Using DOE in Service Quality

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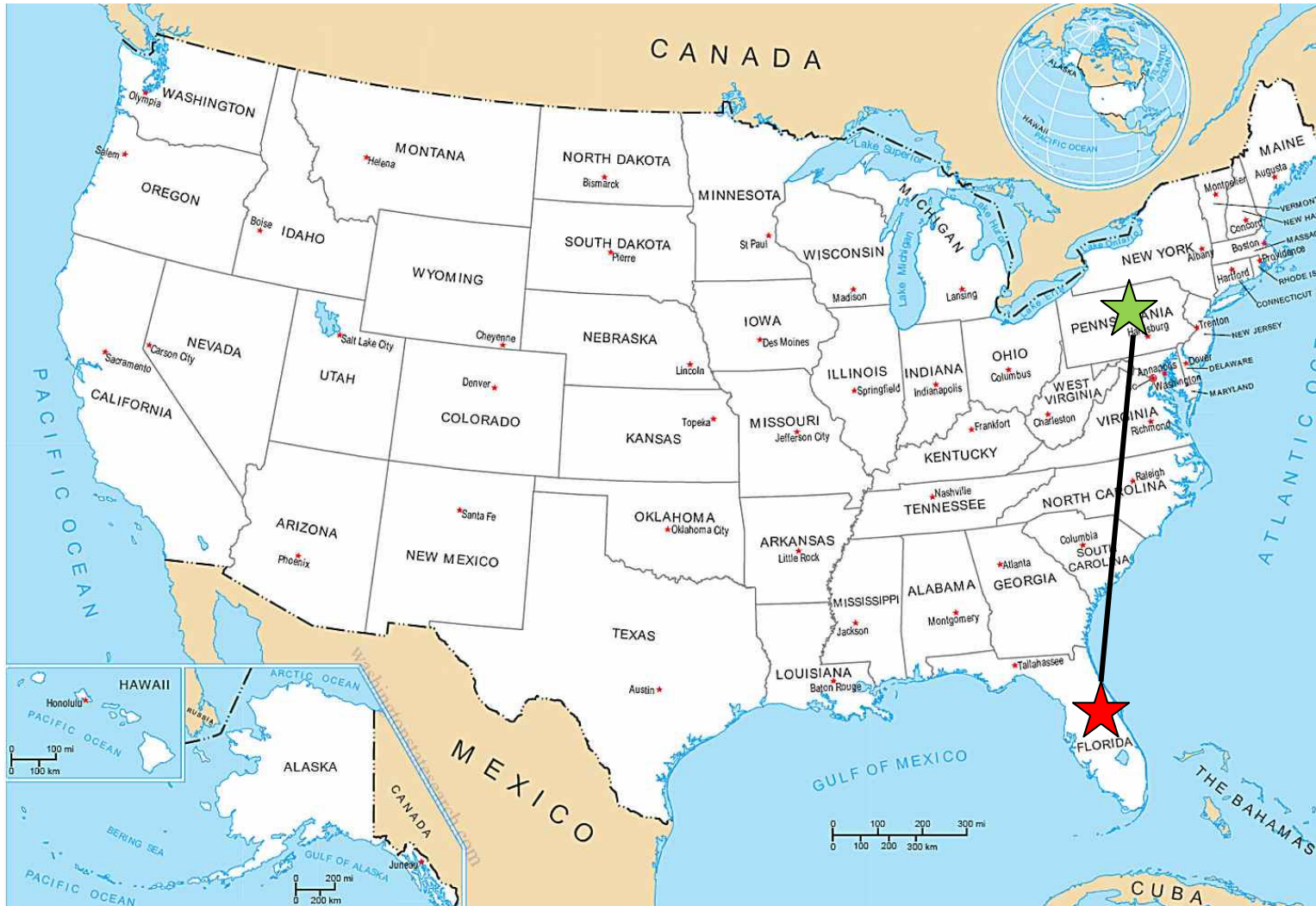**TECHMAX** HONG KONG

Outline

▶ **Minitab**

▶ **Six Sigma & DMAIC**

▶ **Industries**

▶ **Design of Experiments**

▶ **Examples**

▶ **Summary**

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Minitab the Company

World Headquarters, State College, PA, USA.

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Minitab the Company

► Developed at Penn State in 1972

► Incorporated in 1985

► Minitab Ltd 1995 – UK   Minitab SARL 1998 – France

► Minitab Pty 2007 -- Australia

► Minitab Partners throughout the world (TechMax HK)

► Products: MINITAB, Quality Companion, Quality Trainer

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Six Sigma

► Six Sigma is a strategy that involves the use of statistical and soft tools within a structured methodology for gaining the knowledge needed to achieve better, faster and less expensive products/ services than the competition.

► The real value of Six Sigma is orchestrating process improvement through the implementation of statistical techniques.

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Six Sigma: DMAIC

▶ **D**efine – What is your problem? Customer needs?

▶ **M**easure – How bad are you?

▶ **A**nalyze – What are your sources of defects and variation?

Design of Experiments

▶ **I**mprove – Make changes.

▶ **C**ontrol – Permanent change!

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Six Sigma

► Six Sigma has evolved from a "Quality Goal" to an enterprise wide strategy for business management and improvement

► Six Sigma has been successfully deployed in multiple industry segments over the past 20 years

► If error reduction is warranted within manufacturing industries, it should be considered even more crucial to service quality such as financial areas, government sectors, and the delivery of healthcare

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Quality Improvement is Everywhere

► Variety of customers

Chickens	Bank
Coffee	Eye ware Company
Hospital	Paper Mill
Power Tool	Mining
Online Buy/Sell	Wind Power
Consumer Products	Dairy Food

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Healthcare

► Wrong Prescriptions

► Bed falls

► Incorrect Surgical Procedures

► Billing / Insurance

► Dropped Babies

► Scheduling of Procedures/ Appointments

► Medical Transcription Errors

► Patient Satisfaction

► Staffing

► Discharge Time

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Finance/Banking

▶ Quality Scores of Loan Processing

▶ Processing Claims

▶ ATM Transactions

▶ Abandon Rates at Call Center

▶ Delinquent Accounts

▶ Credit Cards

▶ Insurance rates

▶ Billing Cycles

▶ Cycle Times

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Government

► Assessing poor air quality

► Time for permits

► Reduce bid costs

► Fire code re-inspections

► Response time to complaints

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Statistical Tools

► In many cases, data for service quality projects tends to be attribute in nature.

- Hypothesis Tests – Proportions, Chi-Square
- Regression – also Logistic Regression
- Gage R&R – Attribute Agreement Analysis
- Control Charts – P & NP or C & U Charts
- Capability – Binomial and Poisson
- DOE – Continuous and Logistic Regression

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Designed Experiments

► Experiments are used to investigate a process and see what factors influence the outcome. Another gain from the experiment is assessing the size of the effect of a factor---financial impact.

► Properly designed and executed experiments will generate more-precise data while using substantially fewer experimental runs than alternative approaches.

► They will lead to results that can be interpreted using relatively simple statistical techniques, in contrast to the information gathered in observational studies, which can be exceedingly difficult to interpret.

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Designed Experiments

► The most important thing to remember is that to make a cause and effect statement, the data collected needs to be from a designed/controlled experiment.

► Going back to historical data from a database can lead to relationships between factors and the response.

