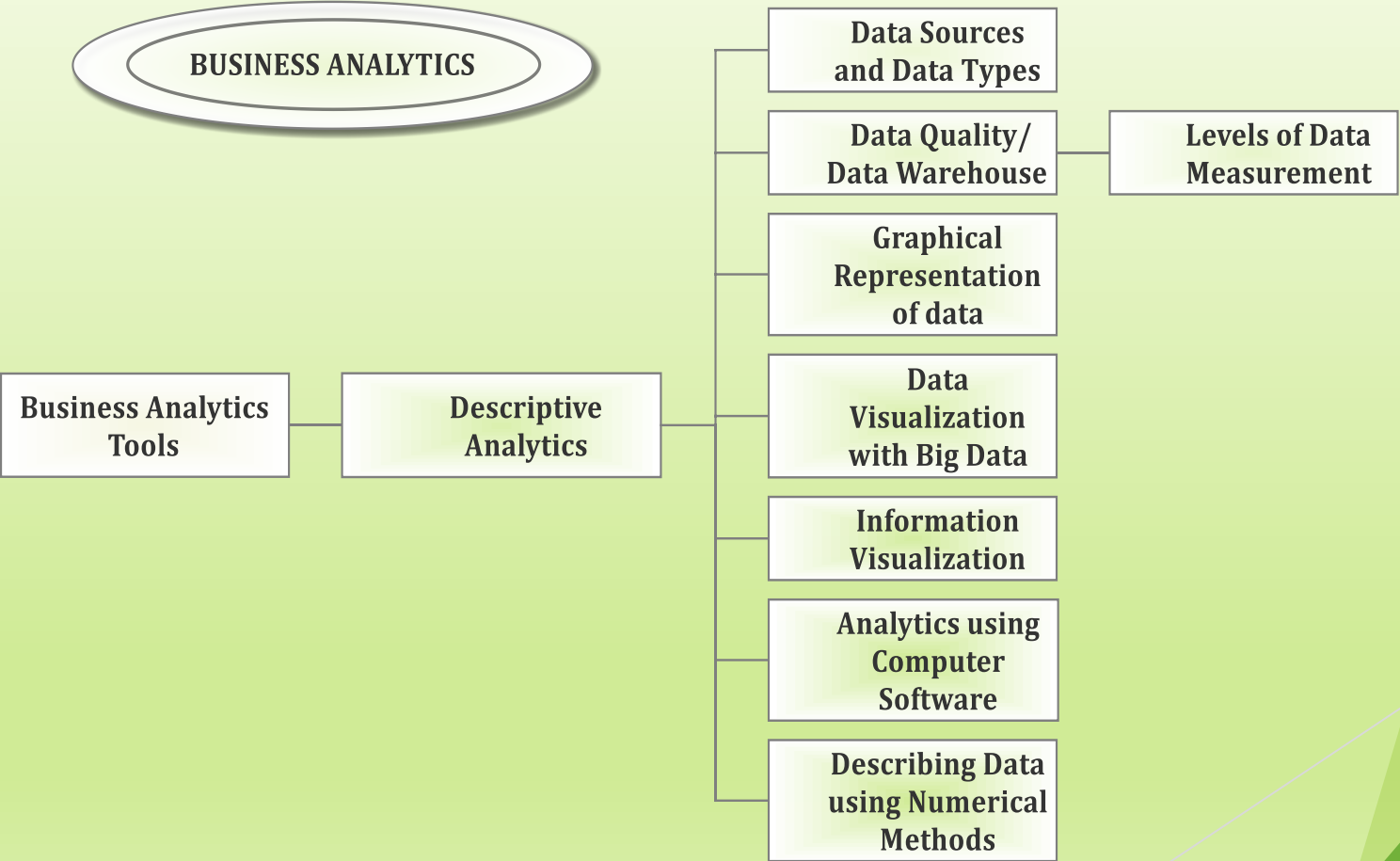




Introduction to Analytics, and Different types of Analytics

Tools of Descriptive, Predictive and Prescriptive Analytics

Figure 1.1: Tools of Descriptive Analytics



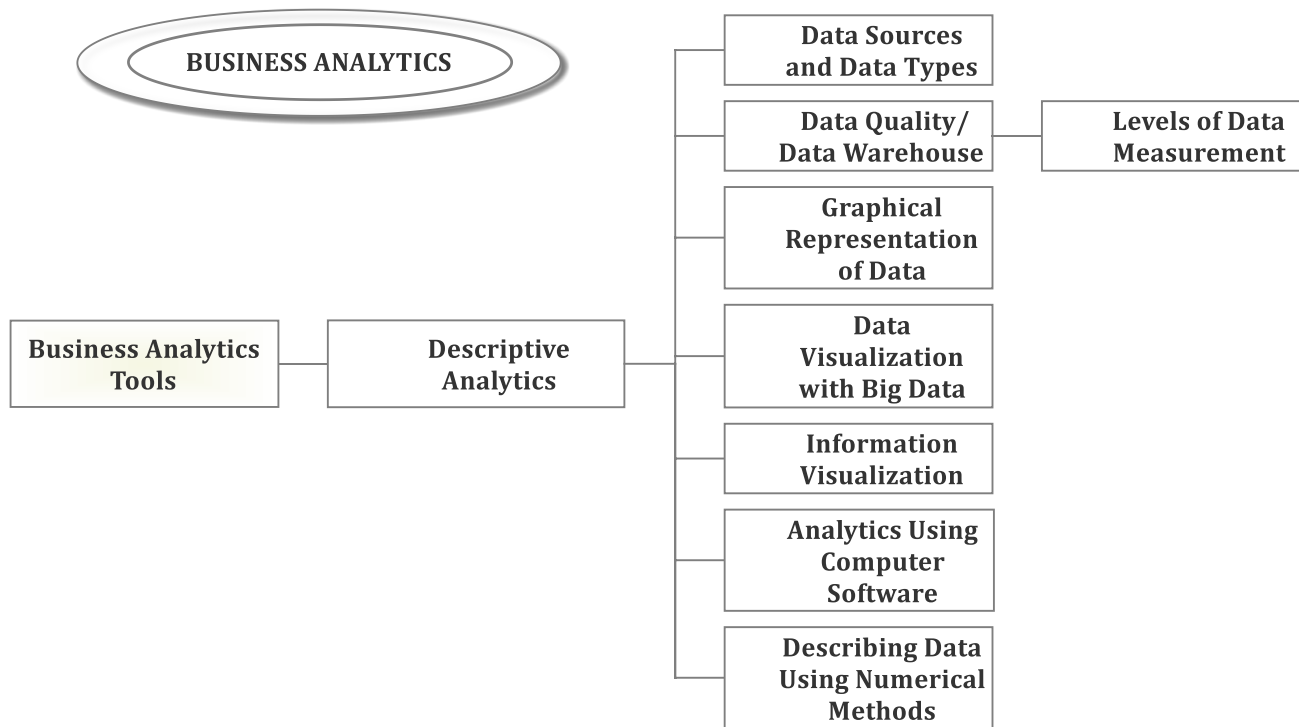
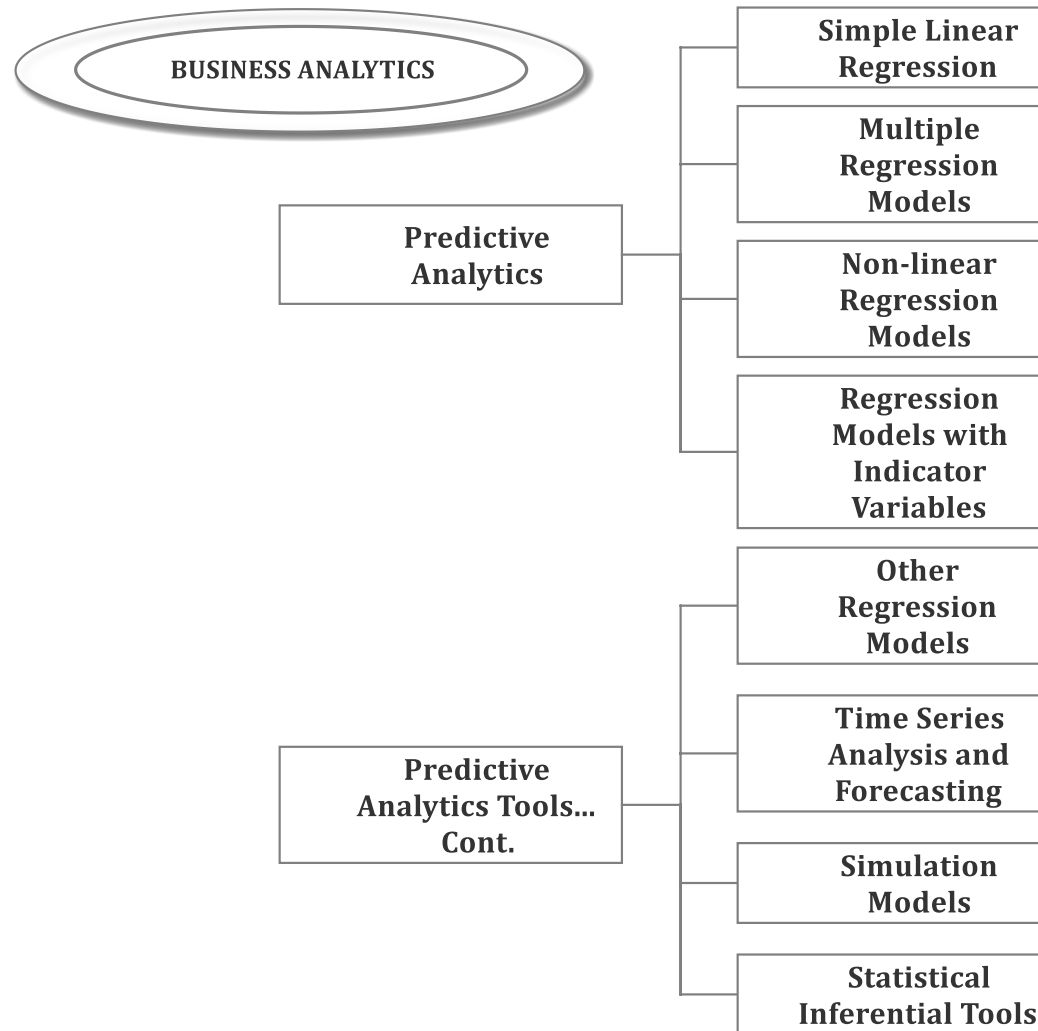


Figure 1.2: Tools of Predictive Analytics



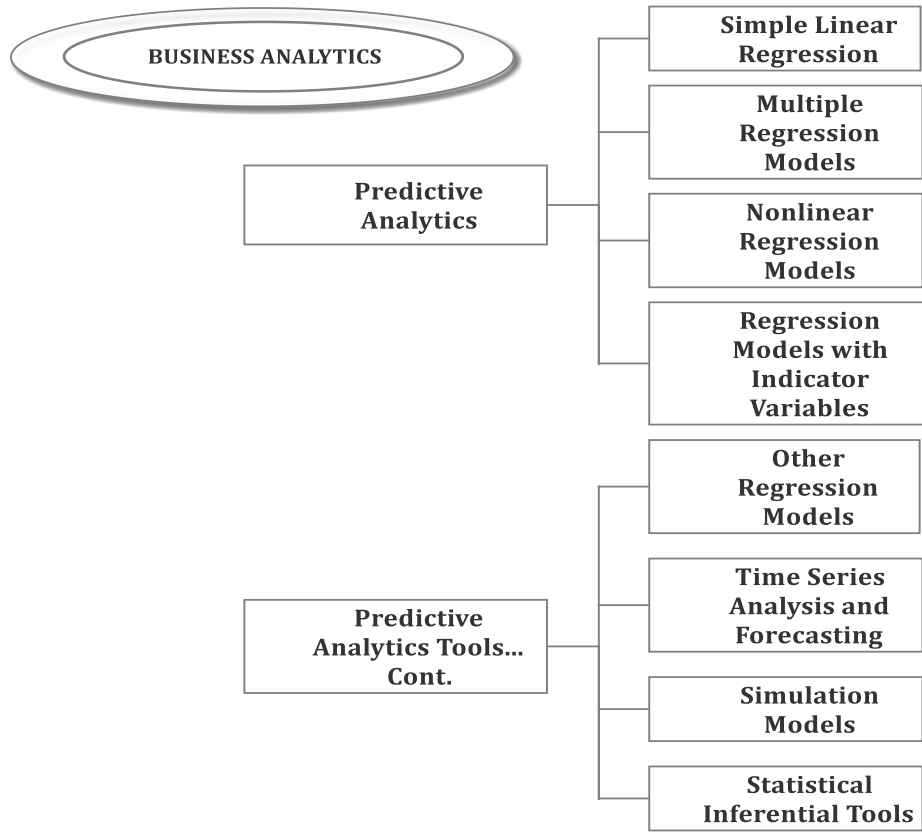
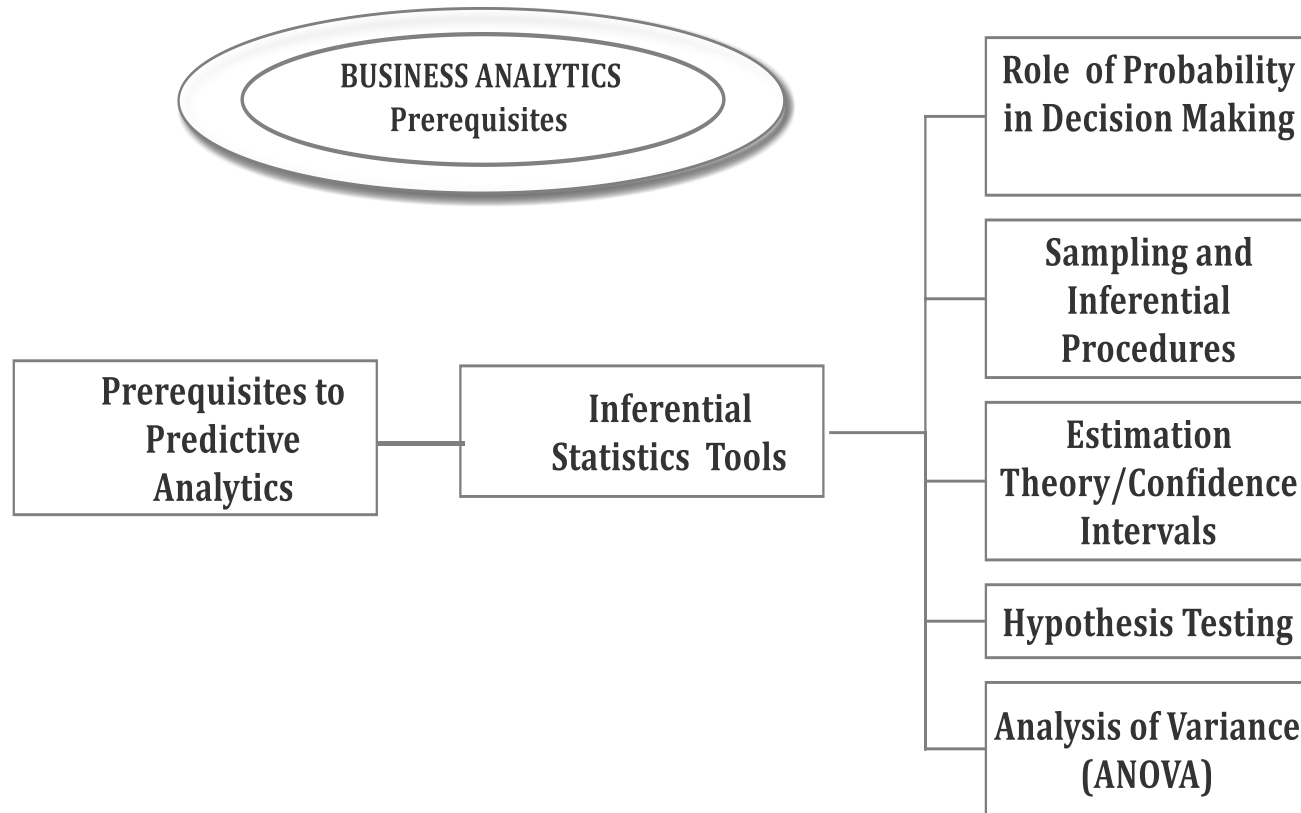


Figure 1.3: Prerequisite to Predictive Analytics



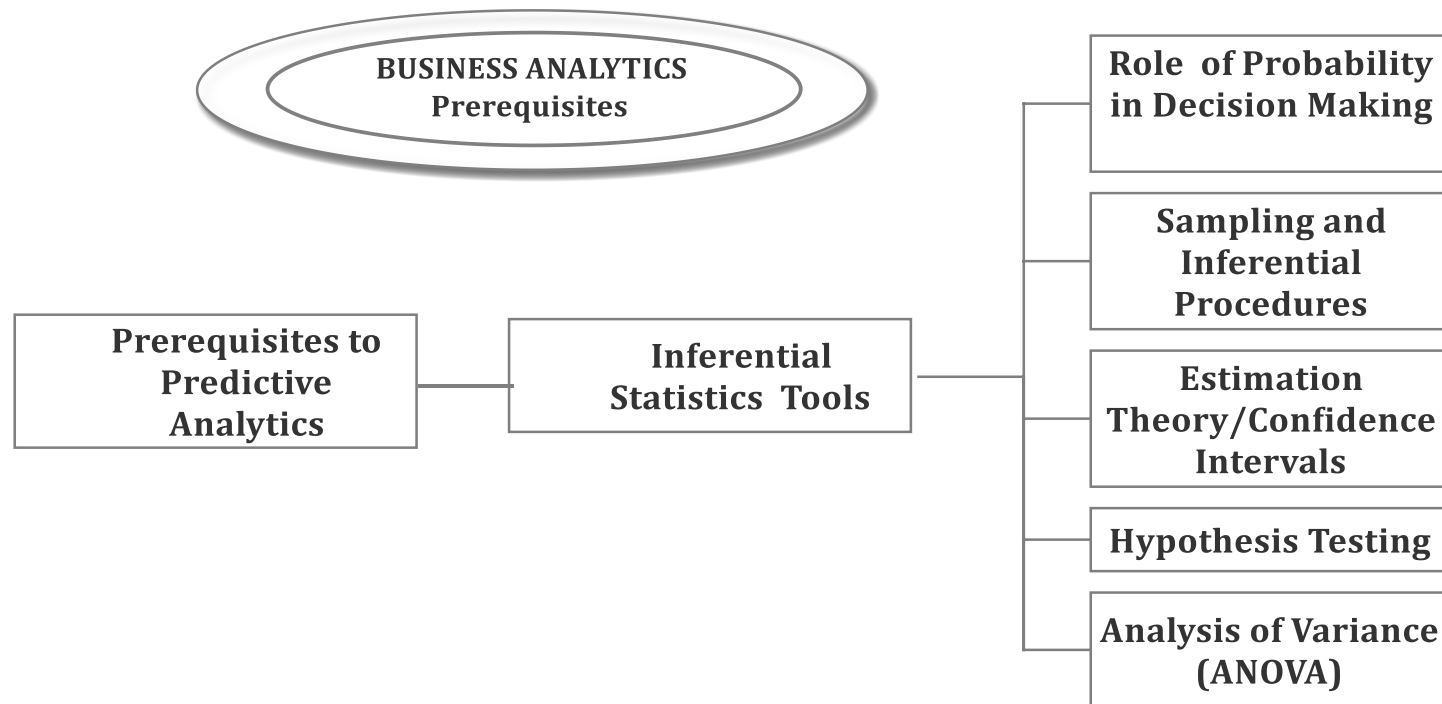
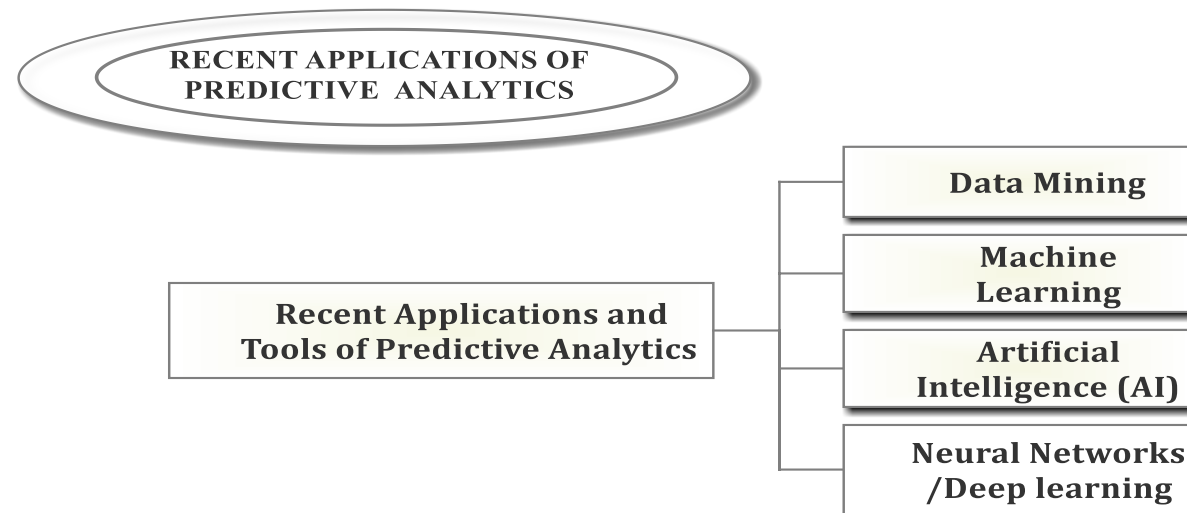


Figure 1.4: Recent Applications and Tools of Predictive modeling

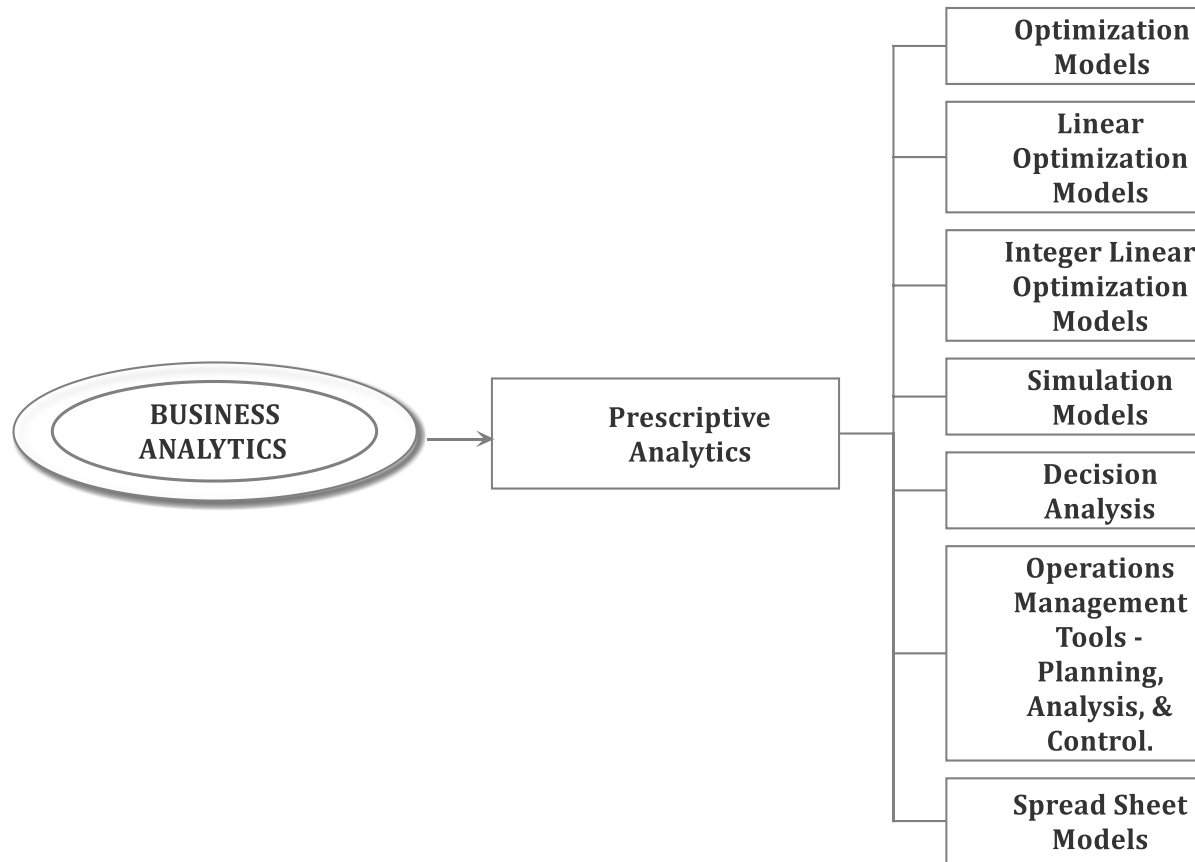


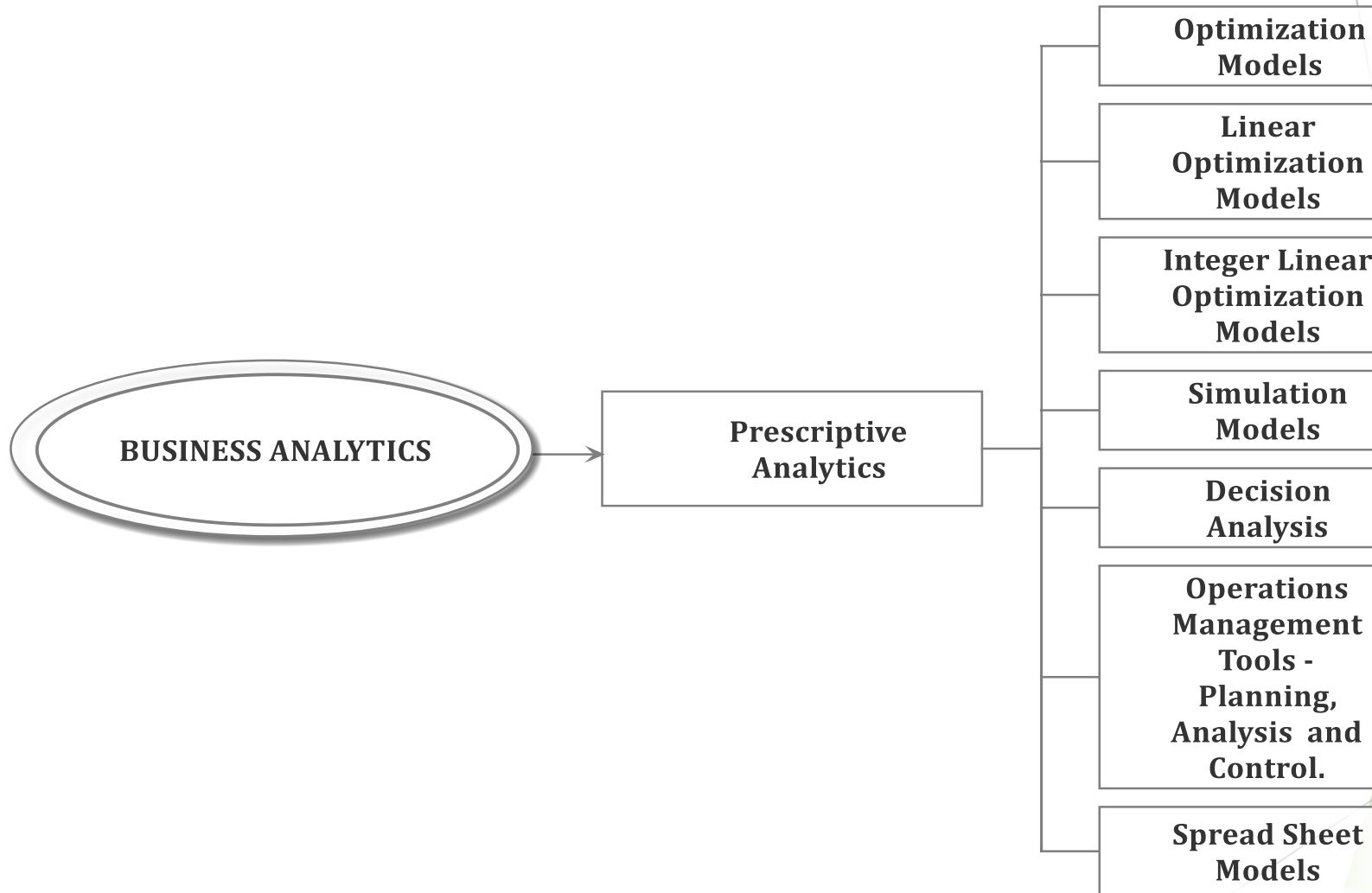
**RECENT APPLICATIONS OF
PREDICTIVE ANALYTICS**

**Recent Applications and
Tools of Predictive Analytics**

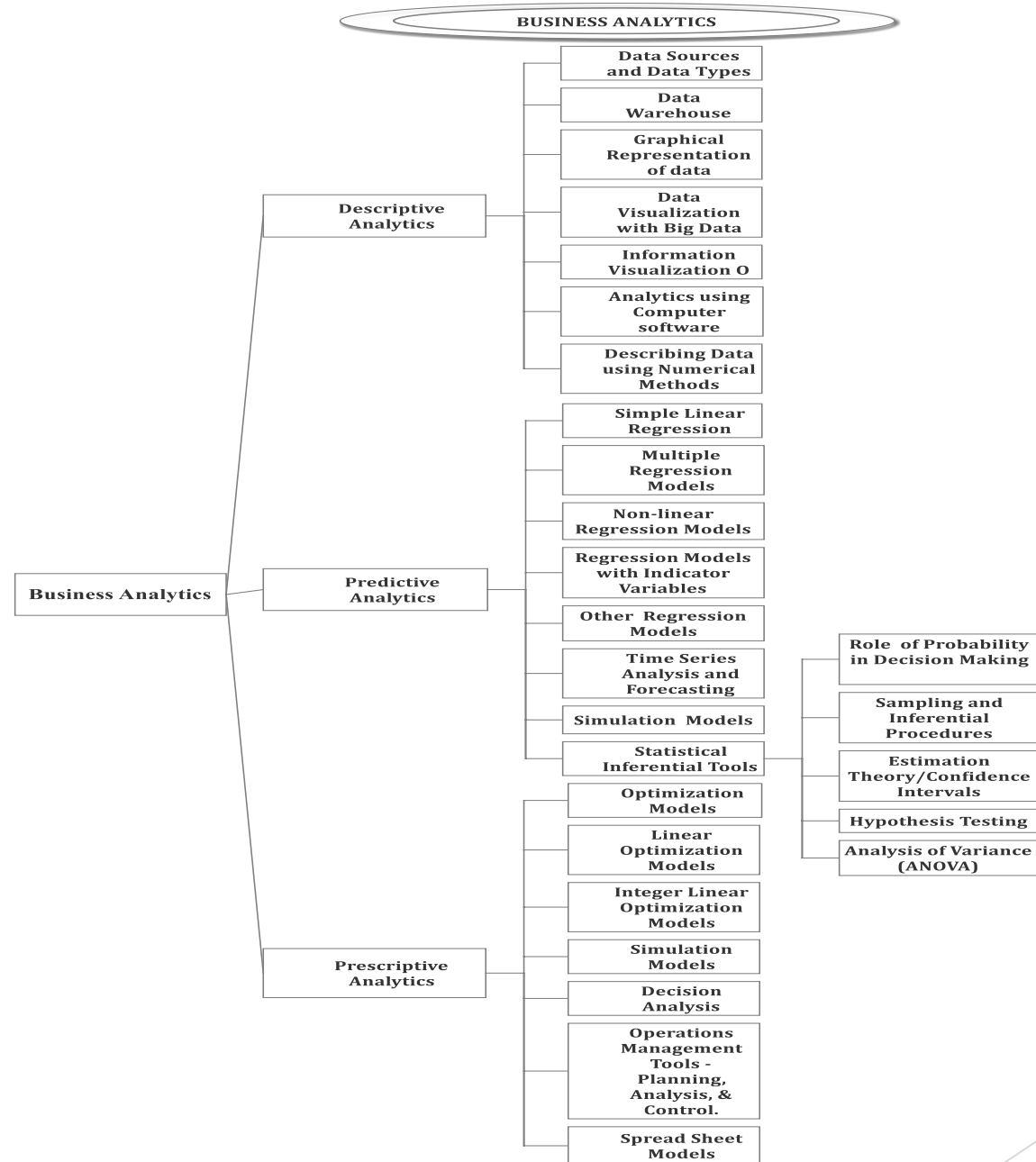
- Data Mining**
- Machine Learning**
- Artificial Intelligence (AI)**
- Neural Networks /Deep Learning**

Figure 1.5: Prescriptive Analytics Tools





. *Figure 1.6: Descriptive, Predictive, and Prescriptive Analytics Tools*



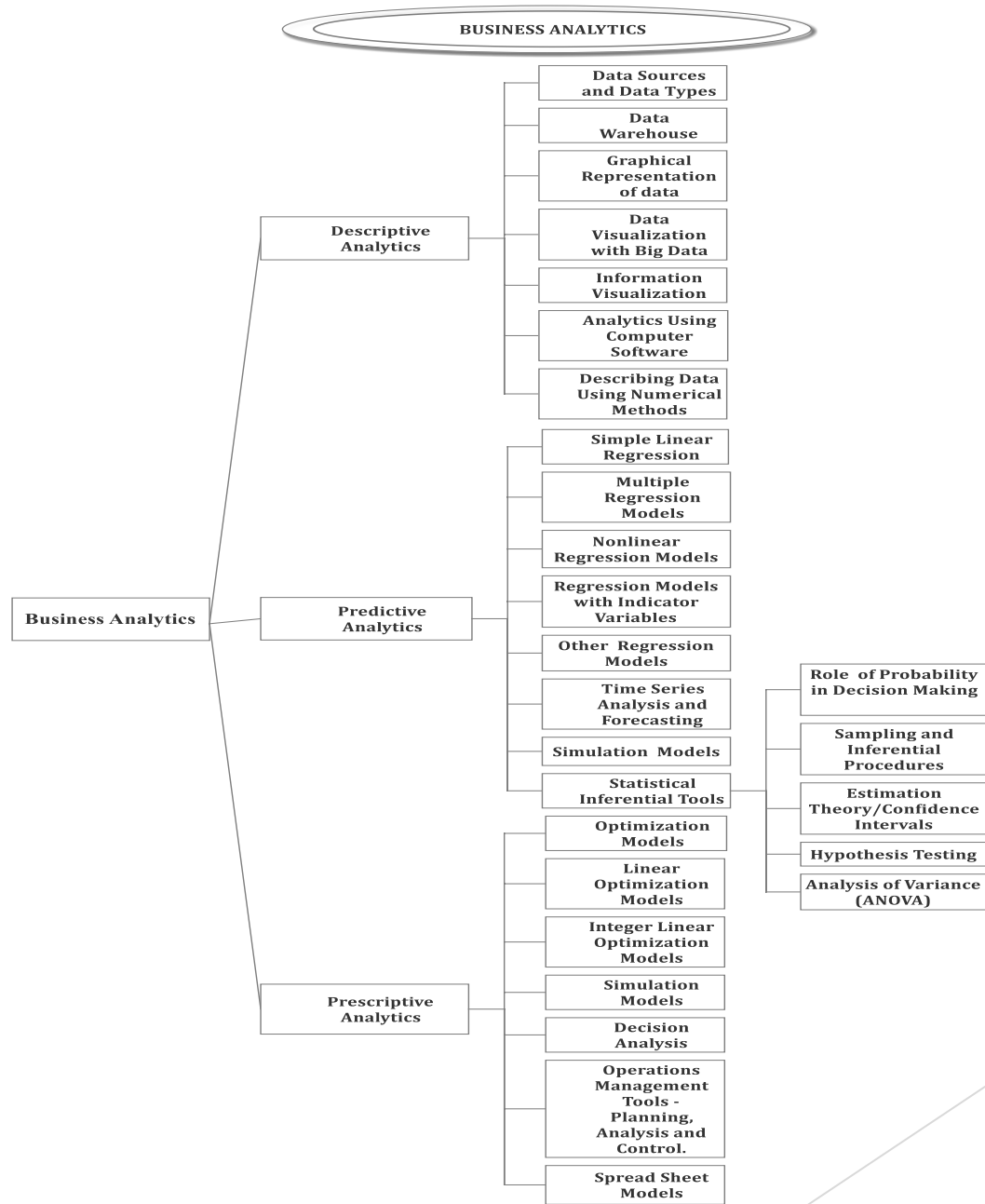
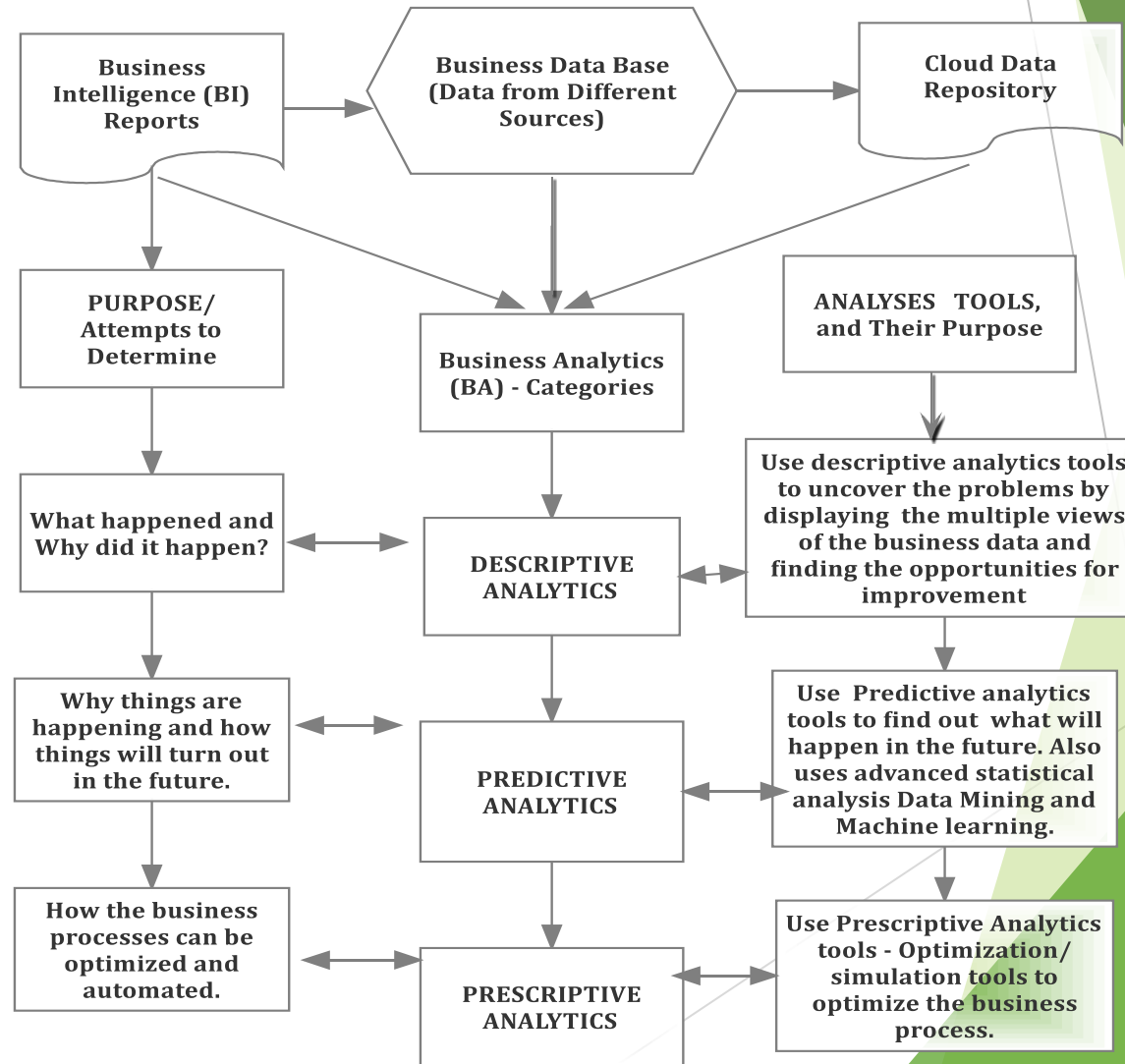


Figure 2.1: Input to the Business Analytics process, types of analytics, and description of tools in each type of analytics

Business Analytics: Process, Purpose and Tools



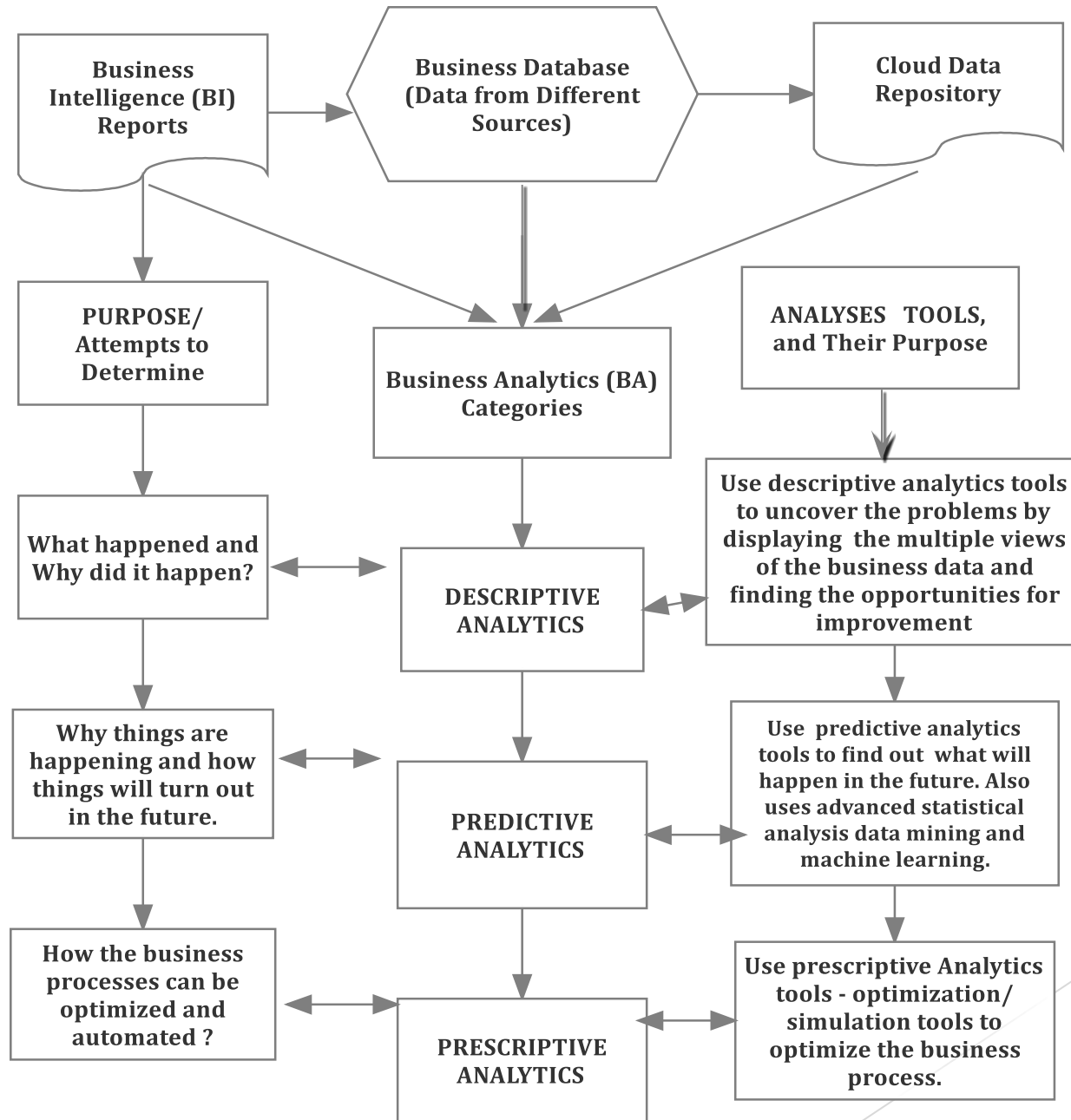
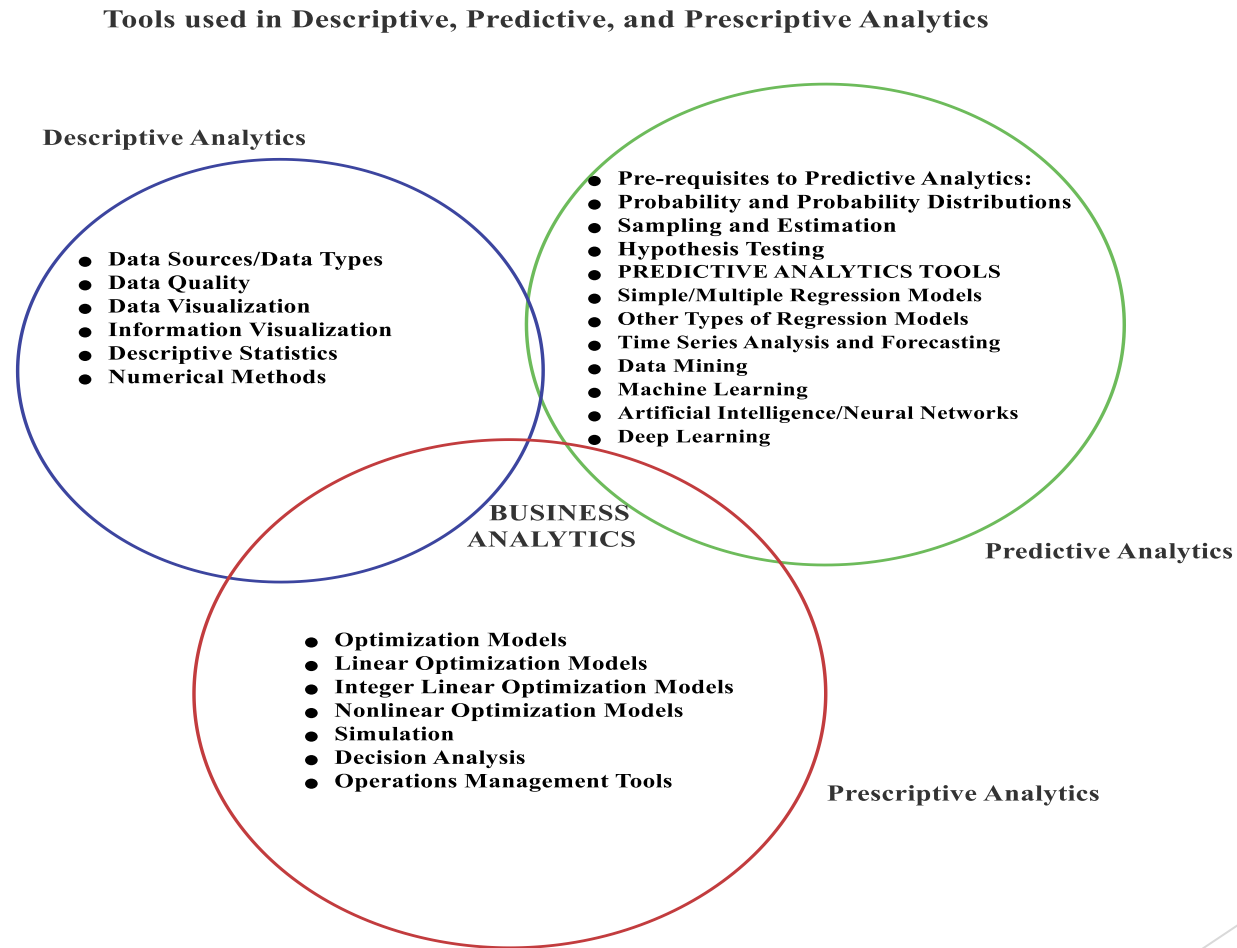


Figure 2.2: Interconnection between the tools of different types of analytics



Descriptive Analytics

- Data Sources/Data Types
- Data Quality
- Data Visualization
- Information Visualization
- Descriptive Statistics
- Numerical Methods

- Prerequisites to Predictive Analytics:
- Probability and Probability Distributions
- Sampling and Estimation
- Hypothesis Testing
- PREDICTIVE ANALYTICS TOOLS
- Simple/Multiple Regression Models
- Other Types of Regression Models
- Time Series Analysis and Forecasting
- Data Mining
- Machine Learning
- Artificial Intelligence/Neural Networks
- Deep Learning

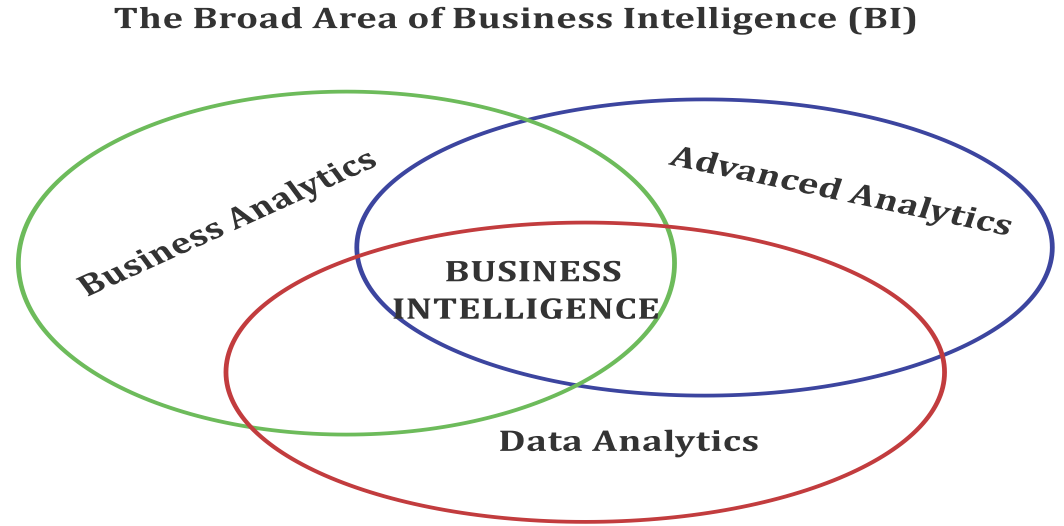
BUSINESS ANALYTICS

Predictive Analytics

- Optimization Models
- Linear Optimization Models
- Integer Linear Optimization Models
- Nonlinear Optimization Models
- Simulation
- Decision Analysis
- Operations Management Tools

