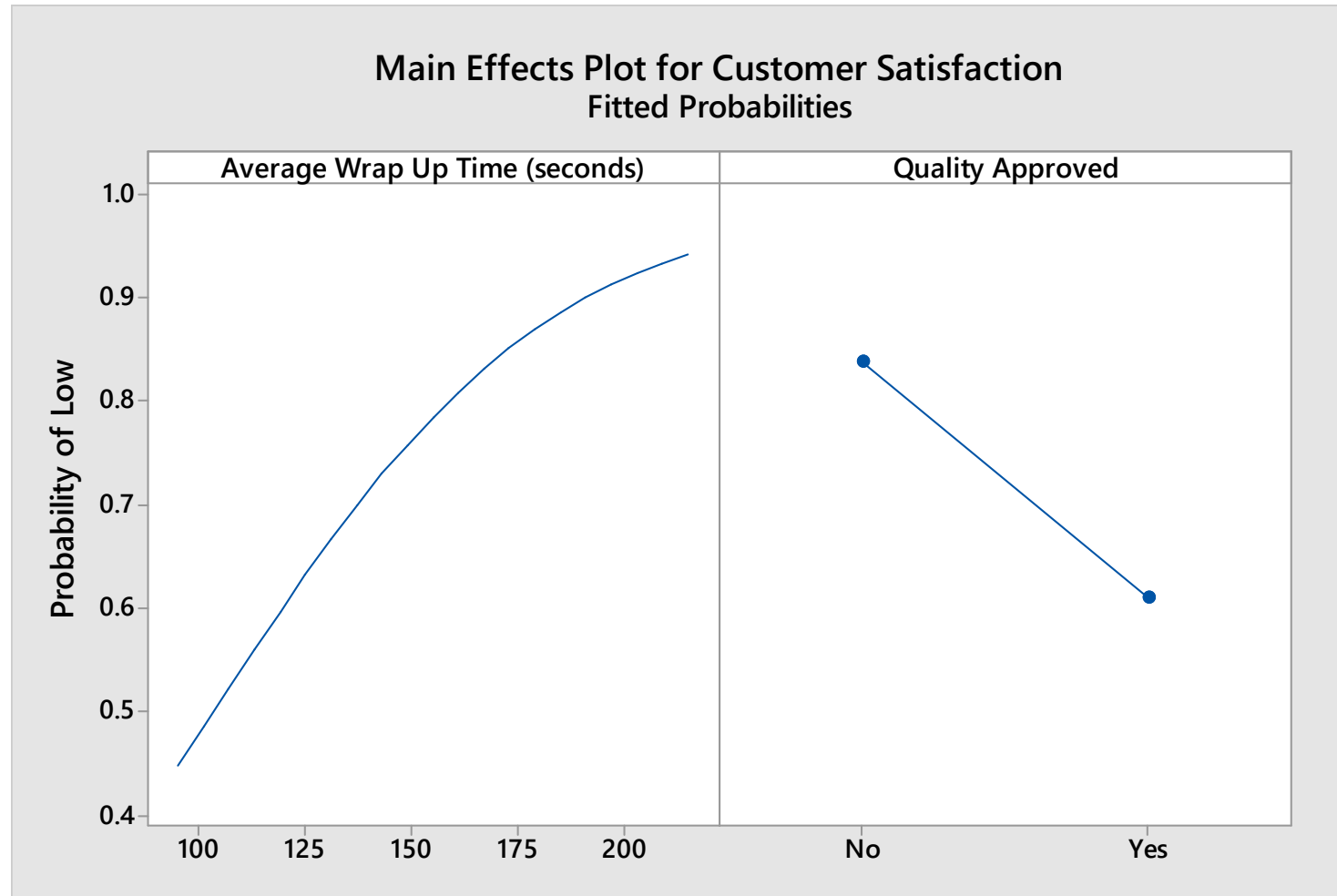
Used to check if model is a reasonable fit for data. We do not want the tests to reject the model (as a good fit) so we are looking for p-values >0.05, which we have in this model.