► However, since there could have been other trends/factors that influence the relationships, it is not wise to draw concrete inferences.

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Some Published Success Stories

► A global newspaper tested 11 creative and 4 price elements in one mail drop for a 41% increase in net response.

► A 19-factor direct mail credit card test pinpointed 5 significant effects for a 15% jump in response rate. (*International Journal of Research in Marketing, 2006*)

► GE Capital saved over $3M by implementing the results of a 7 factor designed experiment studying methods to collect unpaid debt. *(QE, 2000)*

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Example One

► A successful magazine seeks to improve the response from its direct mail subscription requests. The historical rate of subscription response is 2%.

► To determine the best package of features to include in the mailing, they run a factorial experiment to test the factors that may increase the number of mail recipients who subscribe.

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Example One

▶ The magazine prepares sixteen sets of direct mailings that contain all combinations of the high and low settings of the four factors.

- Insert Act   Now insert (yes or no)
- Money Back   Money back offer (yes or no)
- Testimonial   Celebrity endorsement (yes or no)
- Personality   Personality identifier (yes or no)

▶ For each combination, 2,500 direct mailings are sent to a random group of potential subscribers. Then, they record the percentage of recipients that subscribe in response to each mailing.

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Example One

► Personality and the Insert*Money Back Interaction are Significant
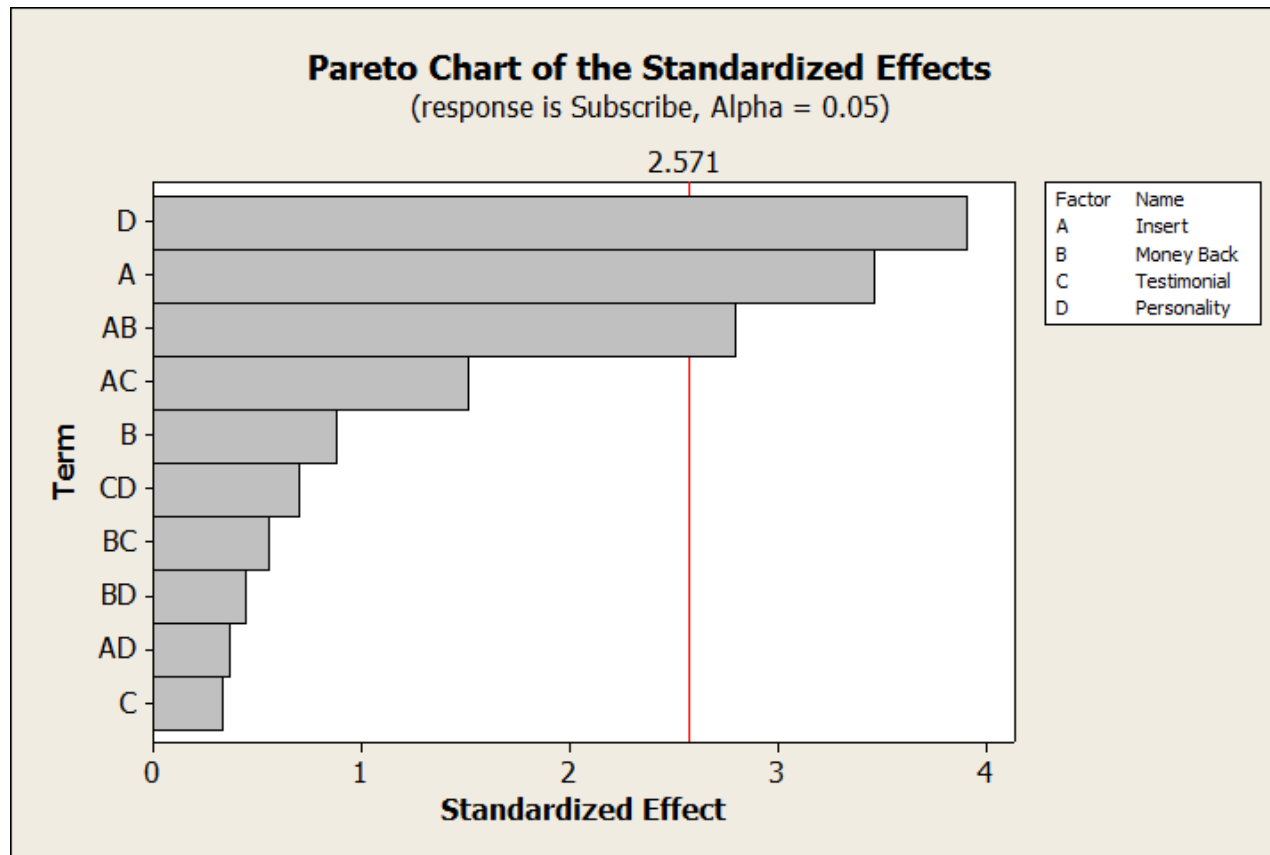
Example One