Prescriptive Analytics

Figure 2.3: The Broad Area of Business Intelligence (BI)



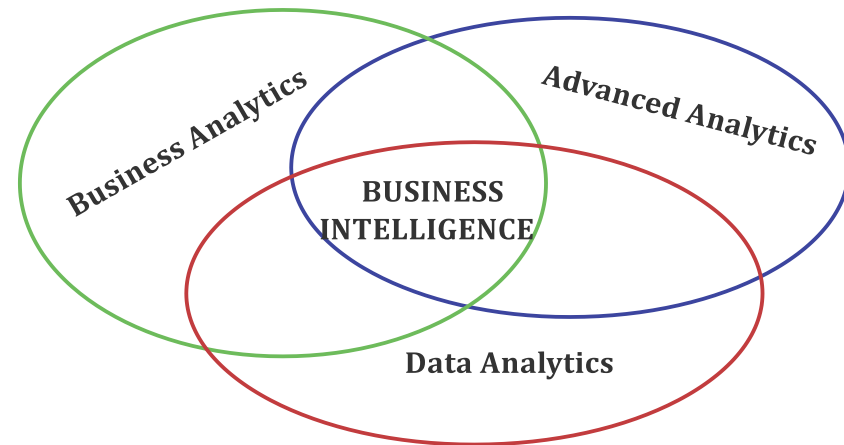
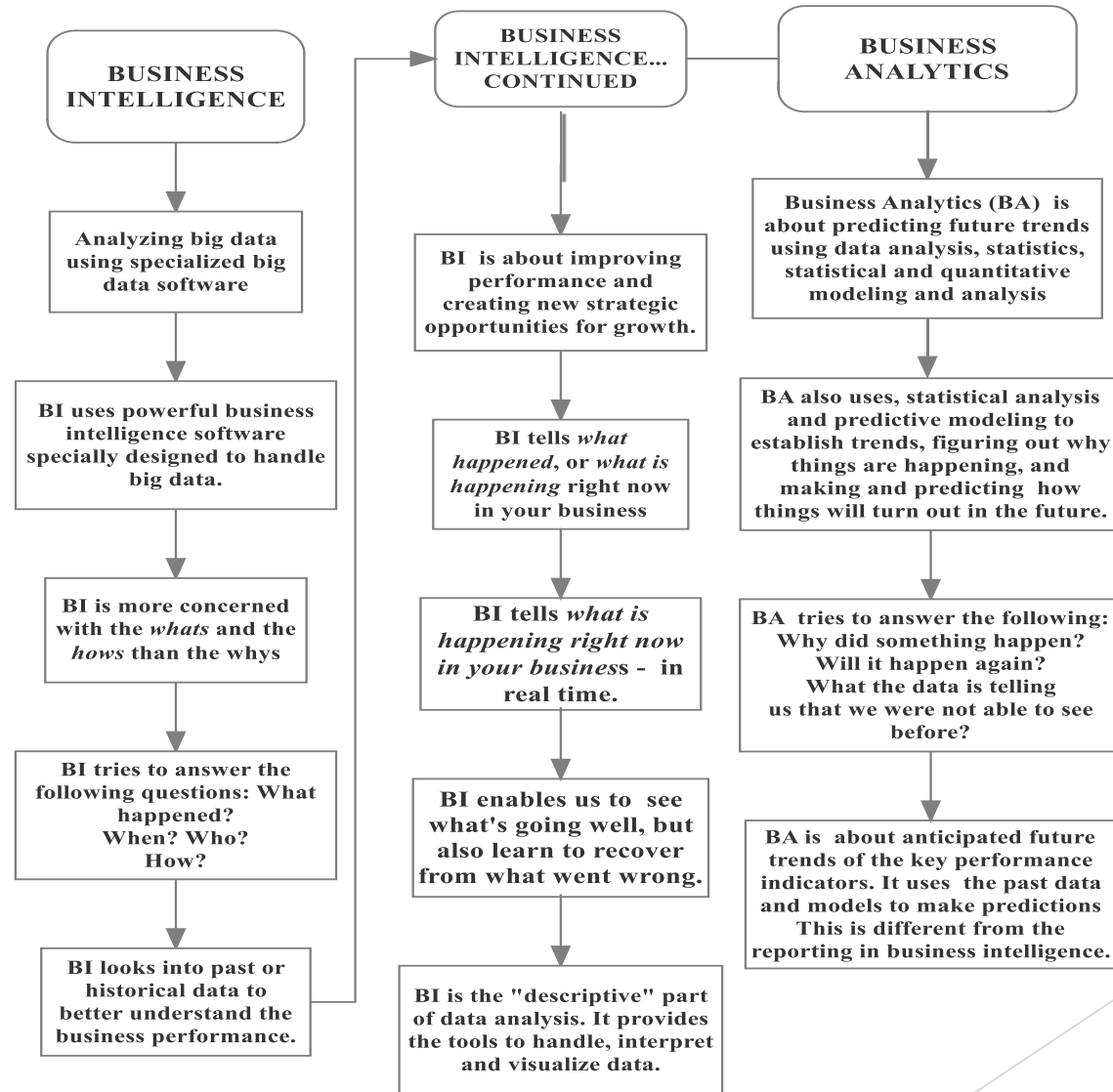


Figure 2.4: Comparing Business Intelligence (BI) and Business Analytics

Business Intelligence (BI) and Business Analytics: Comparison



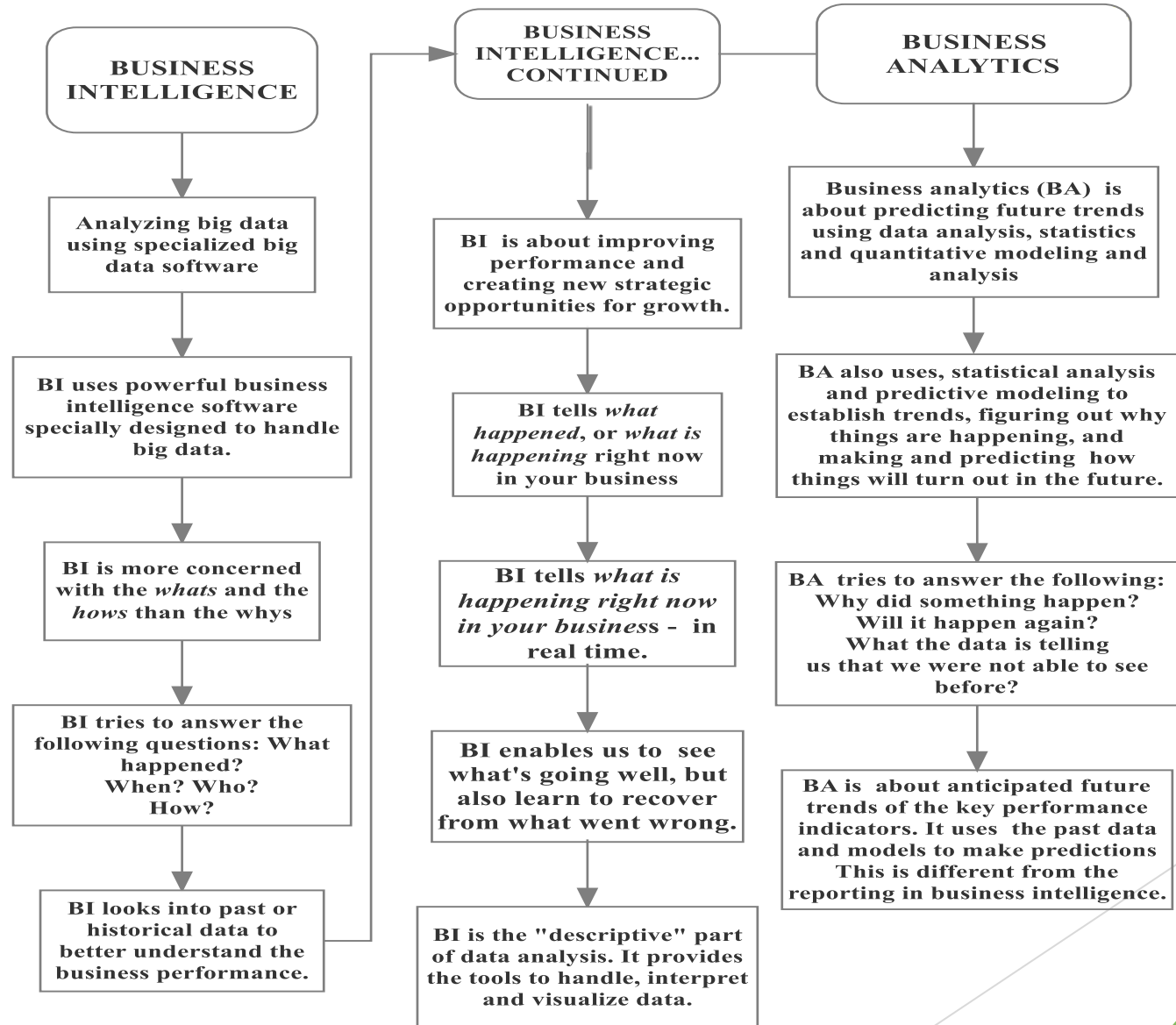
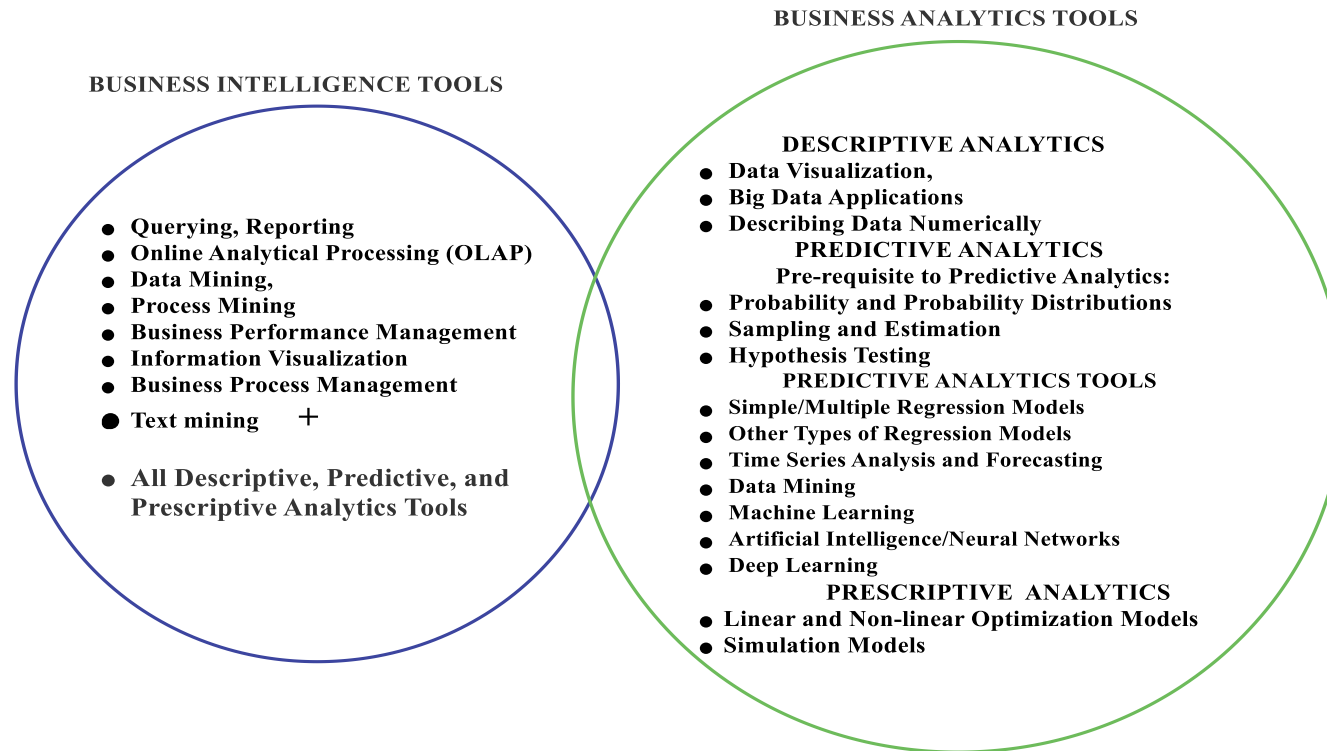


Figure 2.5: Business Intelligence (BI) and Business Analytics (BA) Tools

Business Intelligence (BI) and Business Analytics: Tools



BUSINESS ANALYTICS TOOLS

BUSINESS INTELLIGENCE TOOLS

- Querying, Reporting
- Online Analytical Processing (OLAP)
- Data Mining,
- Process Mining
- Business Performance Management
- Information Visualization
- Business Process Management
- Text mining +

- All Descriptive, Predictive, and Prescriptive Analytics Tools

DESCRIPTIVE ANALYTICS

- Data Visualization,
- Big Data Applications
- Describing Data Numerically

PREDICTIVE ANALYTICS

Pre-requisite to Predictive Analytics:

- Probability and Probability Distributions
- Sampling and Estimation
- Hypothesis Testing

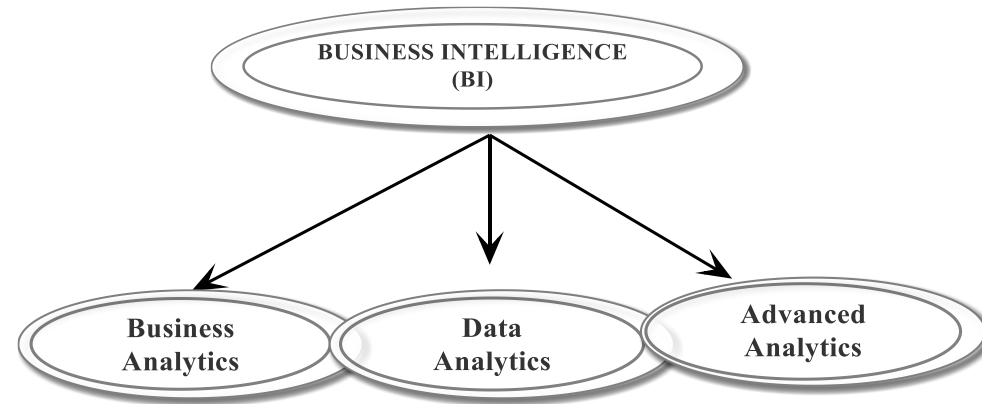
PREDICTIVE ANALYTICS TOOLS

- Simple/Multiple Regression Models
- Other Types of Regression Models
- Time Series Analysis and Forecasting
- Data Mining
- Machine Learning
- Artificial Intelligence/Neural Networks
- Deep Learning

PRESCRIPTIVE ANALYTICS

- Linear and Non-linear Optimization Models
- Simulation Models

Figure 3.1 Business Intelligence and Support Systems



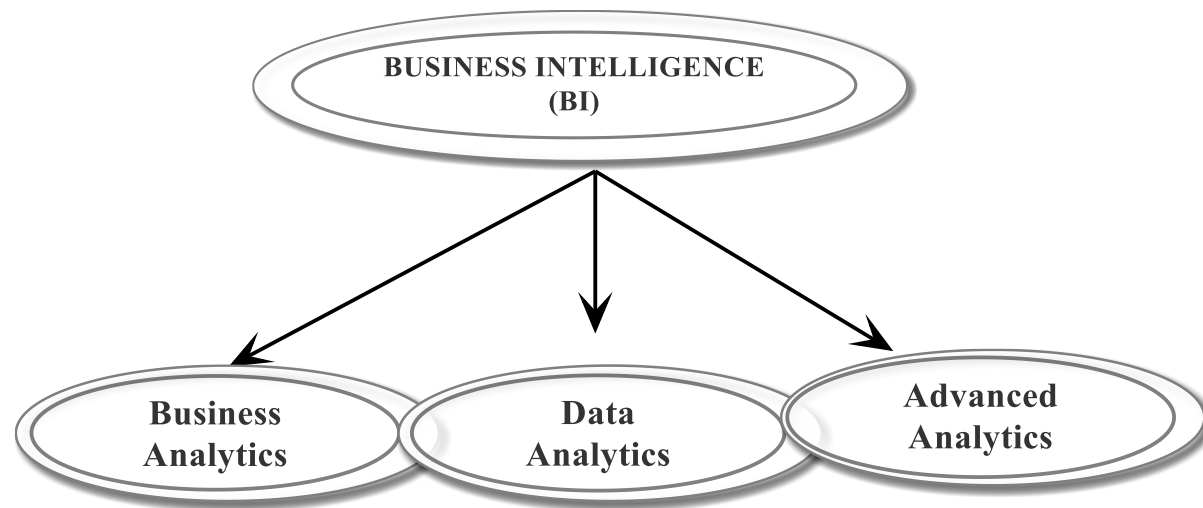
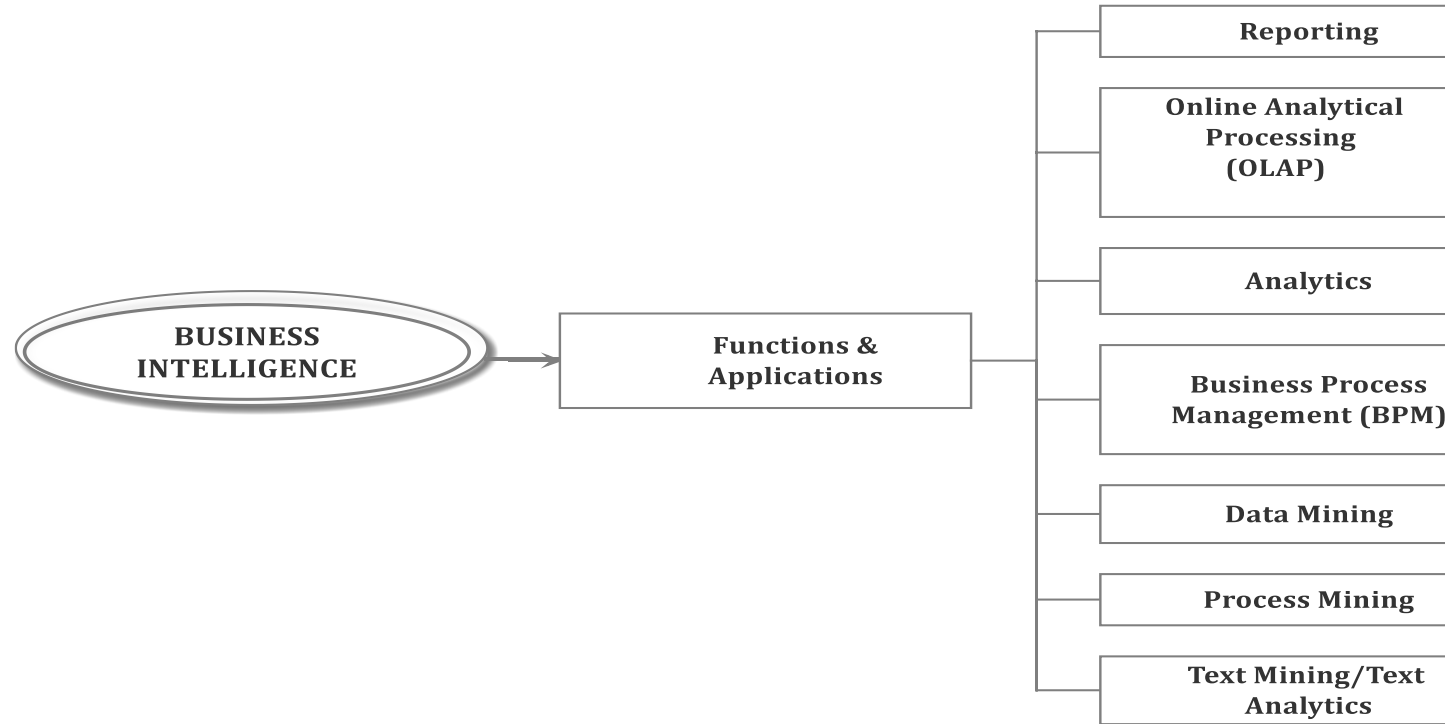


Figure 3.2: Functions and Application Areas of Business Intelligence (BI)



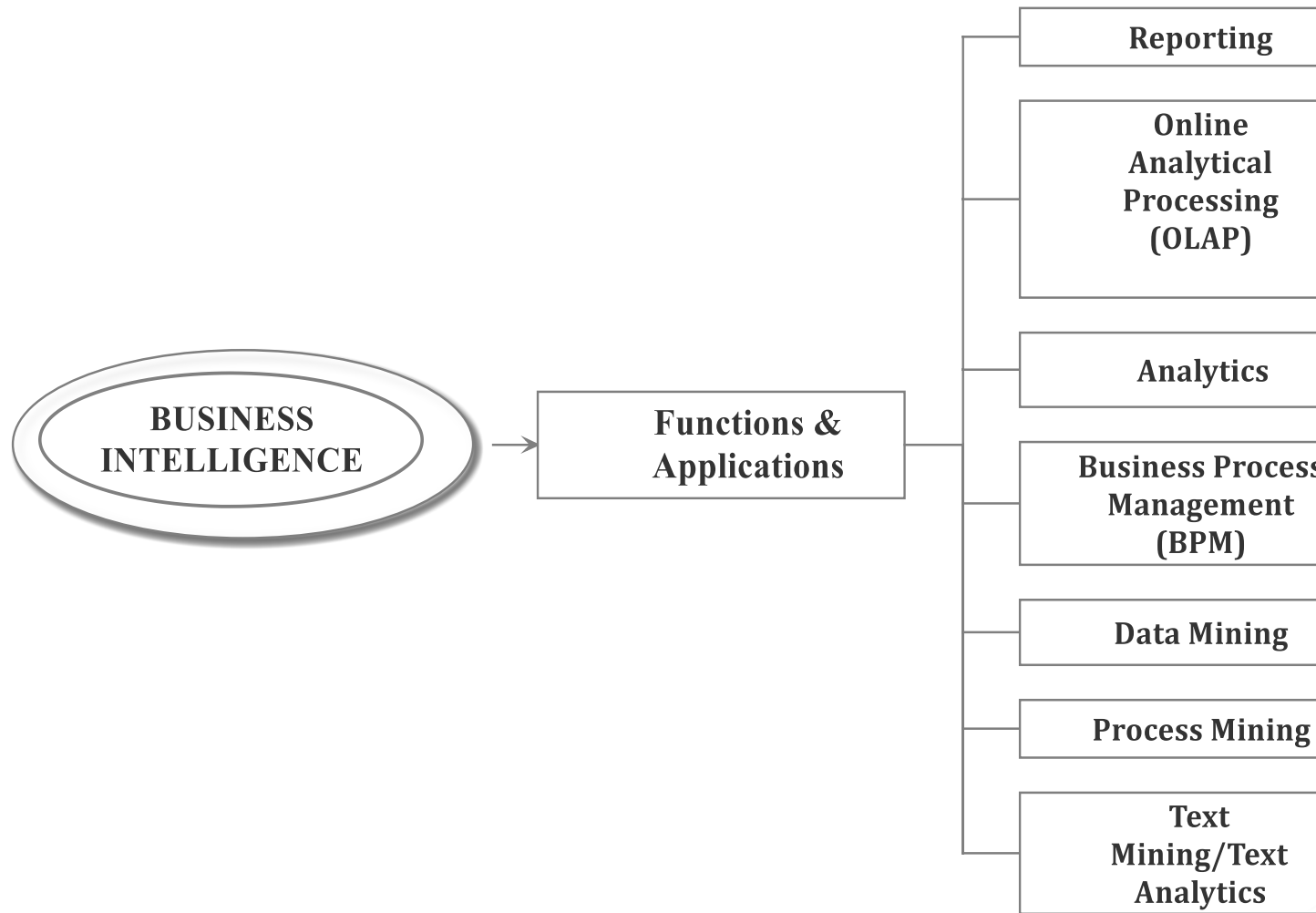
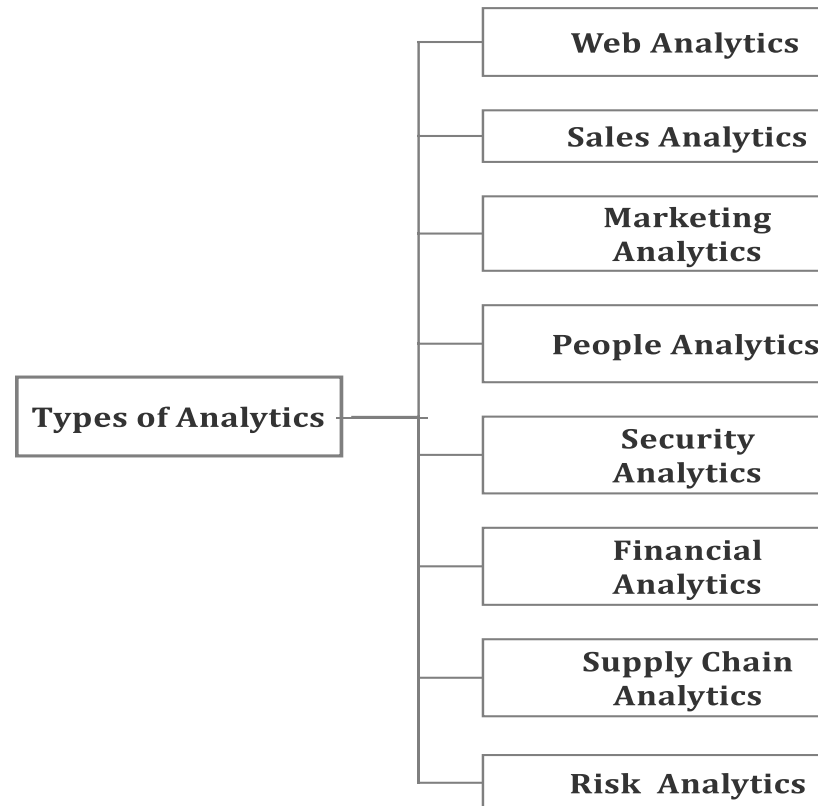


Figure 3.3: Types of Analytics



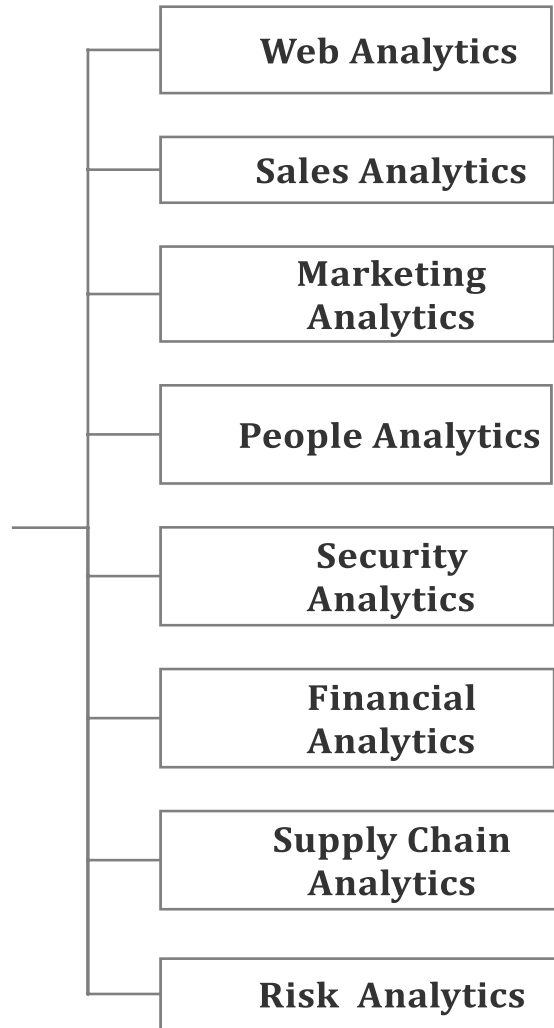
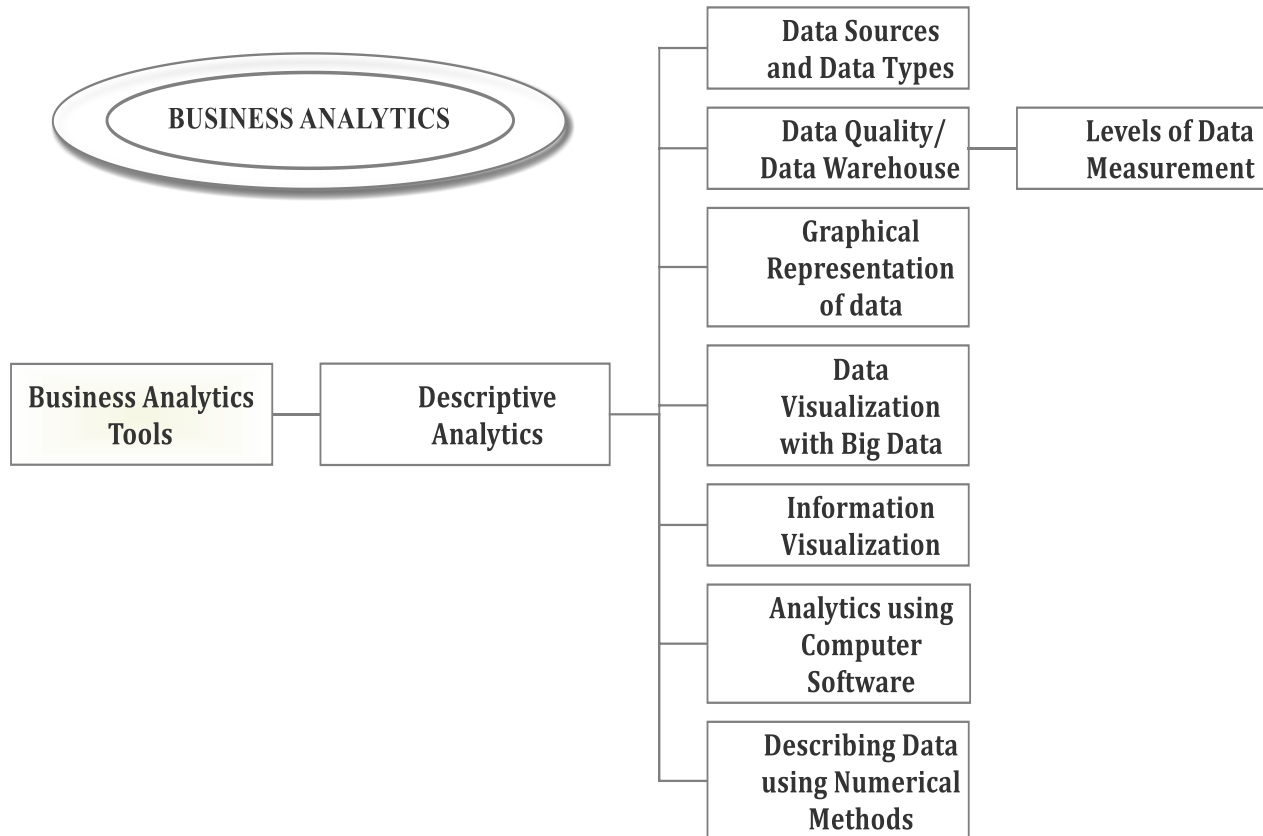


Figure 4.1: Tools and Methods of Descriptive Analytics



BUSINESS ANALYTICS

Business Analytics Tools

Descriptive Analytics

- Data Sources and Data Types**
- Data Quality/ Data Warehouse**
- Graphical Representation of Data**
- Data Visualization with Big Data**
- Information Visualization**
- Analytics Using Computer Software**
- Describing Data Using Numerical Methods**

Levels of Data Measurement

Figure 4.2: Number of Orders by Day

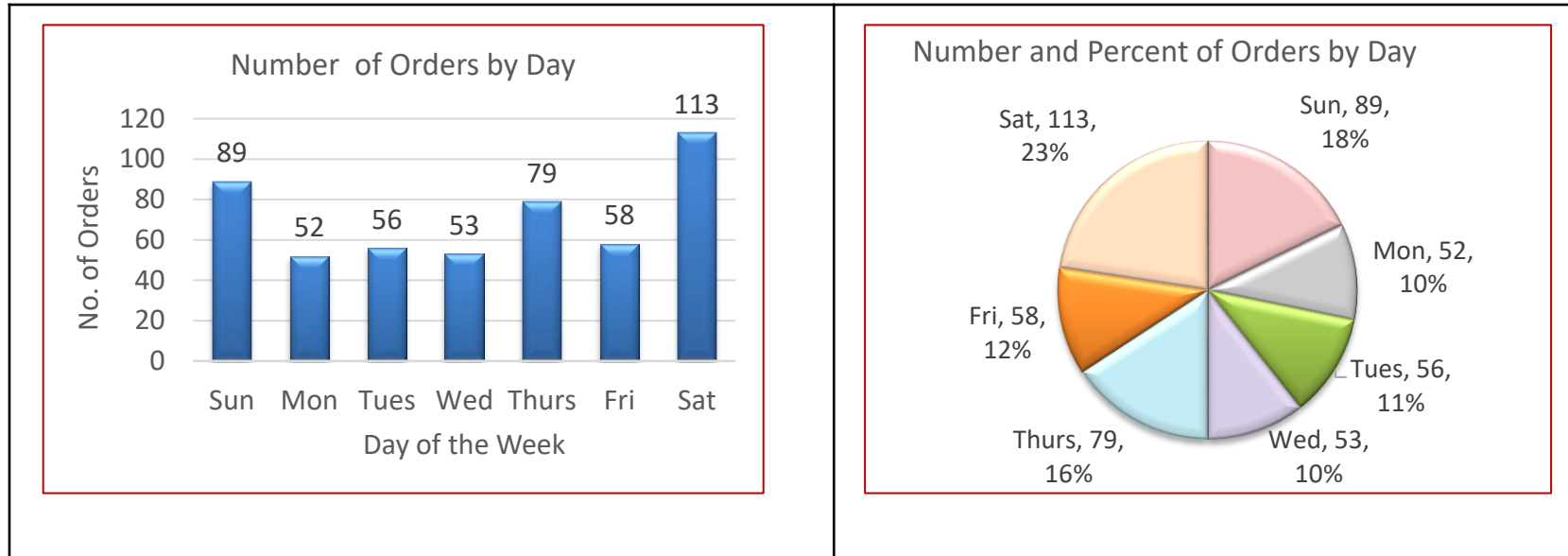
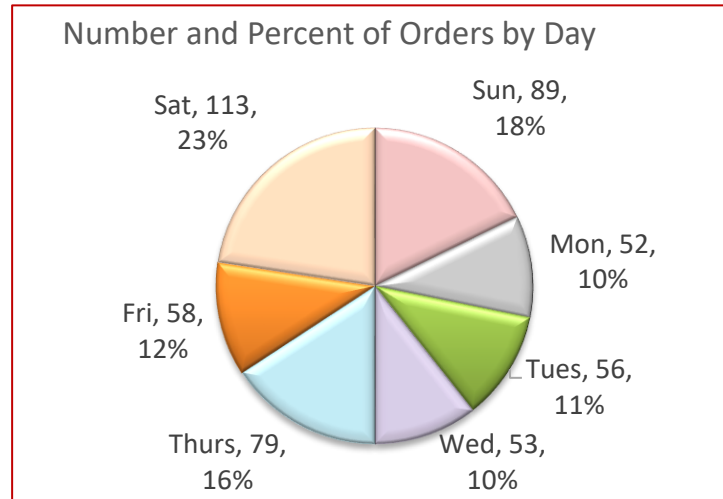


Figure 4.3: Number and Percent of Orders



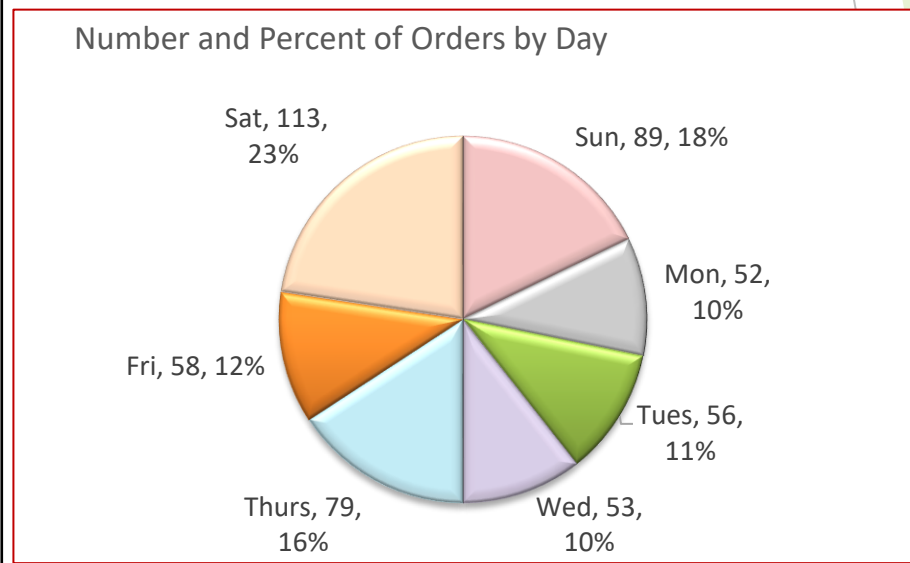
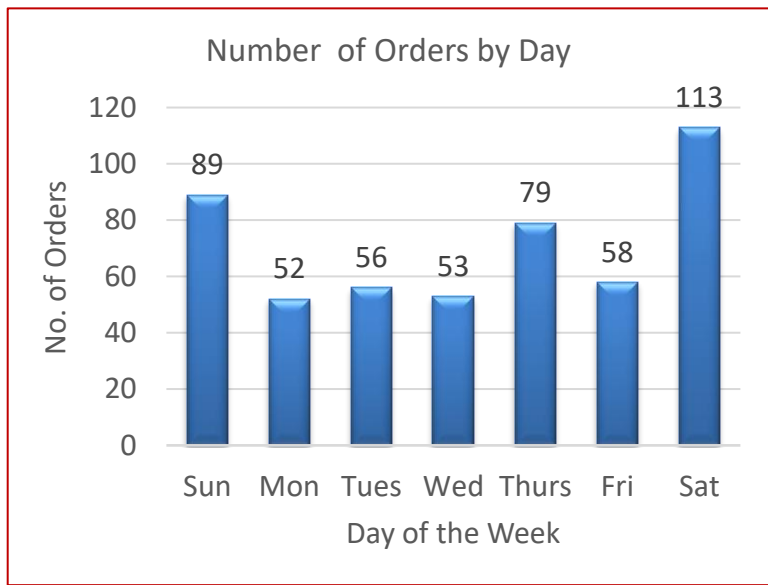
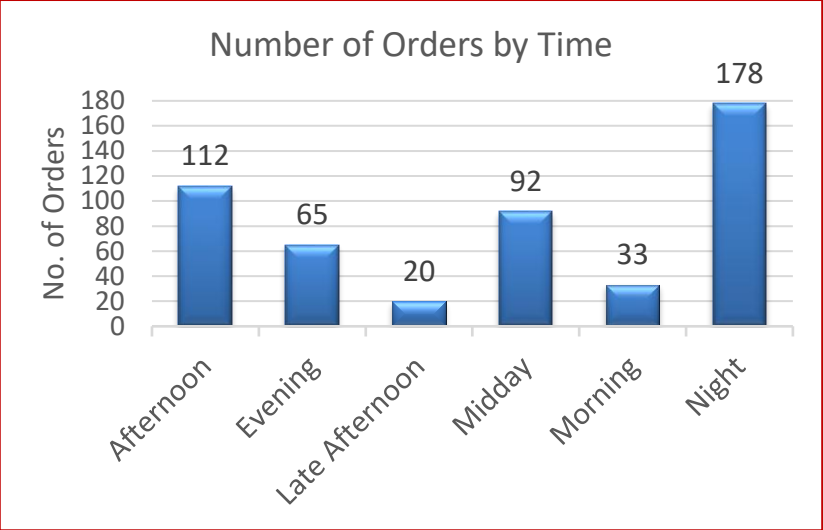


Figure 4.4: Plot of Number of Orders by Time



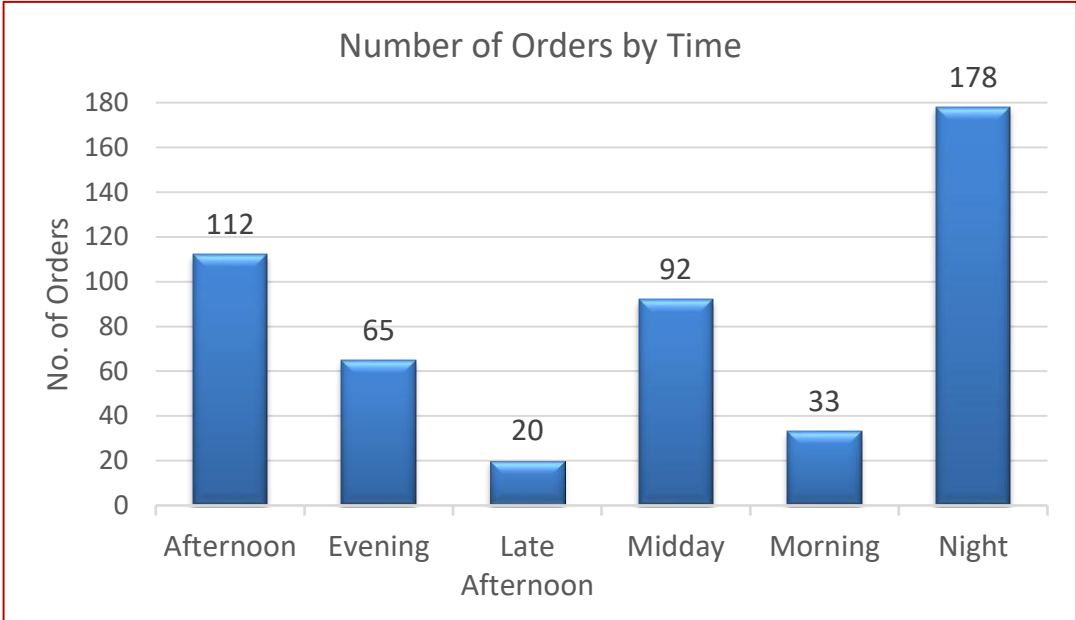


Figure 4.5: Number of Orders by Region

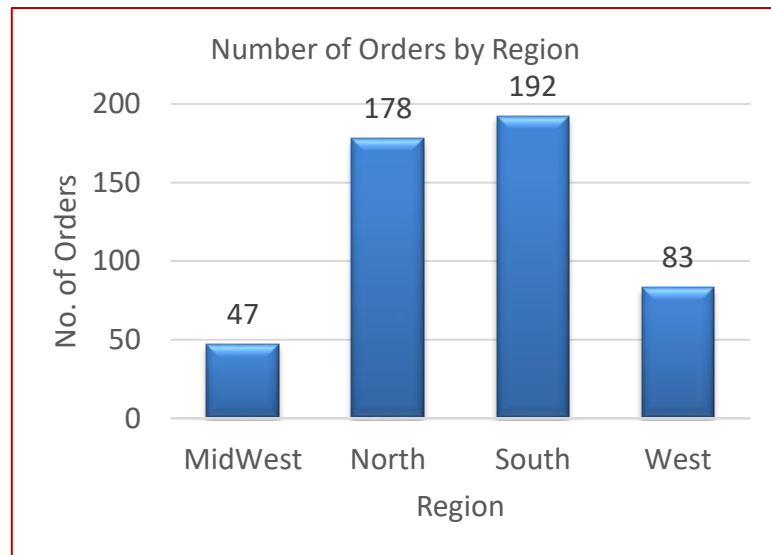
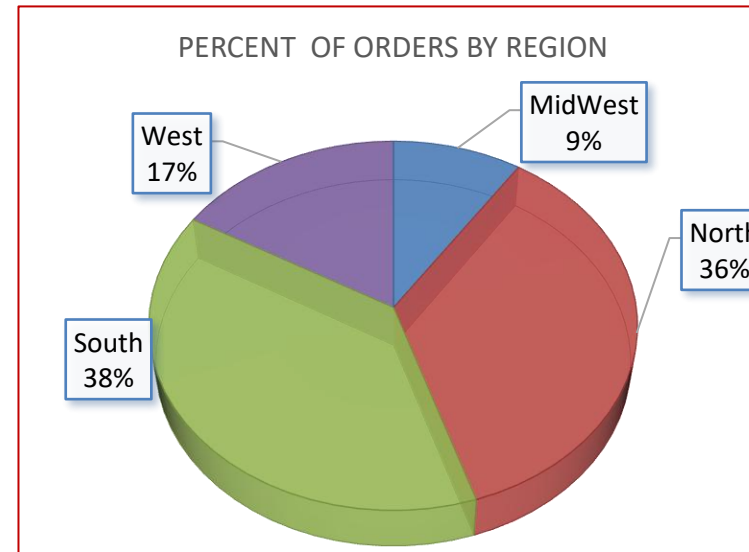


Figure 4.6: Percent of Orders by Region



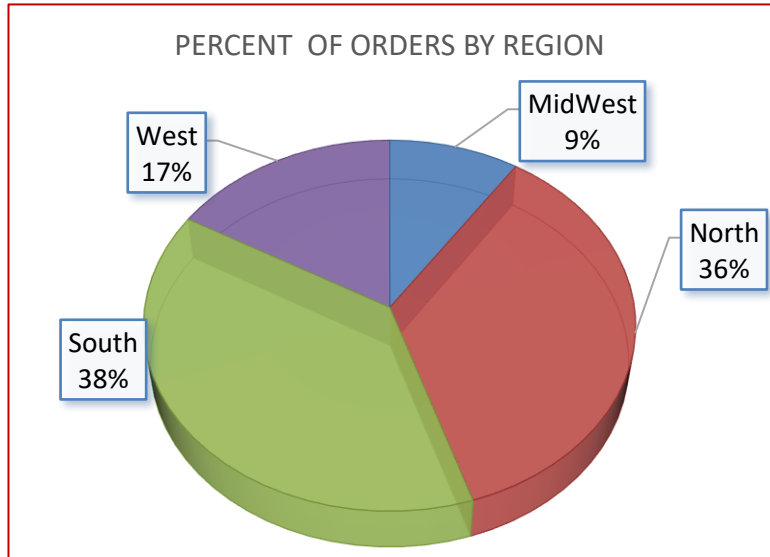
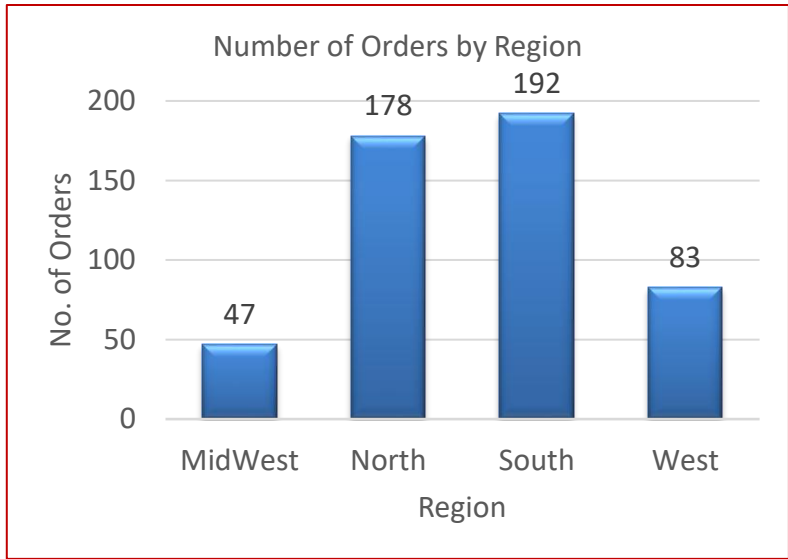
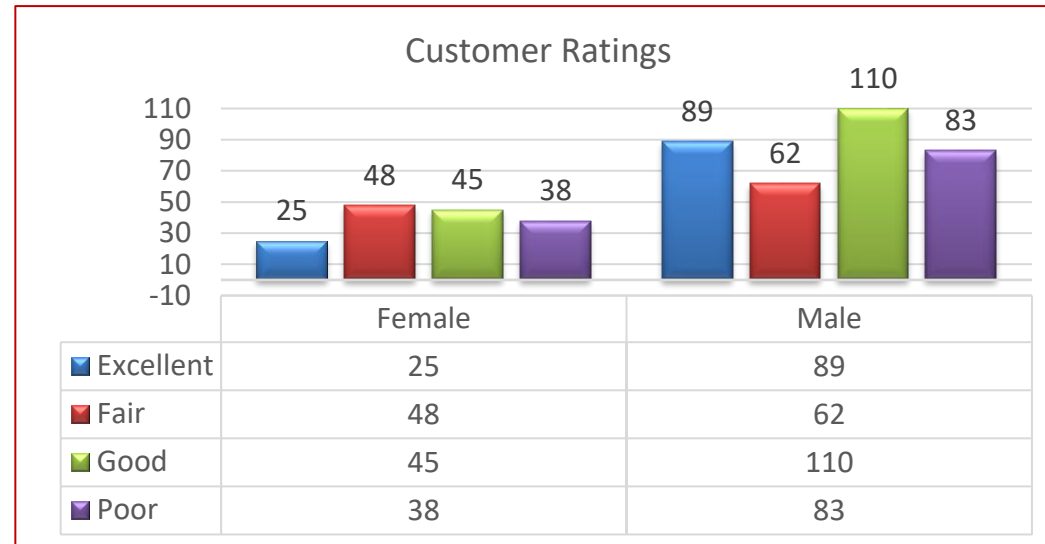
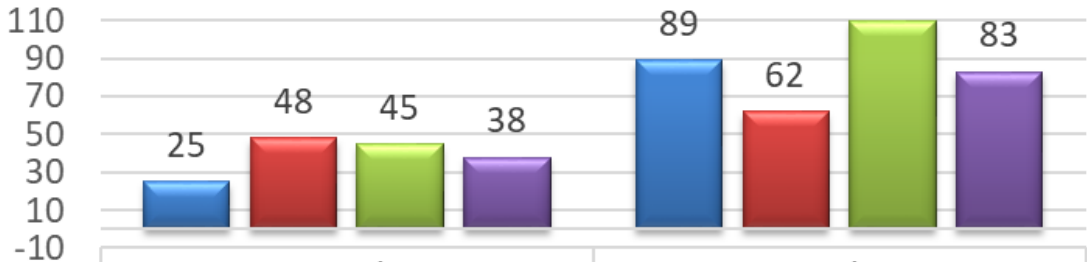