LSSM Text: Binary Logistic Regression: (Residuals)

Residuals are random over time –
indicating a good model



Binary Logistic Regression



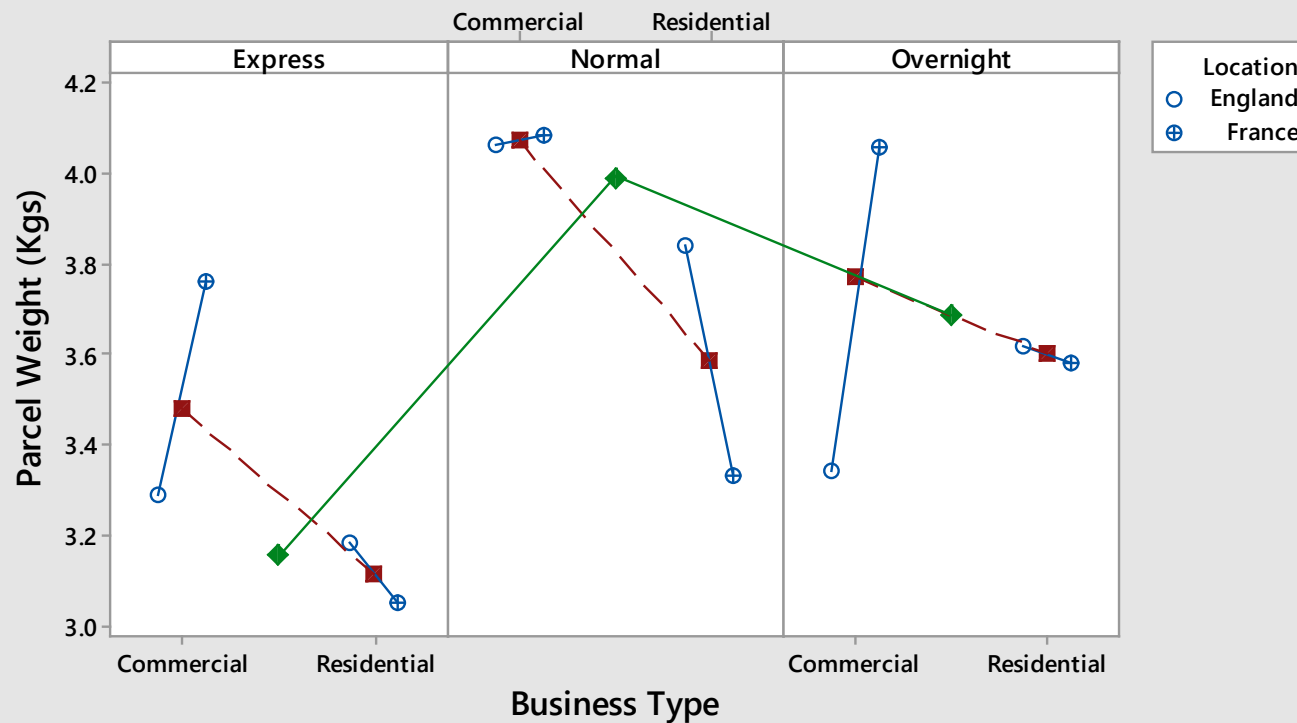
Probability of Low Customer Satisfaction increases as *Wrap Up Time* increases,
decreases for call centers that are *Quality Approved*

Text 2: Multi-Vari Charts

- Useful for an initial look at data that has been stratified by several different factors. Box Plots and Individual Value Plots can then focus on specific factors in more detail.
- Example:
 - Data from parcel weights from a courier process.
 - Categorical information on the Location, Business and Service was collected along with the weight of each parcel.
 - This can be used for further understanding of process.
 - Analyze data from Minitab worksheet (data in columns representing variables).

LSSM Text: Multi-Vari Charts: Transactional (Logistics example)

Multi-Vari Chart for Parcel Weight (Kgs) by Location - Service Used



Panel variable: Service Used

- On average:
- *Residential* parcel weights are lower than for *Commercial*
 - *Express* parcel weights are lowest, and *Normal* highest
 - *French* parcel weights are higher than *English* for *Commercial* parcels, but lower for *Residential* parcels