► They should make the Personality Statement

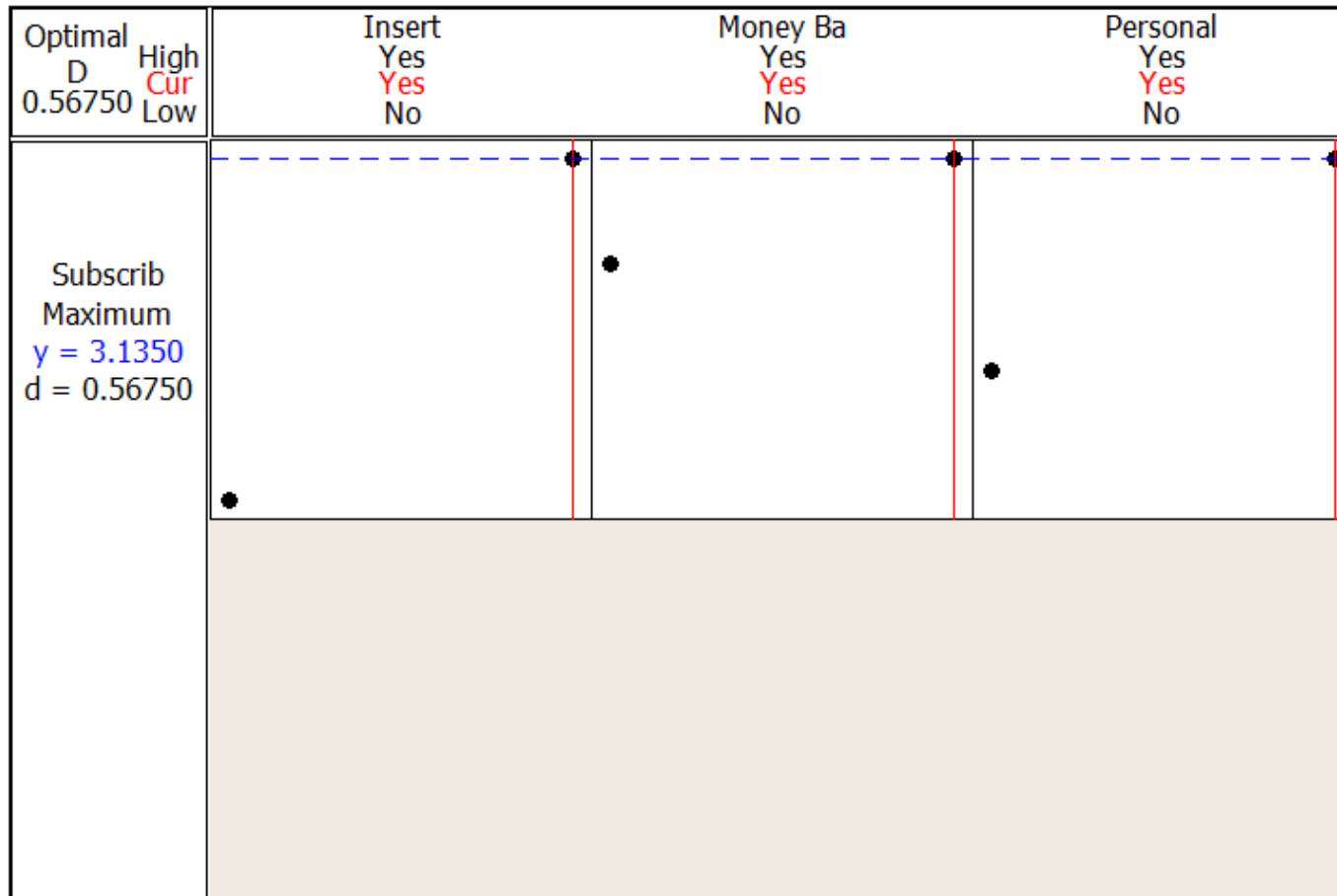**Minitab® Statistical Software**
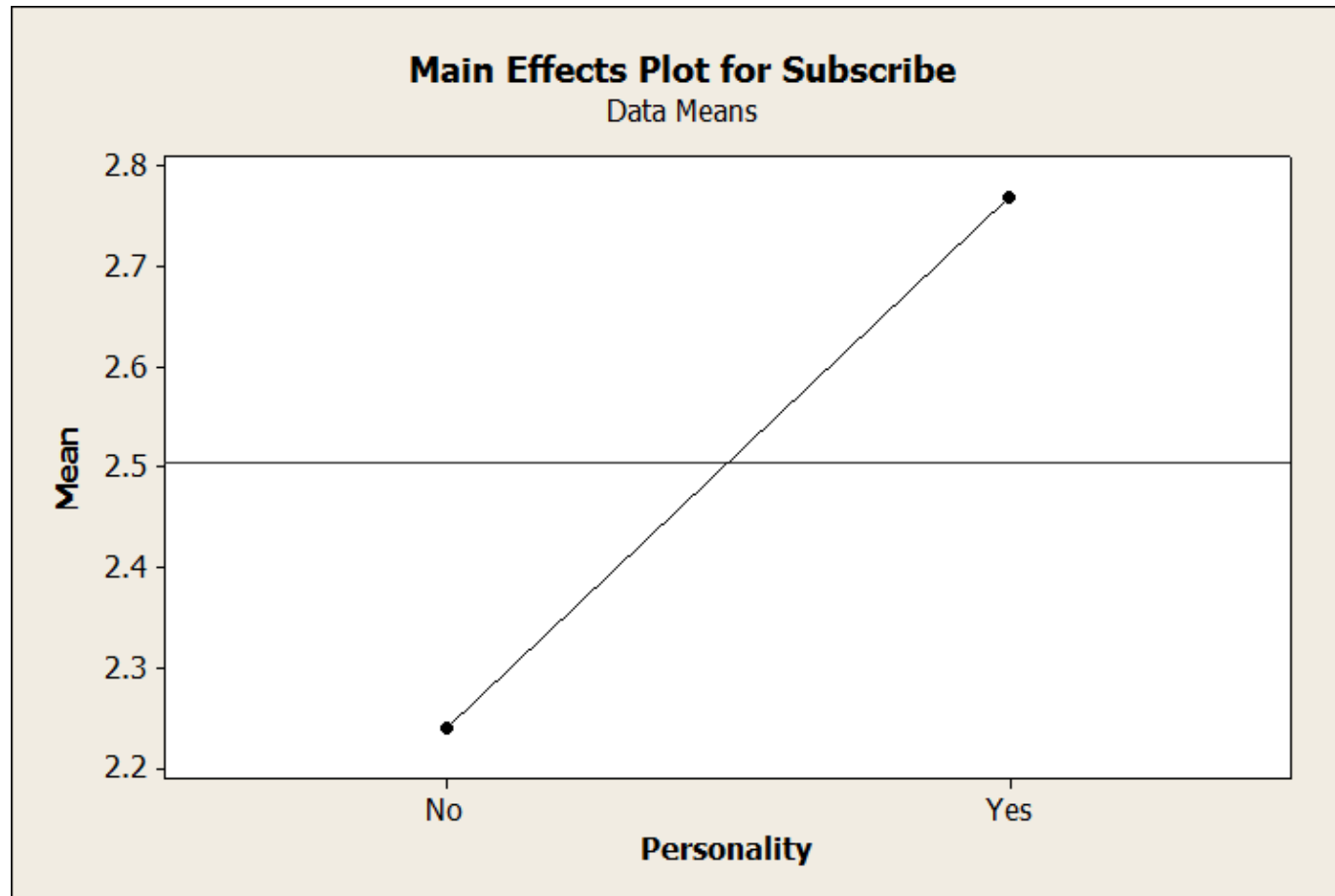
Example One

► Include an Insert with Money Back Offer

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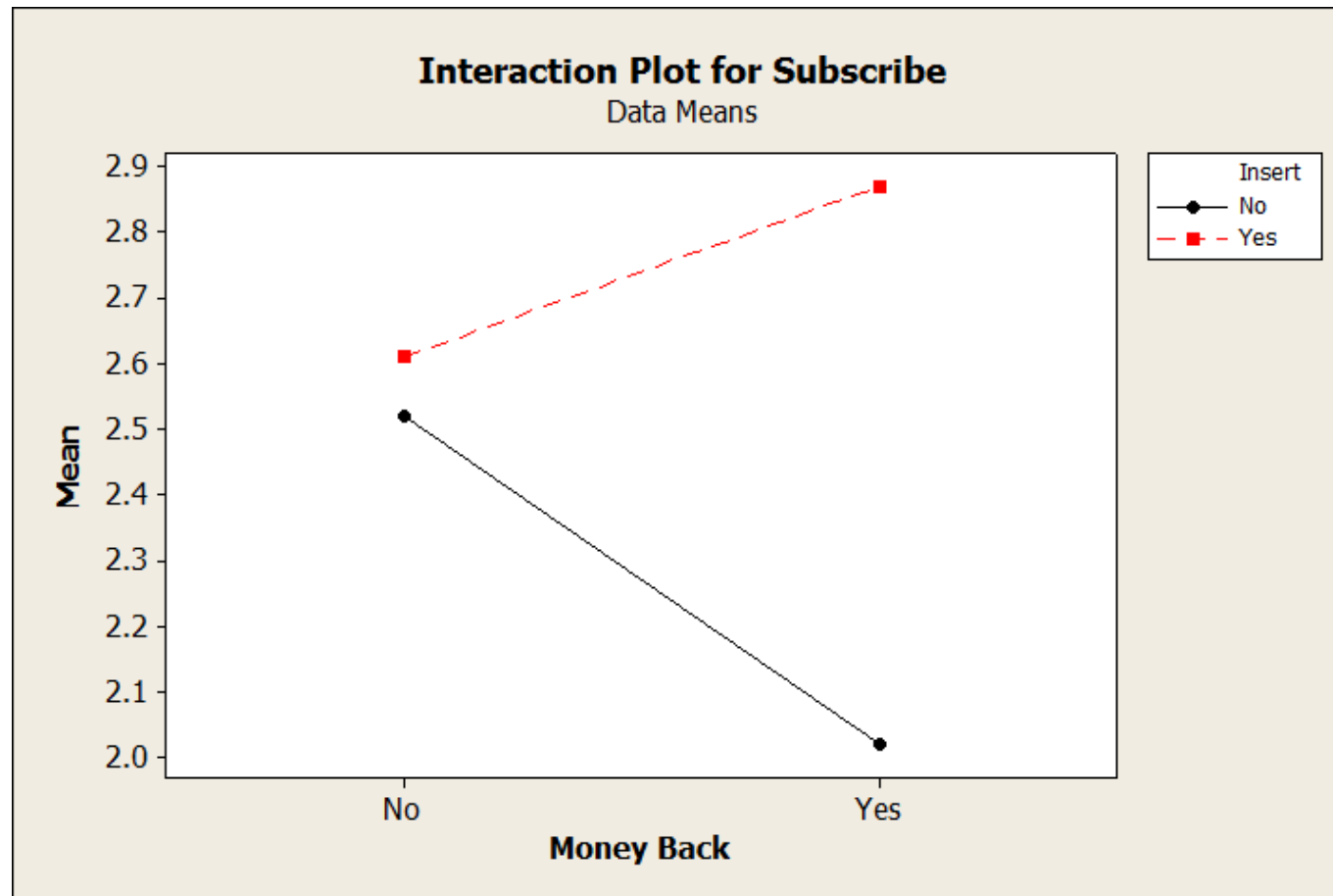
Example One