Figure 4.7: Customer Ratings by Gender

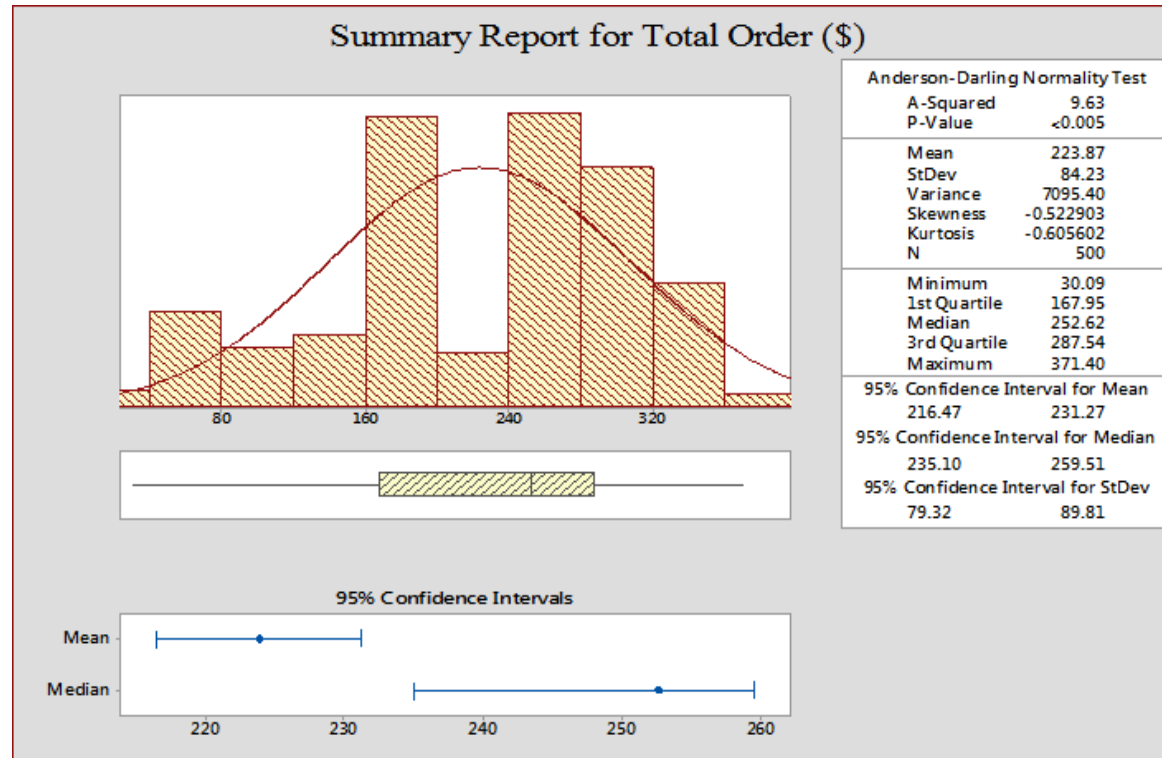


Customer Ratings

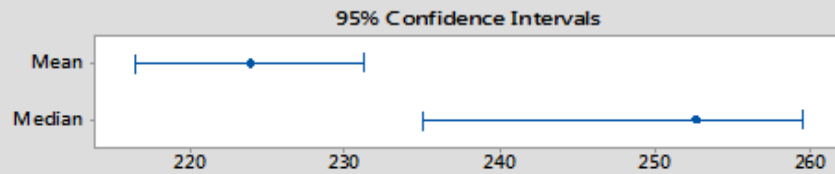
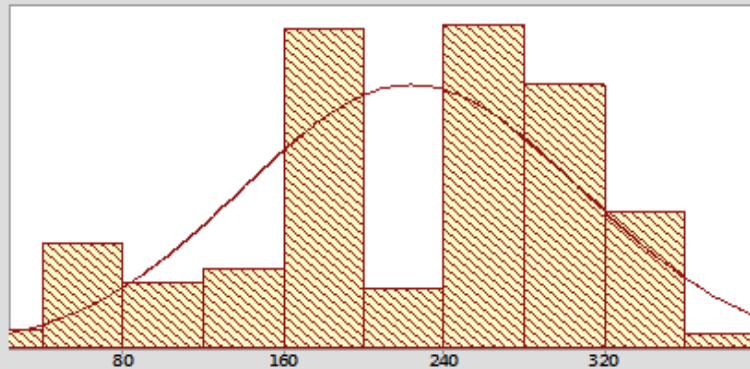


	Female	Male
Excellent	25	89
Fair	48	62
Good	45	110
Poor	38	83

Figure 4.8: Graphical Summary of the Total Orders Data



Summary Report for Total Order (\$)



Anderson-Darling Normality Test

A-Squared	9.63
P-Value	<0.005

Mean	223.87
StDev	84.23
Variance	7095.40
Skewness	-0.522903
Kurtosis	-0.605602
N	500

Minimum	30.09
1st Quartile	167.95
Median	252.62
3rd Quartile	287.54
Maximum	371.40

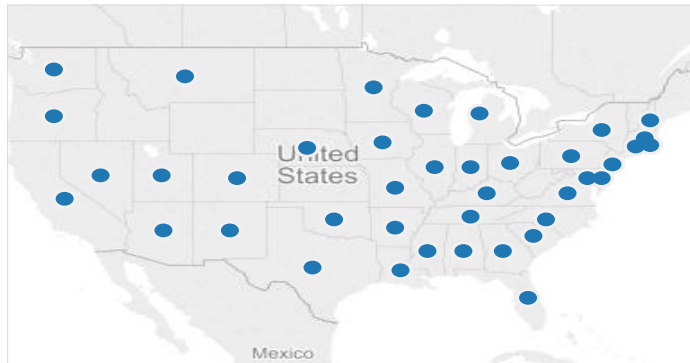
95% Confidence Interval for Mean	216.47	231.27
----------------------------------	--------	--------

95% Confidence Interval for Median	235.10	259.51
------------------------------------	--------	--------

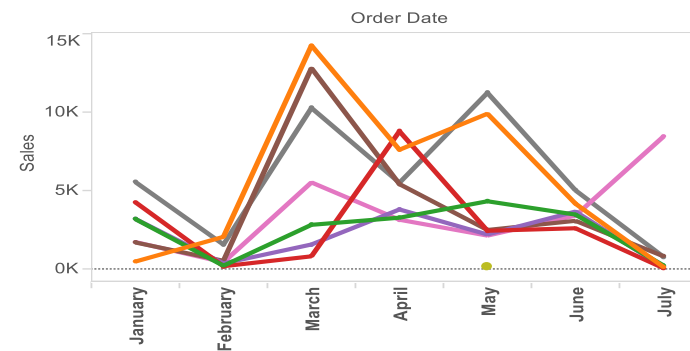
95% Confidence Interval for StDev	79.32	89.81
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Figure 4.9: A dashboard of Online Orders Data

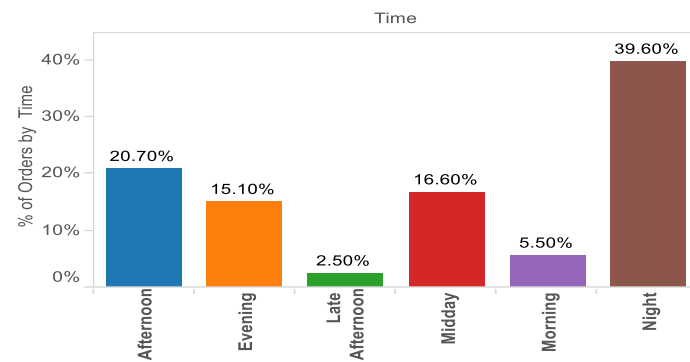
Order Map



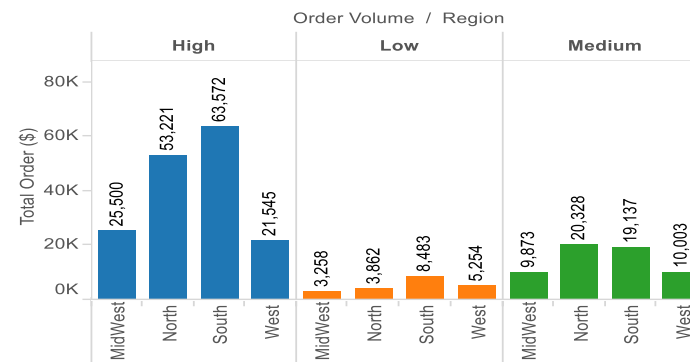
Sales by Month



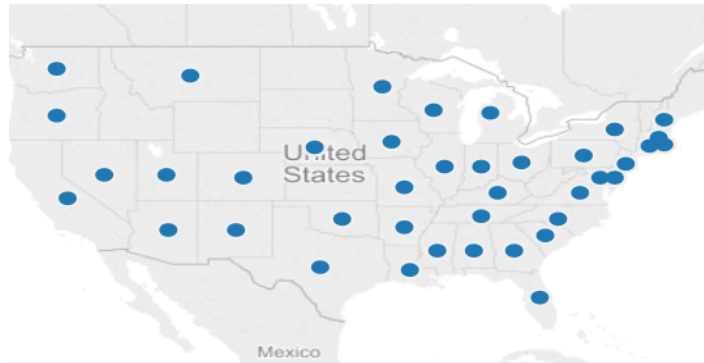
% of Orders by Time



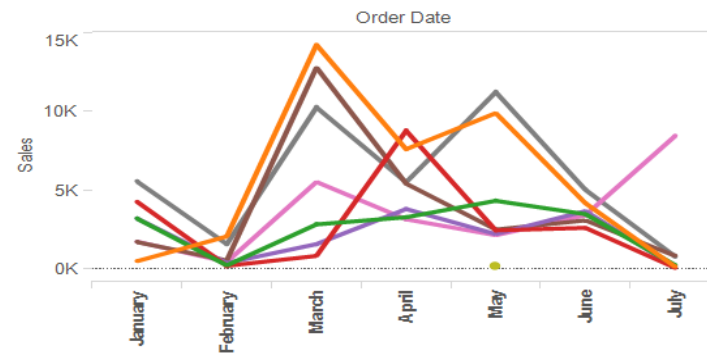
Total Orders by Region



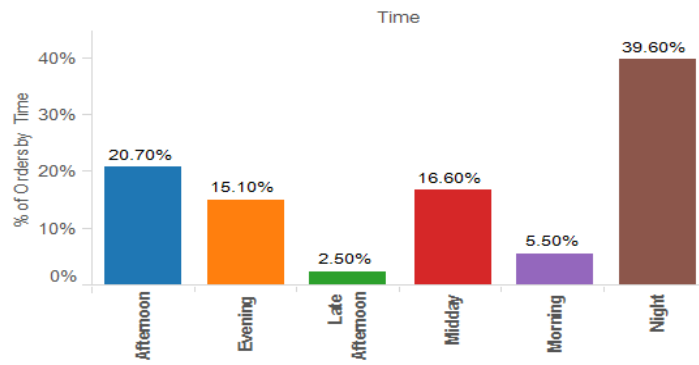
Order Map



Sales by Month



% of Orders by Time



Total Orders by Region

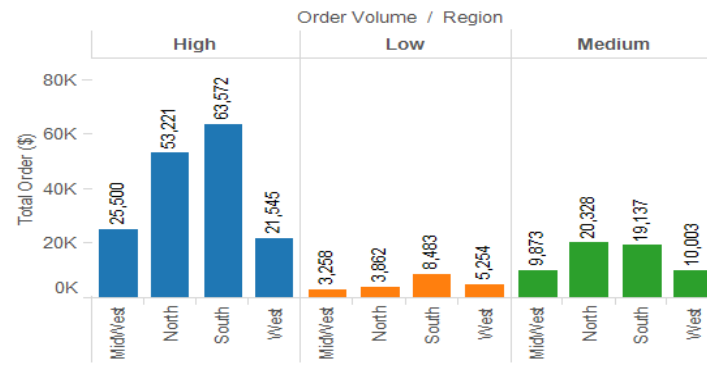
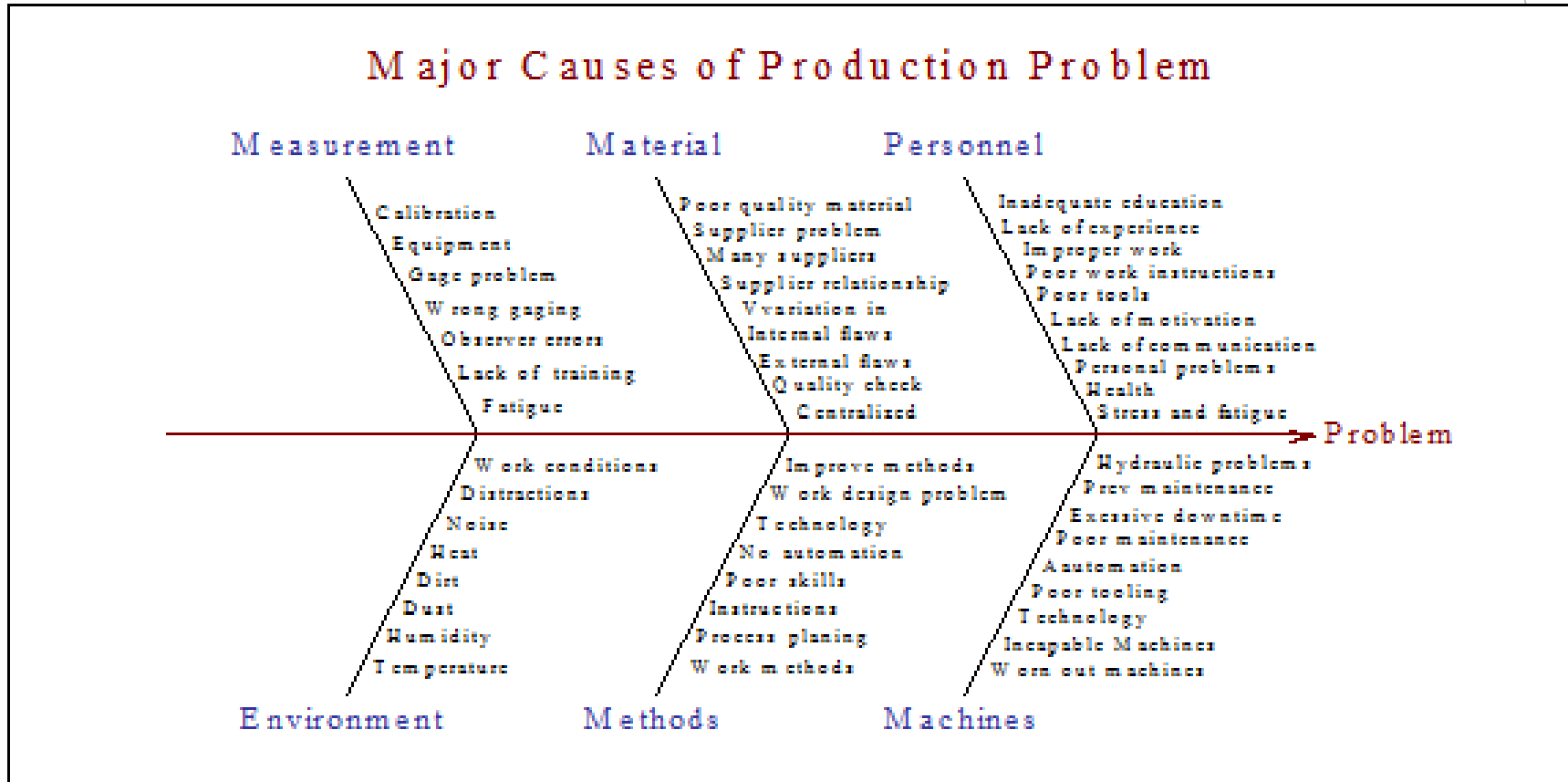


Figure 5.1: Logic Driven Model of Predictive Analytics



Major Causes of Production Problem

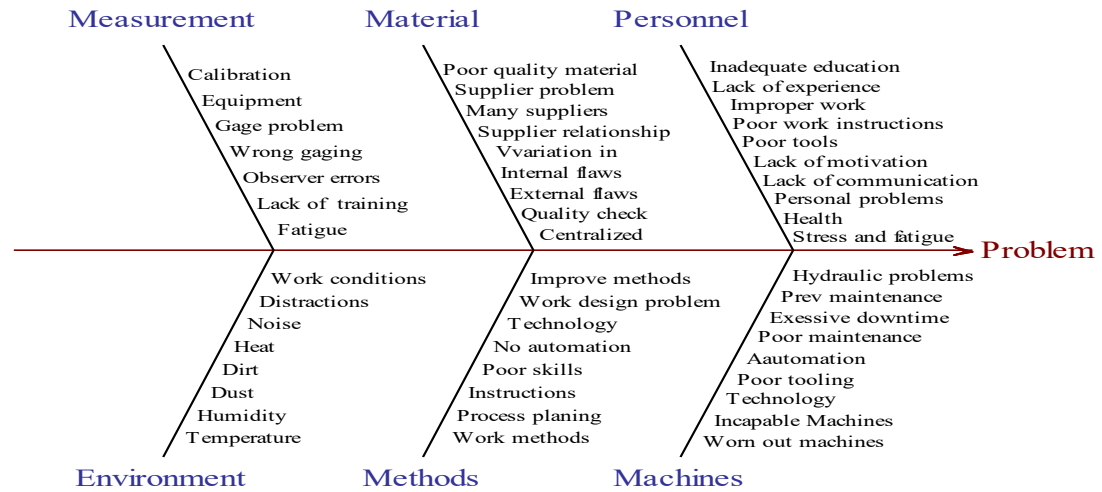
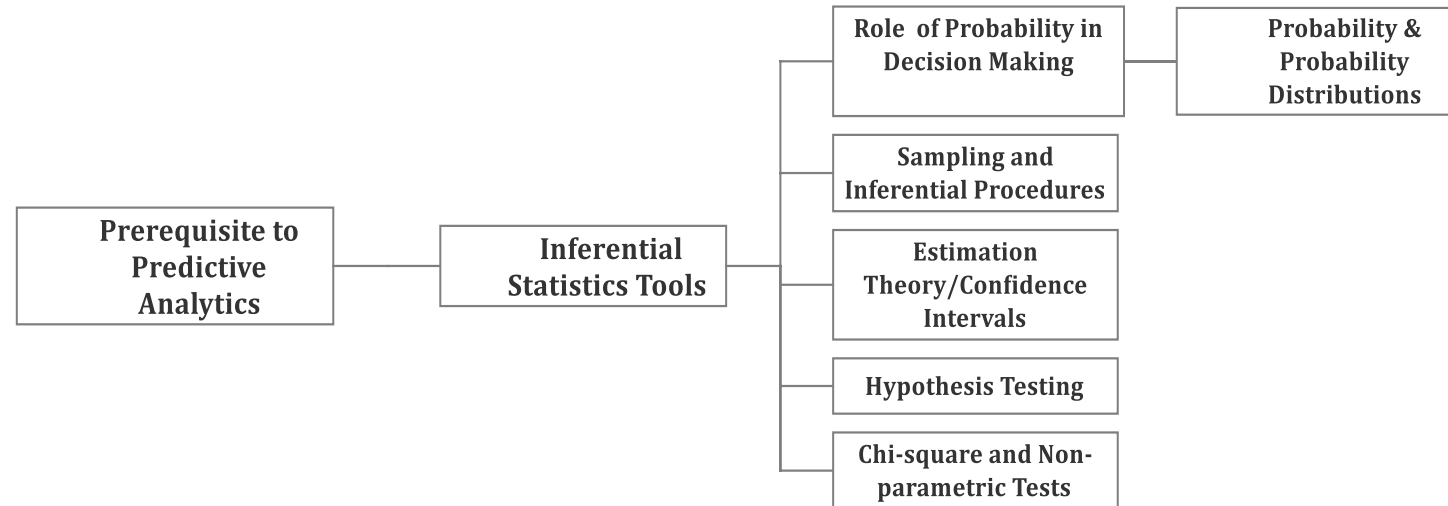


Figure 5.2: Pre-requisite and Models for Predictive Analytics



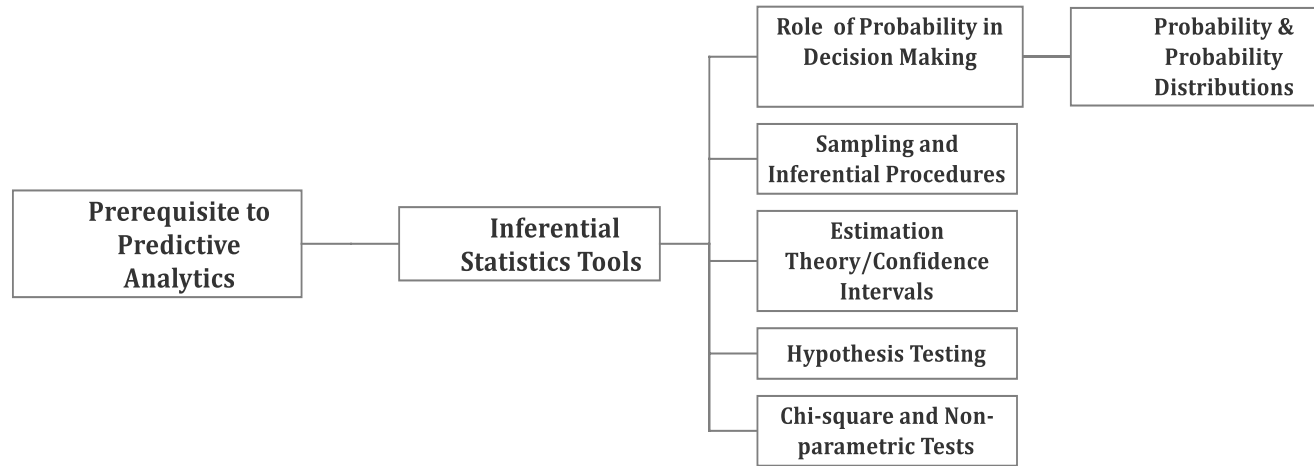
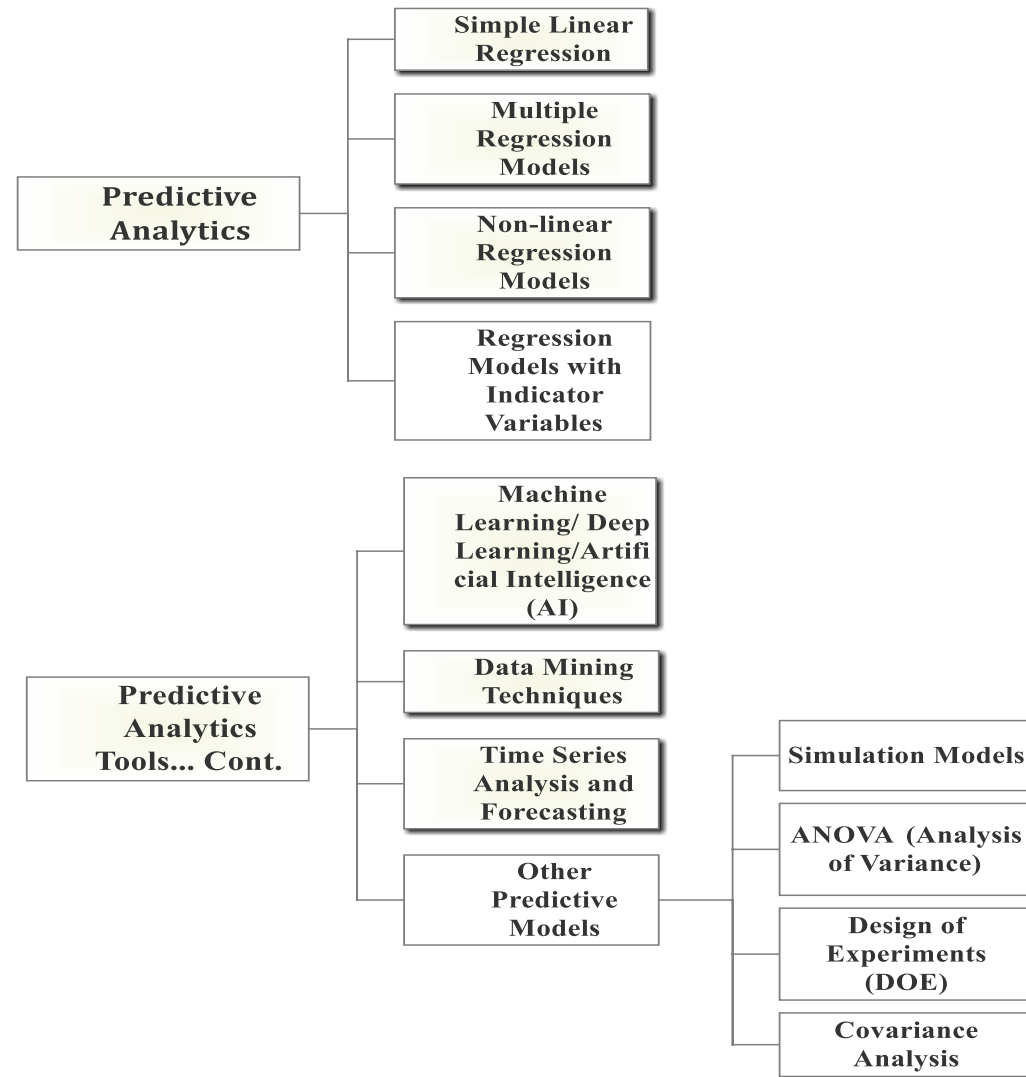


Figure 6.1: Predictive Modeling Tools



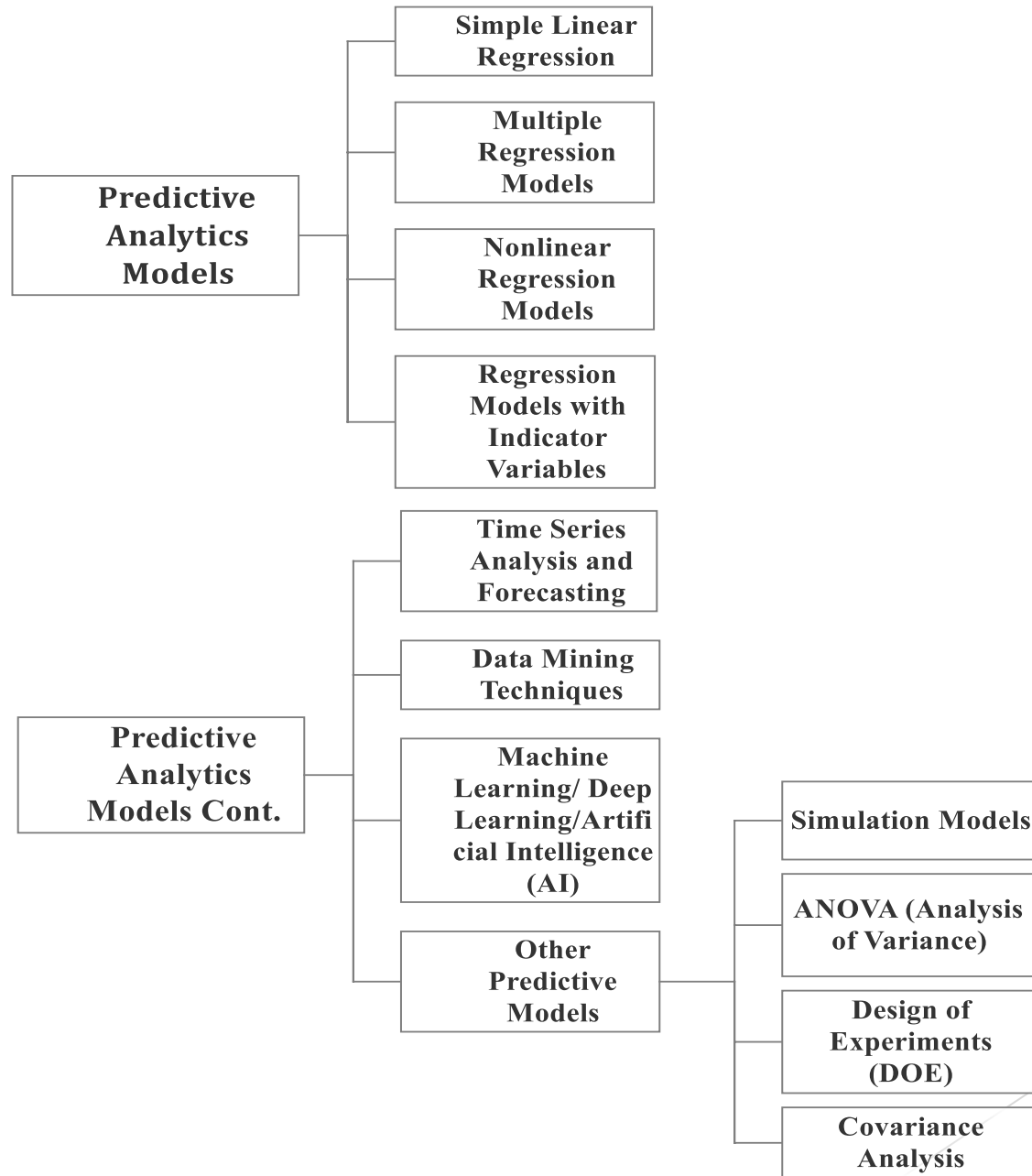
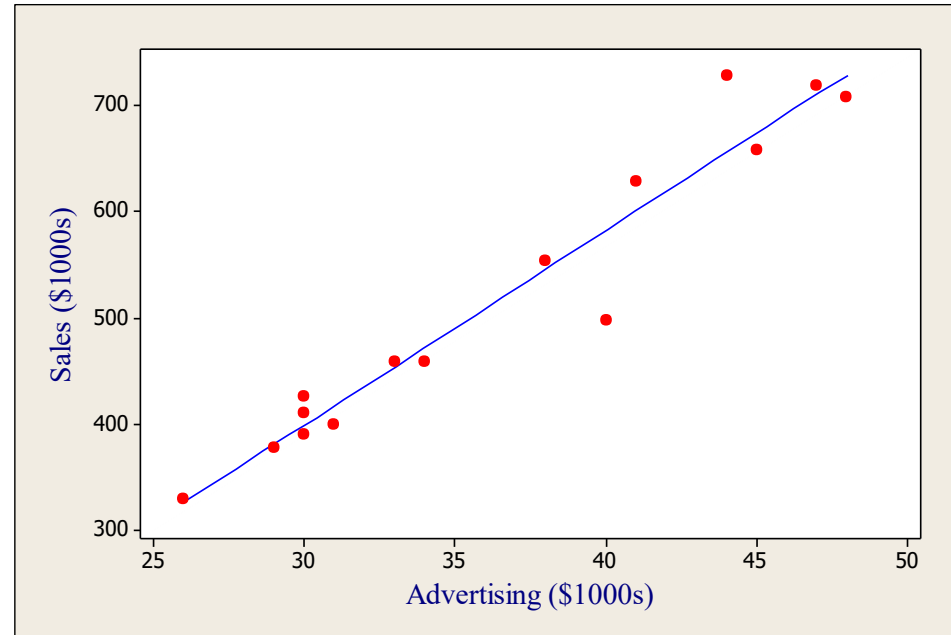


Figure 6.2: Scatter Plot of Sales vs. Advertising



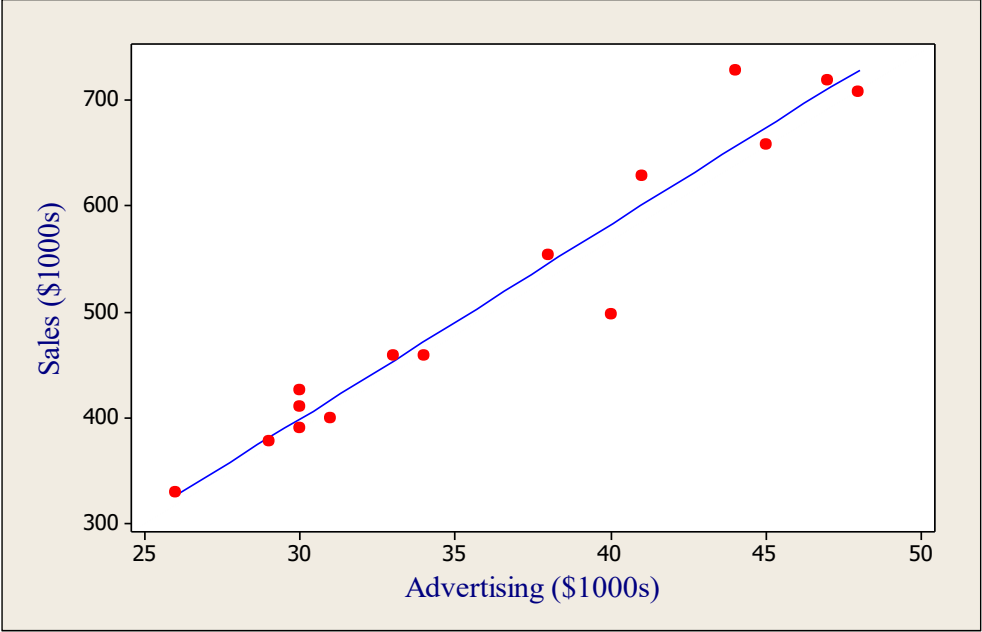
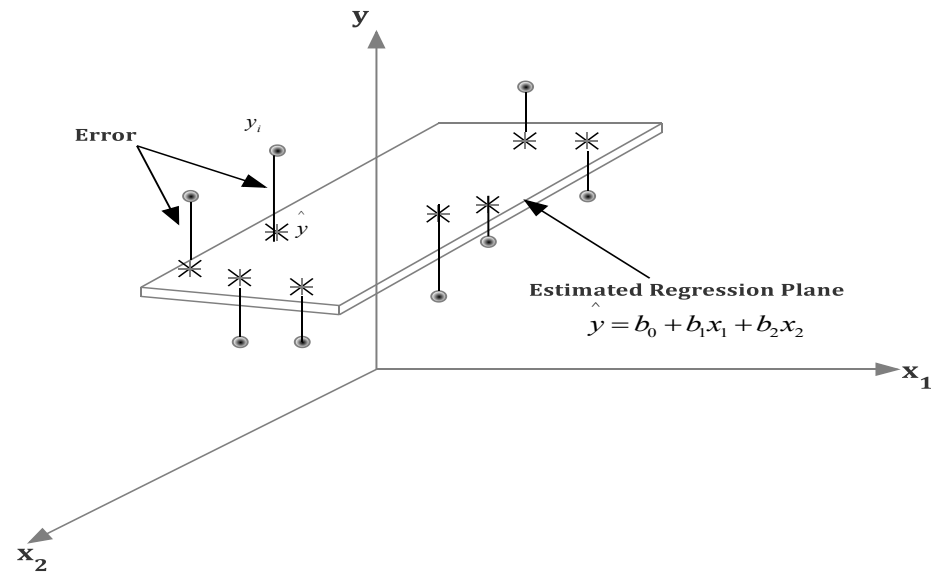


Figure 6.3: A Multiple Regression Model



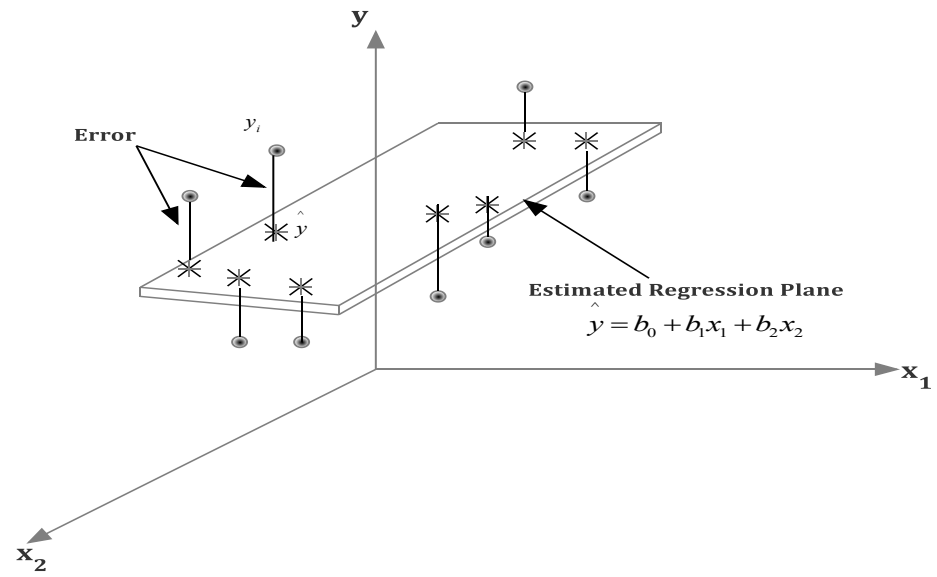
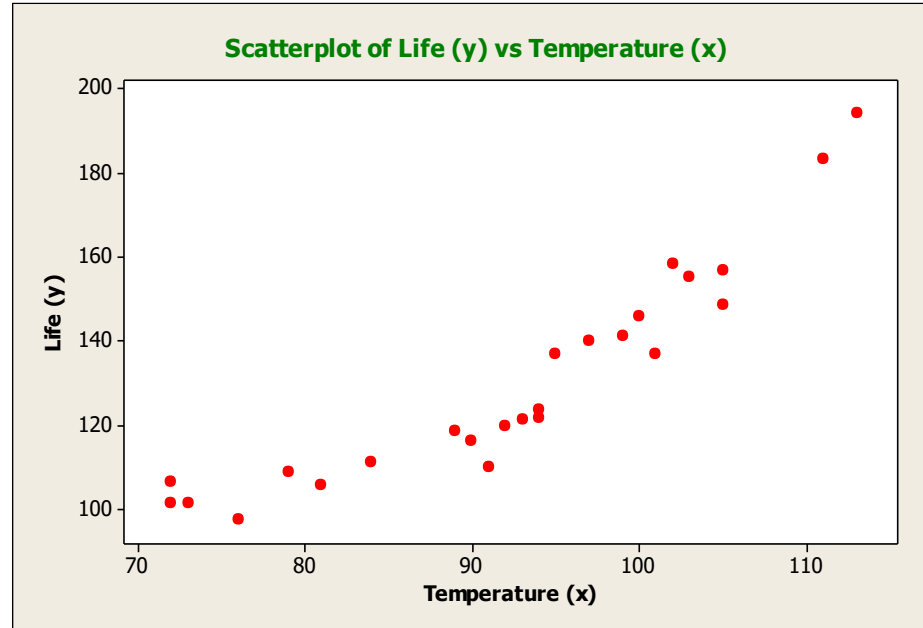


Figure 6.4: Scatter Plot of Life (y) vs. Operating Temp. (x)



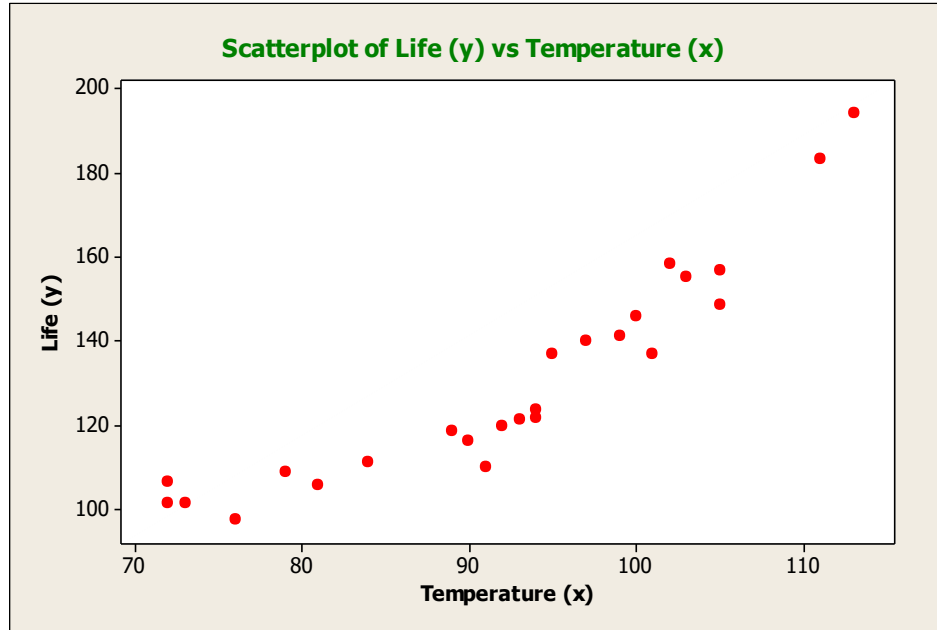
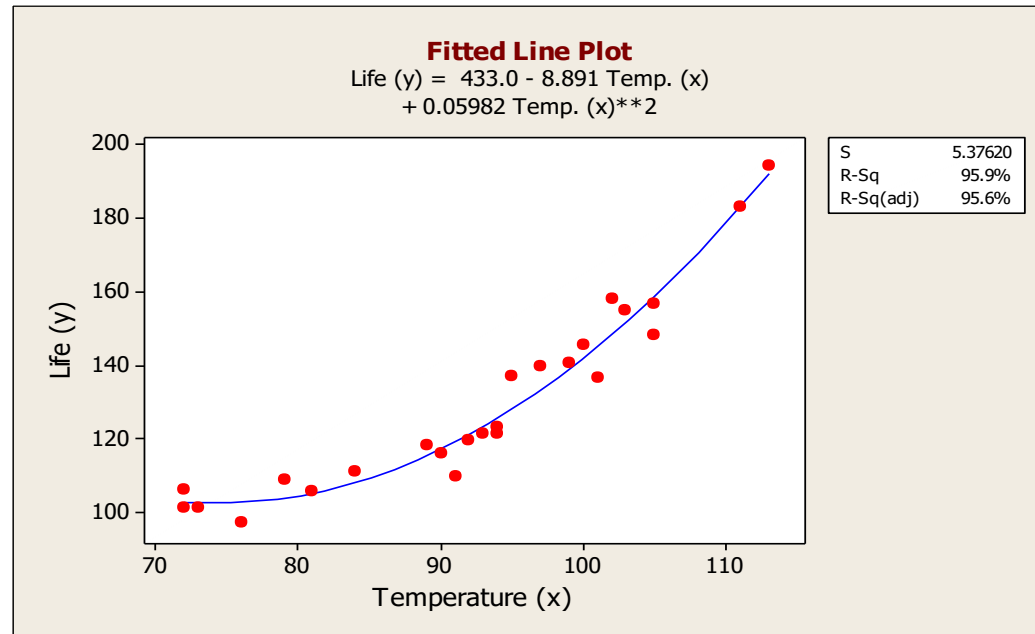


Figure 6.5: A Second-order Regression Model



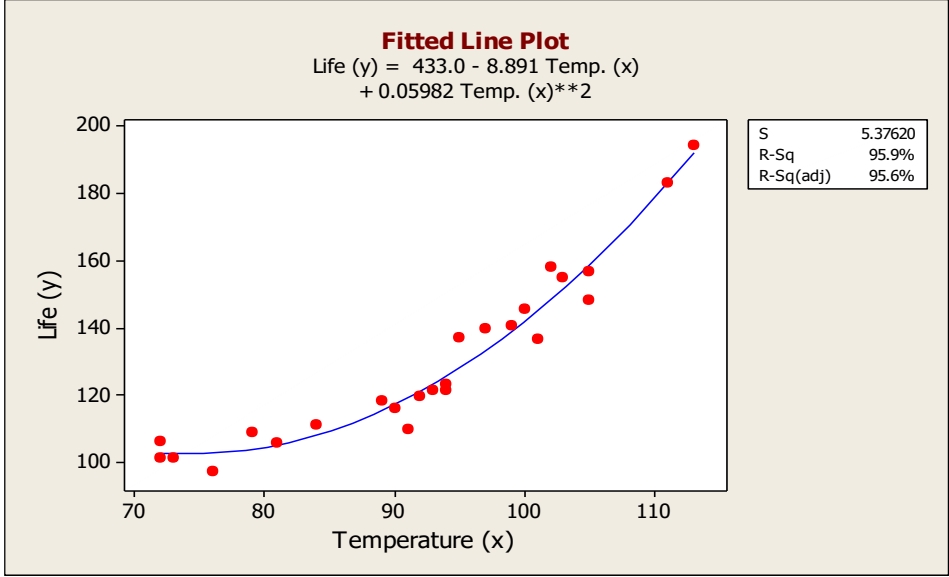
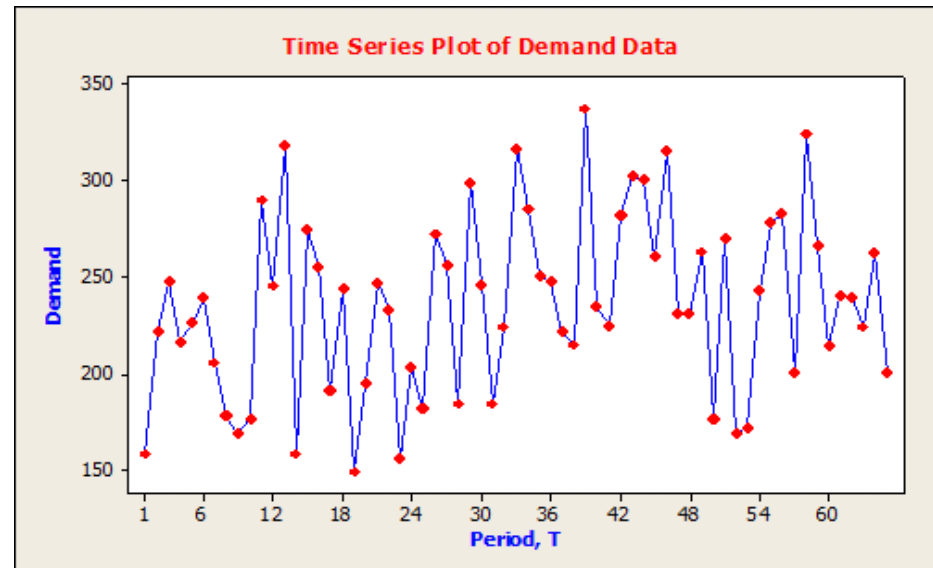


Figure 6.6: Plot of Demand over Time



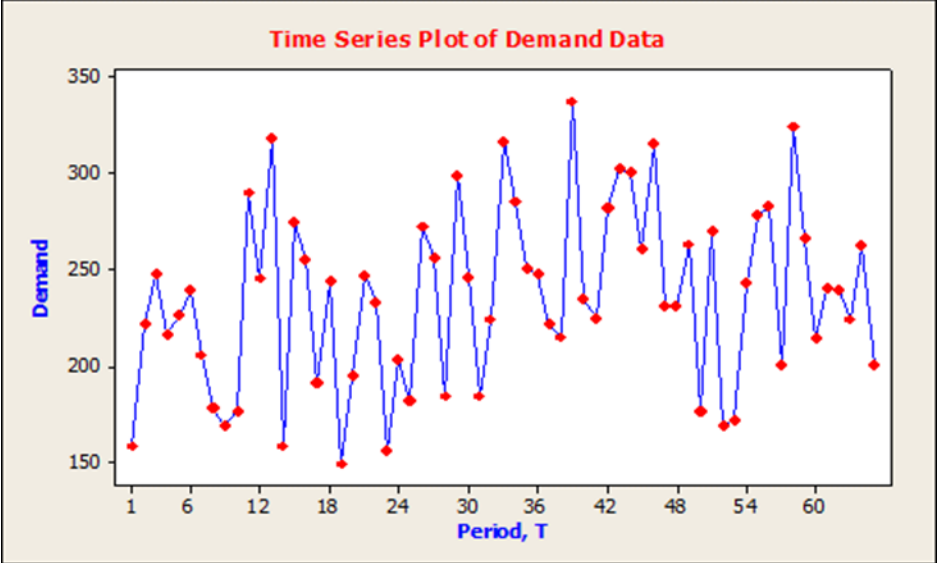
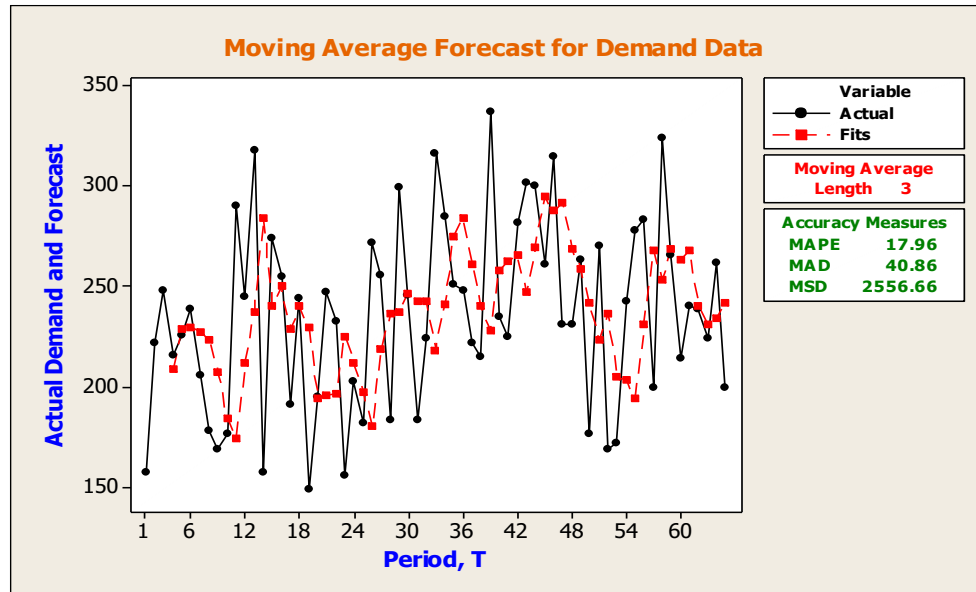