► Increased from 2% to 3.14%, over 50% increase

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Example Two

▶ A Hospital wants to minimize the percentage of insured patients whose discharge is longer than 50 minutes leading to increased customer satisfaction, increasing the number of admissions and turnovers, and increasing profit.

▶ Current discharge longer than 50 minutes is 65%.

▶ They use Sigma Quality Level as the response:

$$SQL = \left(\frac{USL - \overline{X}}{s} \right) + 1.5$$

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Example Two

► Four factors are considered:

- Resident time: time from resident called until arrives
- Porter time: time for porter to get file from pharmacy to accounting
- Insurance time: time required to complete approval process
- Pharmacists: number of pharmacists on duty

► The design is a 2^4 full factorial with 10 replicates to understand the variation.
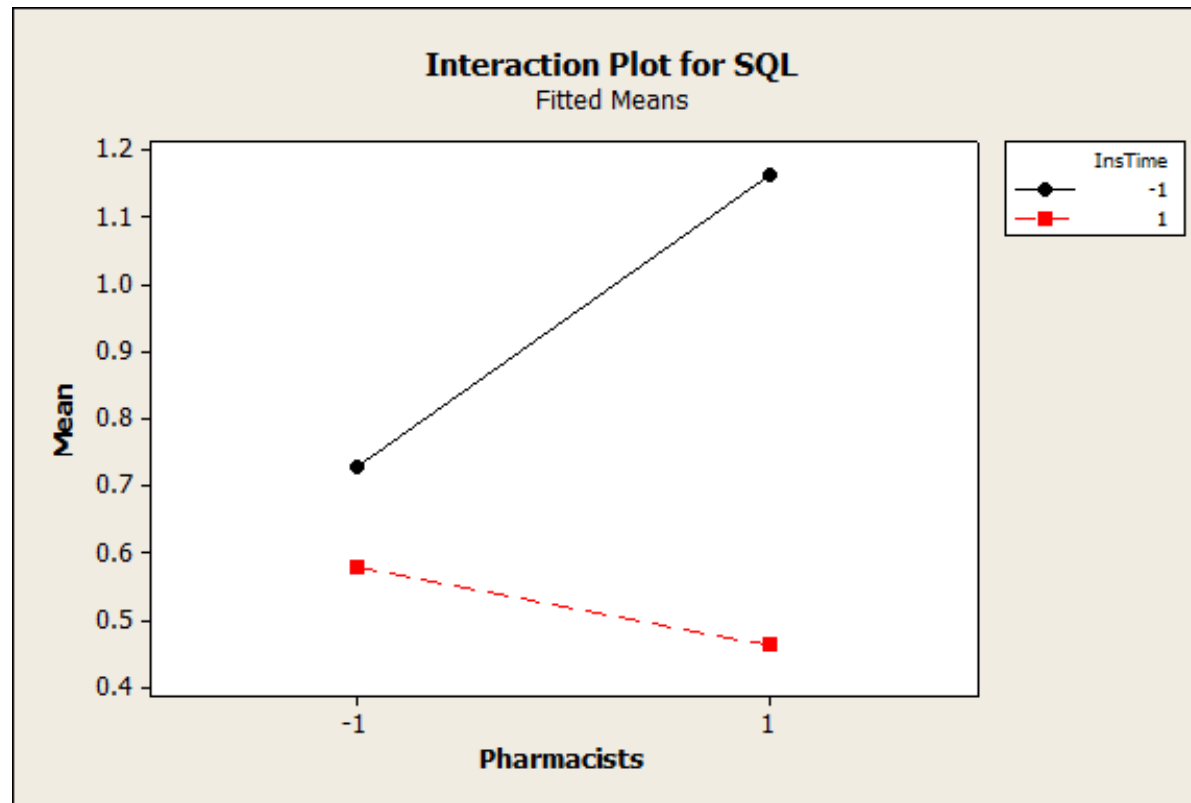
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Example Two

► Interactions between Insurance Time and Number of Pharmacists & Resident Time and Porter Time exist.

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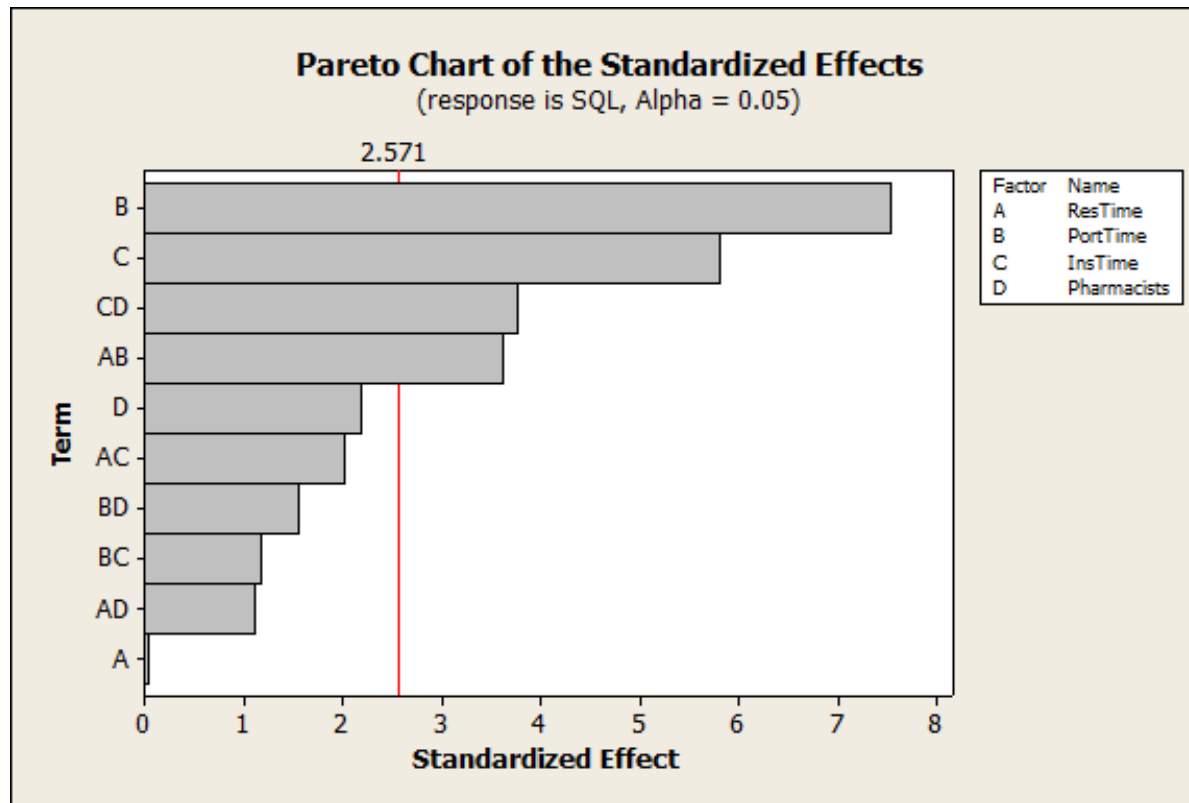
Example Two

► Interaction between Insurance Time and Number of Pharmacists.

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Example Two

► Interaction between Resident Time and Porter Time.

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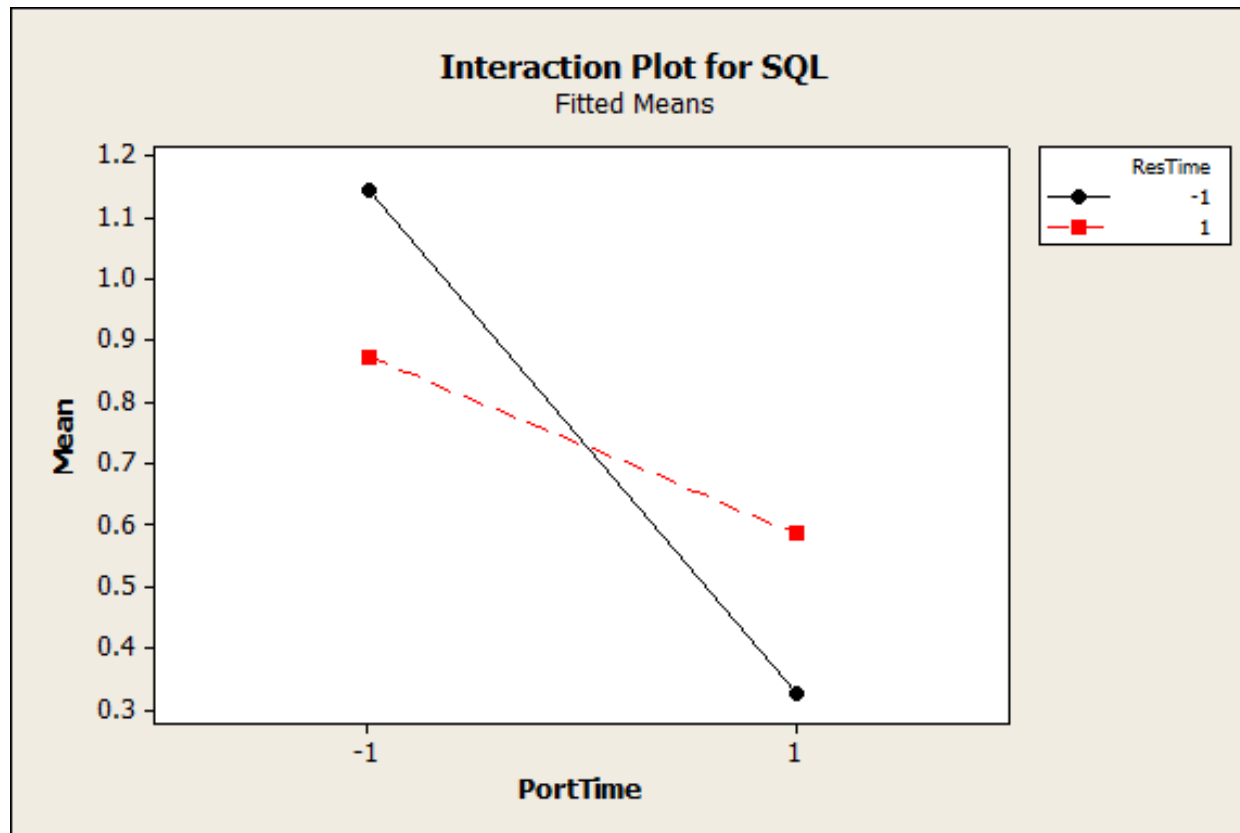
Example Two

► Use Optimizer to explore What If scenarios.

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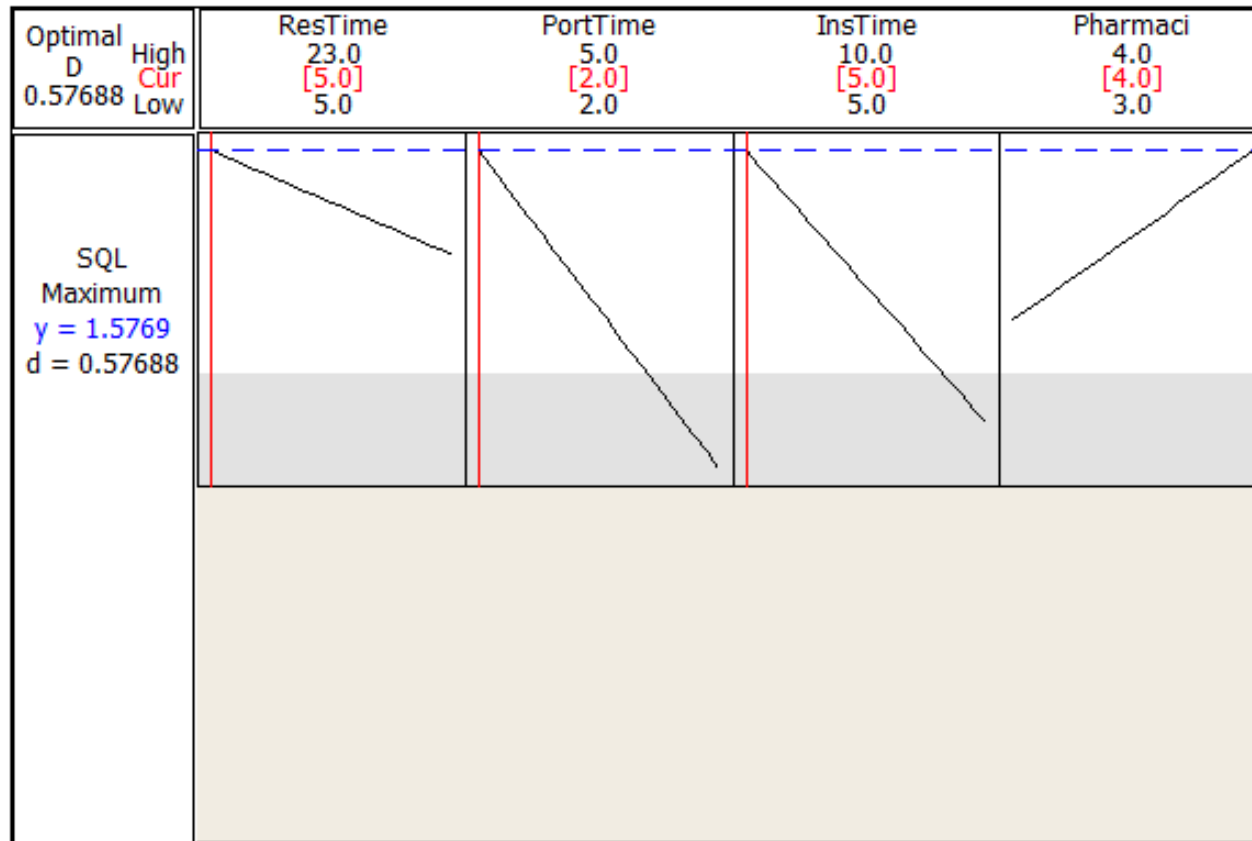
Example Two