Figure 6.7: Demand and Forecast



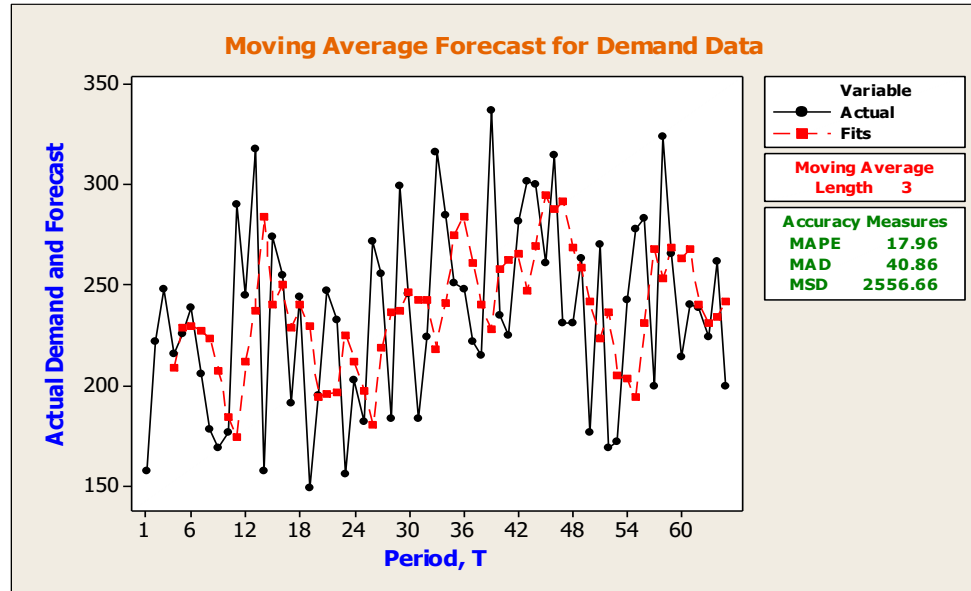
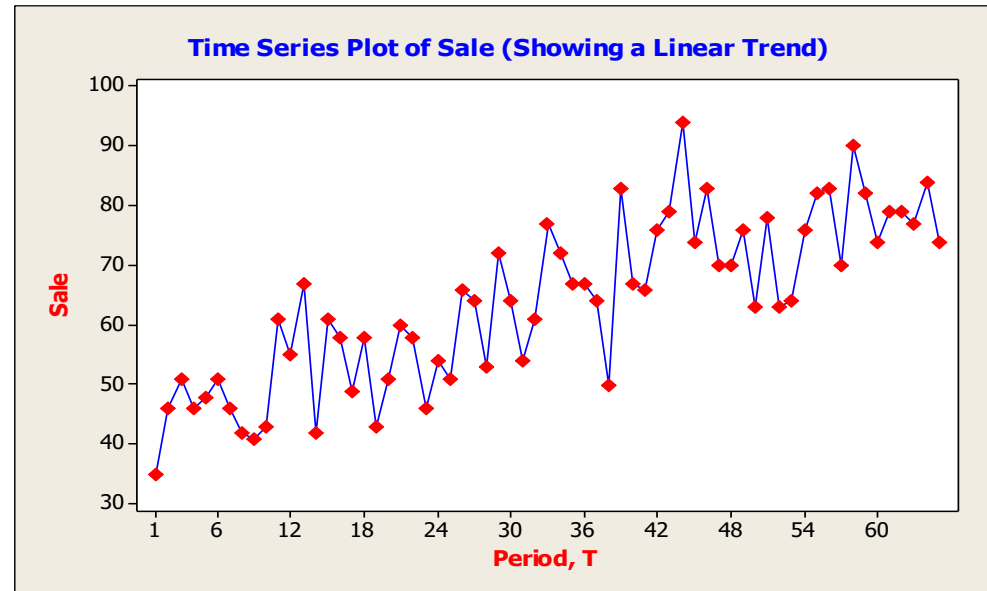


Figure 6.8 (a) Sales over Time



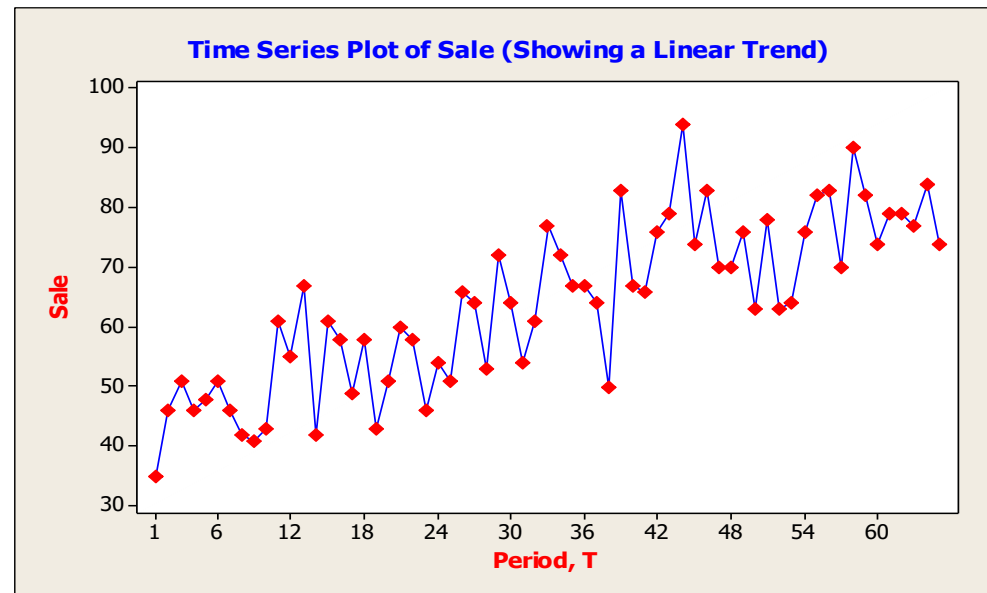
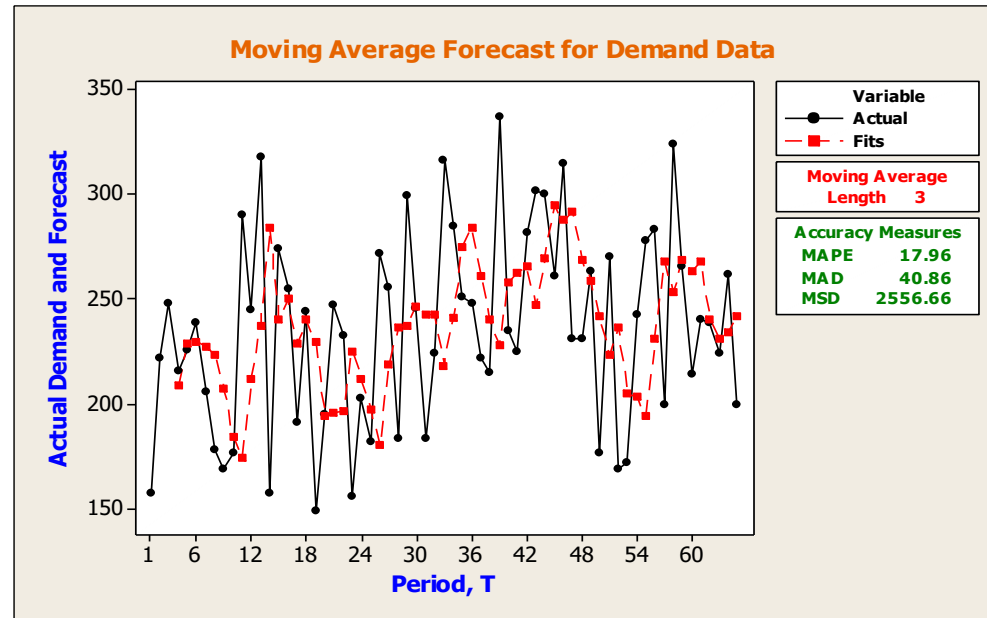


Figure 6.8 (b): Sales and Forecast for the Data in Figure 6.8(a)



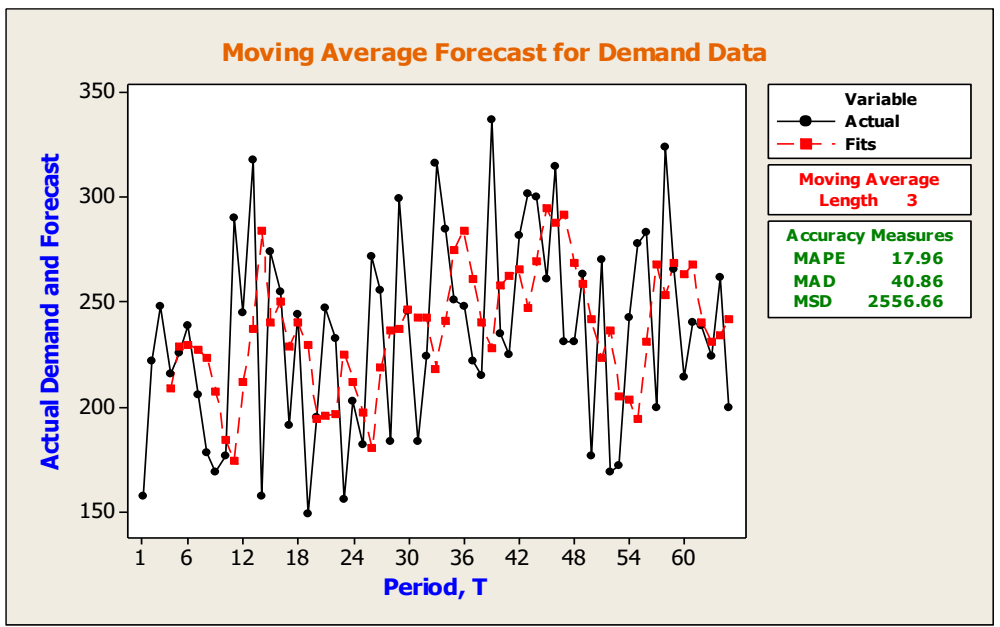
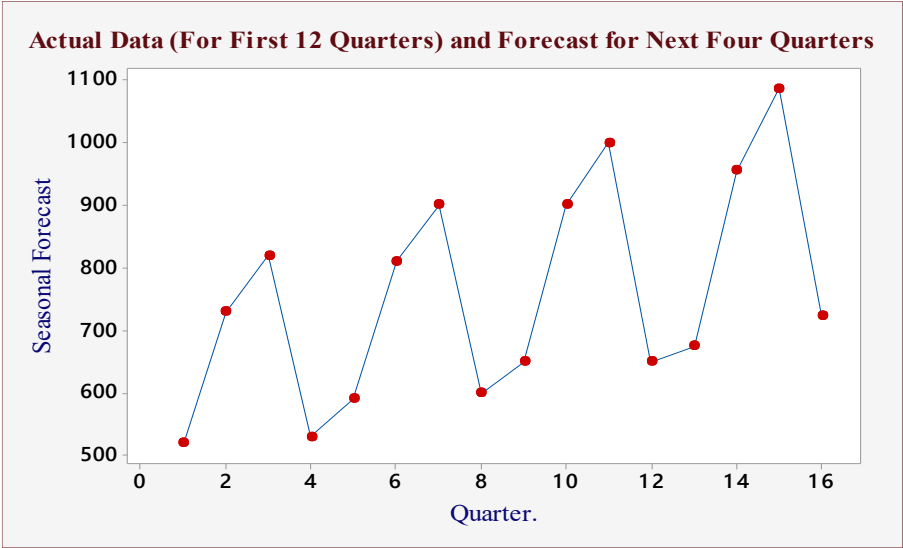


Figure 6.9: A Seasonal Pattern



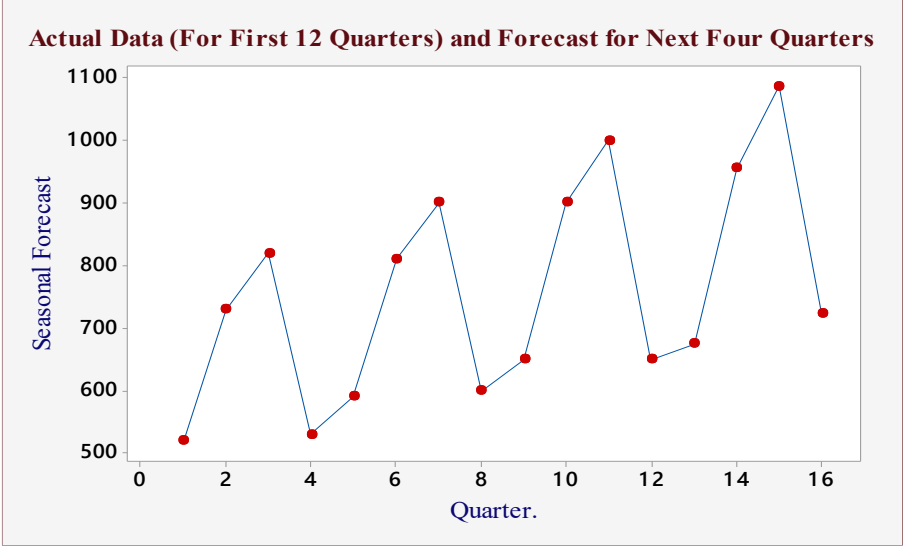
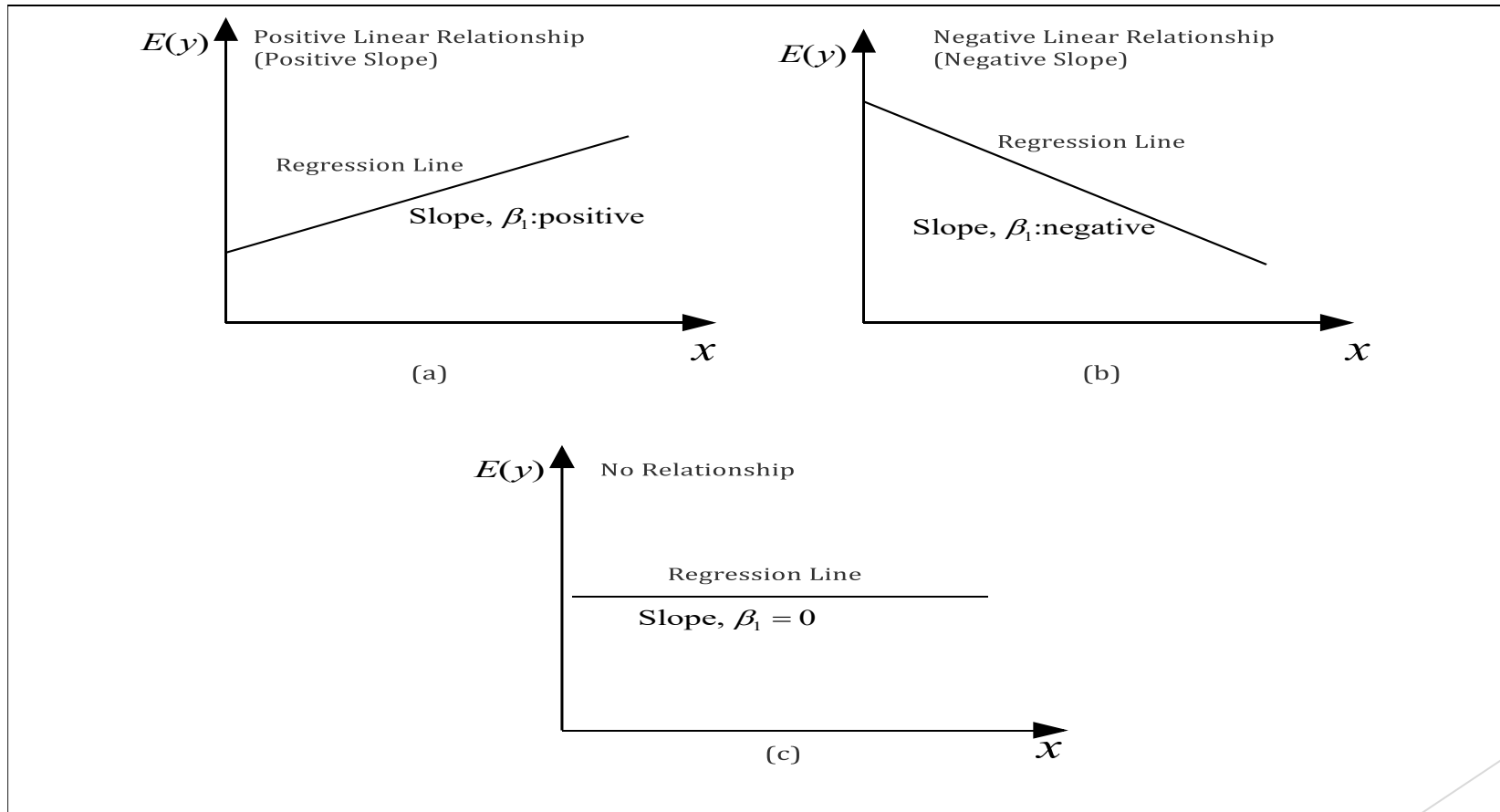


Figure 7.1: Possible Linear Relationship between $E(y)$ and x in Simple Linear Regression



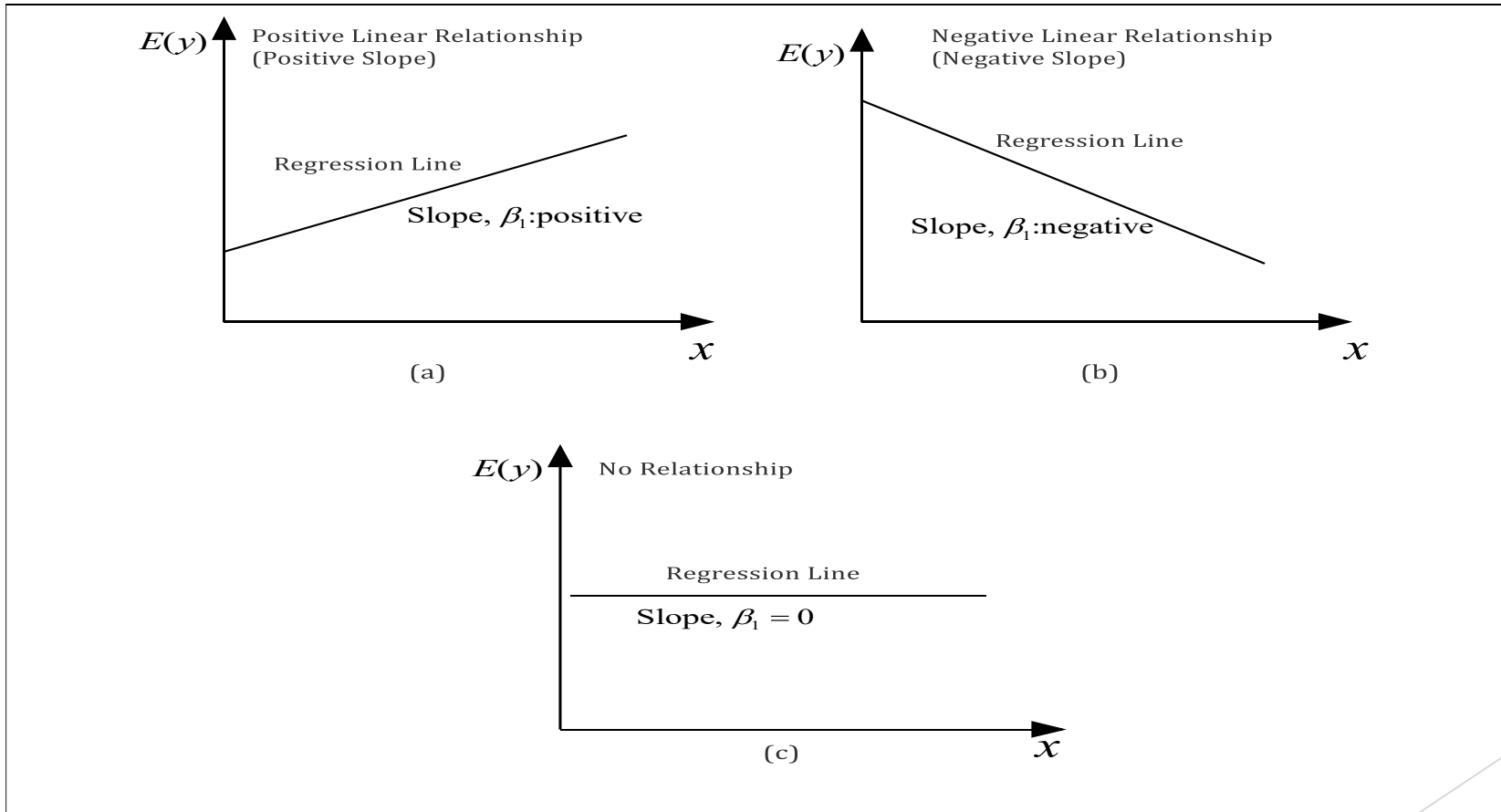
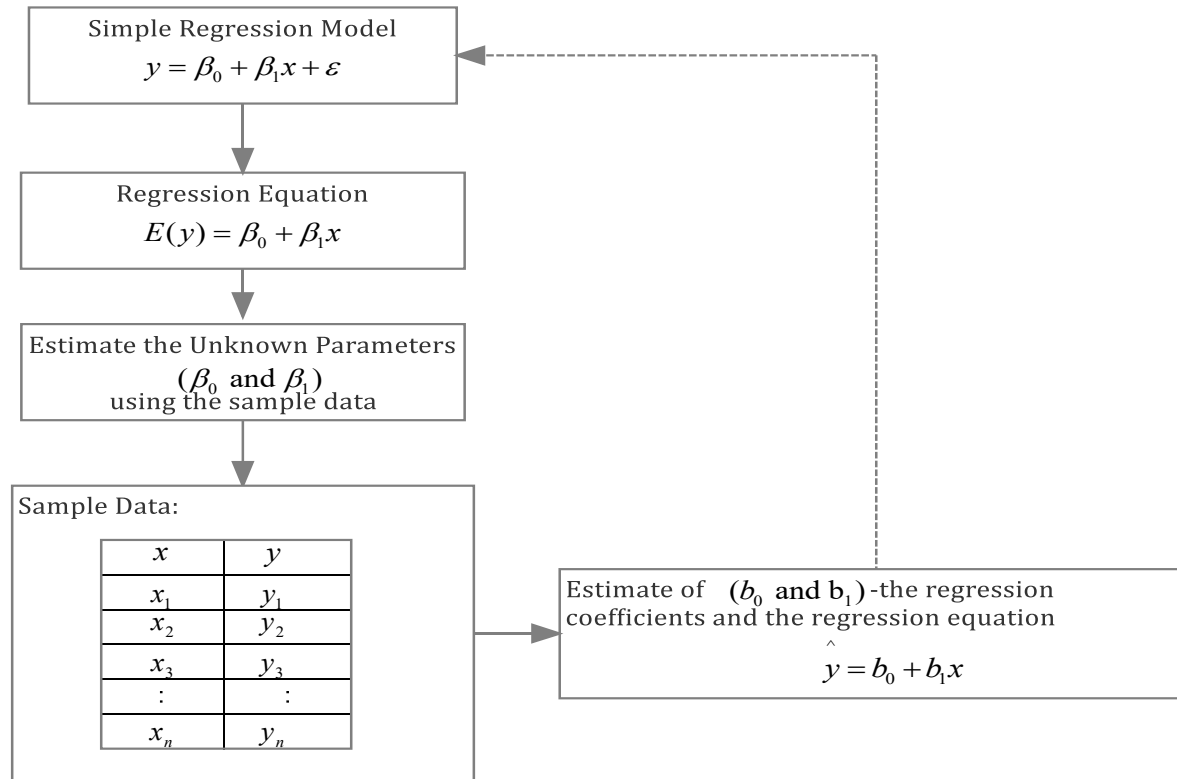


Figure 7.2: Estimating the Regression Equation



Simple Regression Model
 $y = \beta_0 + \beta_1 x + \varepsilon$

Regression Equation
 $E(y) = \beta_0 + \beta_1 x$

Estimate the Unknown Parameters
(β_0 and β_1)
using the sample data

Sample Data:

x	y
x_1	y_1
x_2	y_2
x_3	y_3
\vdots	\vdots
x_n	y_n

Estimate of (b_0 and b_1)-the regression coefficients and the regression equation
 $\hat{y} = b_0 + b_1 x$

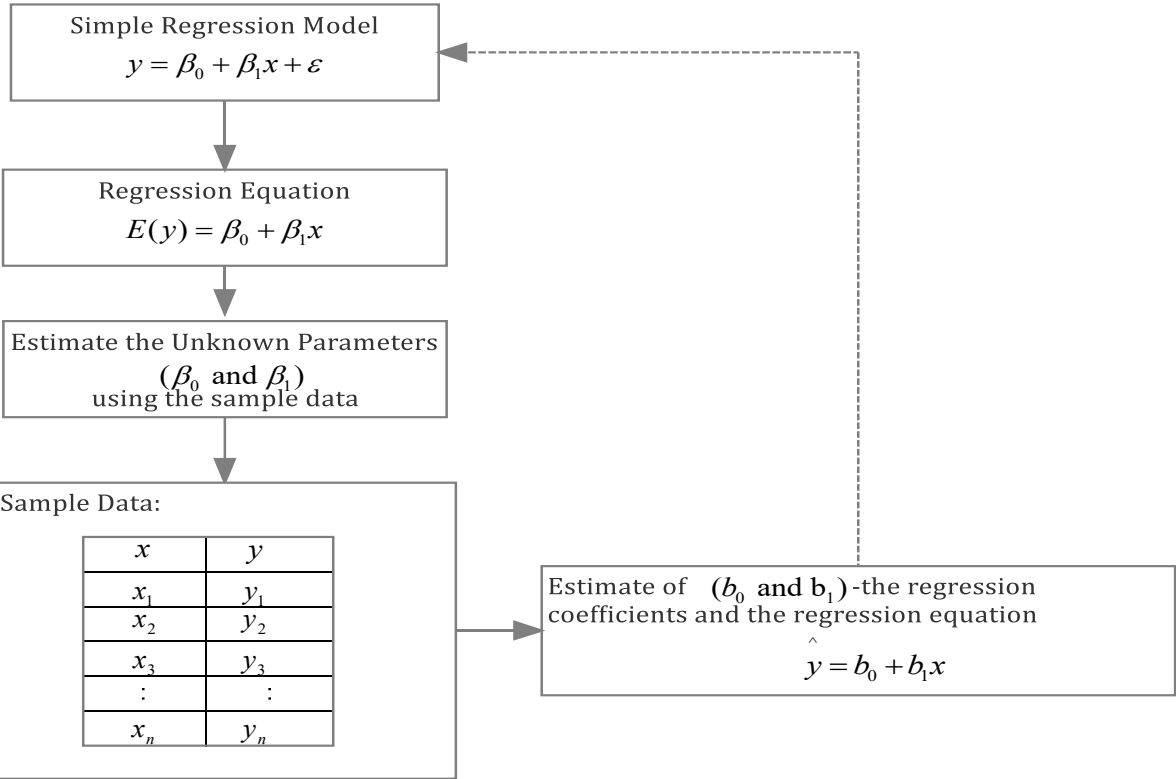
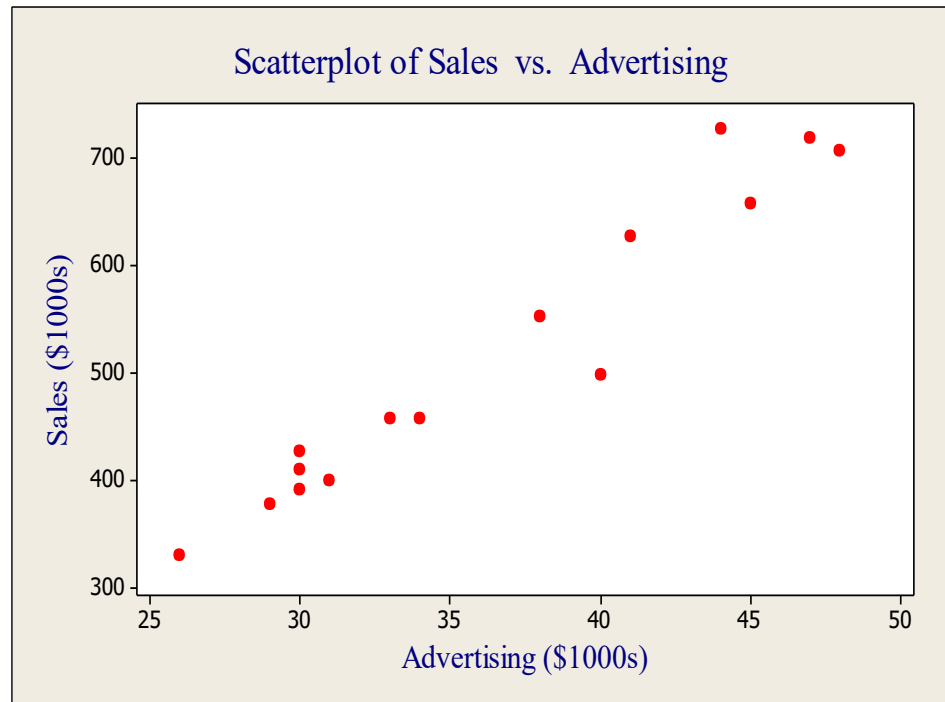


Figure 7.3: Scatterplot of Sales and Advertisement Expenditures



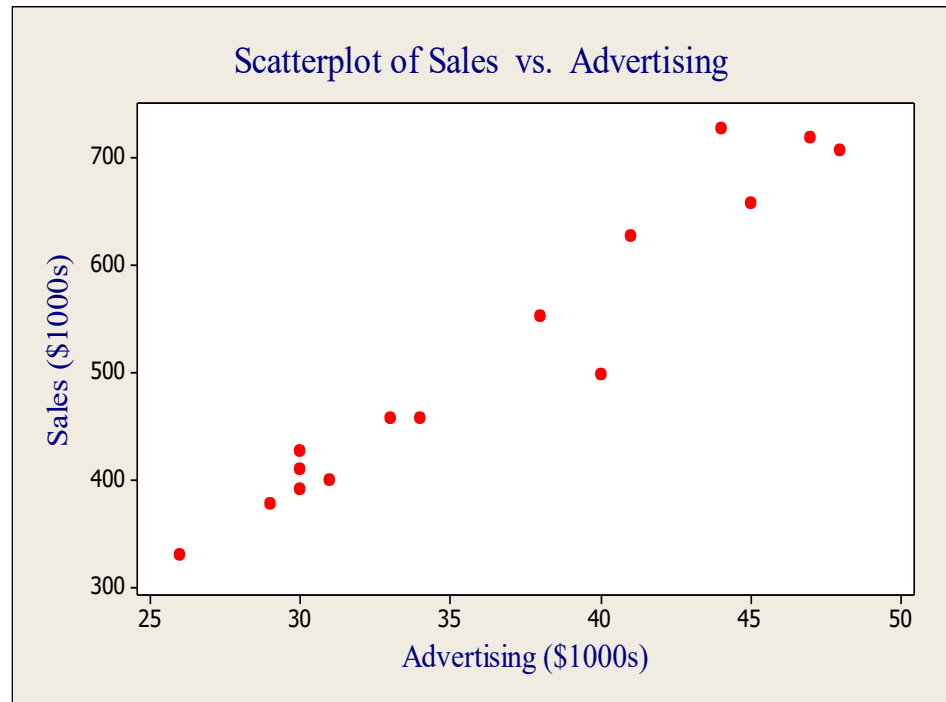
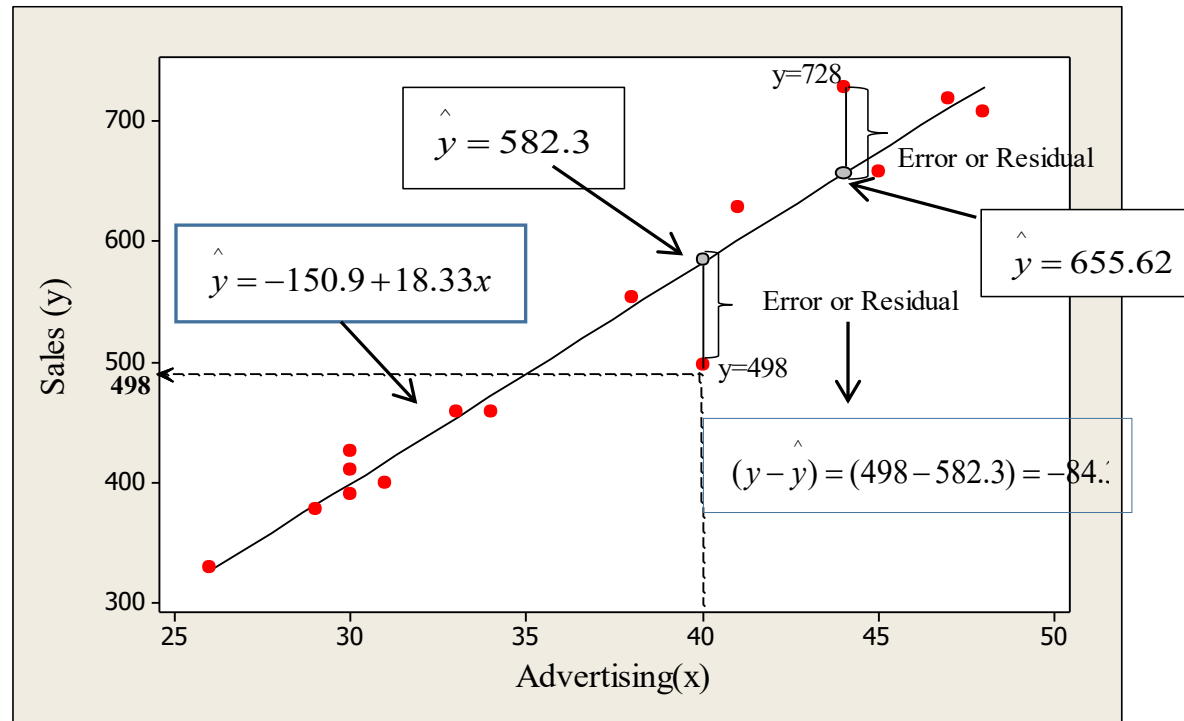


Figure 7.4: Fitting the Regression Line to the Sales and Advertising Data of Table 7.1



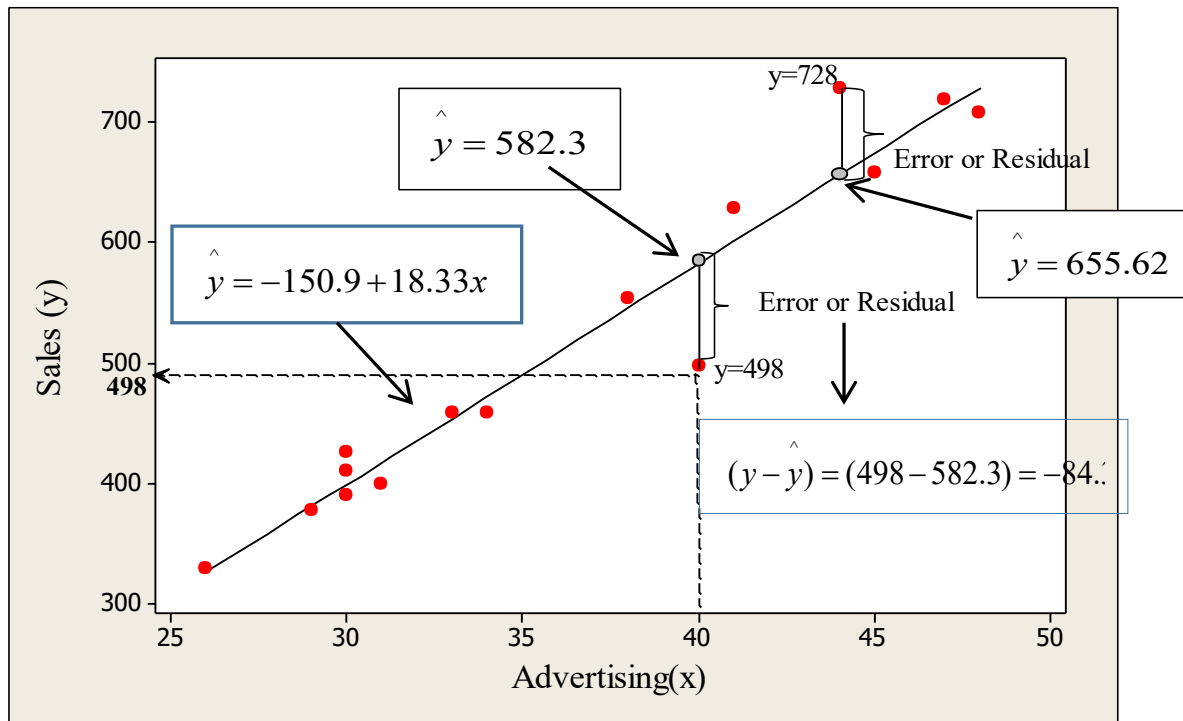
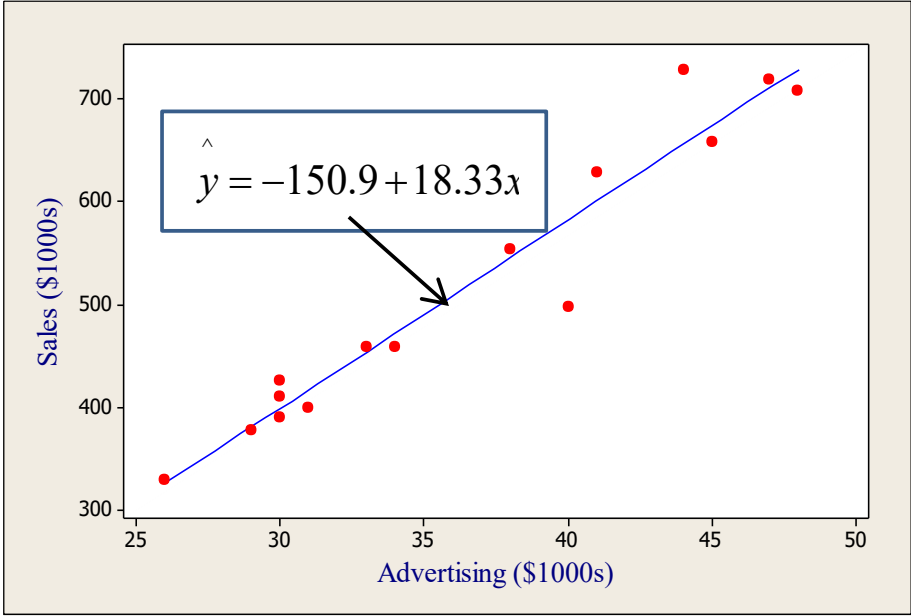


Figure 7.5: Graph of the Estimated Regression Equation



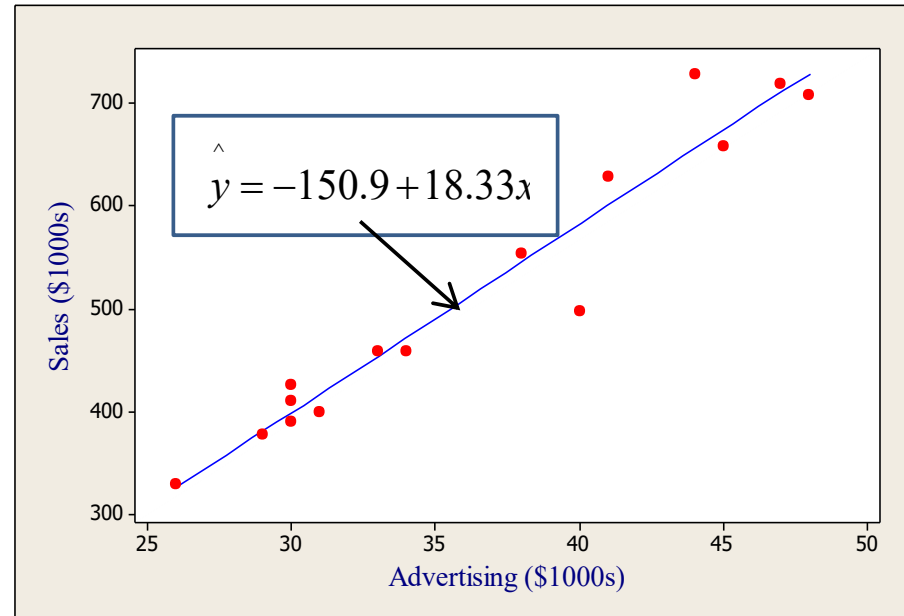
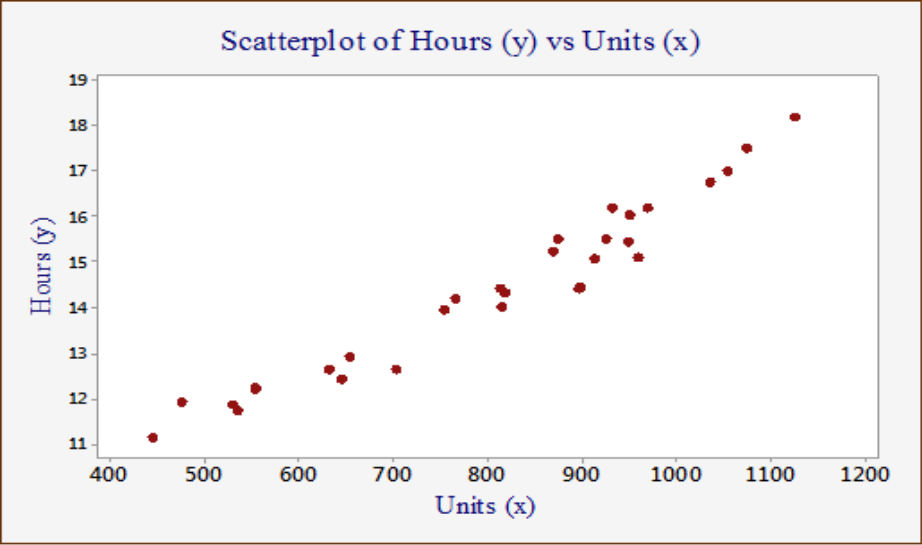


Figure 7.6: Scatter Plot of Hours (y) and Units (x)



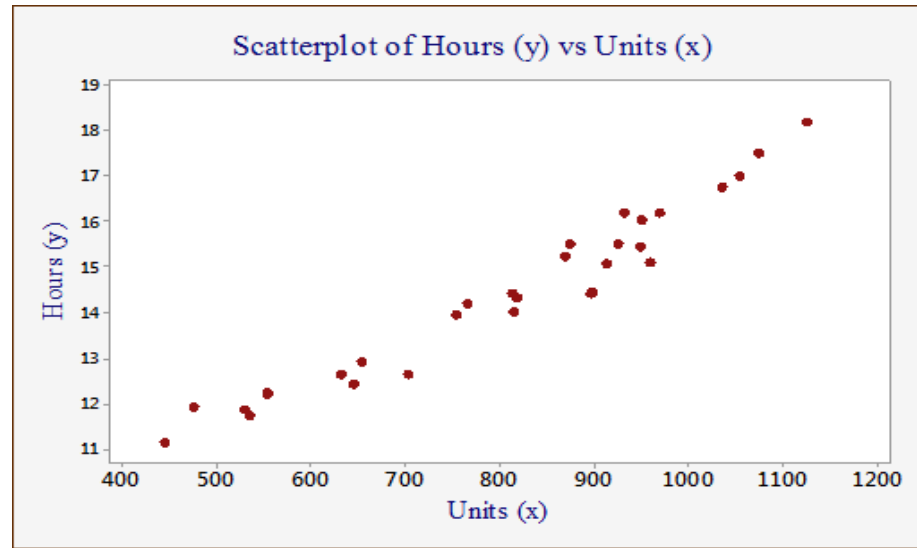
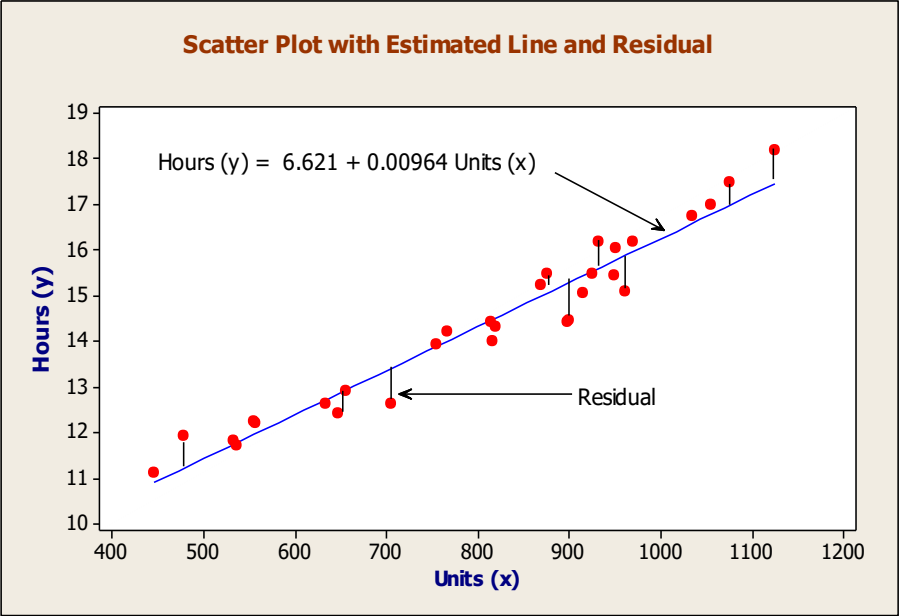
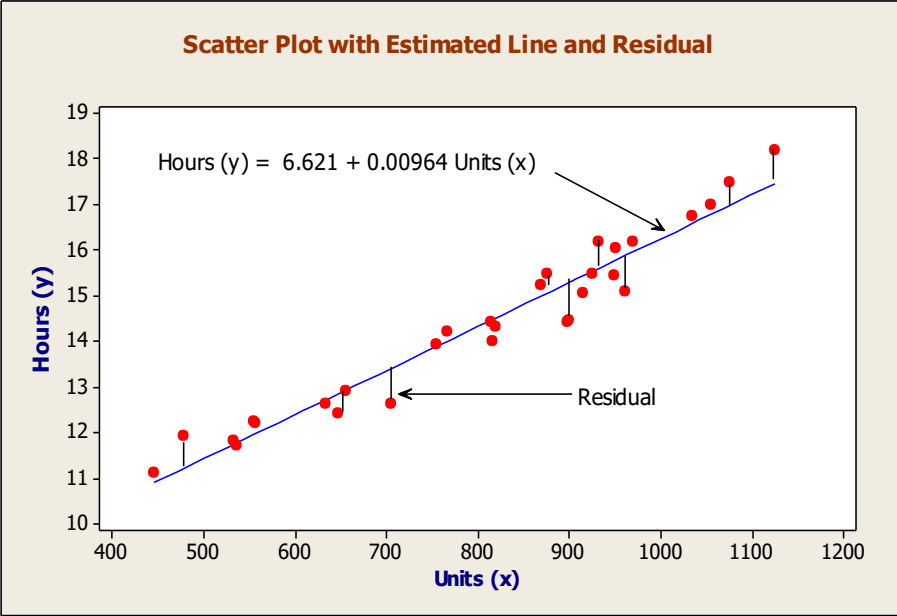


Figure 7.7: The Least Squares Line and Residuals





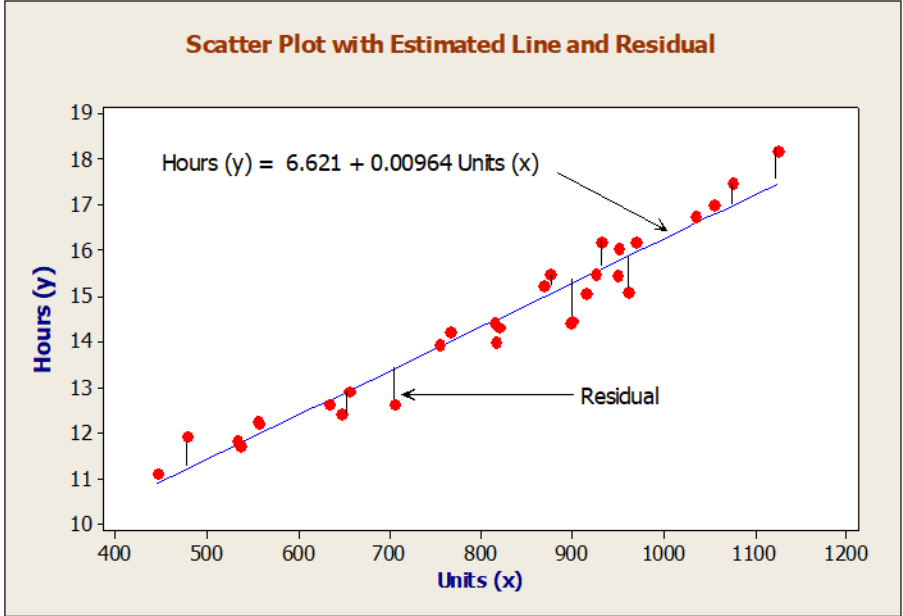
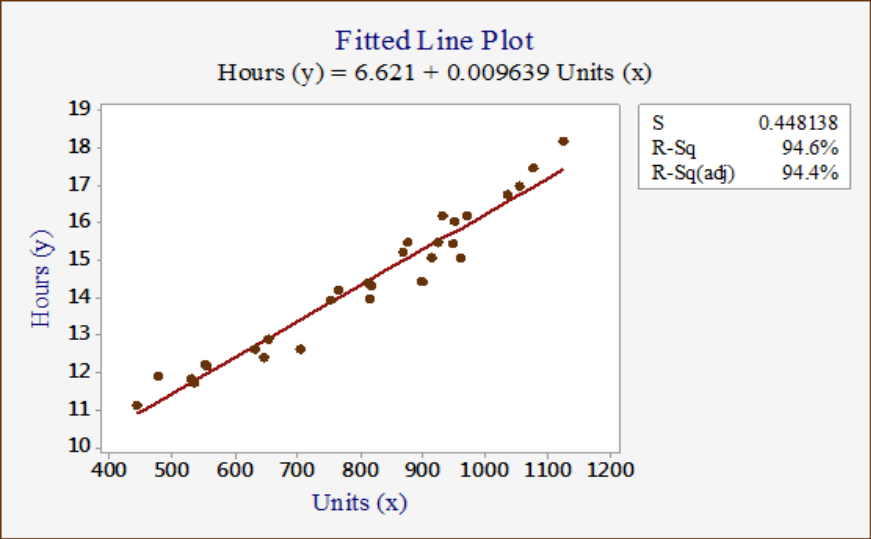