► Best setting is 47% compared to where they started at 65%.

Distribution Plot
Normal, Mean=0, StDev=1

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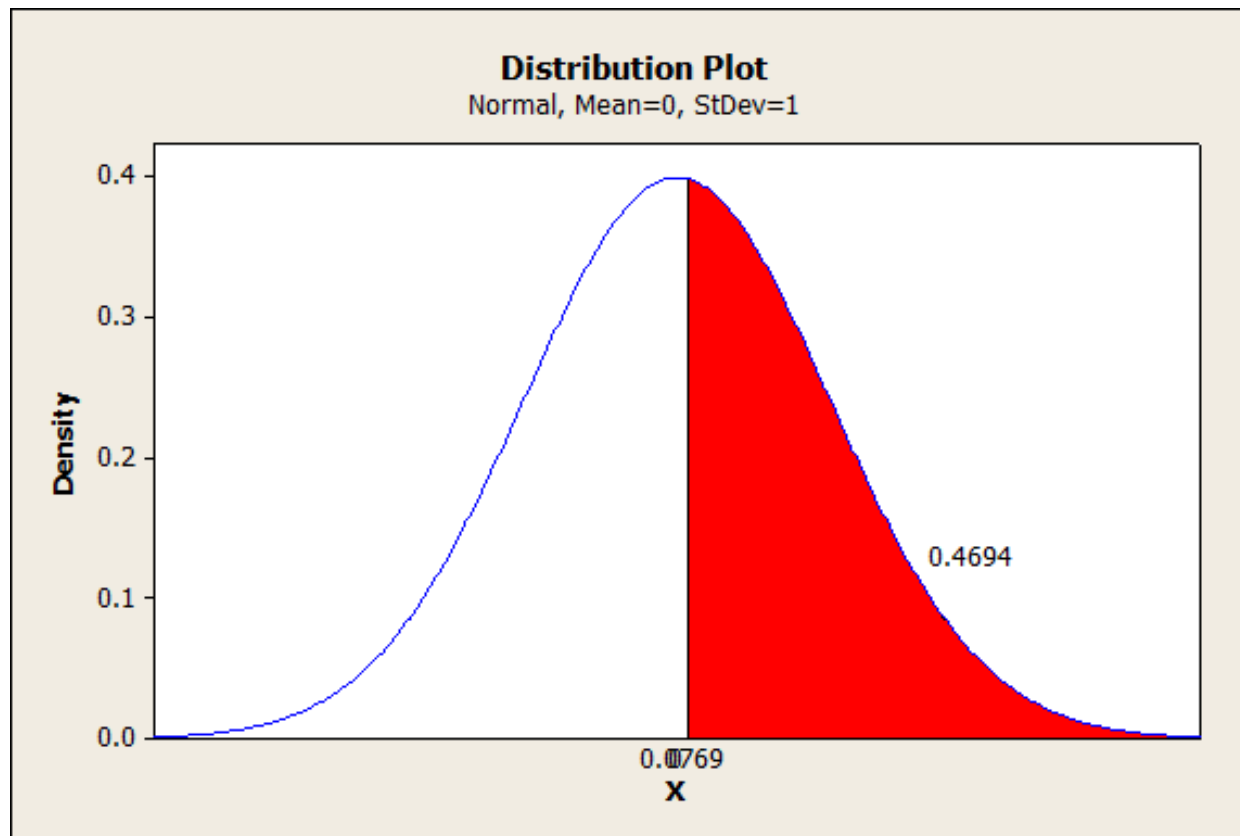
Example Two

► Be careful with combined responses like SQL.

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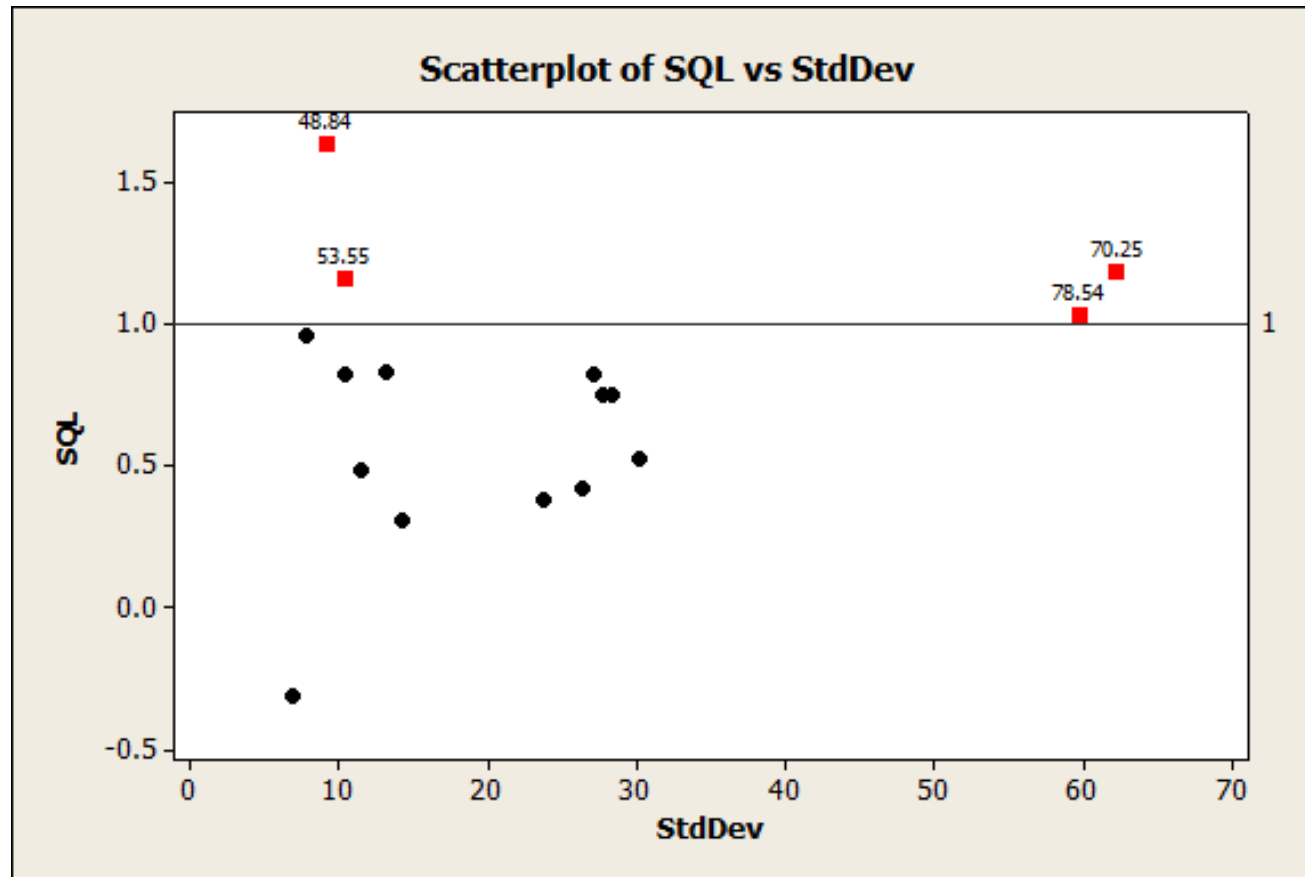
Example Three

► A credit card company wants to determine what type of offer encourages customers to apply for its credit card.

► The company focuses on three variables:
  - introductory annual percentage rate (APR)—0% and 4%
  - the duration of the introductory APR---6 and 9 months
  - envelope type—Offer and Plain

► The company randomly sent 160,000 offers, 20,000 of each combination to people on their mailing list. For each set of 20,000 letters, they record how many new accounts were opened within 6 months of the mailing.

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Logistic Regression

▶ Builds a regression model for an attribute response

▶ Response can be

  • Binary – two possible outcomes (most common)
  • Nominal – more than two categories
  • Ordinal – more than two ordered categories (Likert scale)

▶ For Binary response, logistic regression models the probability of observing an event

▶ For DOE, you try to minimize this probability if the event is a failure, or maximize if the event is a success

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Logistic Regression

► In general, the DOE menu should not be used to evaluate response variables that are bounded, such as percentages and proportions, because its functions do not recognize bounds such as 0 and 1.

► Additionally, if the distribution of the response is binomial, the normality and constant variance assumptions are violated in the ANOVA analysis.

► Binary logistic regression, however, recognizes the boundaries of a proportion and is designed to handle binomial responses.

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Stat>Regression>Binary logistic regression

Logistic Regression

► You should understand how to write the model

$$Model = -2.648 + .098\,IntroAPR + .145\,Length - .126\,I_{plain} - .028\,IntroAPR * Length$$

► where
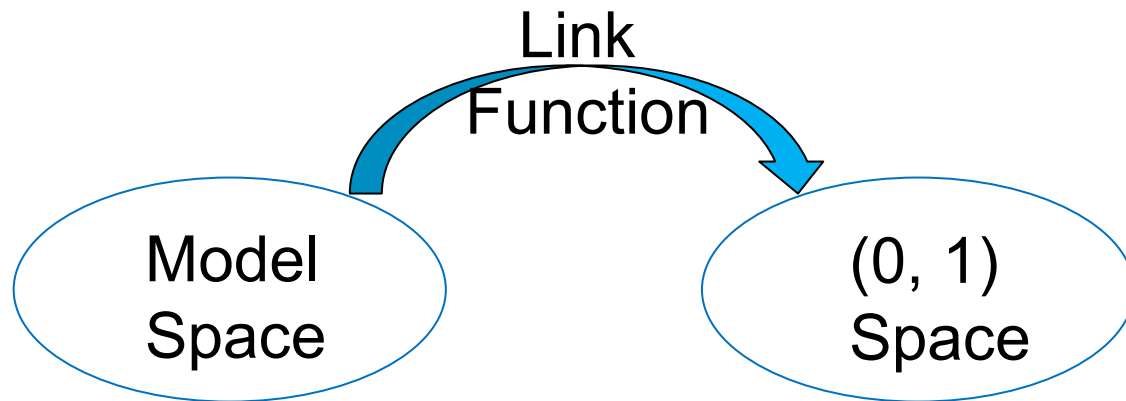$$I_{plain} = \begin{cases} 1 & \text{if envelope is plain} \\ 0 & \text{not} \end{cases}$$

► Prediction for APR=0, Length=9, Envelope=Offer

$$Model = -2.648 + .145 * 9 = -1.343 \quad \text{Problem!!!}$$

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Logistic Regression

► We need something that will guarantee the prediction is between 0 and 1
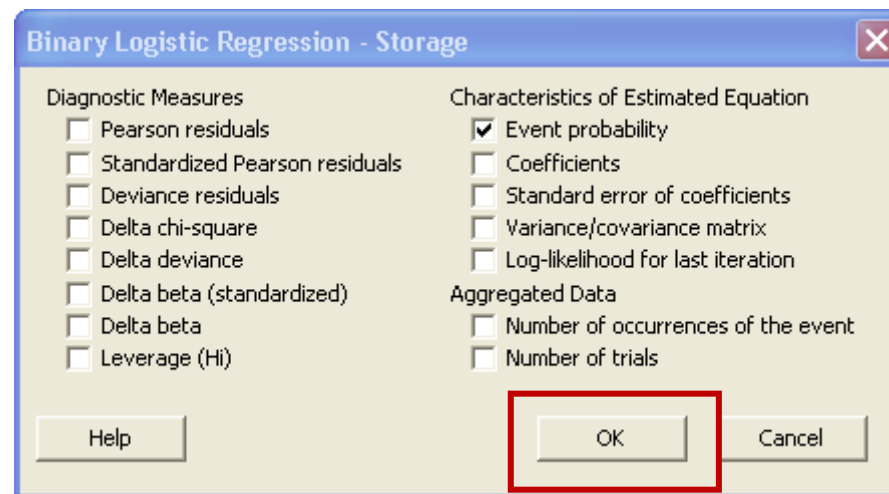
► Link Function