Figure 7.8: Fitted Line Regression Plot



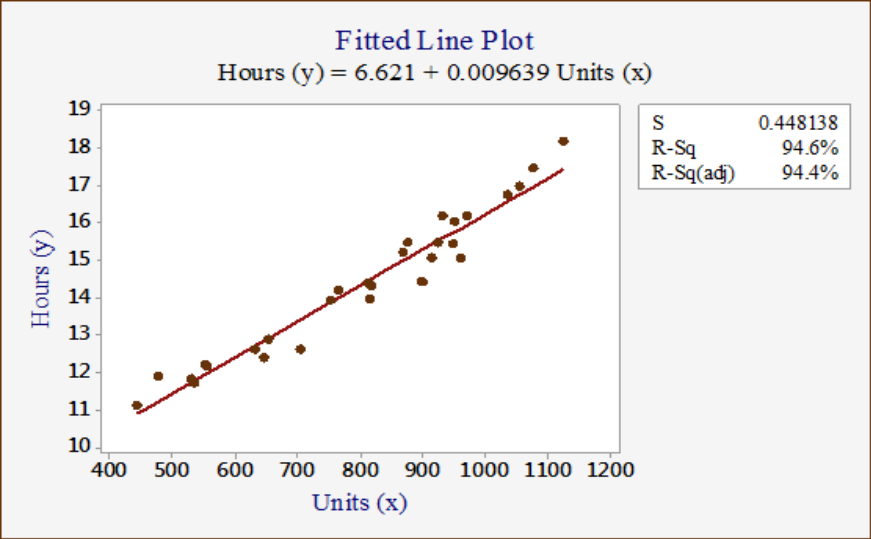
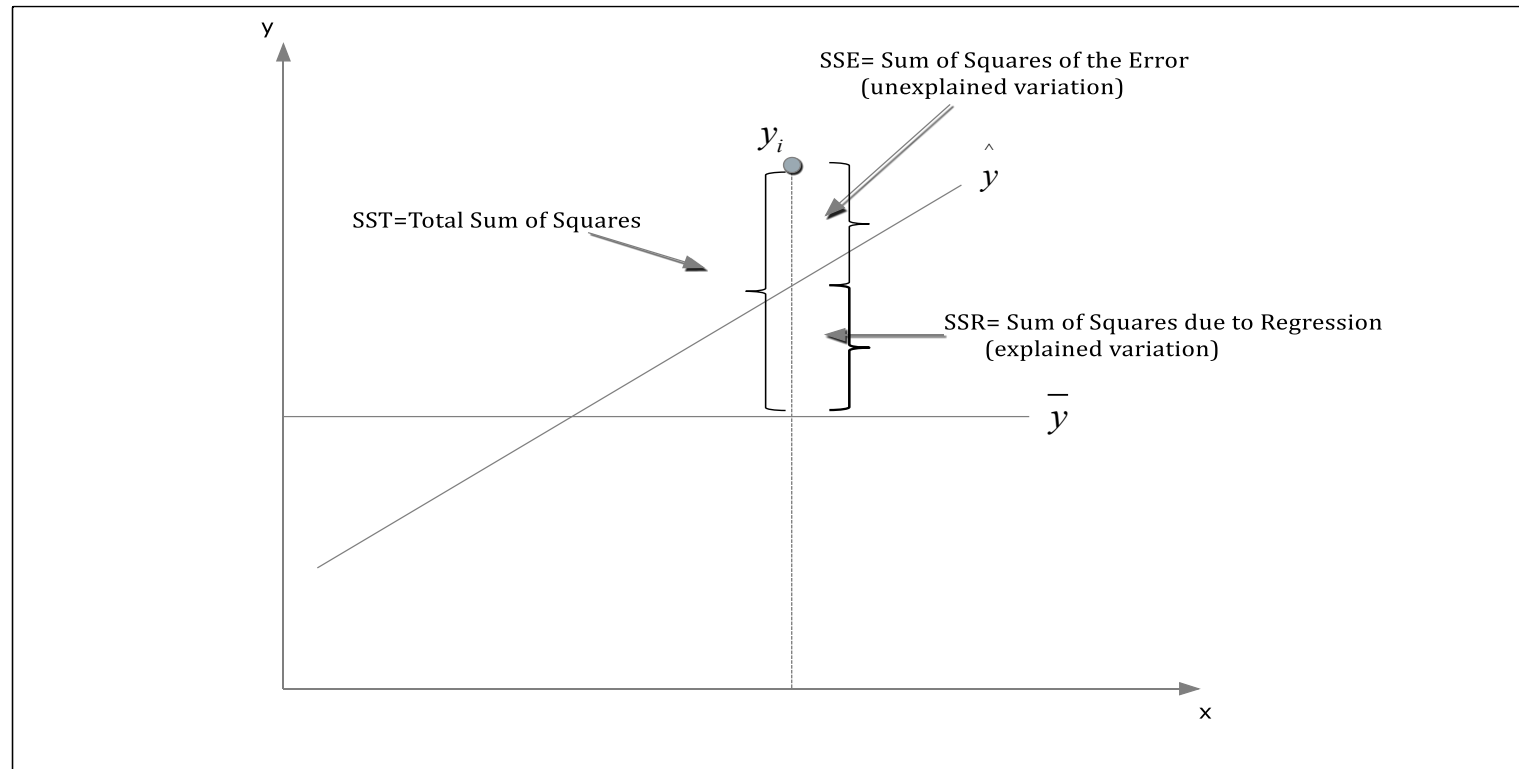
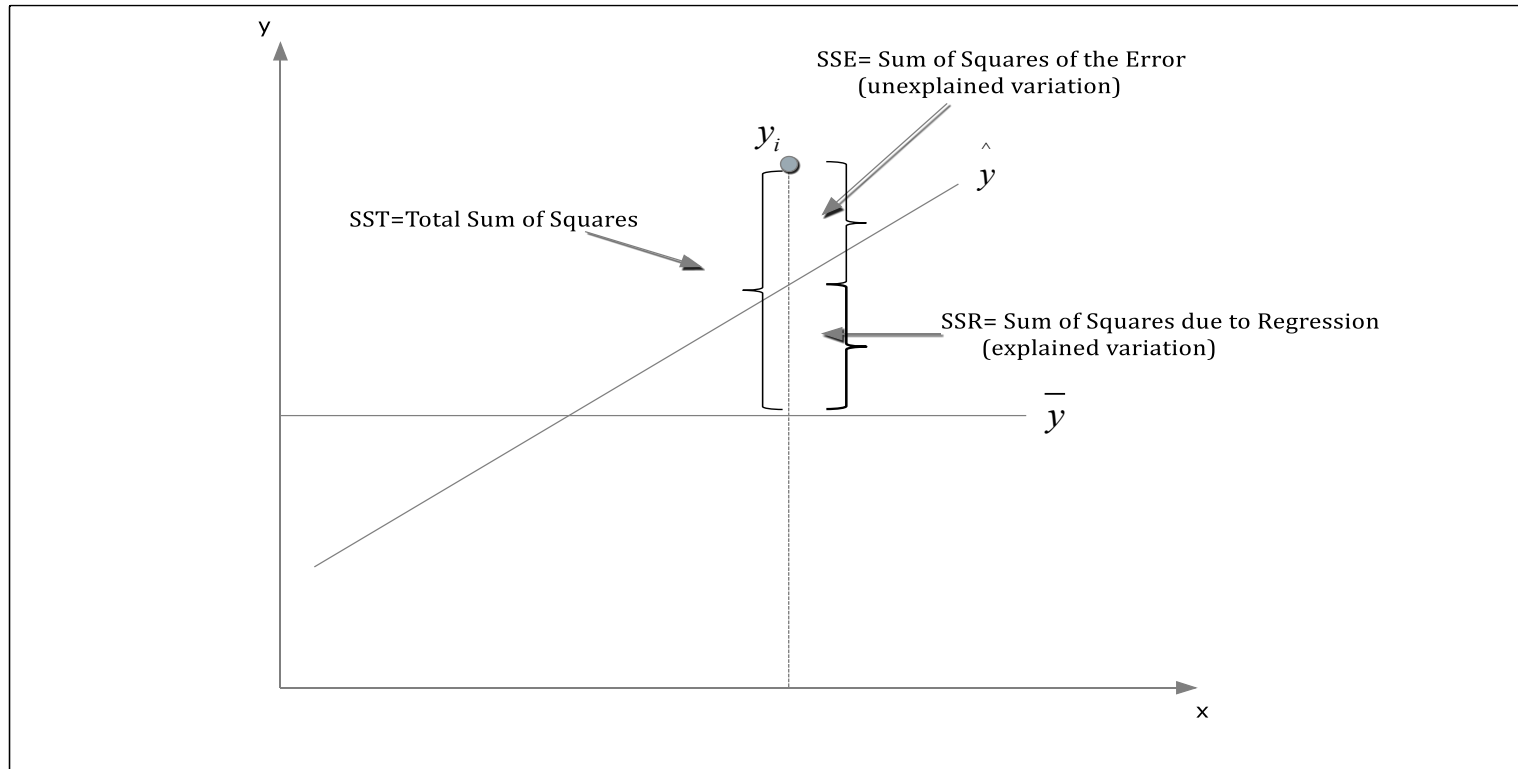
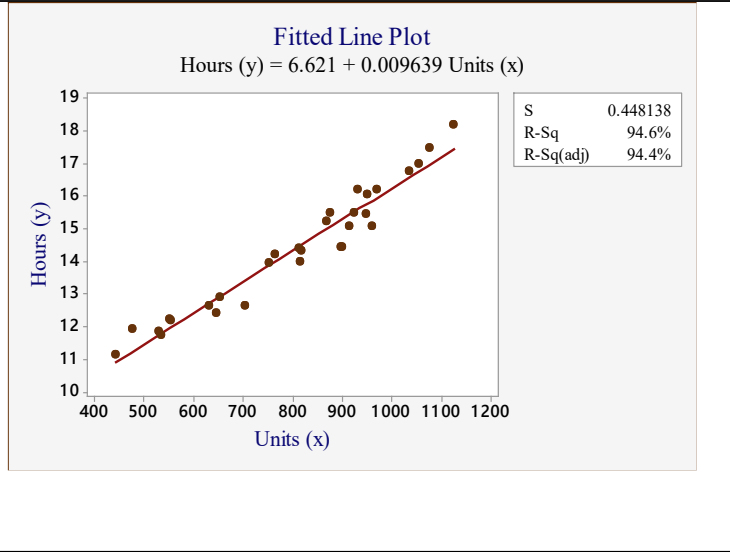
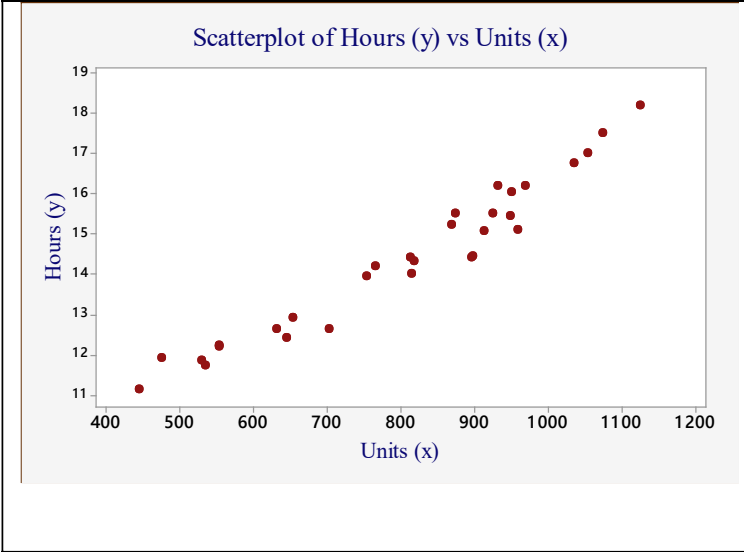


Figure 7.9: $SST = SSR + SSE$







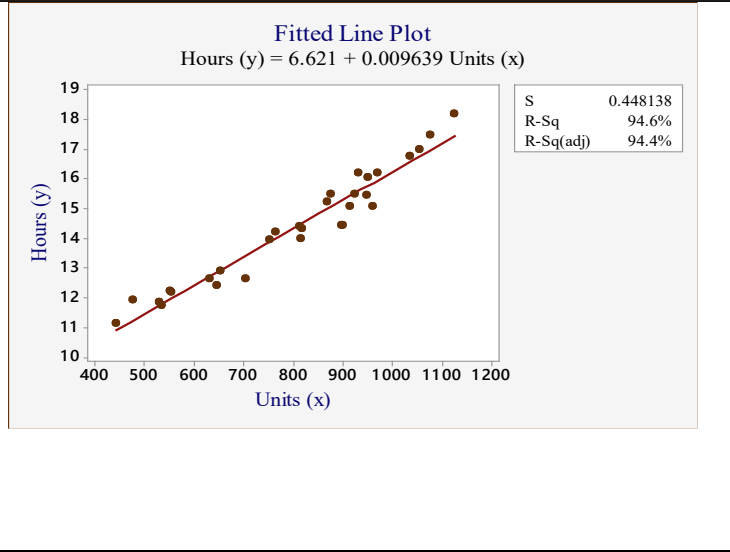
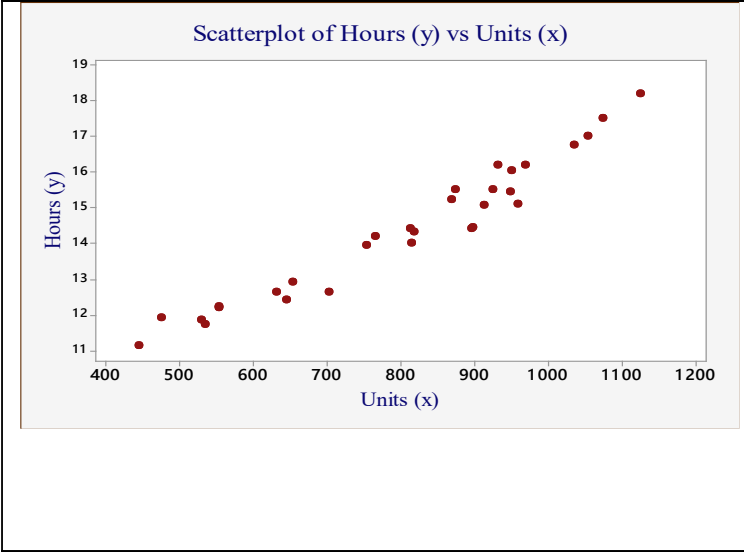
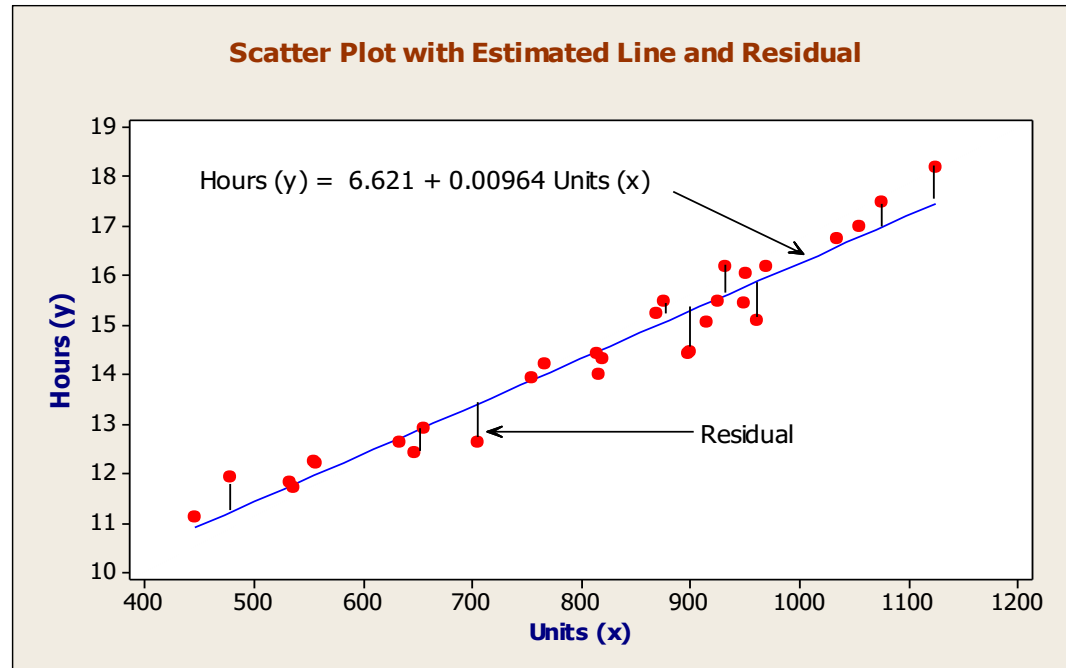


Figure 7.12: The Least Squares Line and Residuals



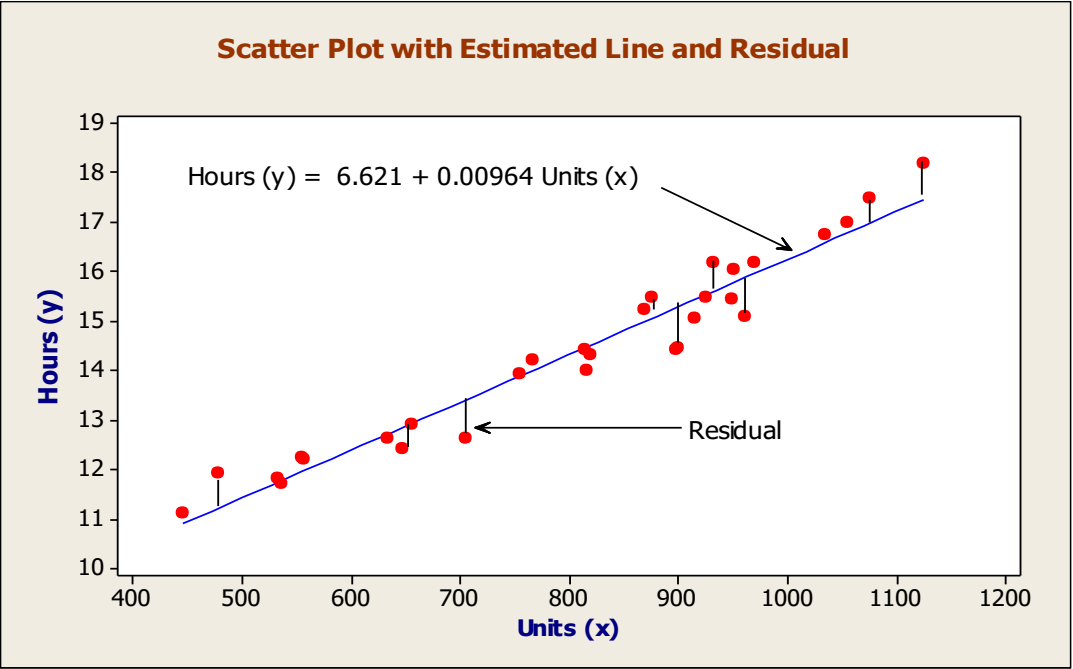
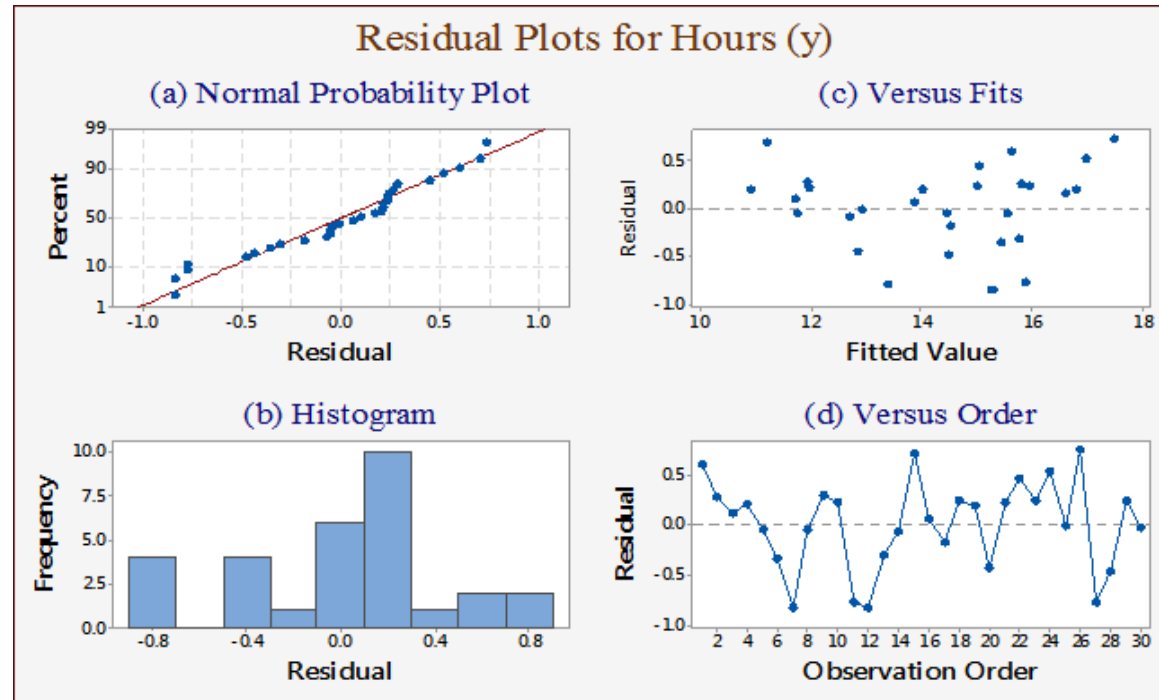
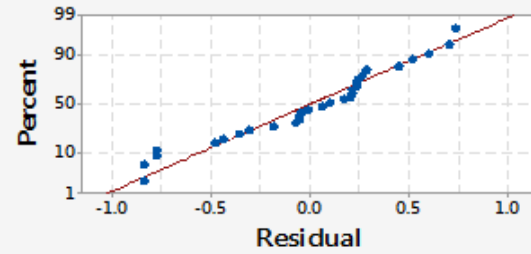


Figure 7.13: Plots for Residual Analysis

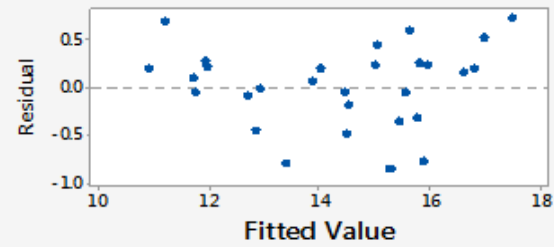


Residual Plots for Hours (y)

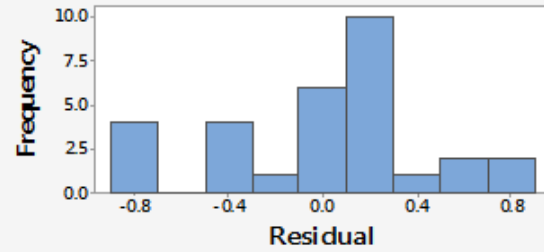
(a) Normal Probability Plot



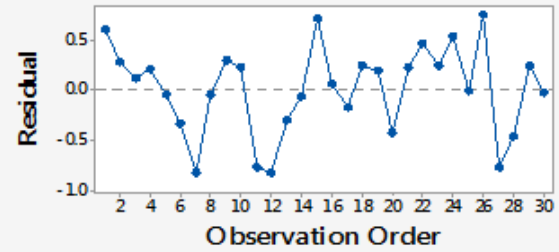
(c) Versus Fits



(b) Histogram

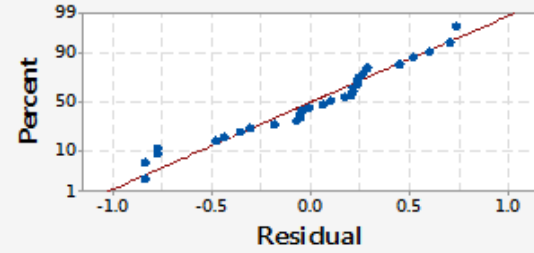


(d) Versus Order

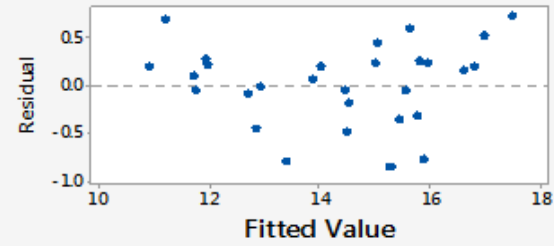


Residual Plots for Hours (y)

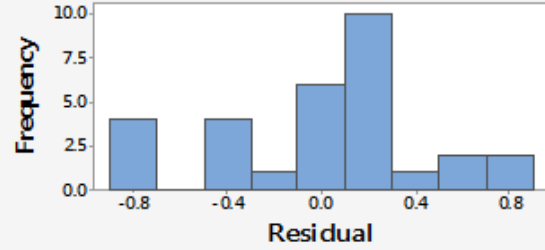
(a) Normal Probability Plot



(c) Versus Fits



(b) Histogram



(d) Versus Order

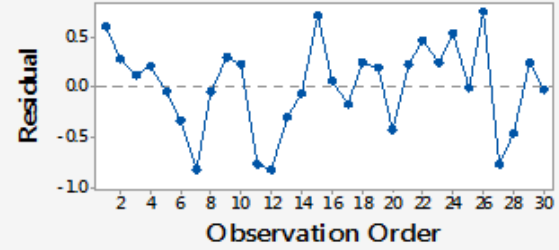
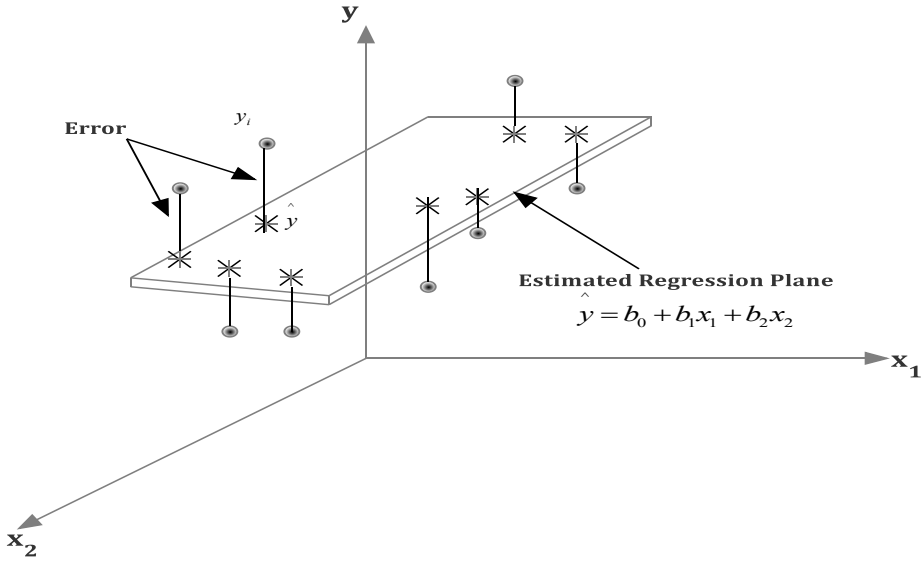


Figure 7.14: Scatter Plot and Regression Plane with Two Independent Variables



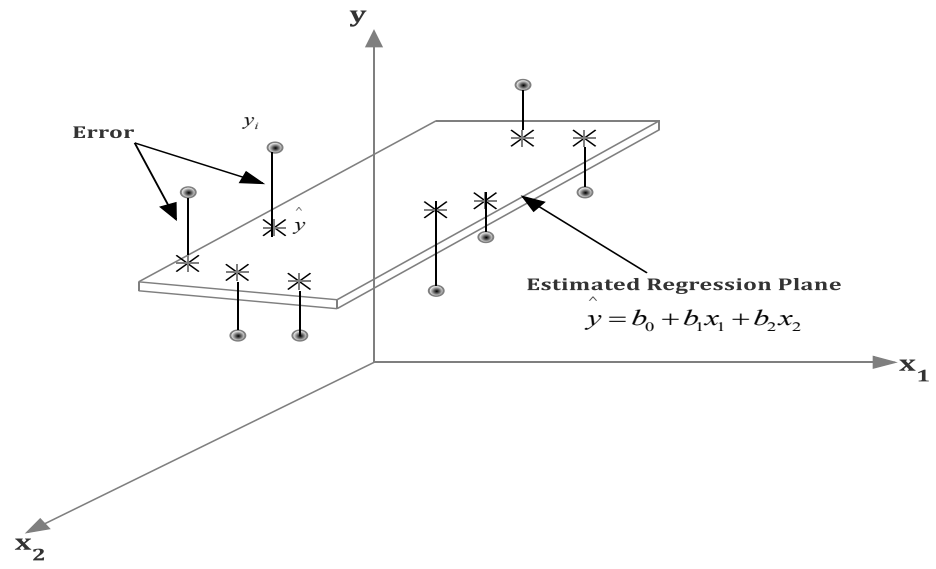
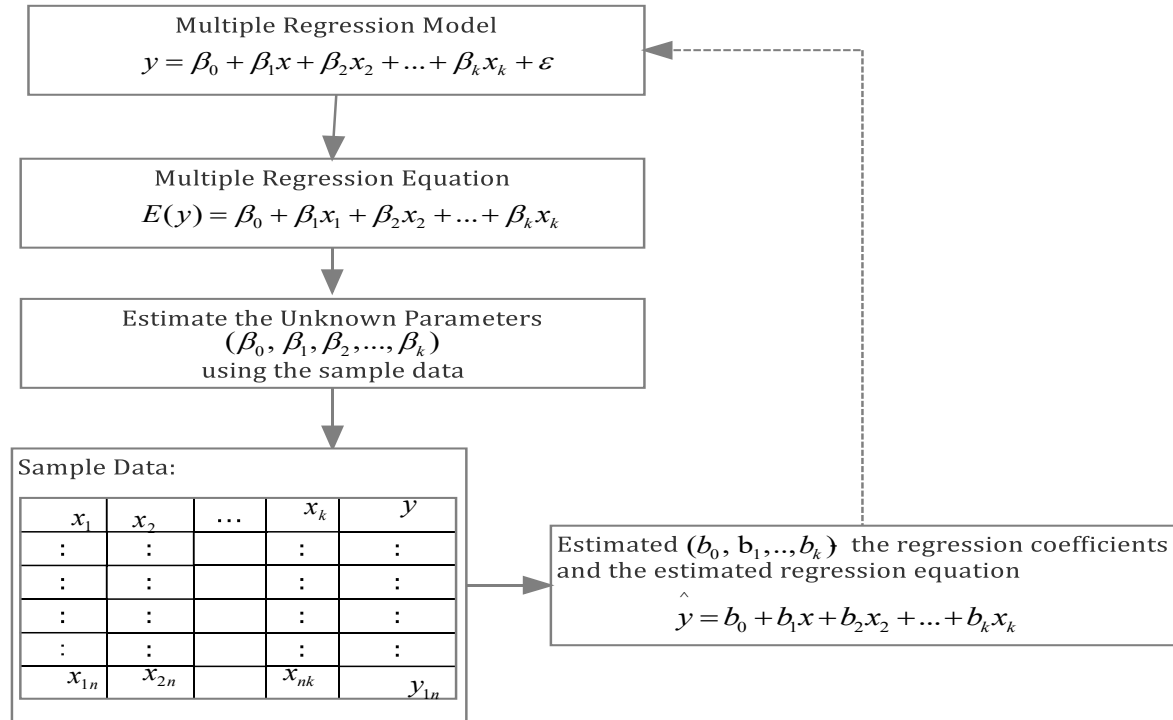


Figure 7.15: Process of Estimating the Multiple Regression Equation



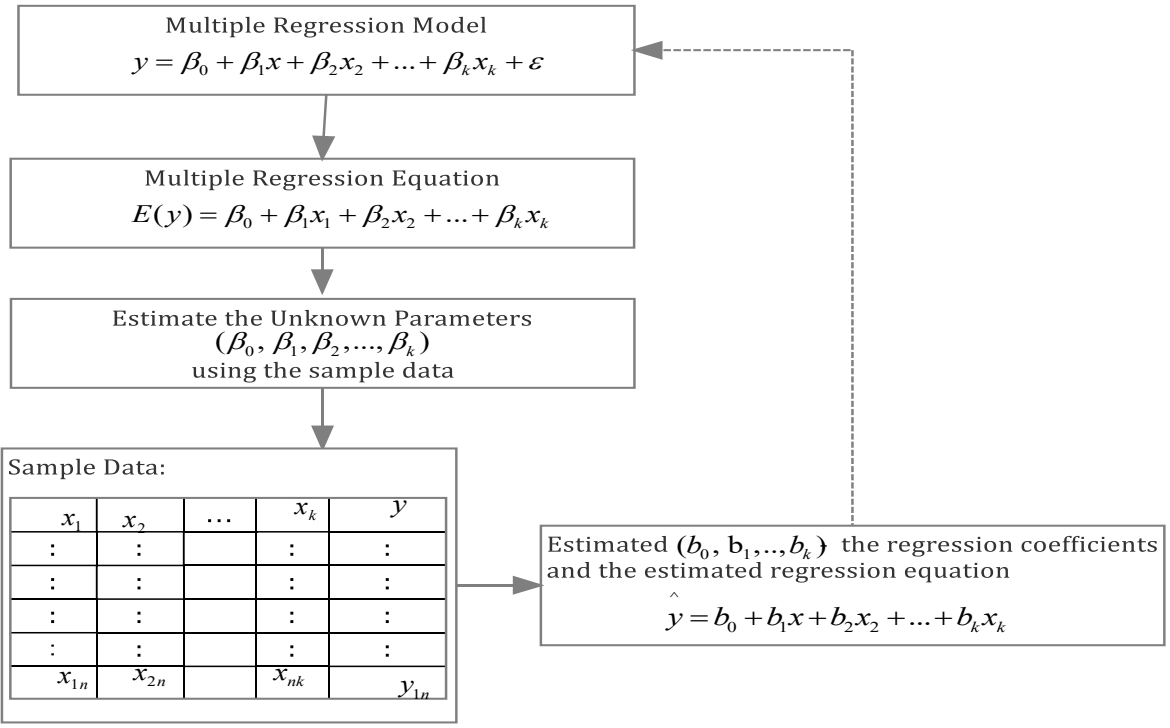
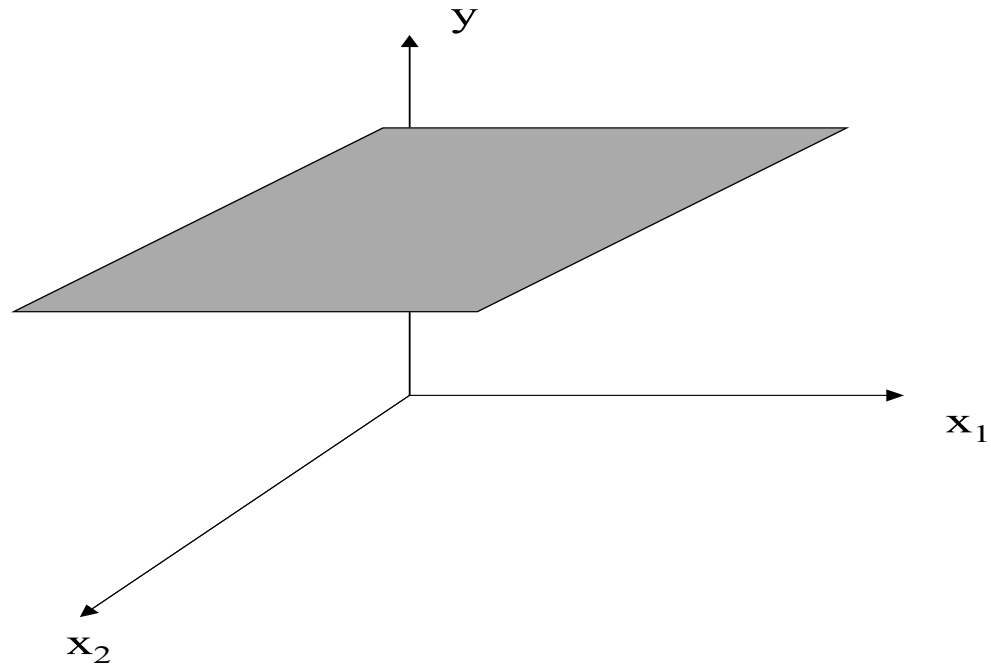


Figure 7.16: A Multiple Regression Model with Two Quantitative Variables



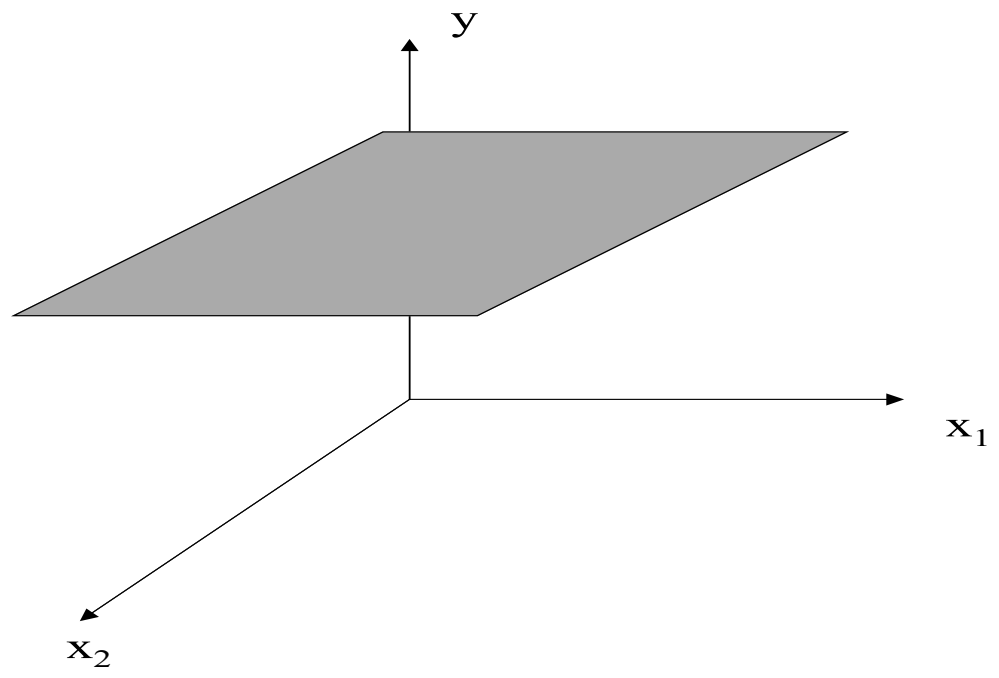
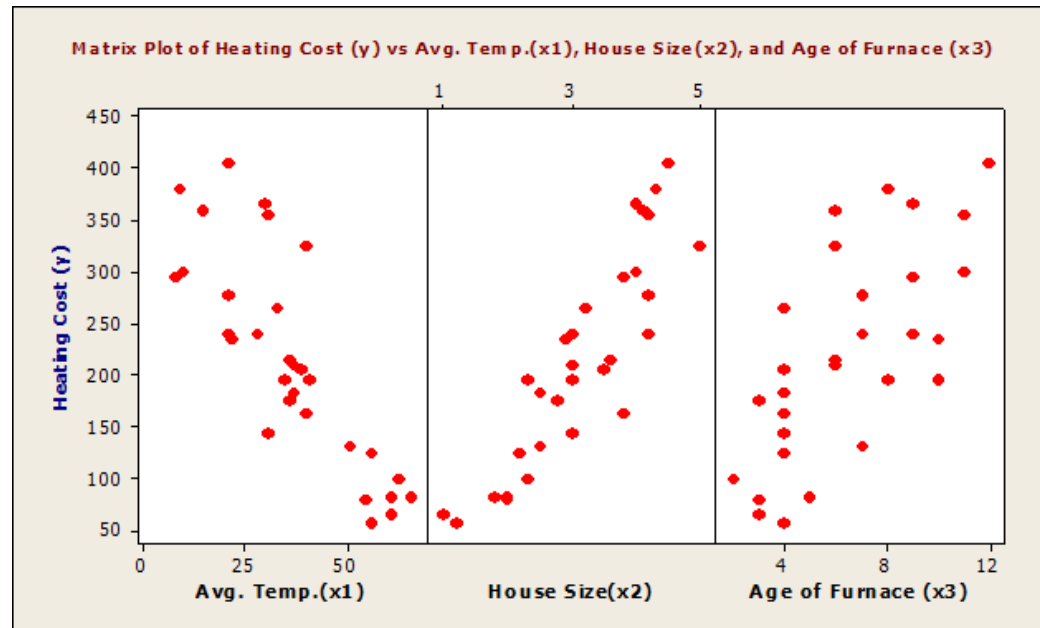


Figure 7.17: Matrix Plot of Each versus Each



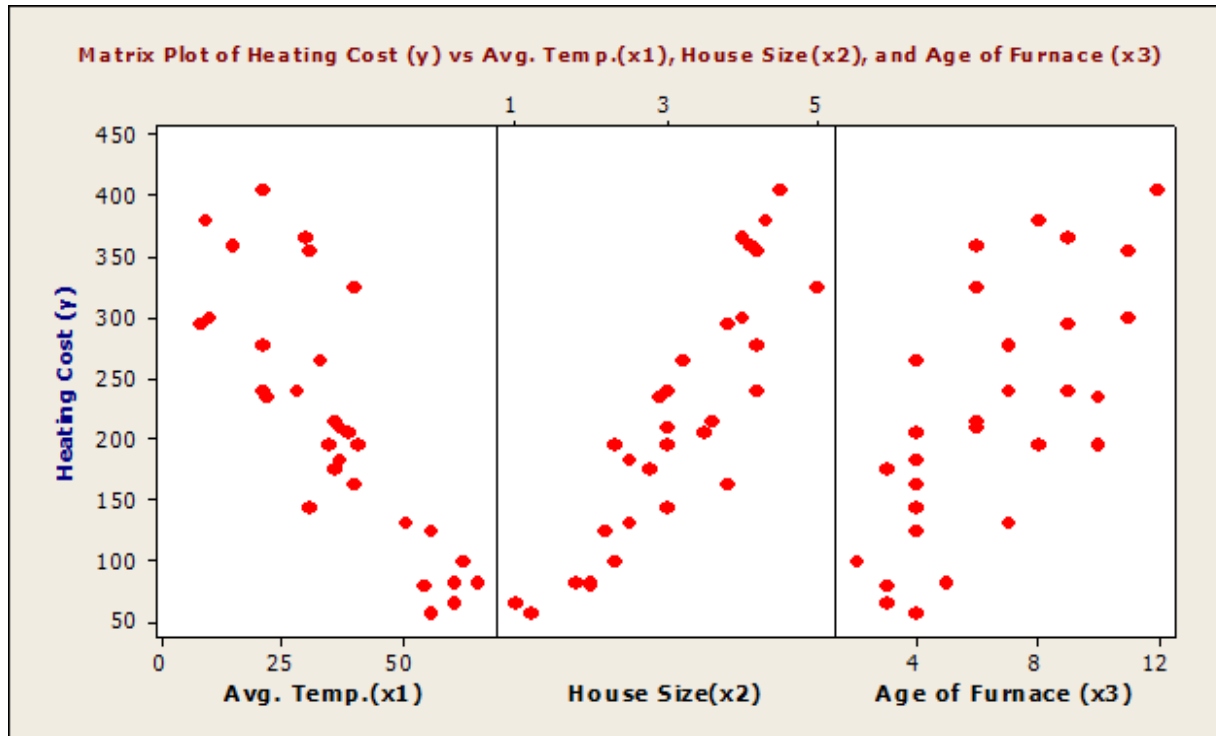
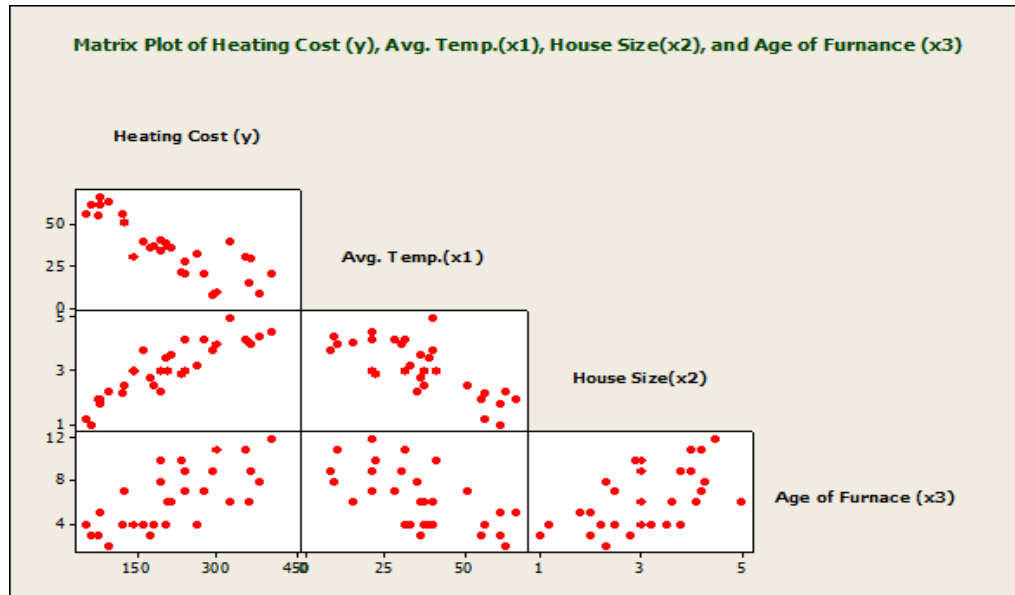


Figure 7.18: Matrix Plot



Matrix Plot of Heating Cost (y), Avg. Temp.(x1), House Size(x2), and Age of Furnance (x3)

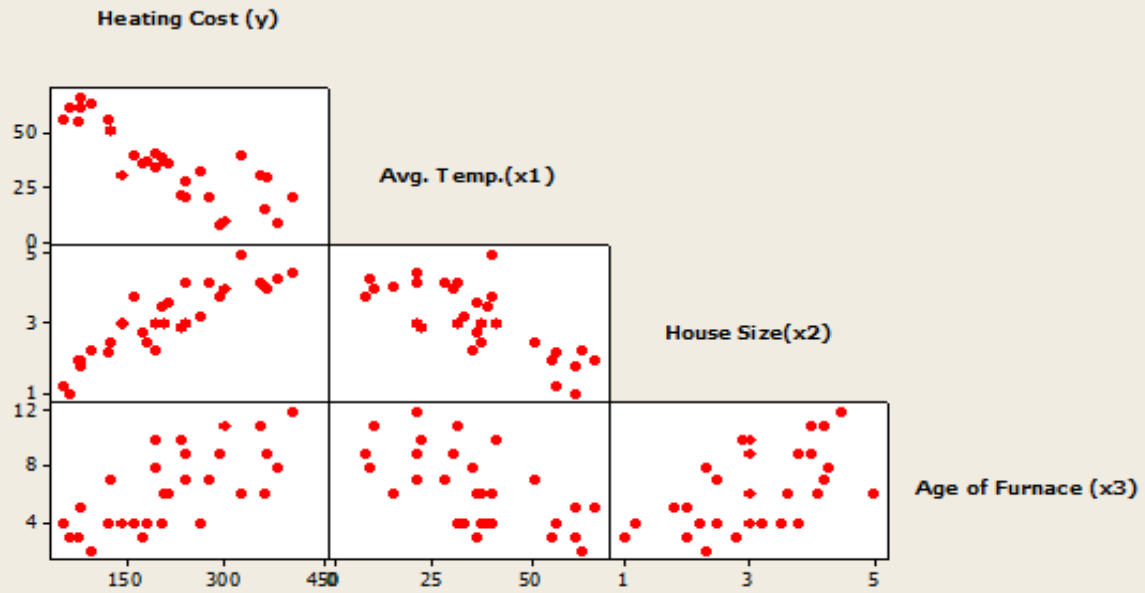
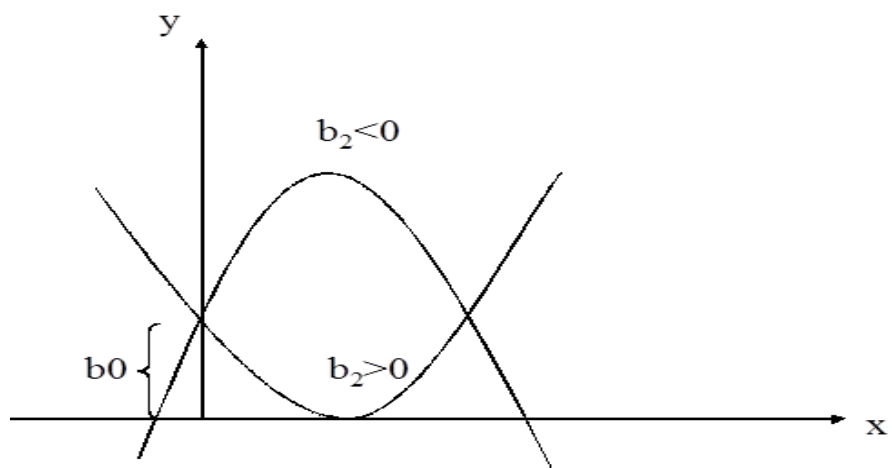


Figure 7.19: The Second Order Model



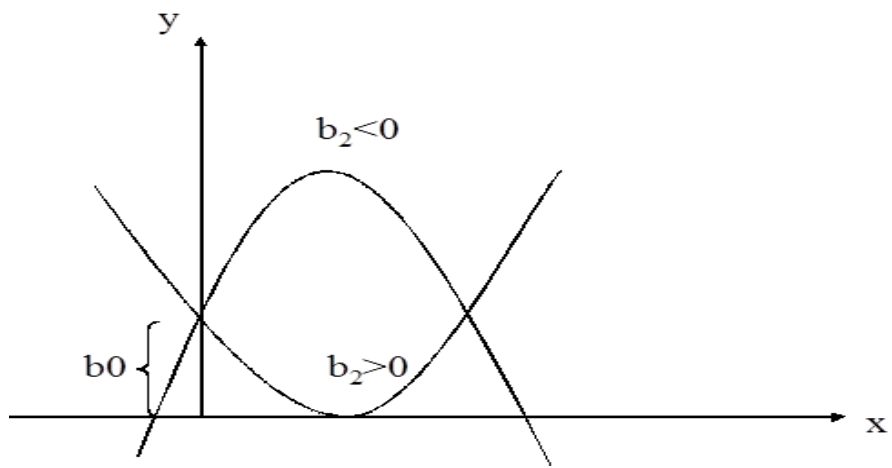
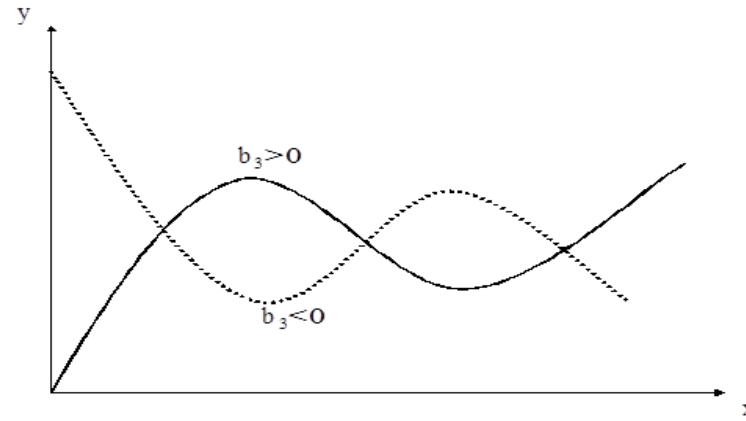
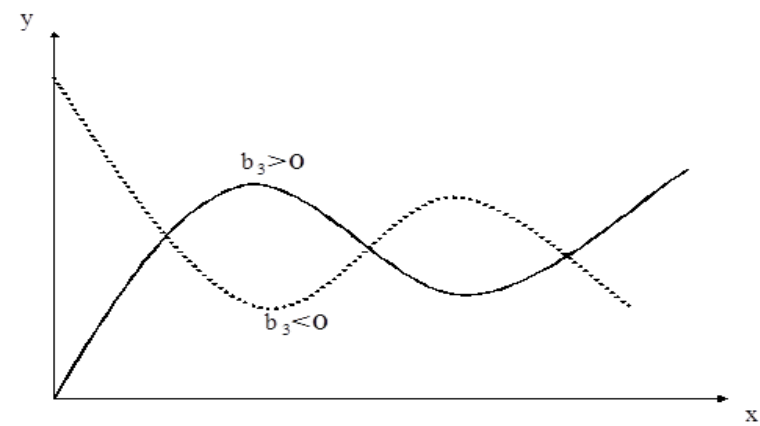


Figure 7.20: The Third-order Model





[Figure 7.21 here]

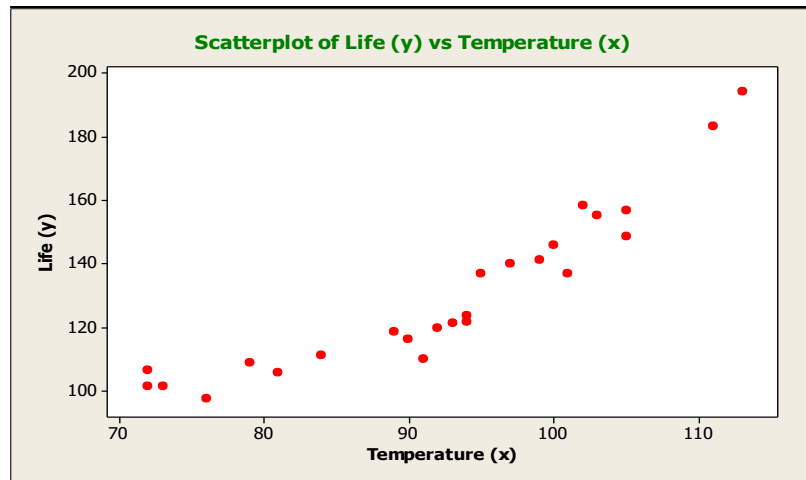


Figure 7.21: Scatter Plot of Life (y) vs. Operating Temp. (x)

[Figure 7.22here]

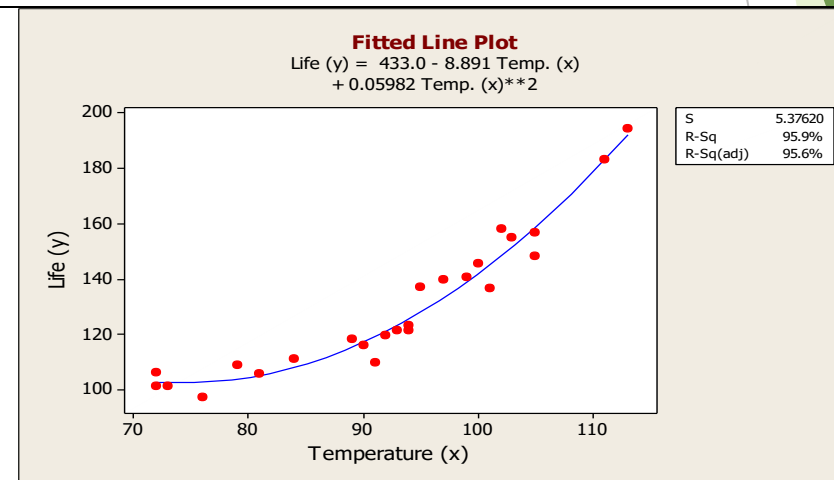


Figure 7.22: Regression Plot with Equation

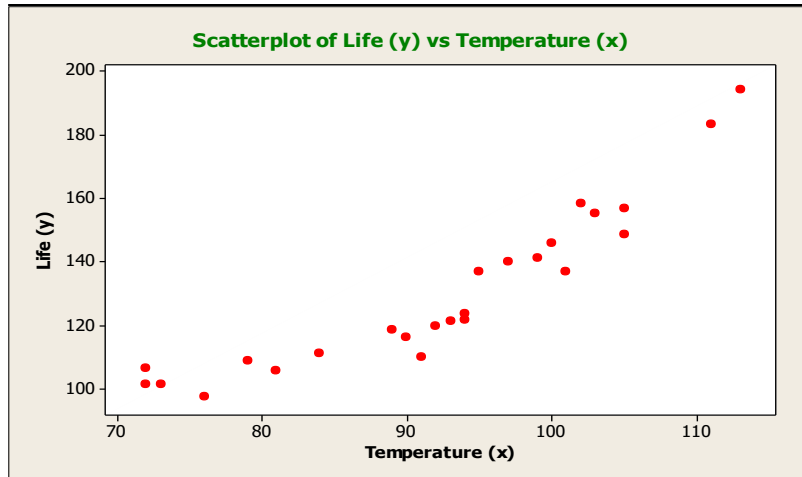


Figure 7.21: Scatter Plot of Life (y) vs. Operating Temp. (x)

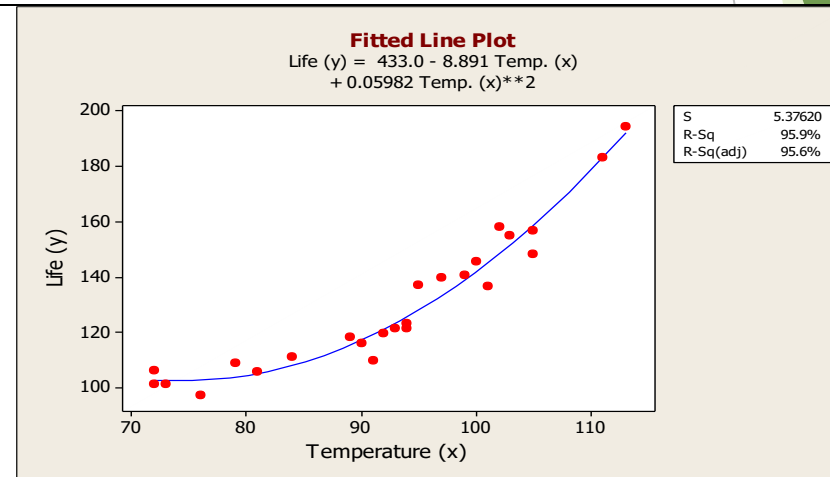
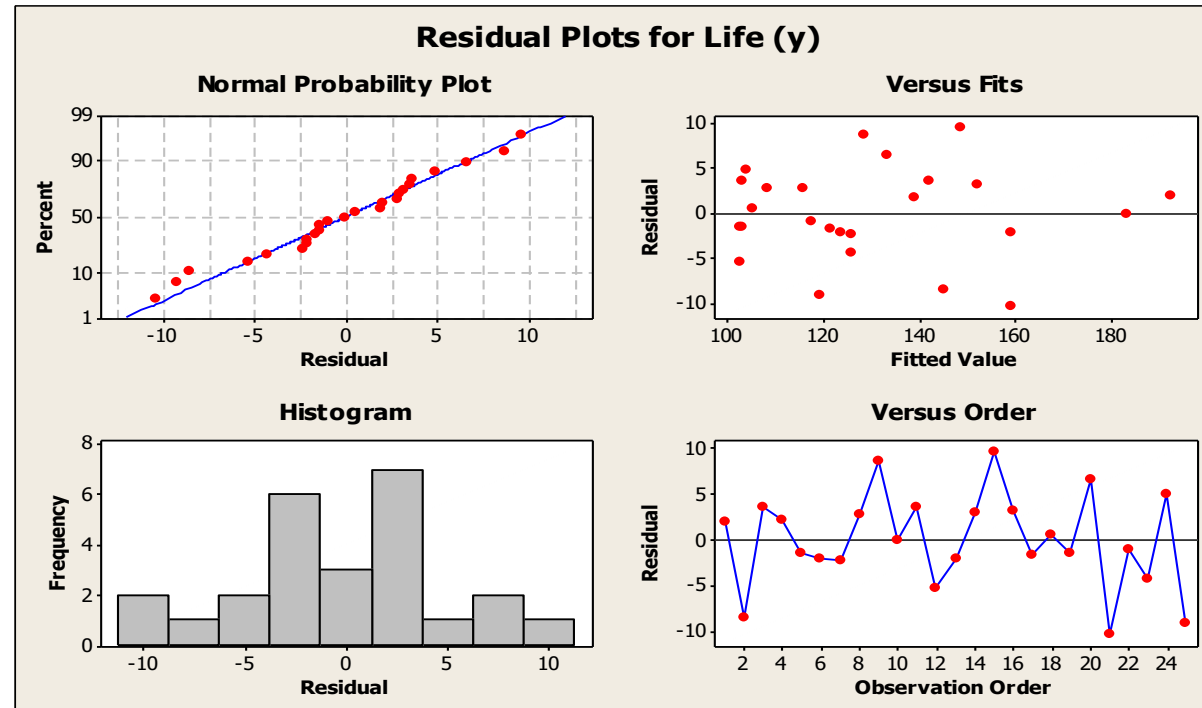


Figure 7.22: Regression Plot with Equation

Figure 7.23: Residual Plots for the Quadratic Model Example



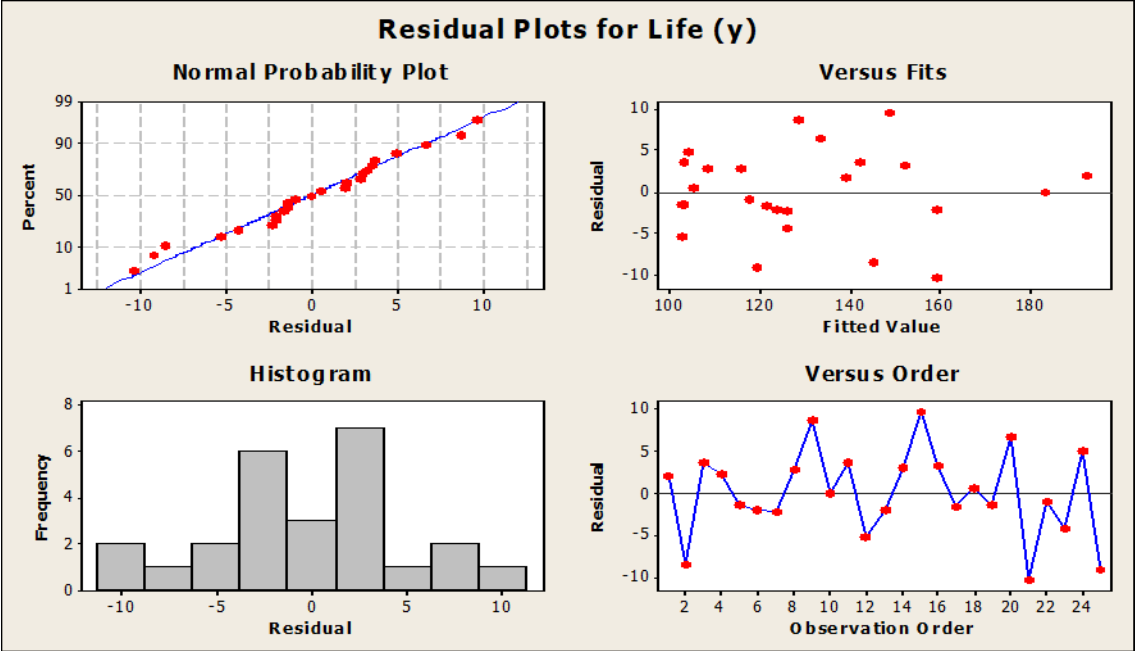
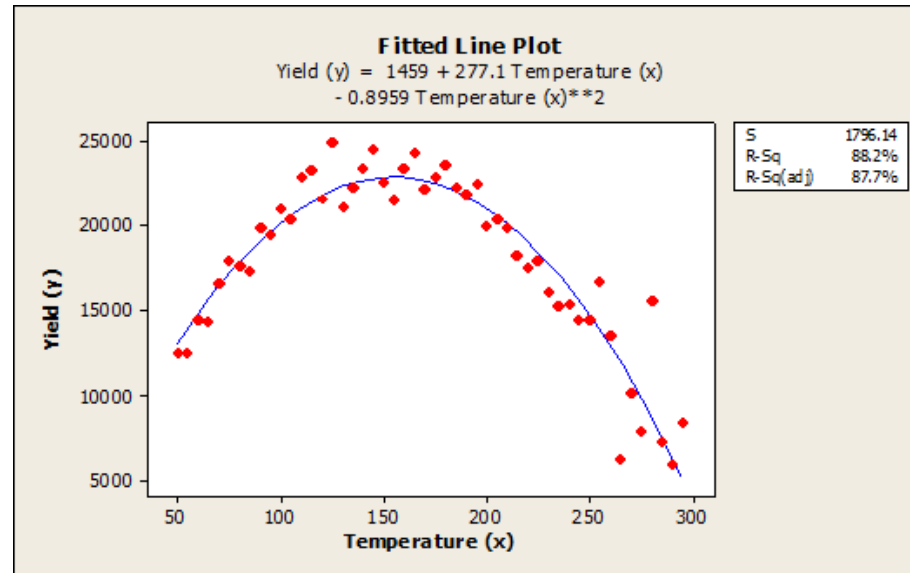


Figure 7.24: Fitted Line Plot showing the Yield of a Chemical Process



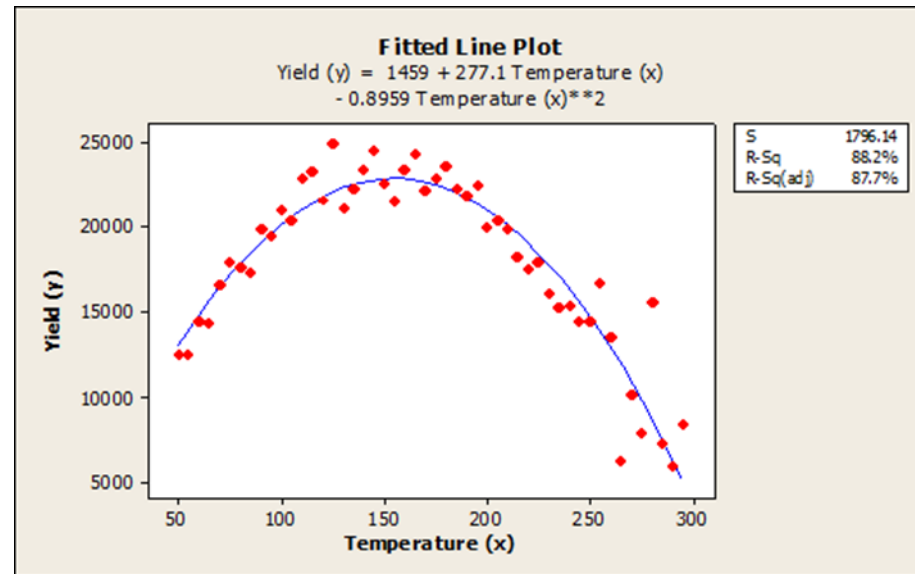
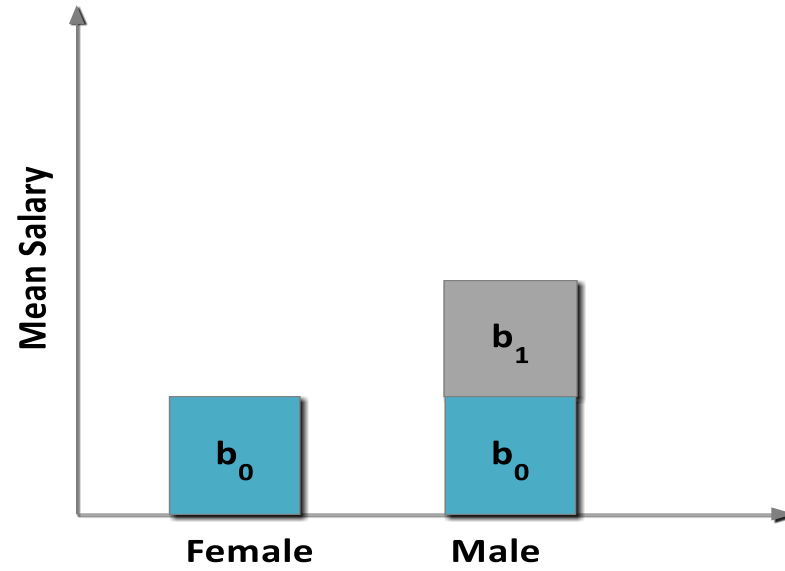


Figure 7.25: Mean Salary of Female and Male Employees



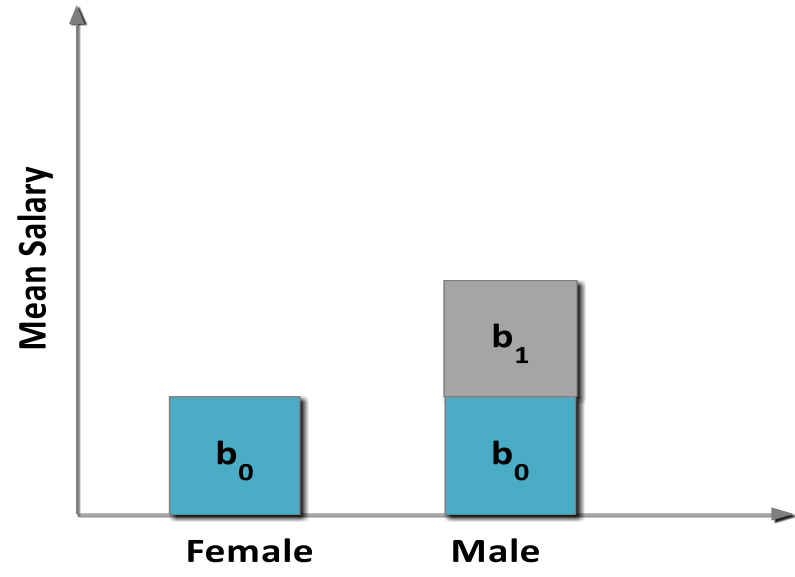
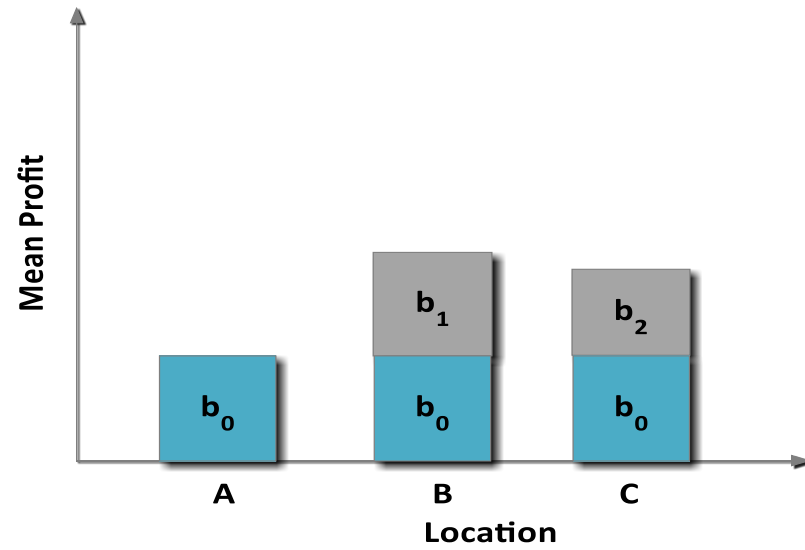


Figure 7.26: Bar Chart Showing the Mean Profit for Three Locations A, B, C



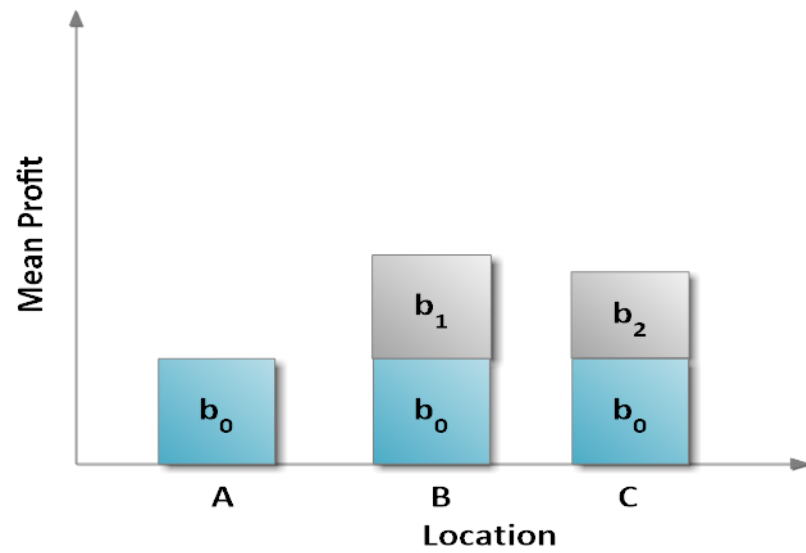
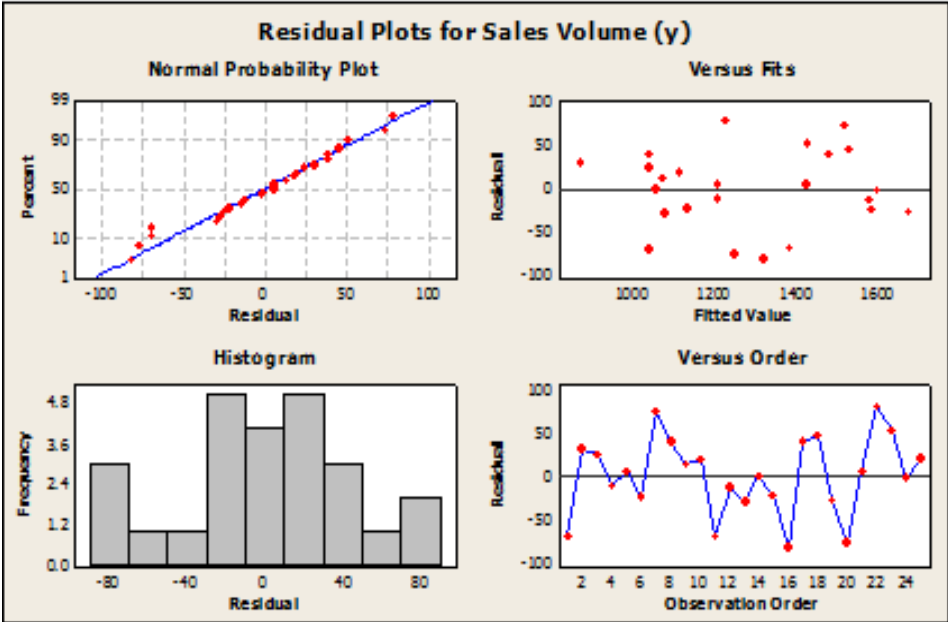


Figure 7.27: Residual Plots for the Dummy Variable Example





[Figure 8.1 here]

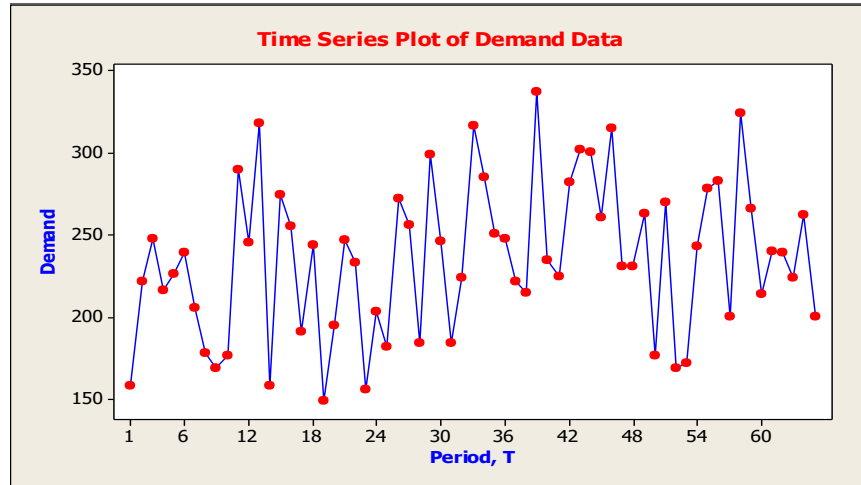


Figure 8.1: A Constant (stable process)

[Figure 8.2 here]

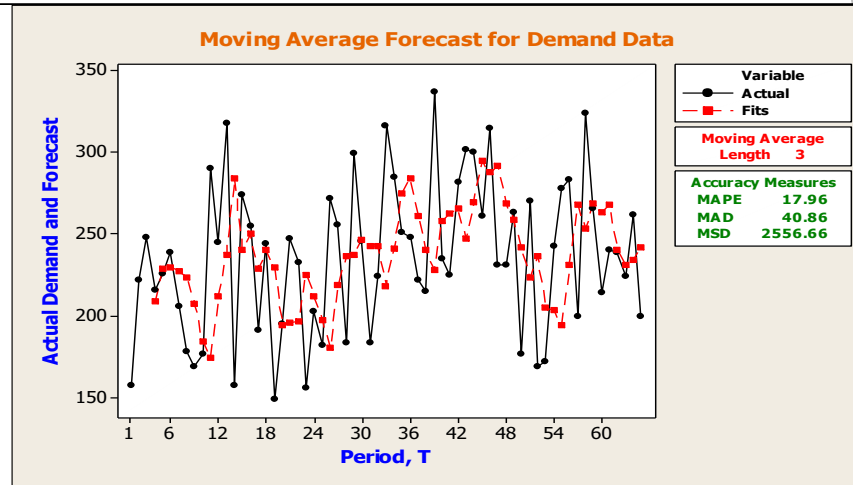
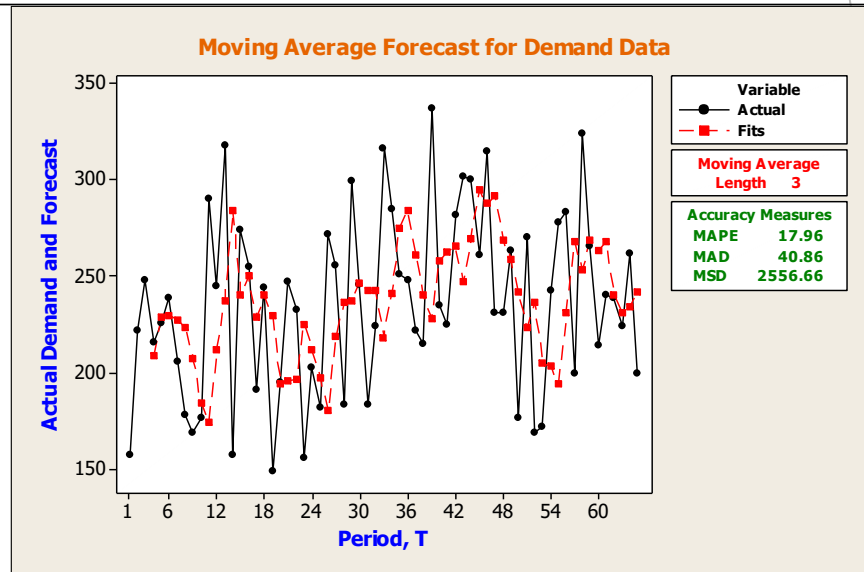
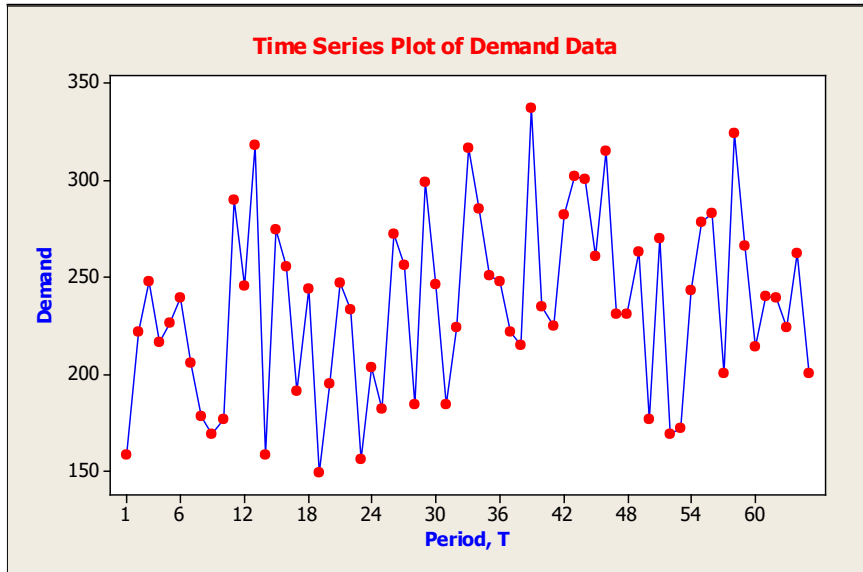


Figure 8.2: Forecast for the Demand Data in Figure 8.1 (forecasts are dotted lines)



[Figure 8.3 here]

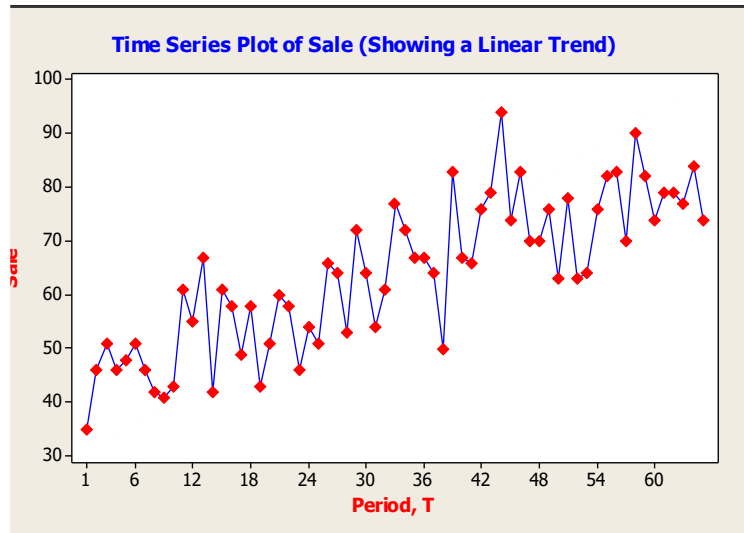


Figure 8.3: A Linear Trend Process

[Figure 8.4 here]

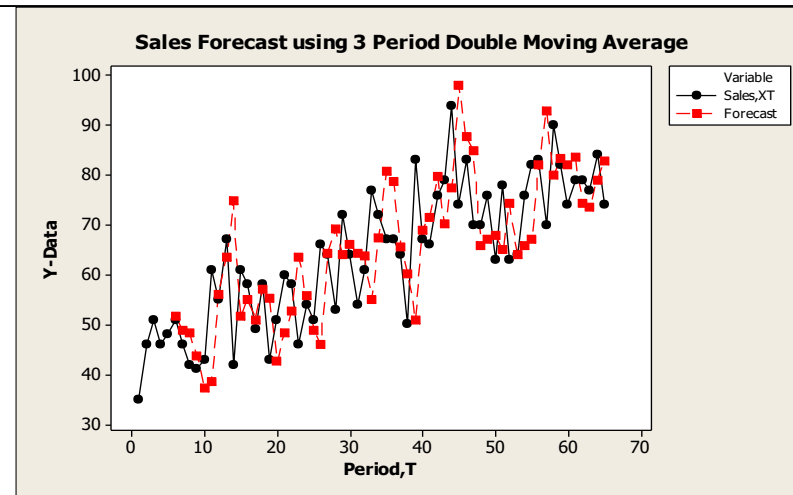


Figure 8.4: Forecast for the Sales Data in Figure 8.3 using Double Moving Average

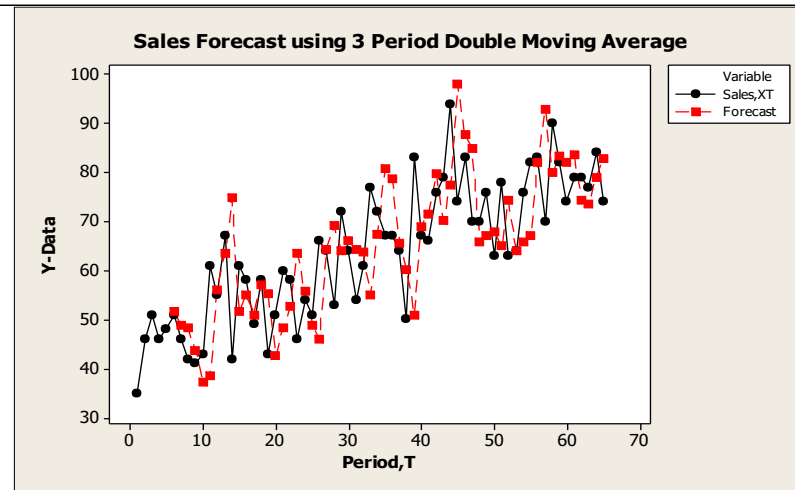
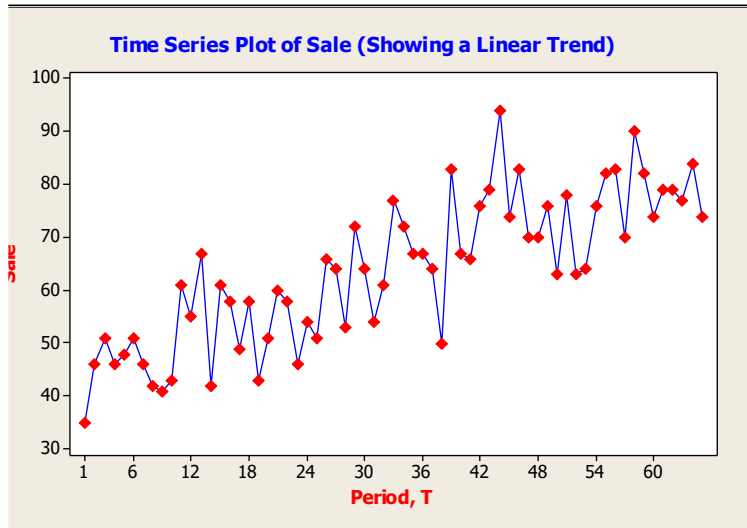
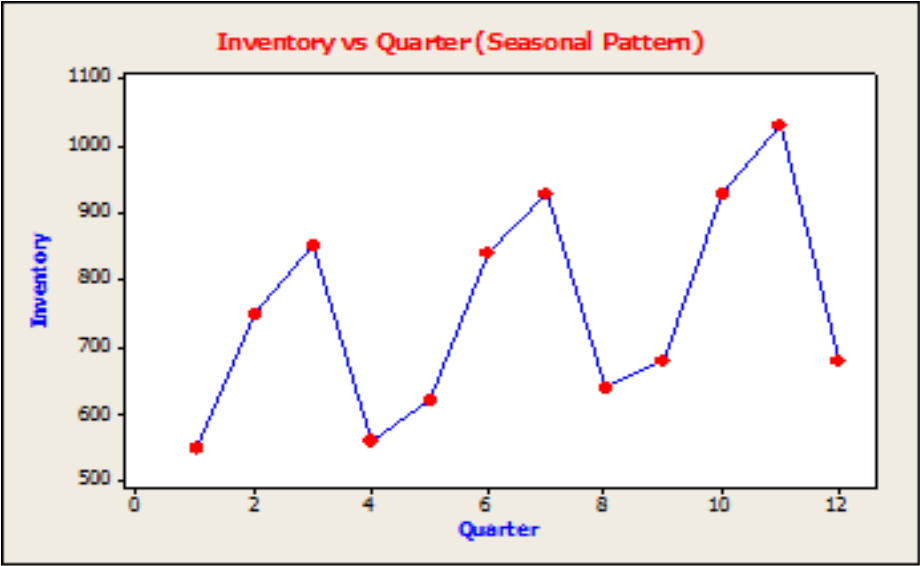


Figure 8.5: Data Showing Seasonal Pattern



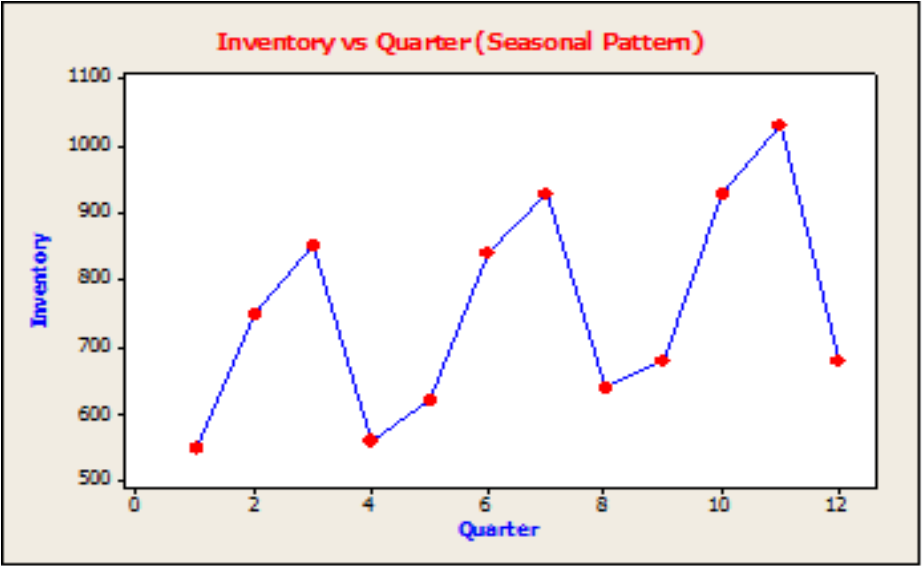


Figure 8.6: Linear Trend Model

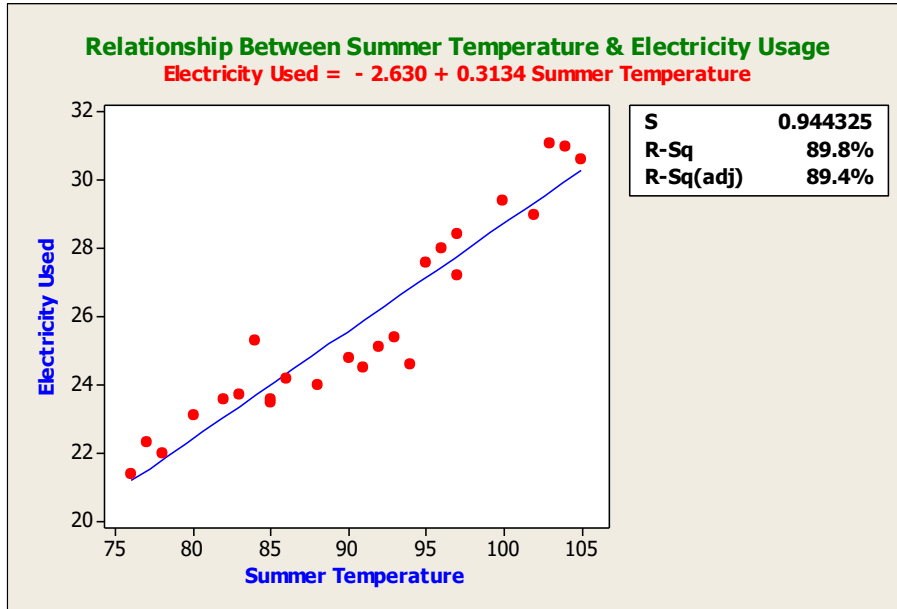
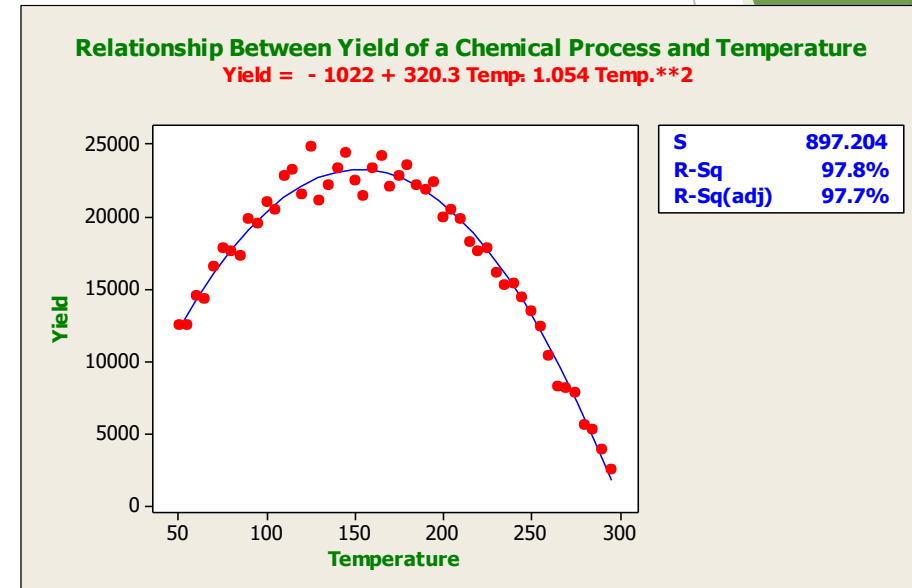


Figure 8.7: Nonlinear Relationship (Quadratic Model)



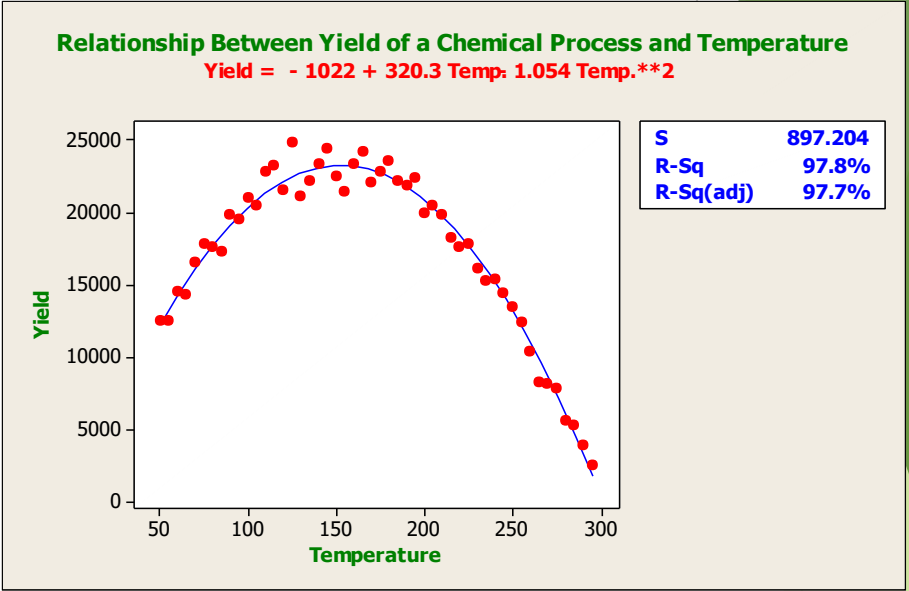
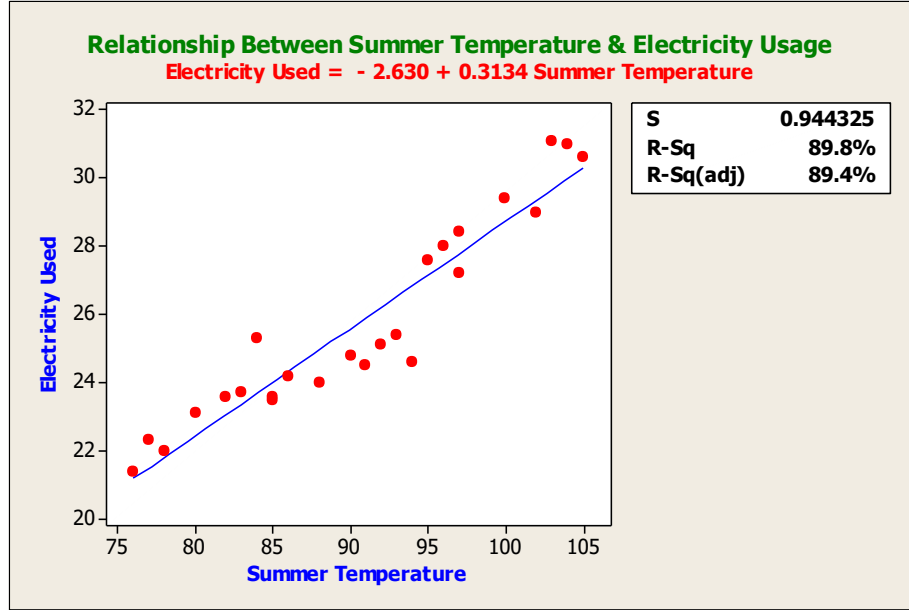
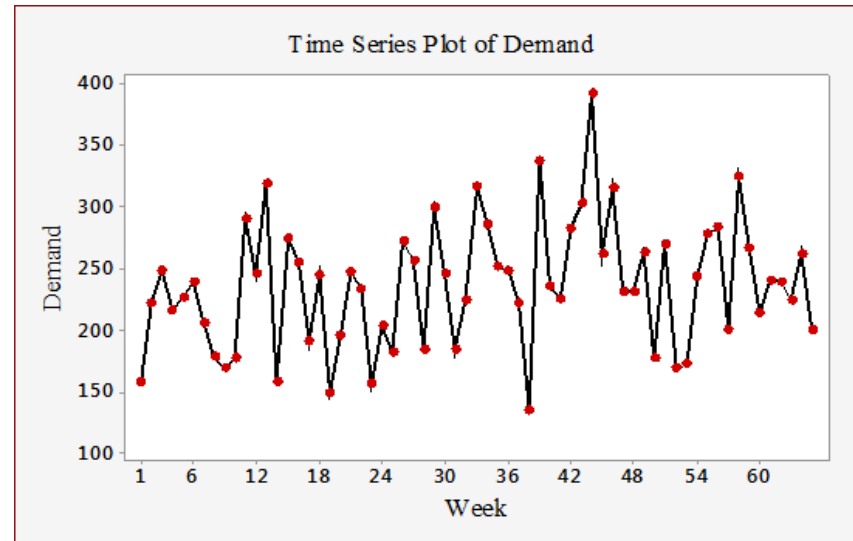