Link Function

Model Space → (0, 1) Space

► Logit Link

$$= \frac{\exp(model)}{1 + \exp(model)}$$

$$\text{Prob}(event) = \frac{\exp(-2.648 + .098 IntroAPR + .145 Length - .126 I_{plain} - .028 IntroAPR * Length)}{1 + \exp(-2.648 + .098 IntroAPR + .145 Length - .126 I_{plain} - .028 IntroAPR * Length)}$$
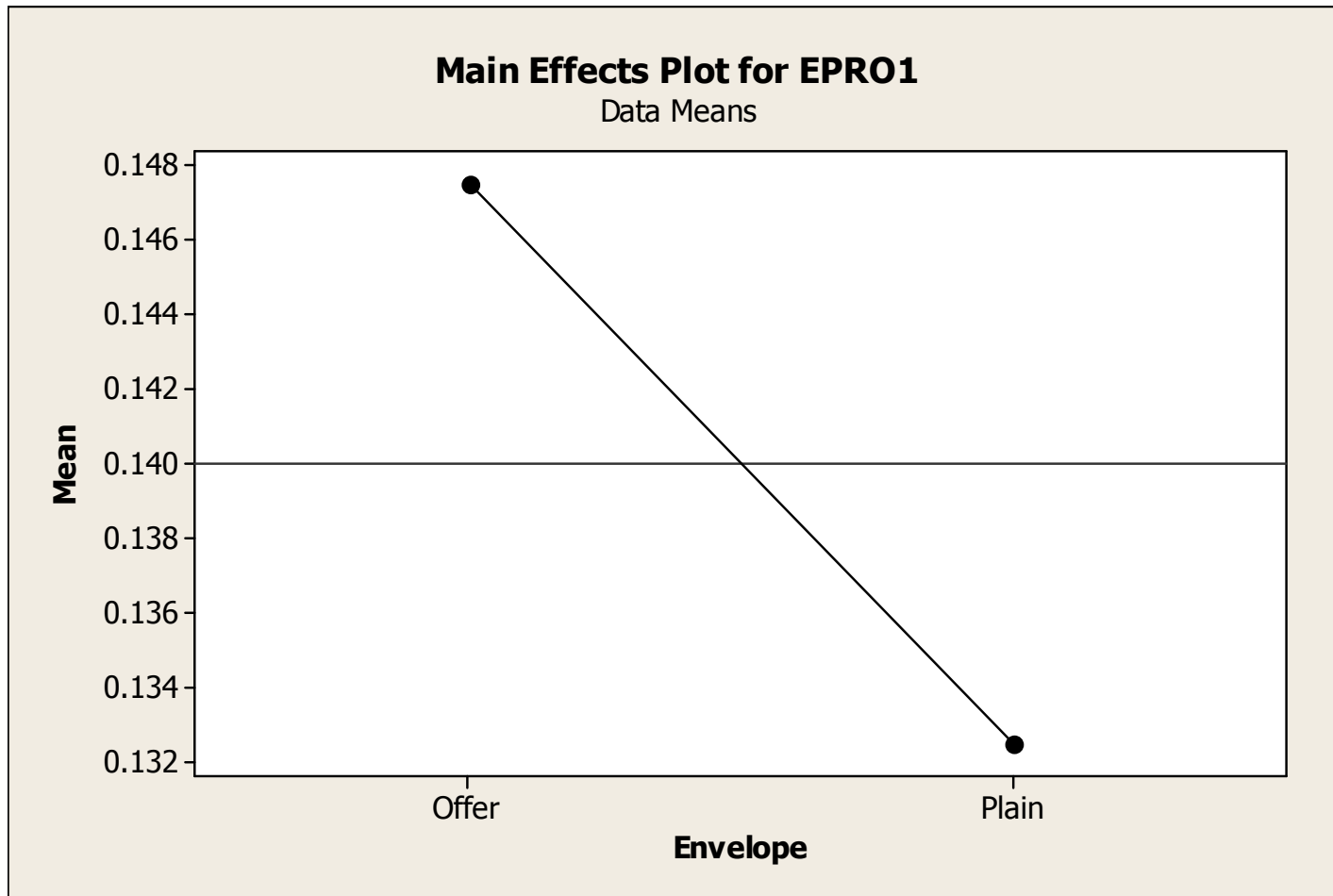
Store Probabilities

► Minitab will store the event probability for you as long as the values are part of the data set
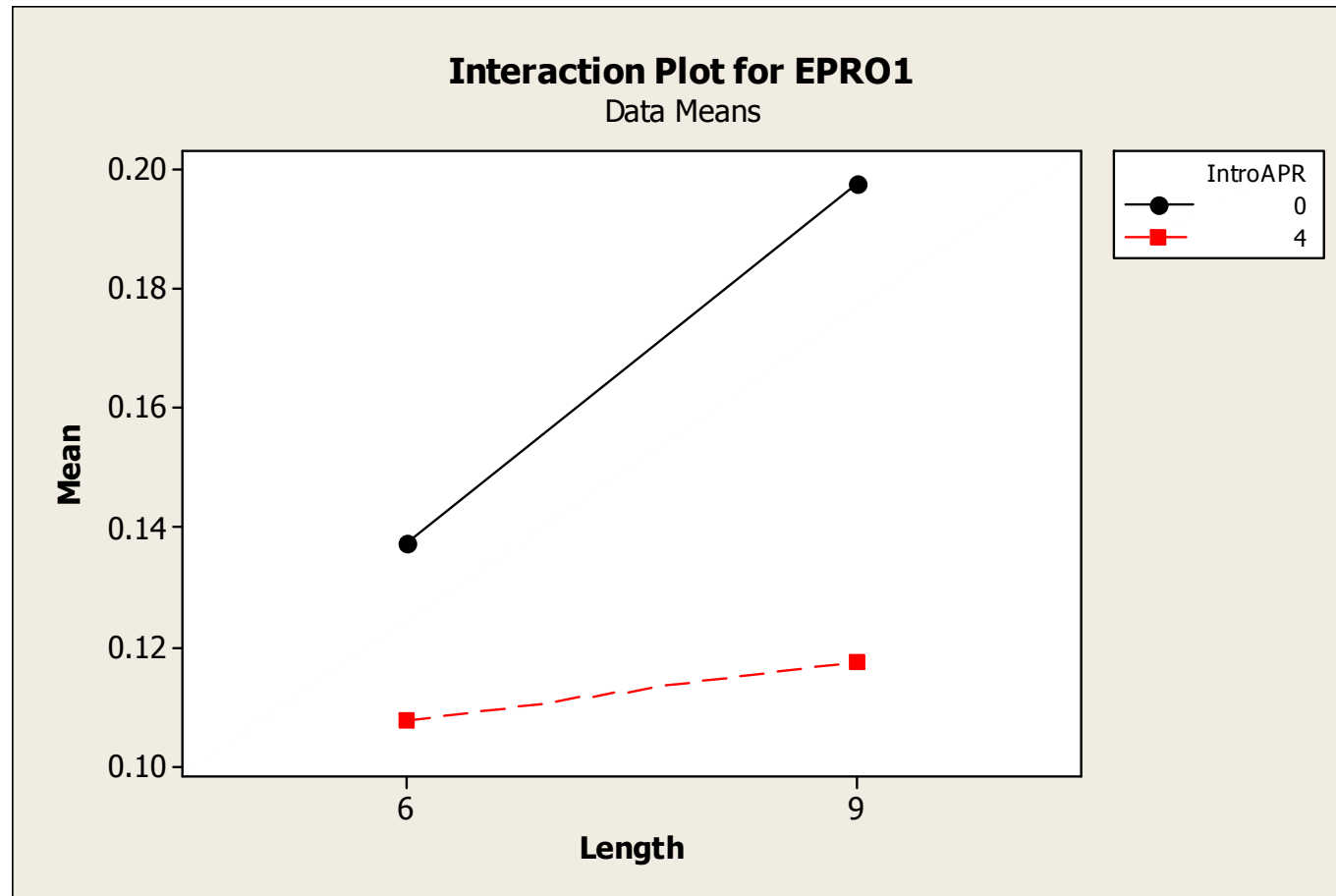
► Choose Storage and Event Probability

► Draw Main Effects plot for Envelope and the Interaction plot for IntroAPR and Length

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Example Three

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Example Three

Interaction Plot for EPRO1
Data Means

► Best setting: Offer, 0% and 9 months = 20.5%

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Summary

▶ There are many opportunities for Six Sigma and DOE in Service Industries.

▶ It is not usually necessary to use ALL of the high power DOE tools.

▶ Use Main effects and Interaction plots.

▶ In the end, it is still a process

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Thank you for your time

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