Figure: 8.8: Time Series Plot of Demand Data



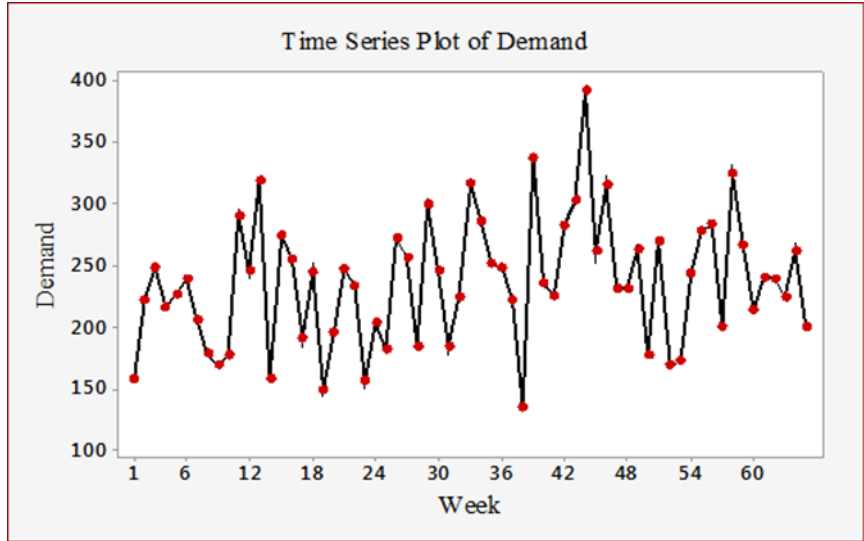
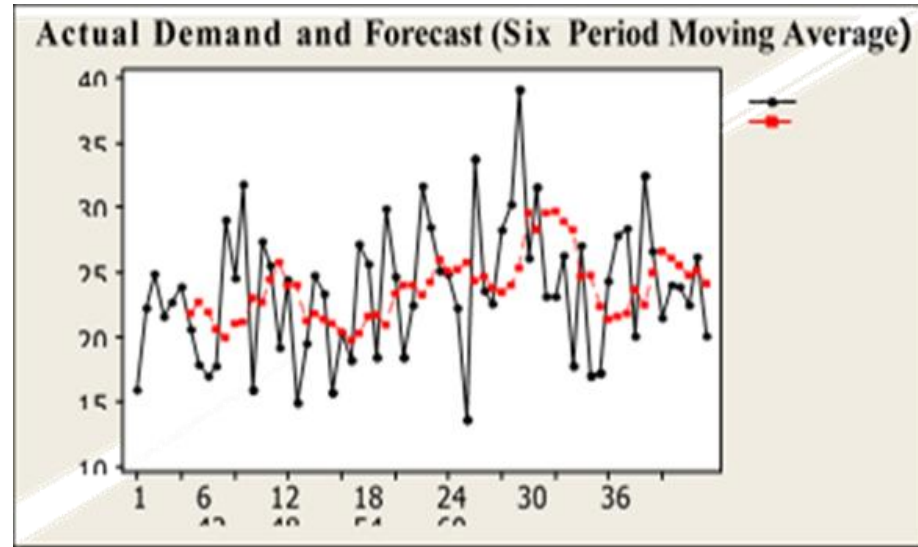


Figure 8.9: Plot of Actual Data and Six Period Moving Average Forecast



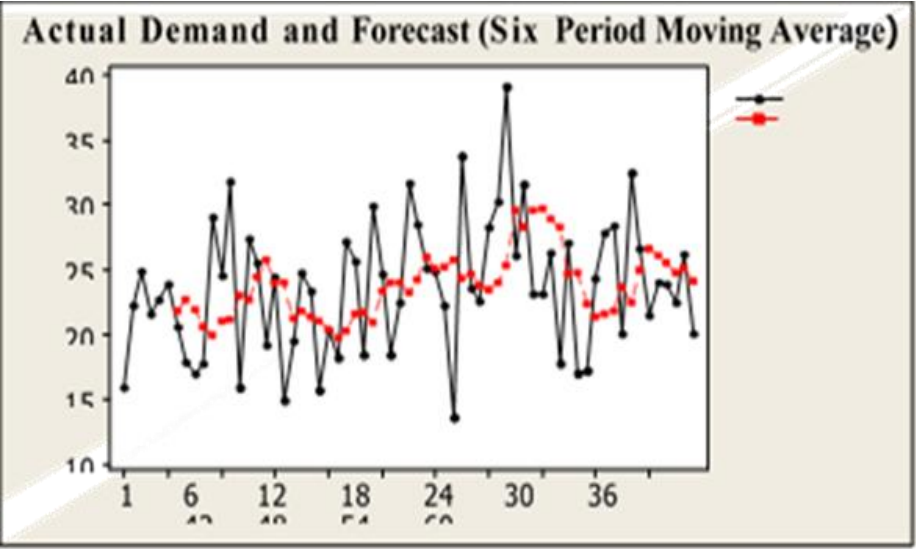
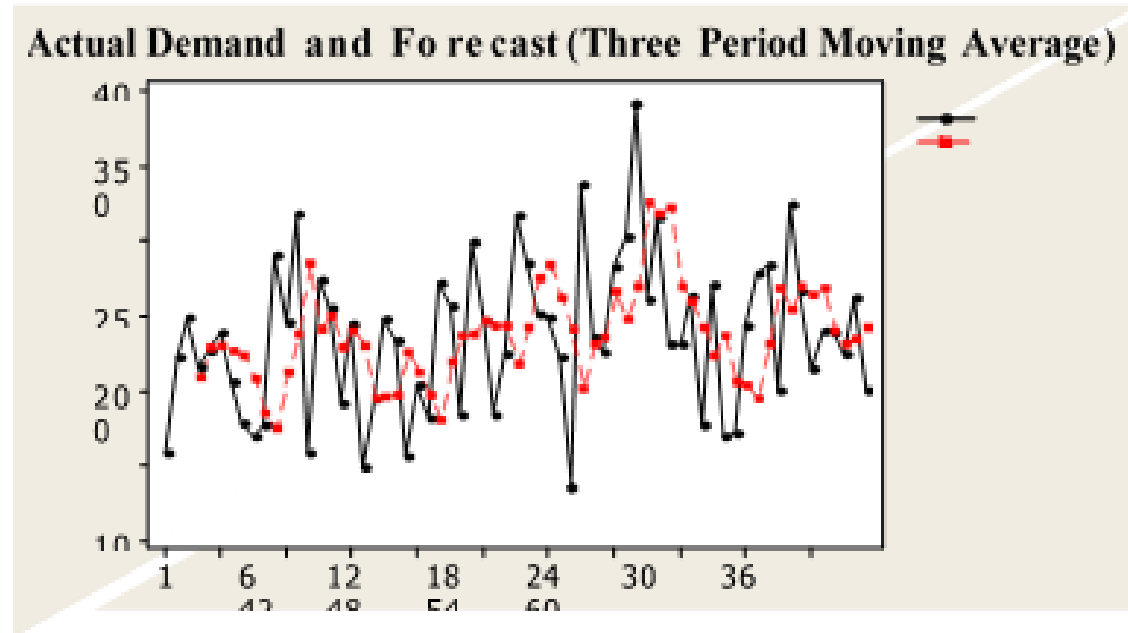


Figure 8.10: Plot of Actual Data and Three Period Moving Average Forecast



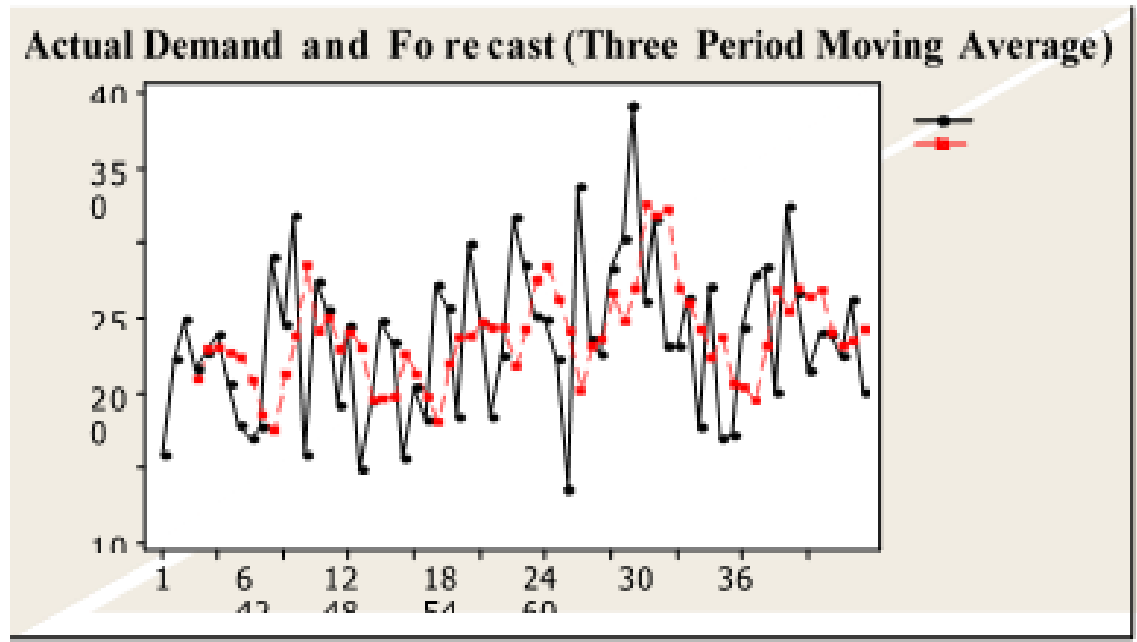
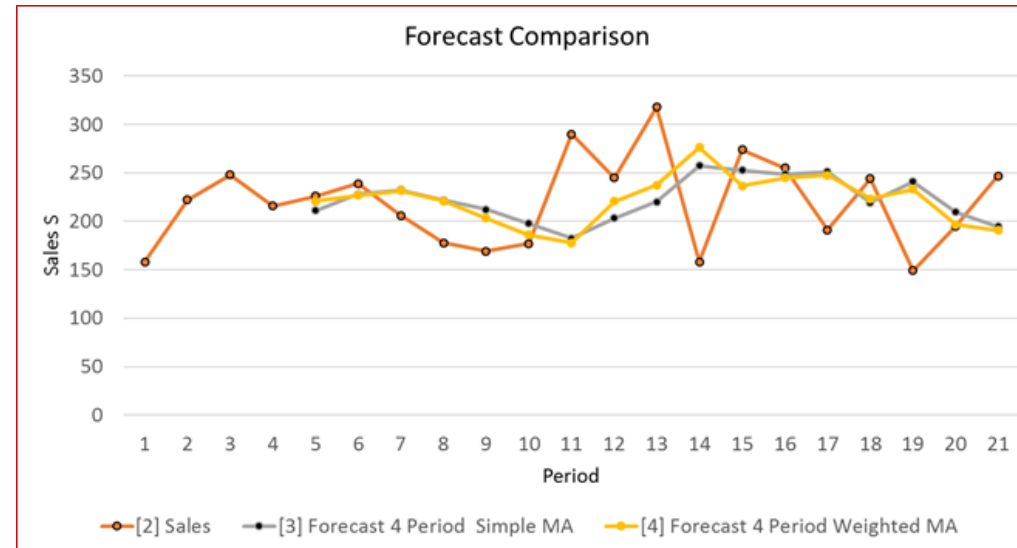


Figure 8.11: 4-period simple moving average and 4-period weighted moving average forecasts



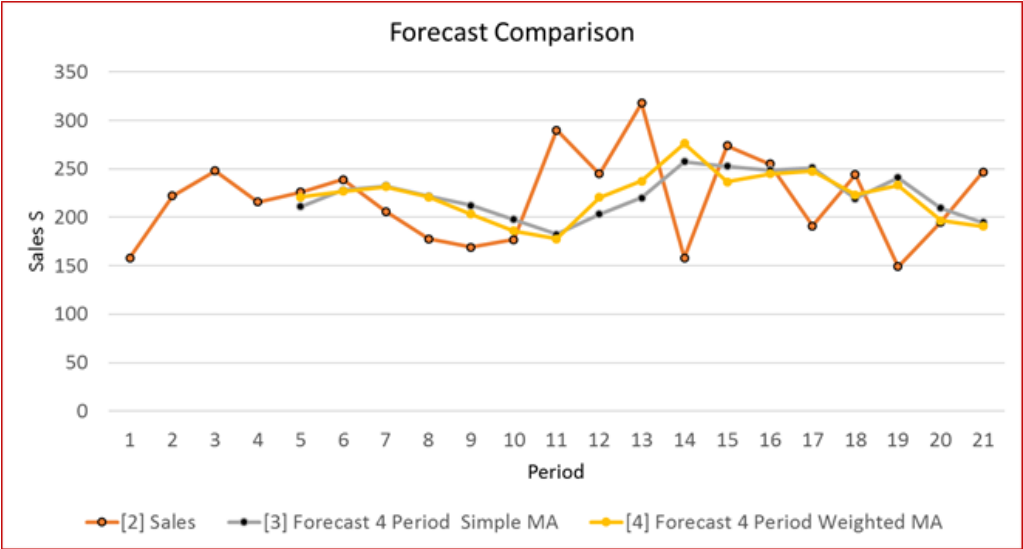


Figure 8.12: Plot of Actual Sales

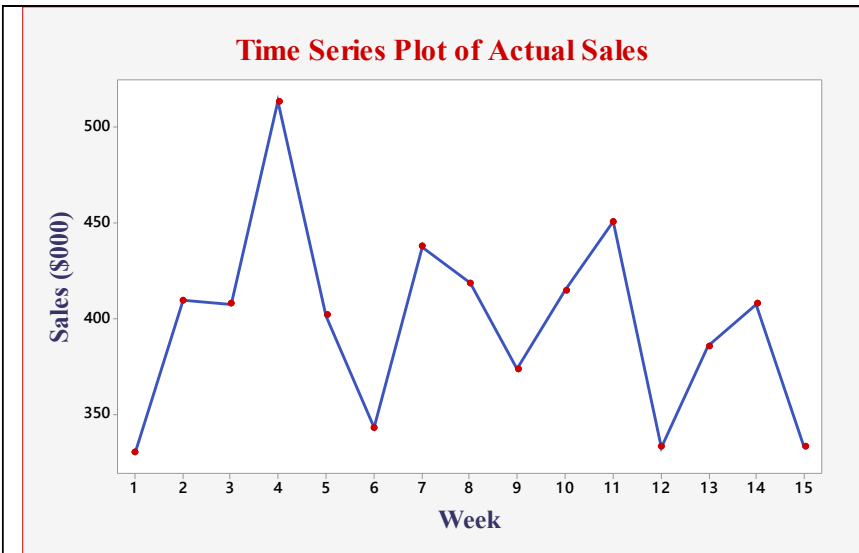


Figure 8.12: Plot of Actual Sales

Figure 8.13: Actual Sales and Forecast

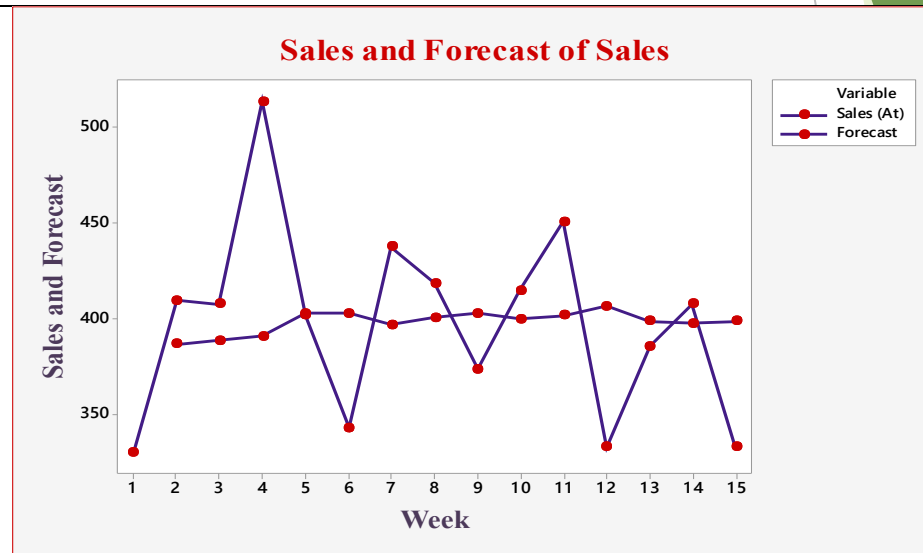


Figure 8.13: Actual Sales and Forecast

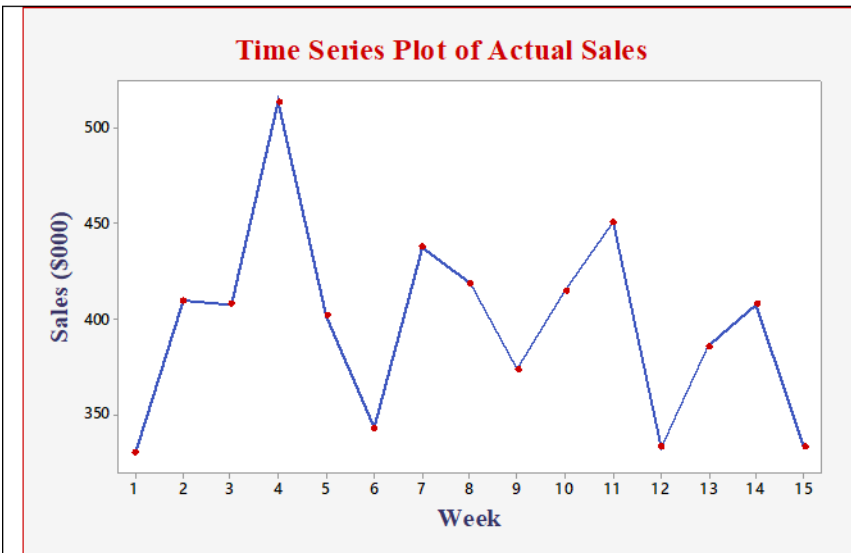


Figure 8.12: Plot of Actual Sales

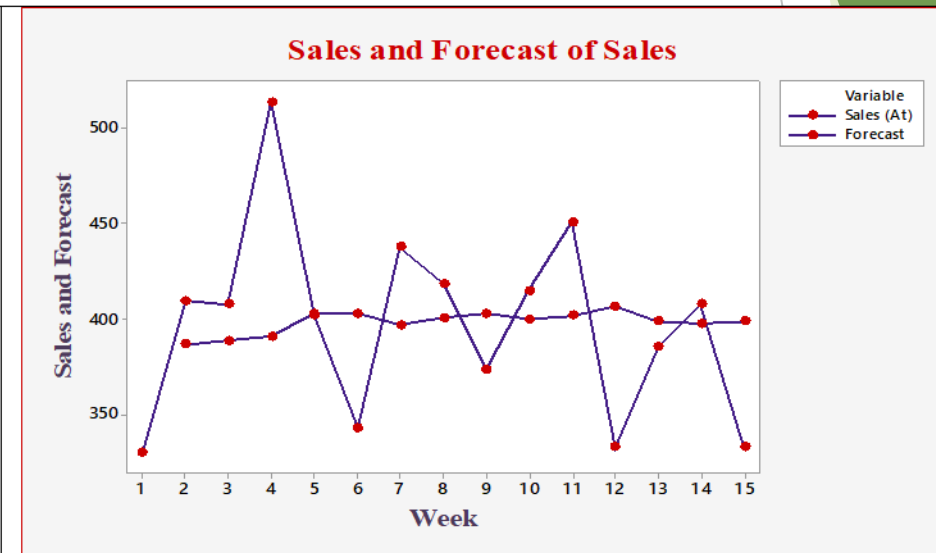
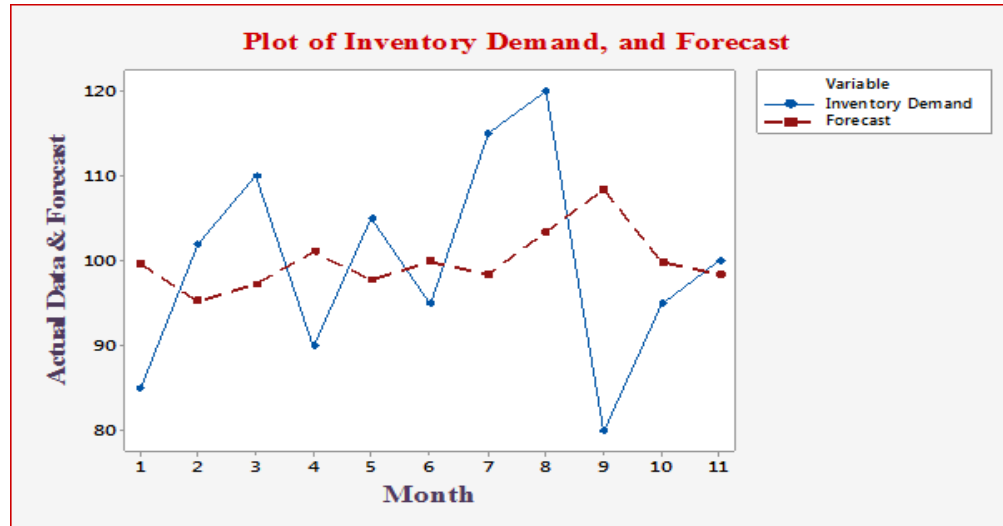


Figure 8.13: Actual Sales and Forecast

Figure 8.14: Inventory demand data and the forecast



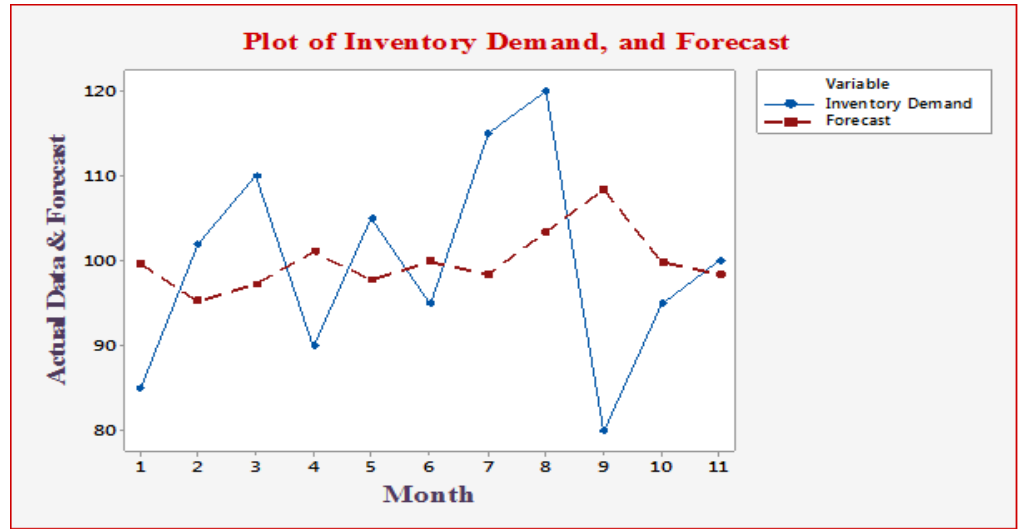
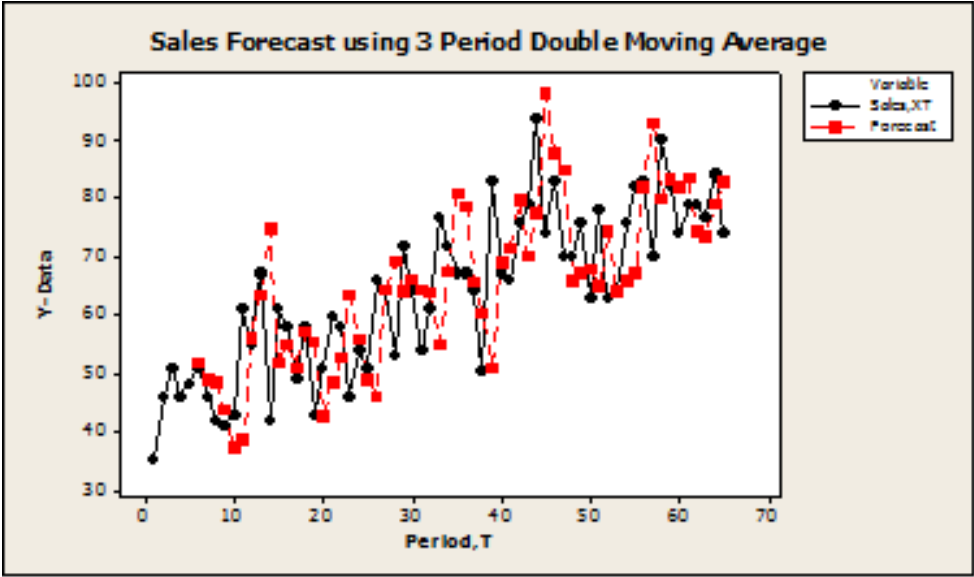
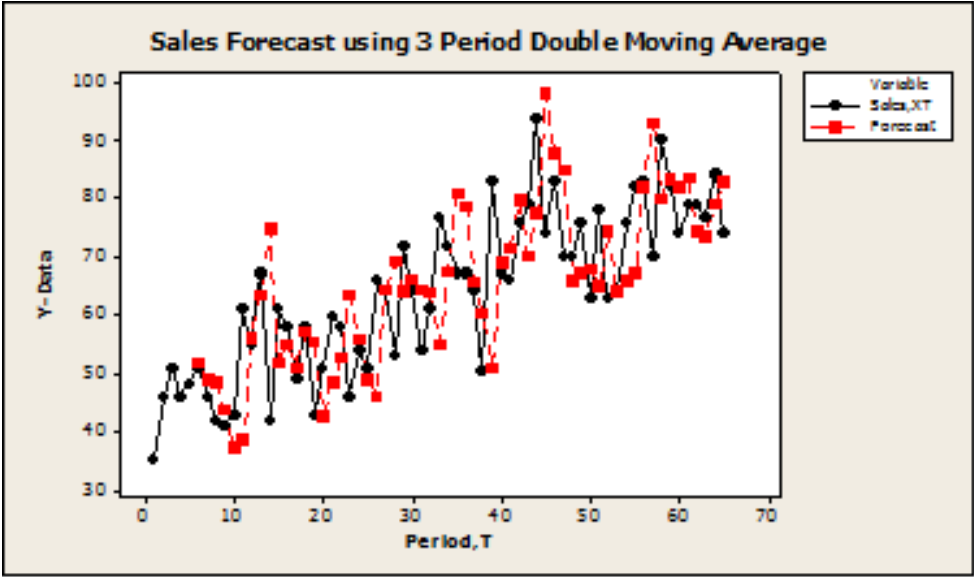


Figure 8.15: Sales and Forecast using Double Moving Average





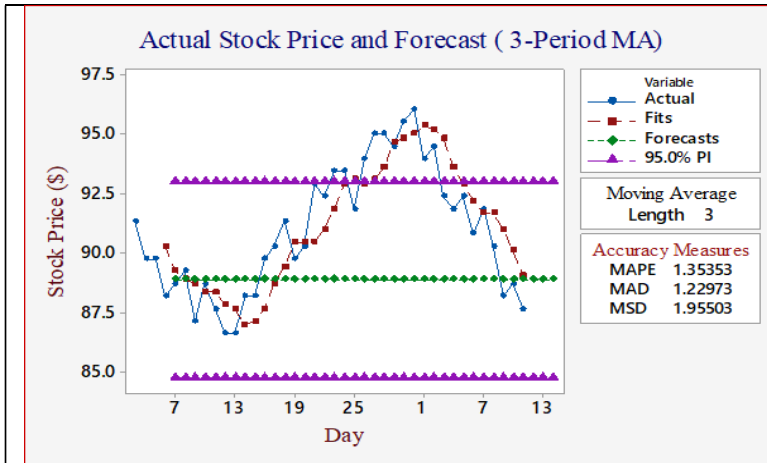


Figure 8.16: 3-Period Moving Average Forecast of Stock Price

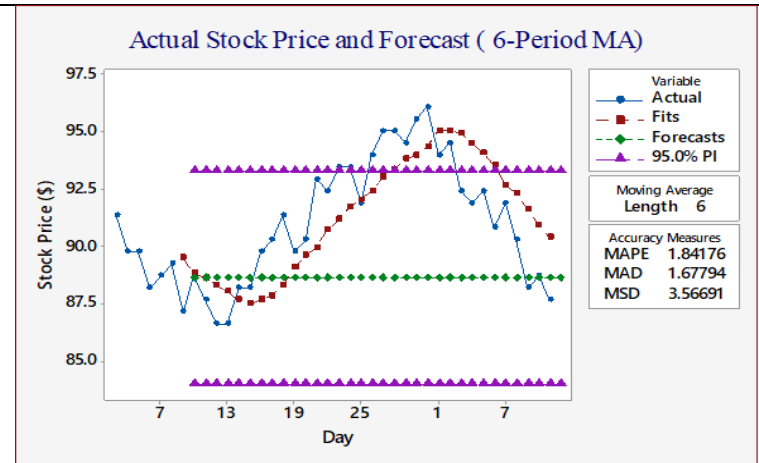


Figure 8.17: 6-Period Moving Average Forecast of Stock Price

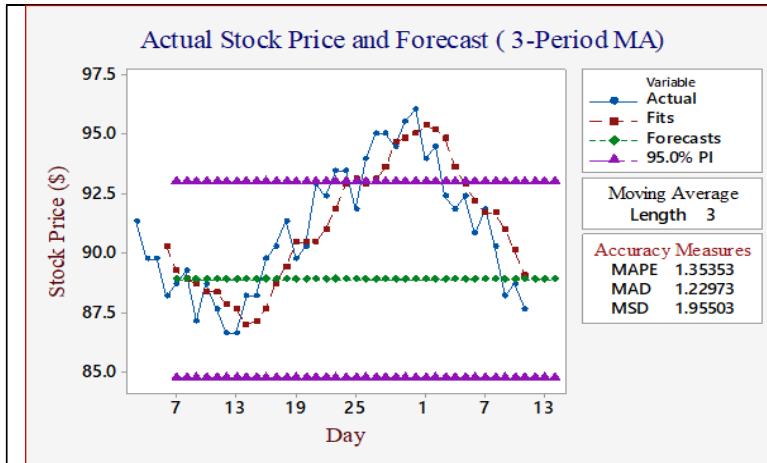


Figure 8.16: 3-Period Moving Average Forecast of Stock Price

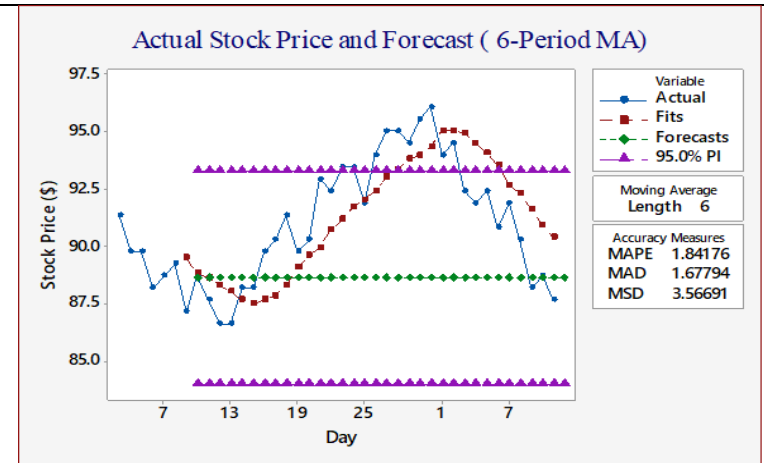


Figure 8.17: 6-Period Moving Average Forecast of Stock Price

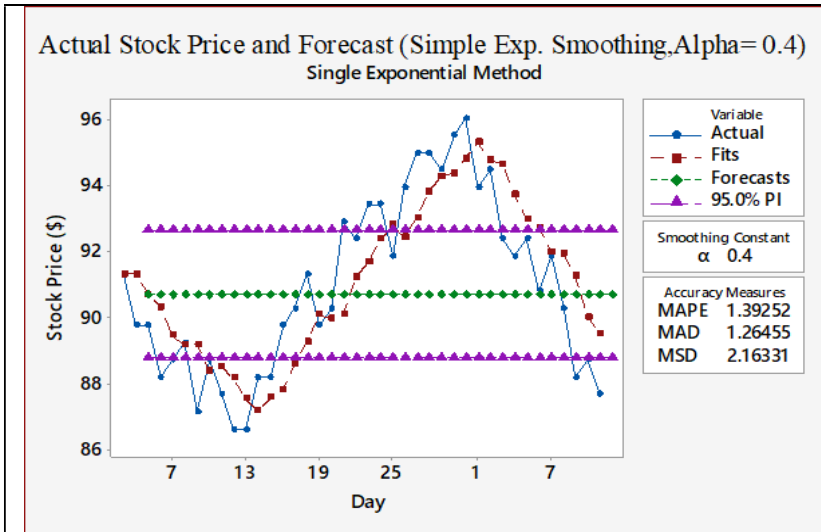


Figure 8.18: Exponential Smoothing Forecast of Stock Price ($\alpha = 0.4$)

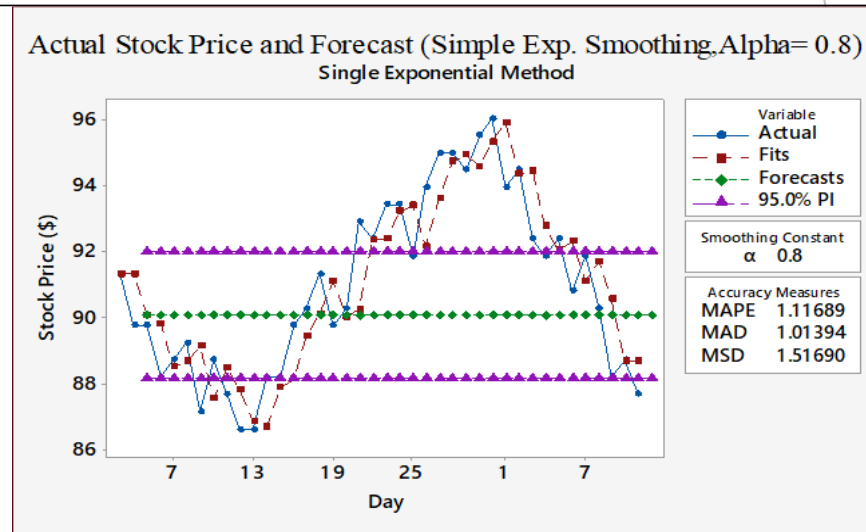
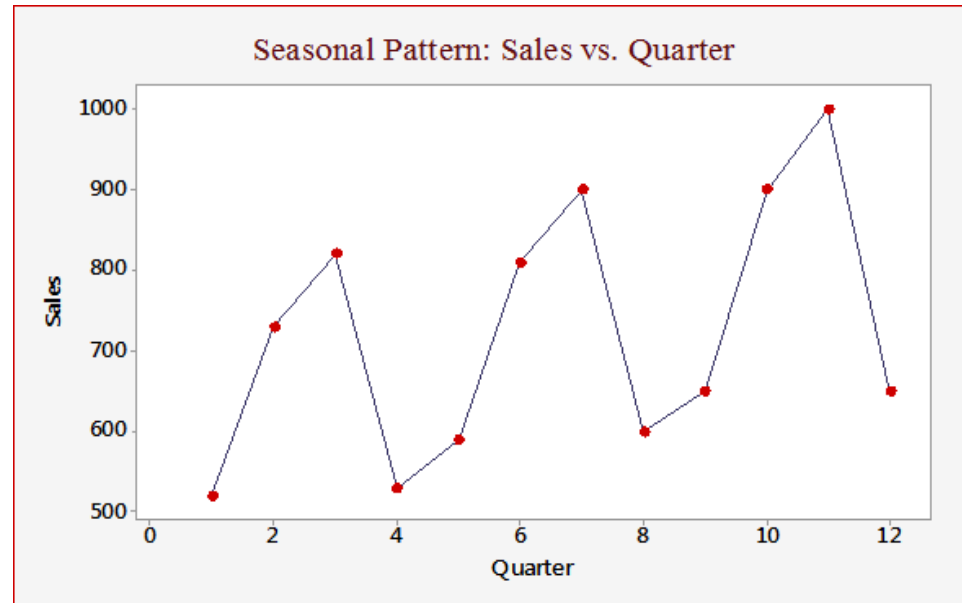


Figure 8.19: Exponential Smoothing Forecast of Stock Price ($\alpha = 0.8$)

Figure 8.20: Historical Data of Quarterly Sales



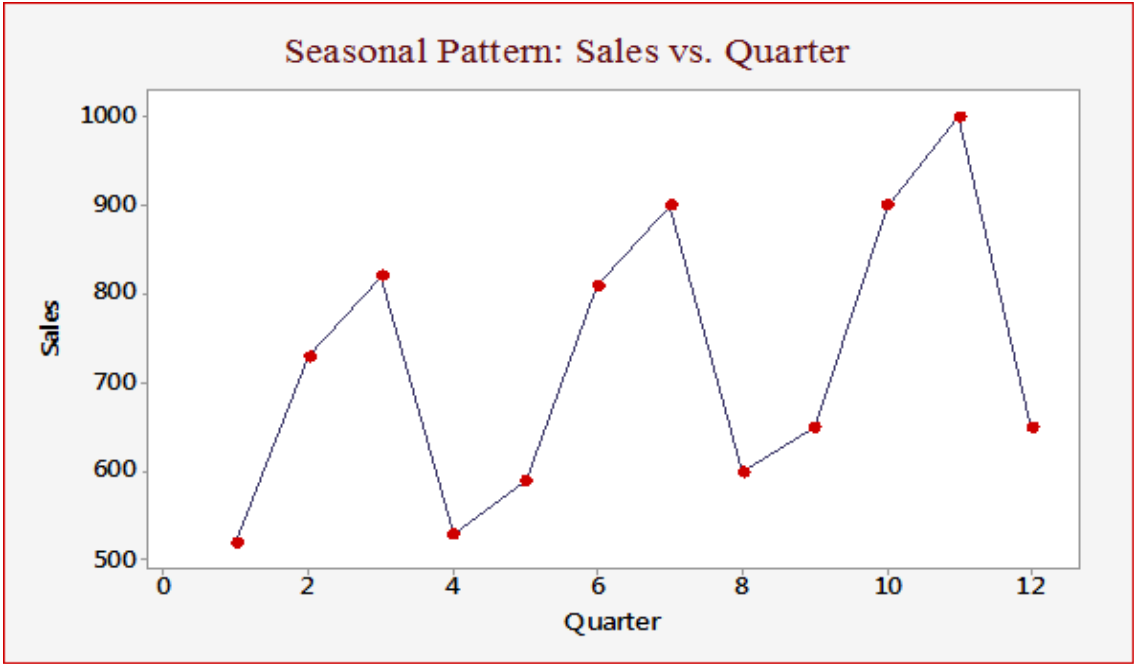
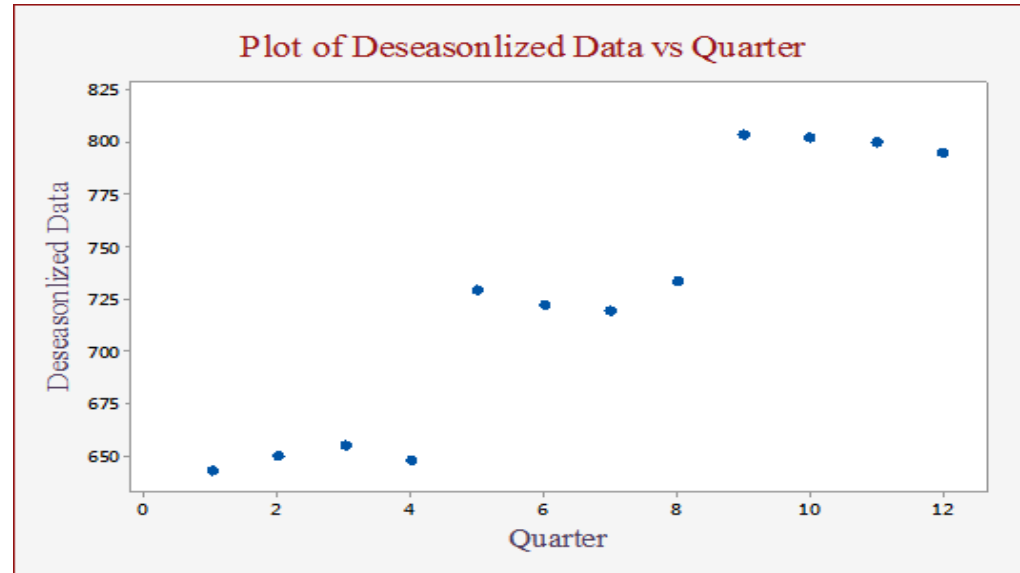


Figure 8.21: plot of deseasonalized data



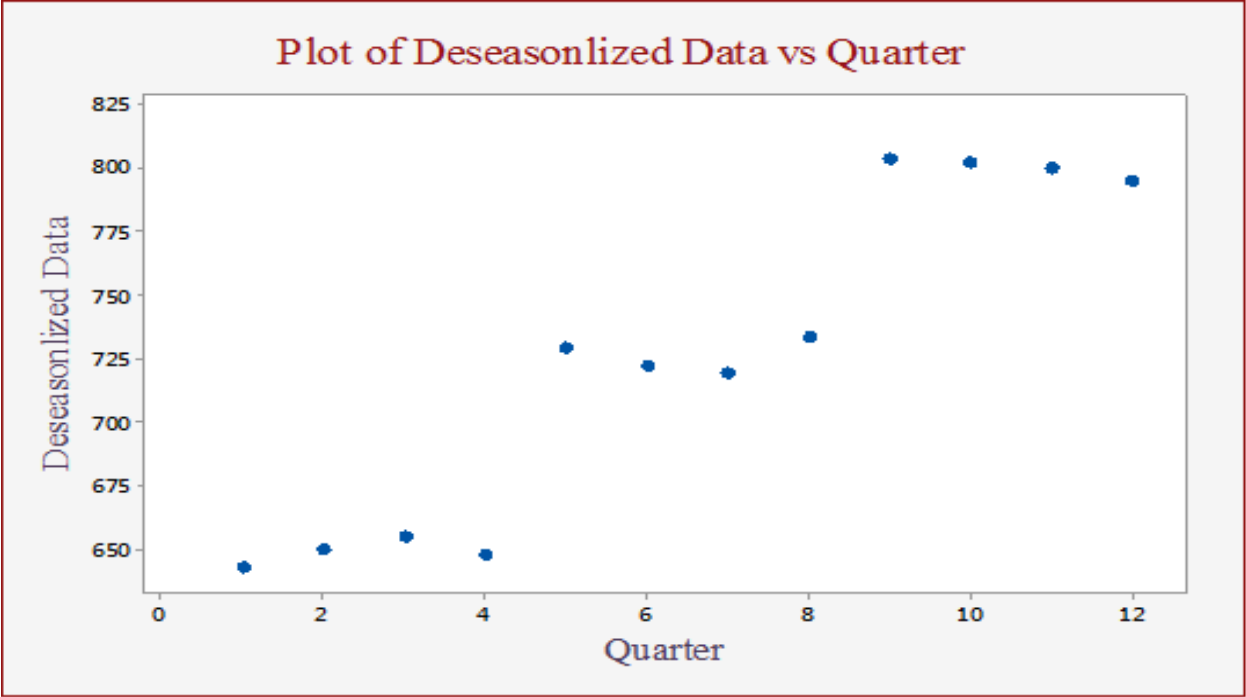
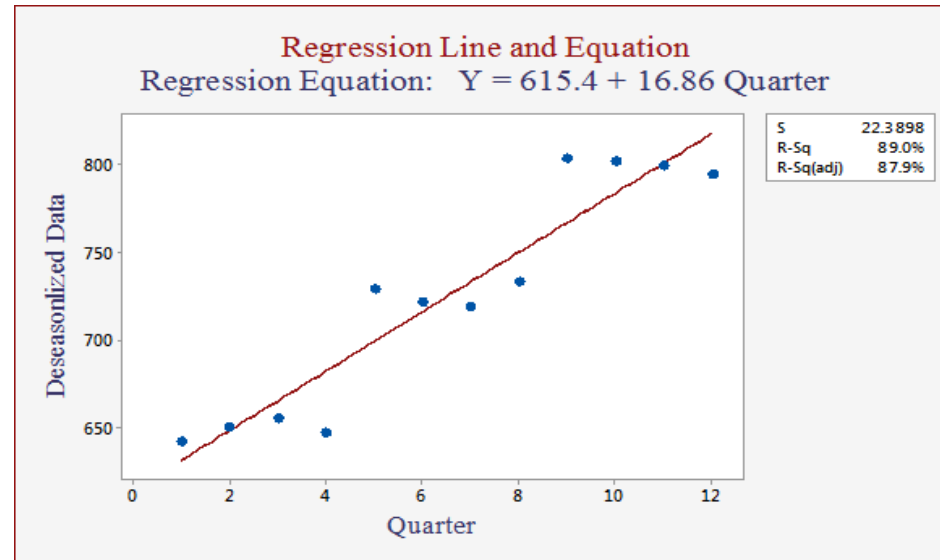


Figure 8.22: Regression on Deseasonalized Data



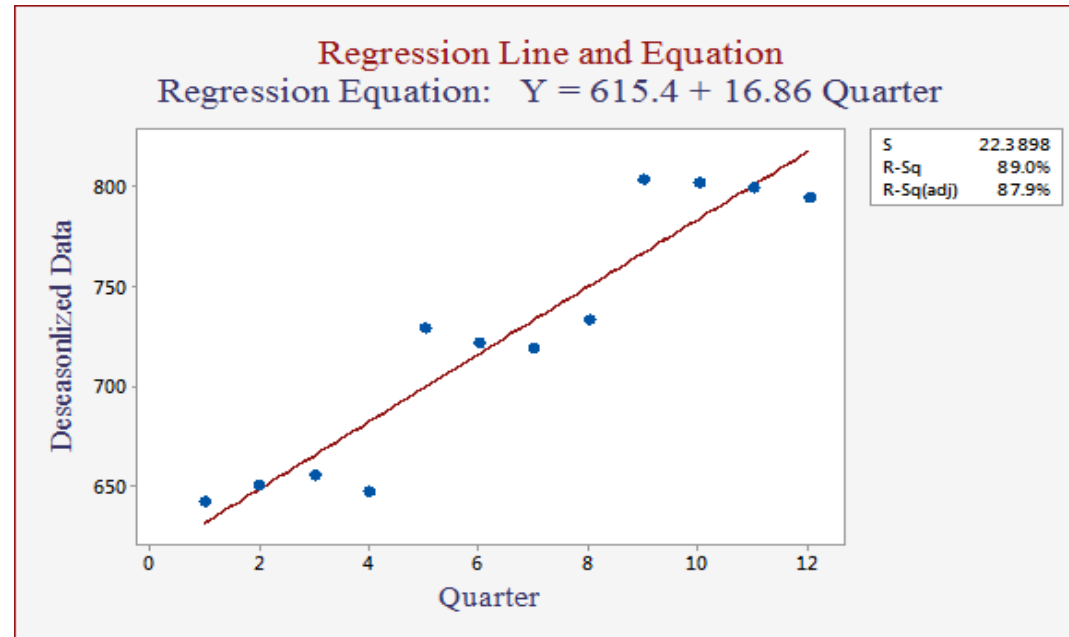
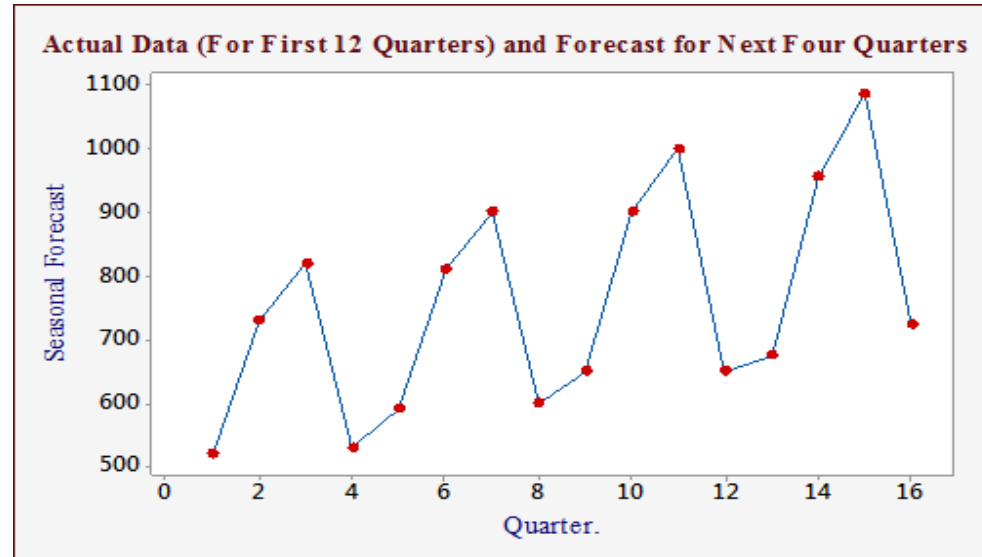


Figure 8.23: Actual Demand Data (first 12 quarters) and the Forecasts for the next Four Quarters (quarters 13 through 16)



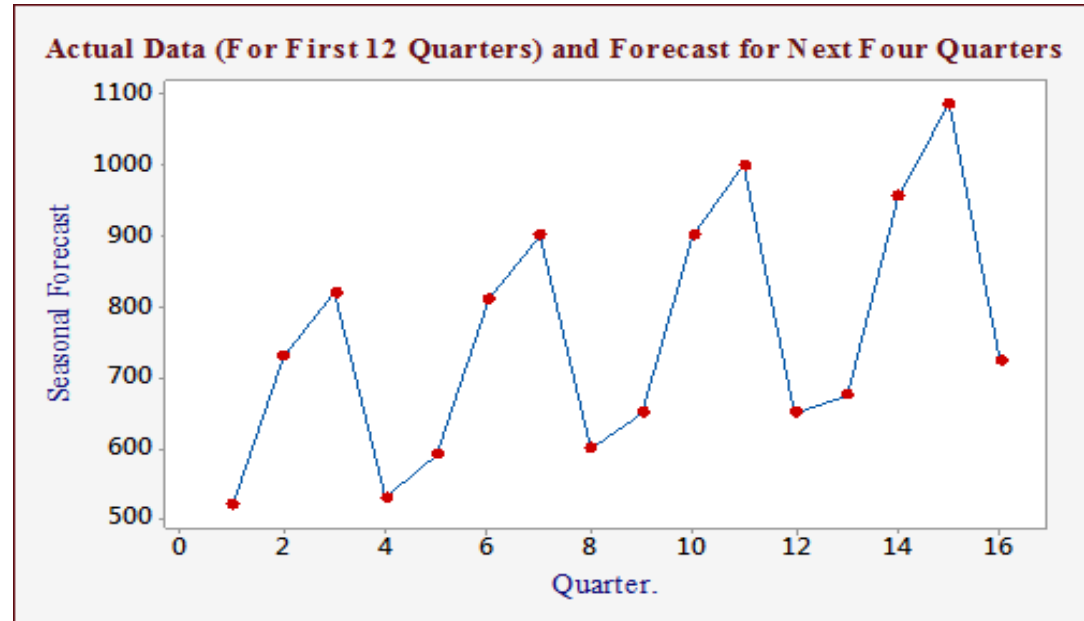
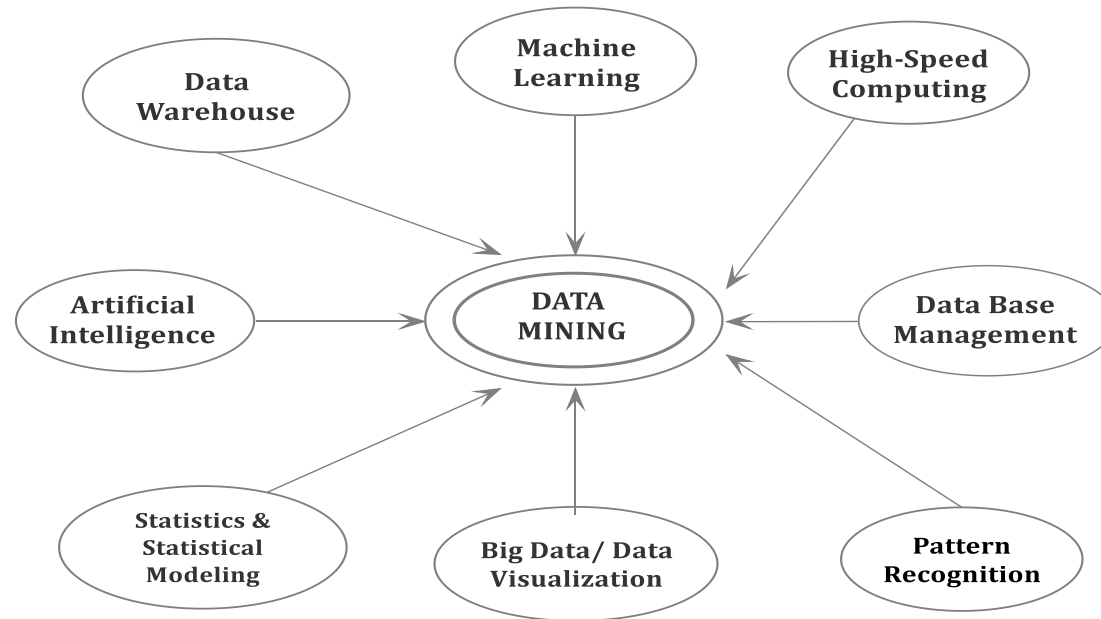


Figure 9.1: Data Mining, its Origin and Areas of Interaction



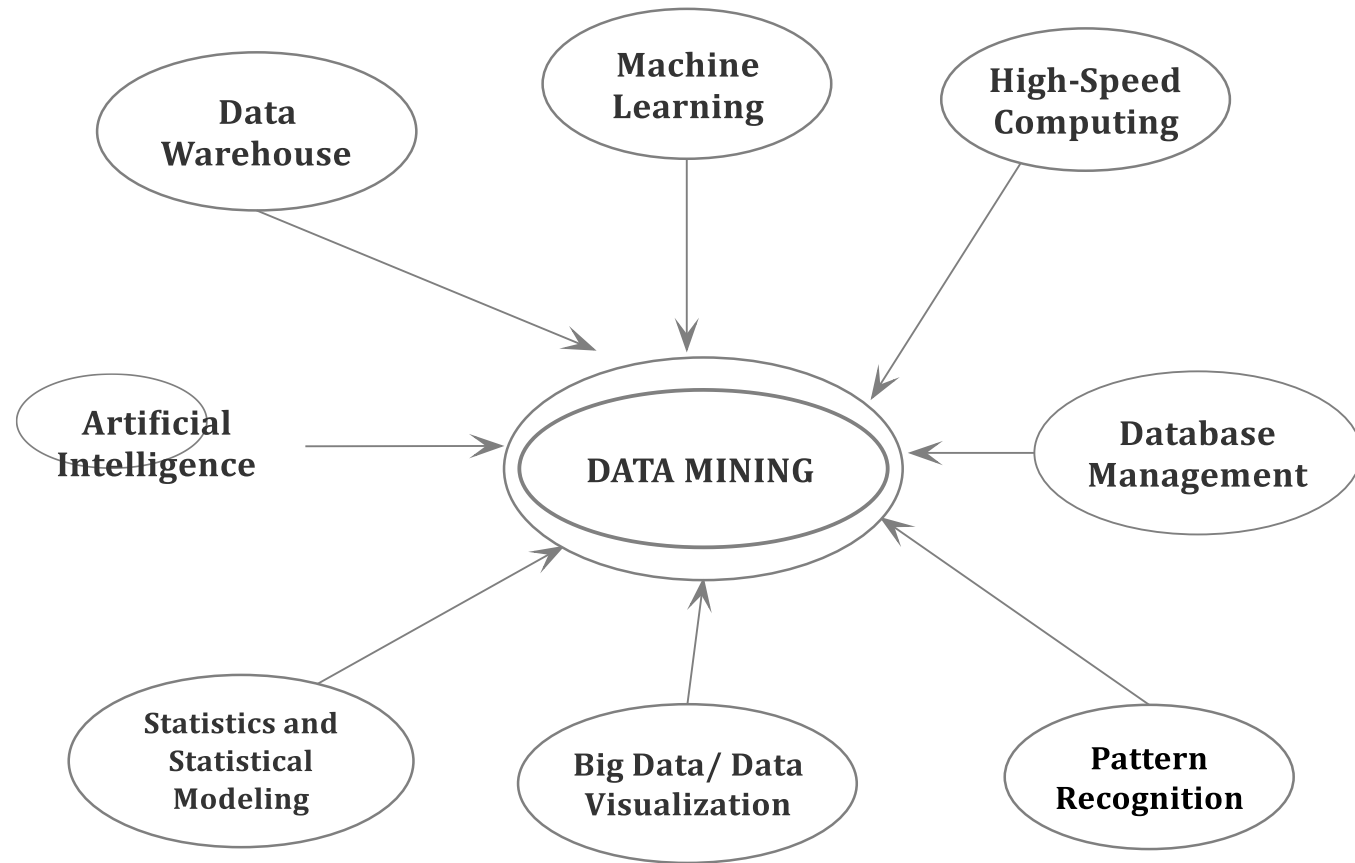
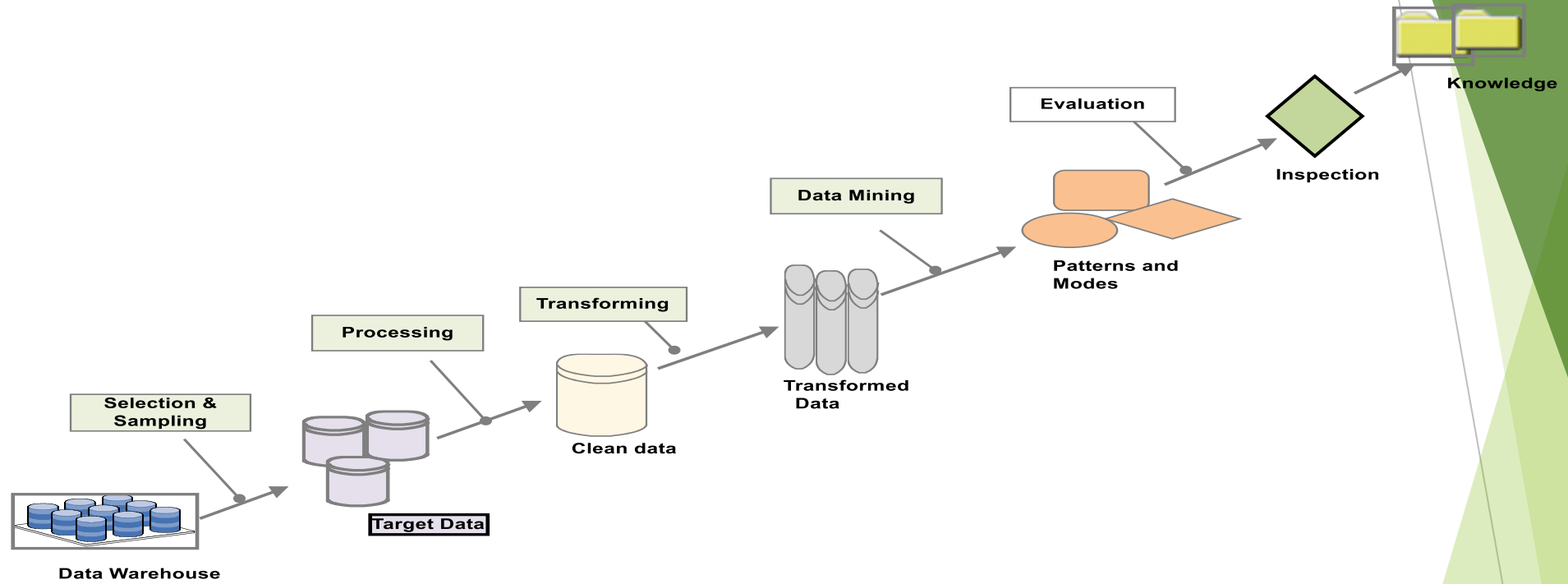


Figure 9.2: The Knowledge Discovery in Data Mining (KDD) Process



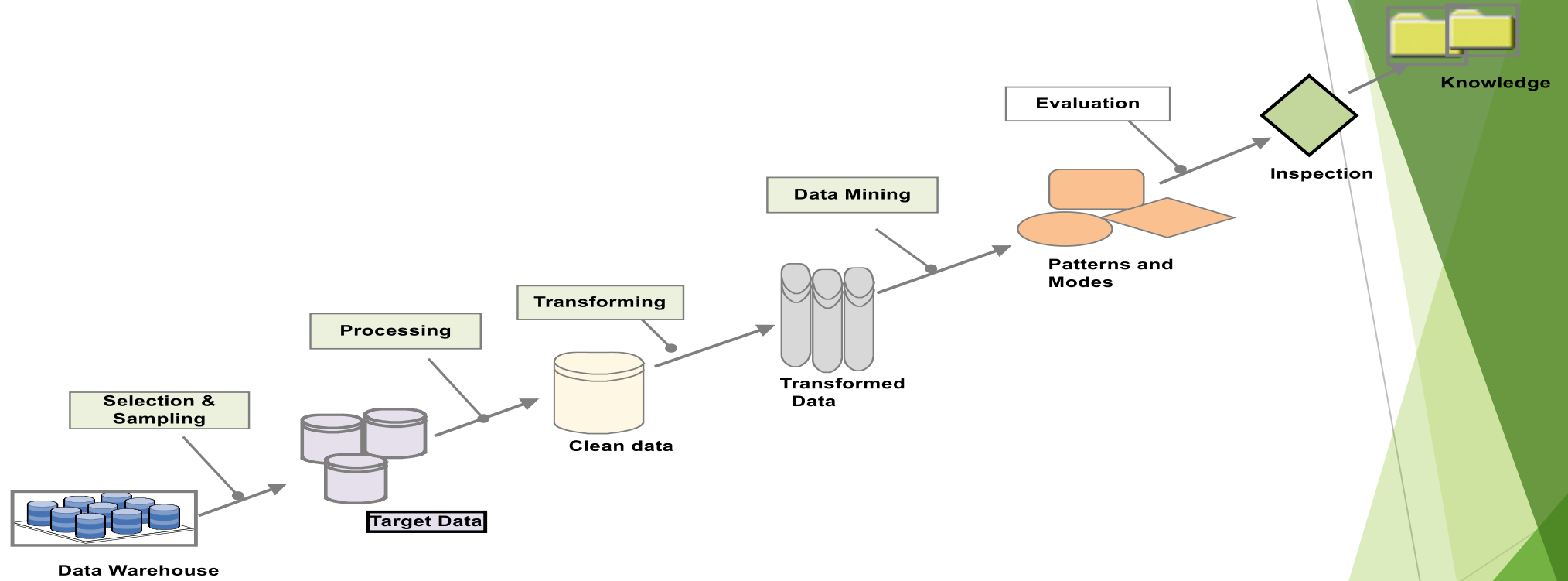
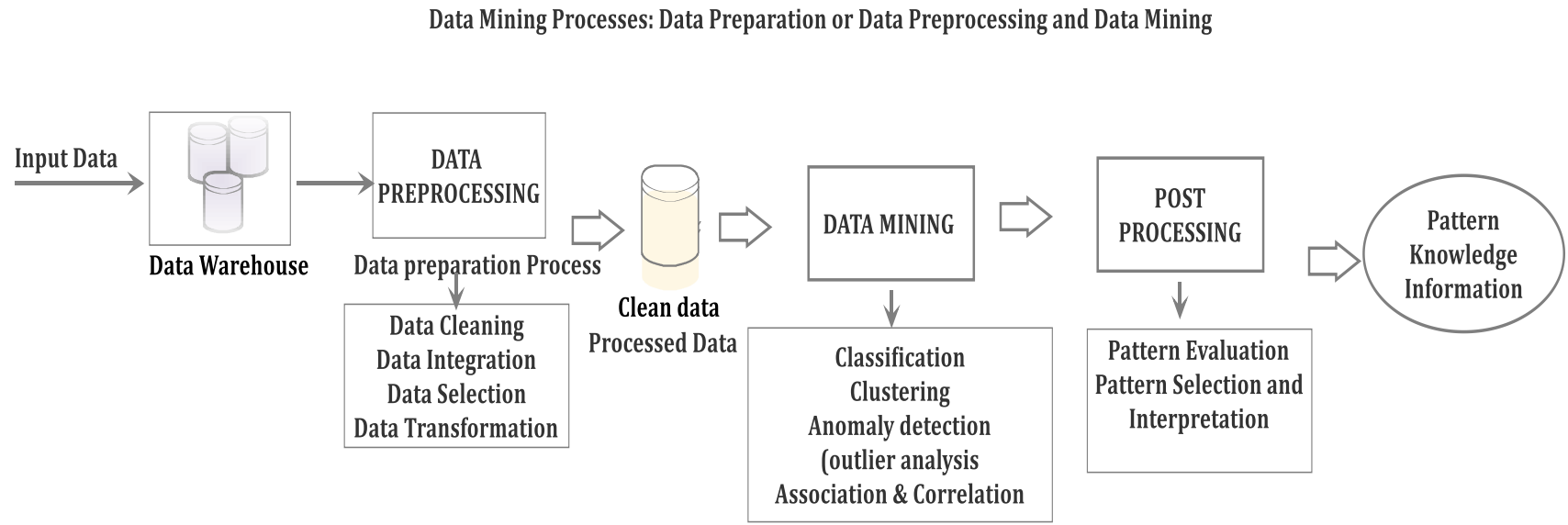


Figure 9.3: Data Mining (KDD) Process: Data Preprocessing and Data Mining Tasks



Data Mining Processes: Data Preparation or Data Preprocessing and Data Mining

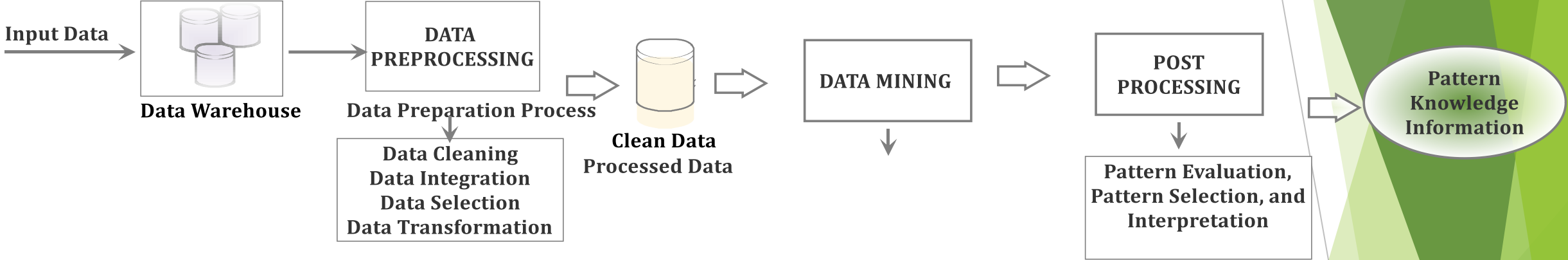
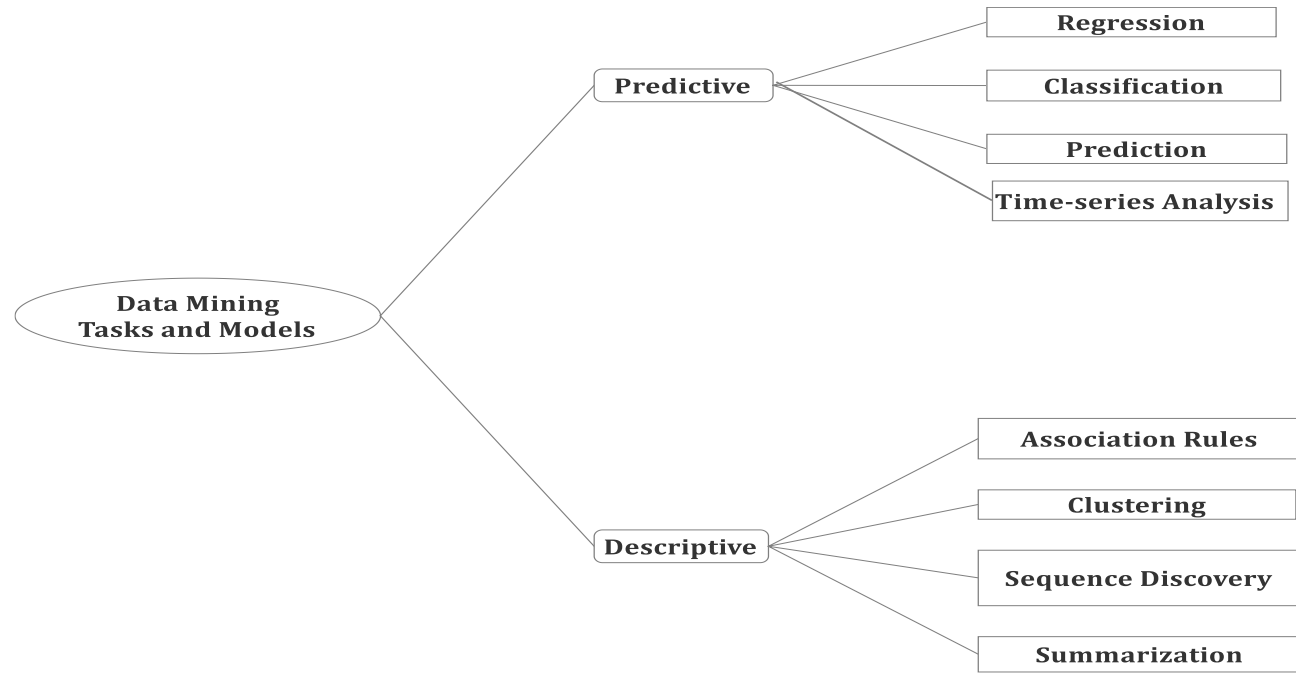


Figure 9.4: Data Mining Tasks



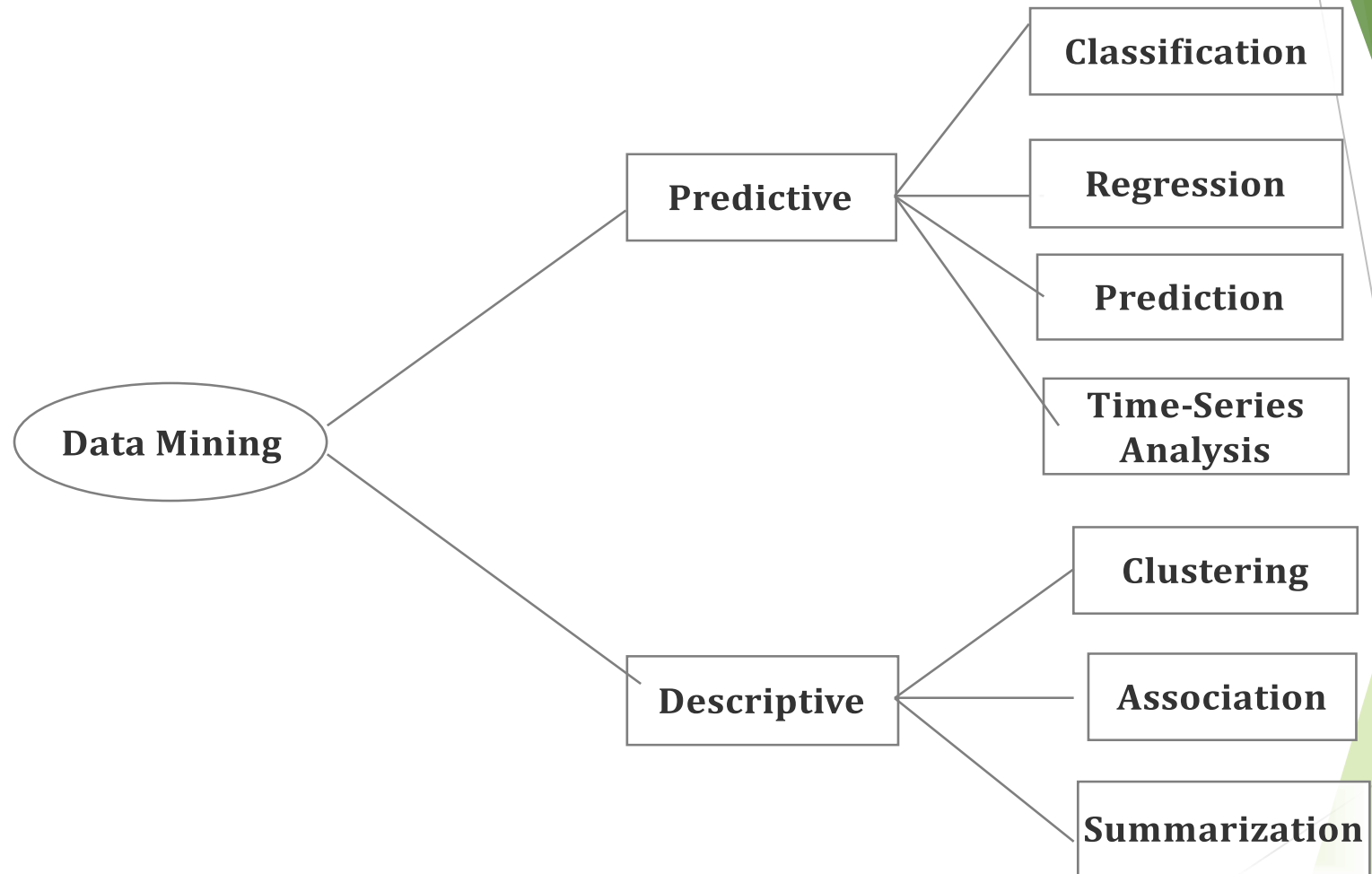
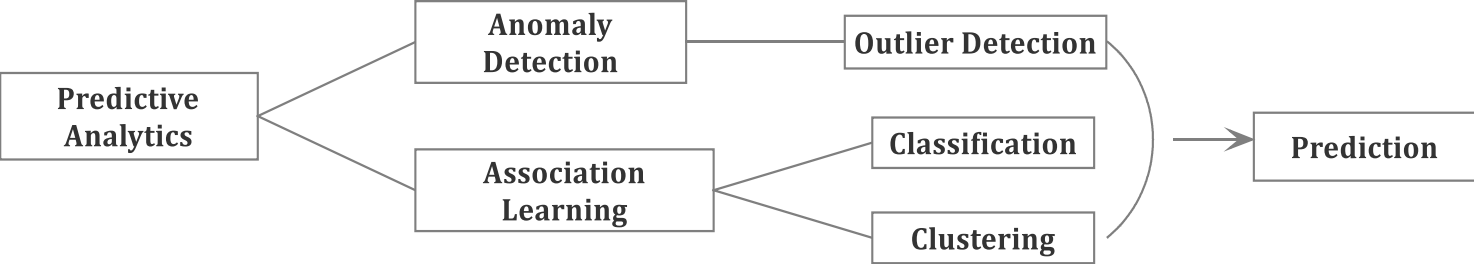


Figure 9.5: Data Mining Methodologies.



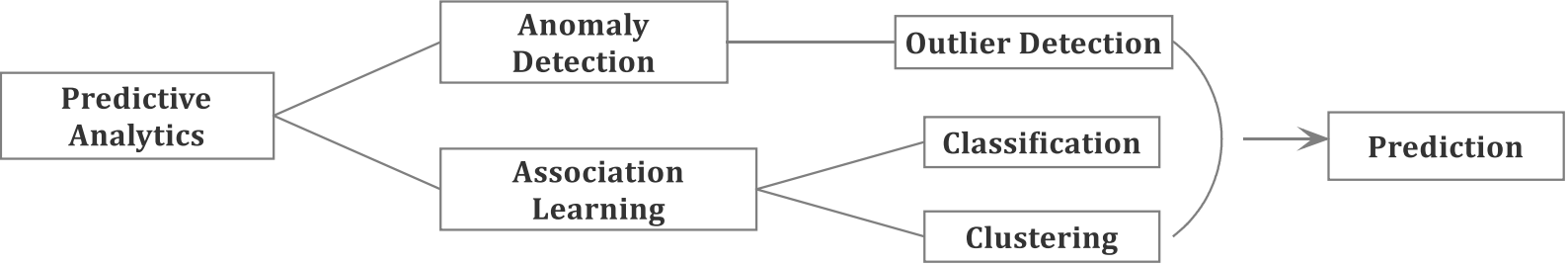


Figure 9.6: Supervised and Unsupervised Learning Techniques

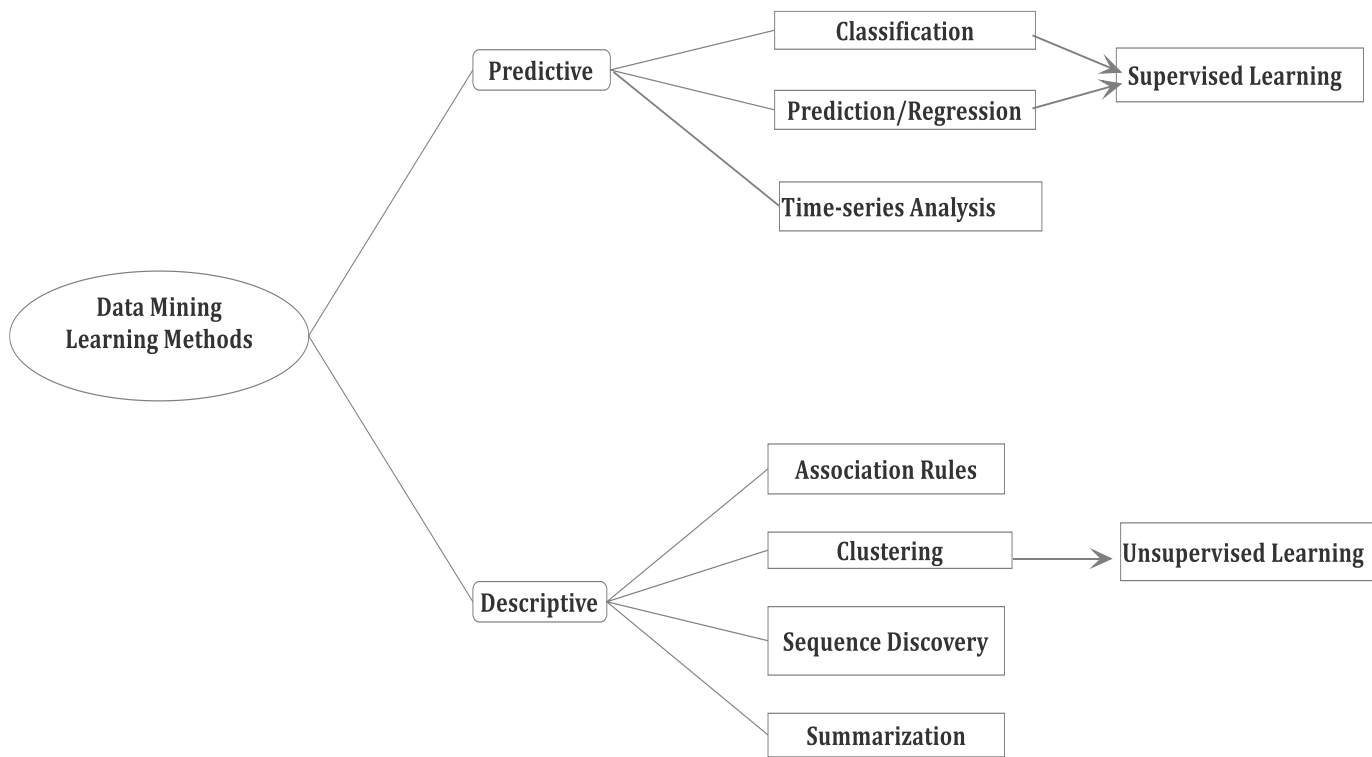
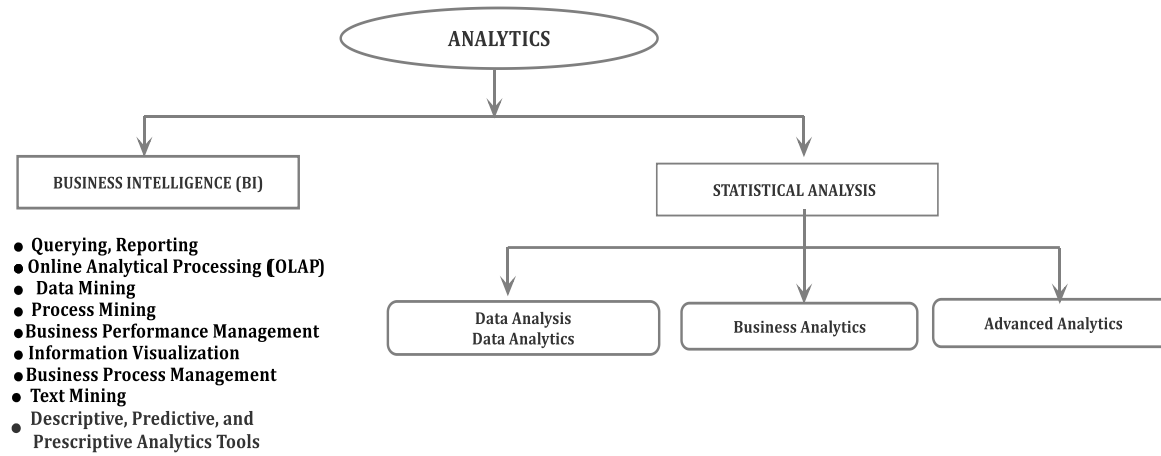


Figure 10.1: Broad area of Analytics



ANALYTICS

BUSINESS INTELLIGENCE (BI)

STATISTICAL ANALYSIS

- **Querying, Reporting**
- **Online Analytical Processing (OLAP)**
- **Data Mining**
- **Process Mining**
- **Business Performance Management**
- **Information Visualization**
- **Business Process Management**
- **Text Mining**
- **Descriptive, Predictive, and Prescriptive Analytics Tools**

**Data Analysis
Data Analytics**

Business Analytics

Advanced Analytics

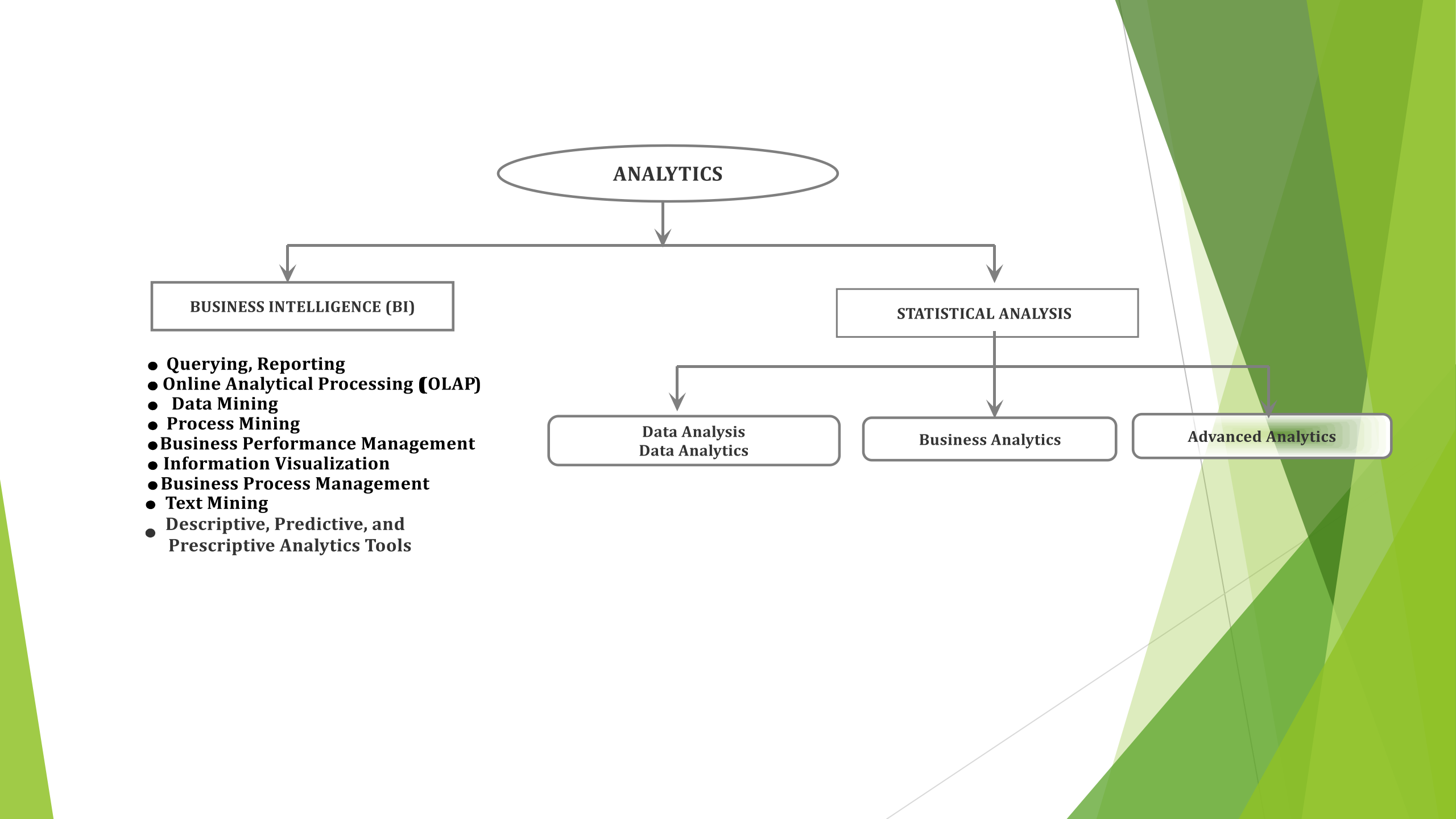
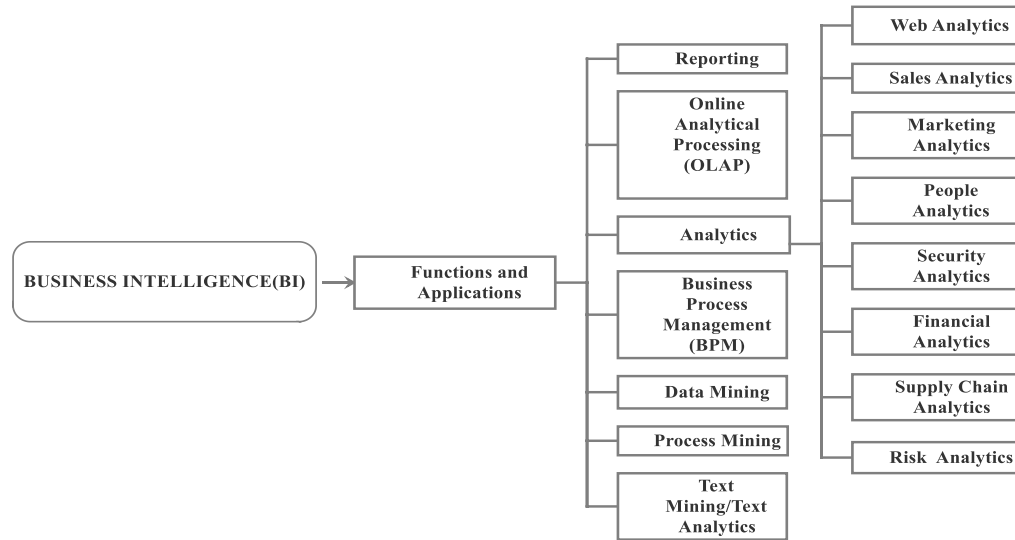


Figure 10.2 Functions of Business Intelligence (BI) and Analytics in Different Areas



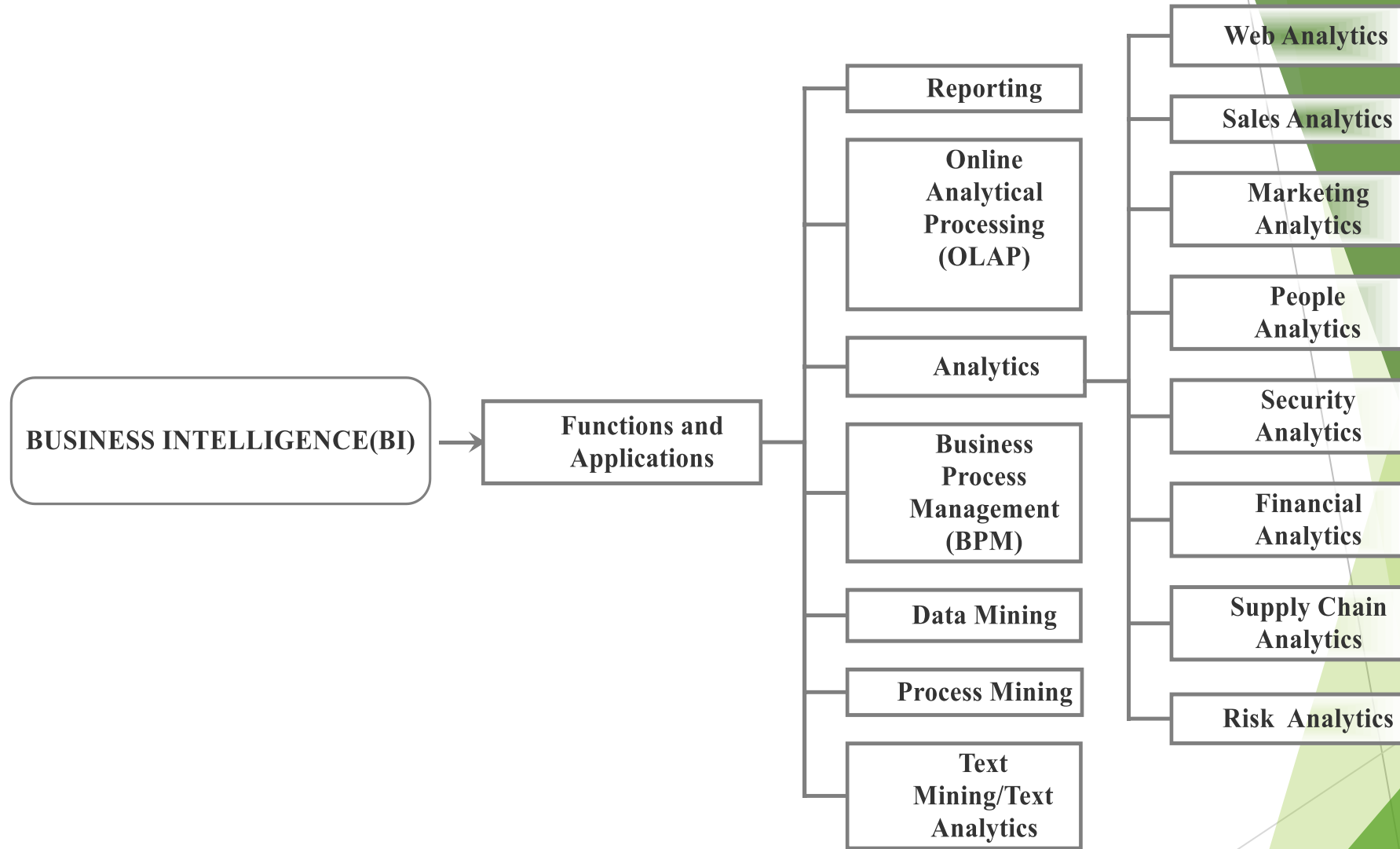
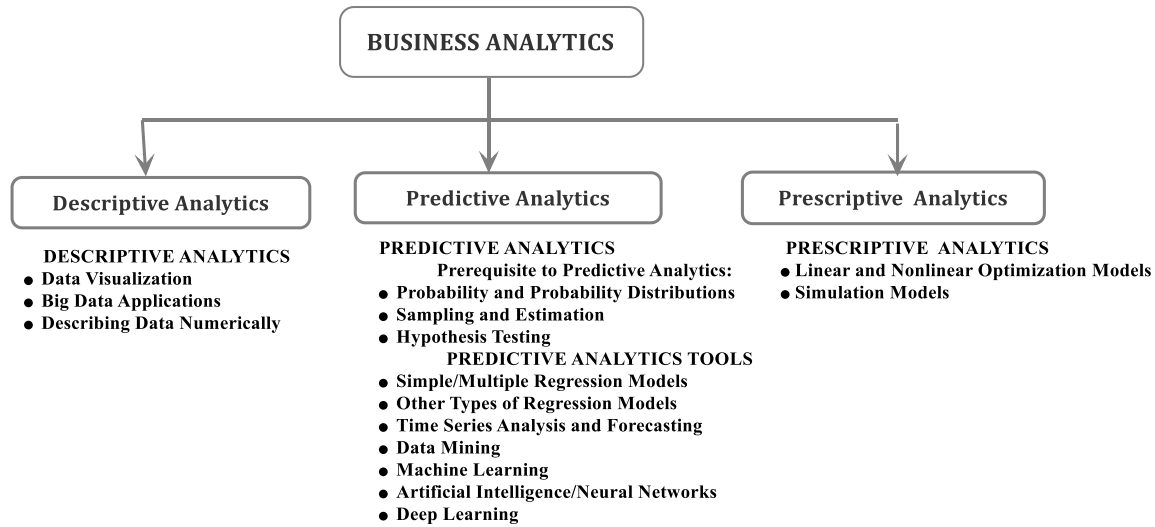


Figure 10.3: Descriptive, Predictive, and Prescriptive Analytics Models



BUSINESS ANALYTICS

```
graph TD; BA[BUSINESS ANALYTICS] --> DA[Descriptive Analytics]; BA --> PA[Predictive Analytics]; BA --> PrA[Prescriptive Analytics];
```

Descriptive Analytics

DESCRIPTIVE ANALYTICS

- Data Visualization
- Big Data Applications
- Describing Data Numerically

Predictive Analytics

PREDICTIVE ANALYTICS

Prerequisite to Predictive Analytics:

- Probability and Probability Distributions
- Sampling and Estimation
- Hypothesis Testing

PREDICTIVE ANALYTICS TOOLS

- Simple/Multiple Regression Models
- Other Types of Regression Models
- Time Series Analysis and Forecasting
- Data Mining
- Machine Learning
- Artificial Intelligence/Neural Networks
- Deep Learning

Prescriptive Analytics

PRESCRIPTIVE ANALYTICS

- Linear and Nonlinear Optimization Models
- Simulation Models

BUSINESS ANALYTICS

```
graph TD; BA[BUSINESS ANALYTICS] --> DA[Descriptive Analytics]; BA --> PA[Predictive Analytics]; BA --> PrA[Prescriptive Analytics];
```

Descriptive Analytics

DESCRIPTIVE ANALYTICS

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Predictive Analytics

PREDICTIVE ANALYTICS

Prerequisite to Predictive Analytics:

- Probability and Probability Distributions
- Sampling and Estimation
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PREDICTIVE ANALYTICS TOOLS

- Simple/Multiple Regression Models
- Other Types of Regression Models
- Time Series Analysis and Forecasting
- Data Mining
- Machine Learning
- Artificial Intelligence/Neural Networks
- Deep Learning

Prescriptive Analytics

Figure 10.4 (a): Predictive Analytics Models

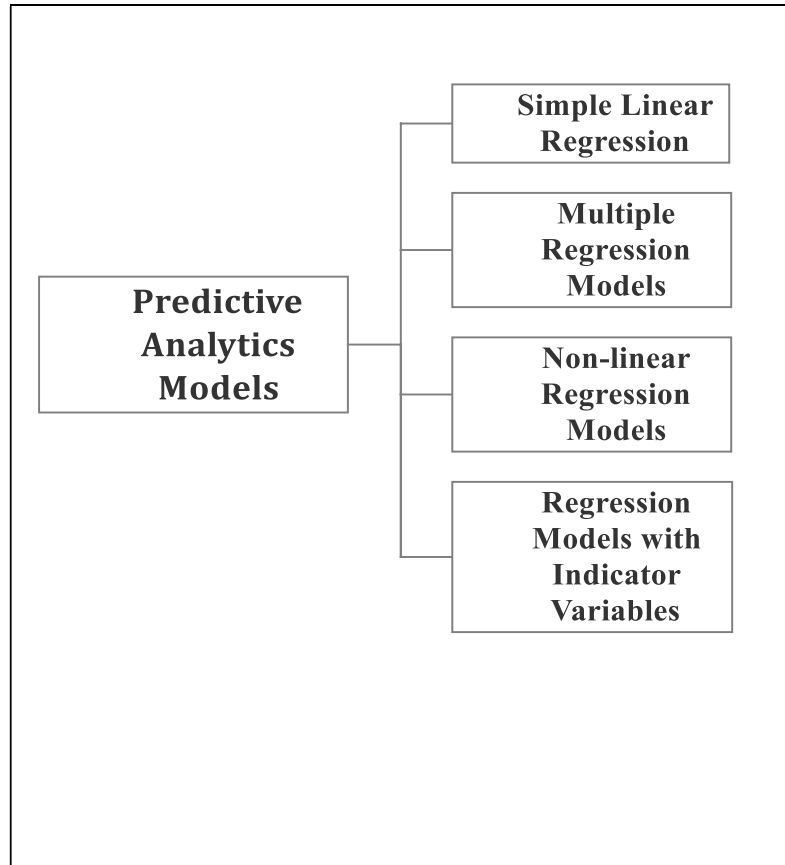


Figure 10.4 (a): Predictive Analytics Models

Figure 10.4 (b): Predictive Analytics Models...Cont..

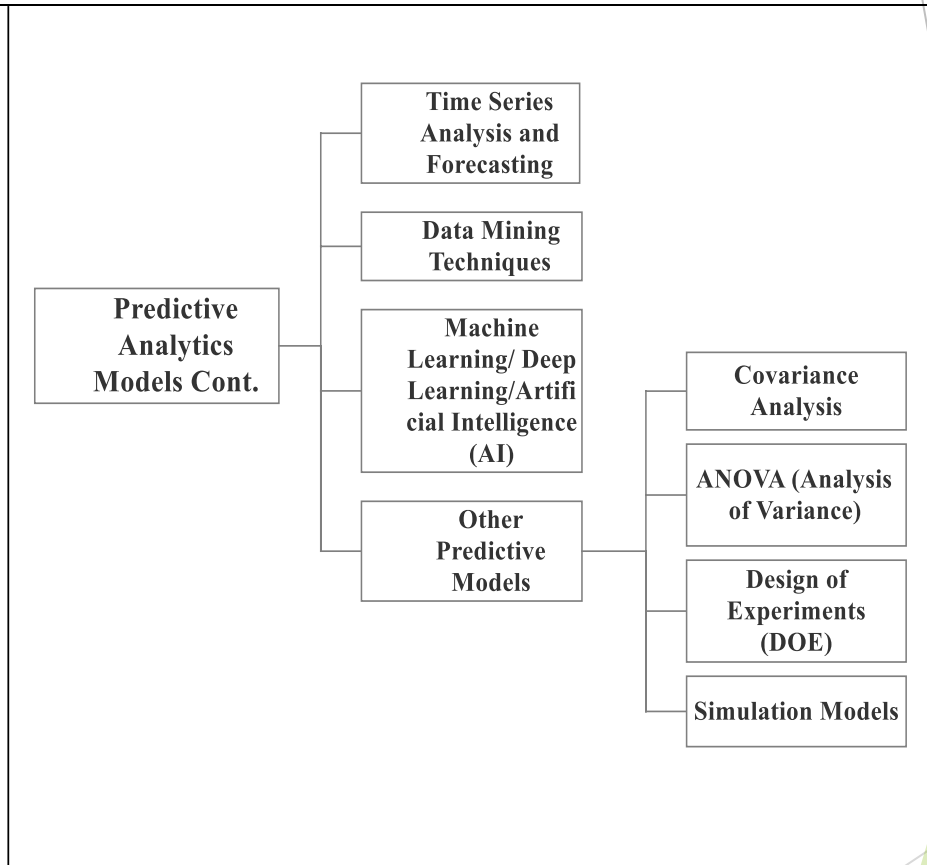


Figure 10.4 (b): Predictive Analytics Models...Cont..

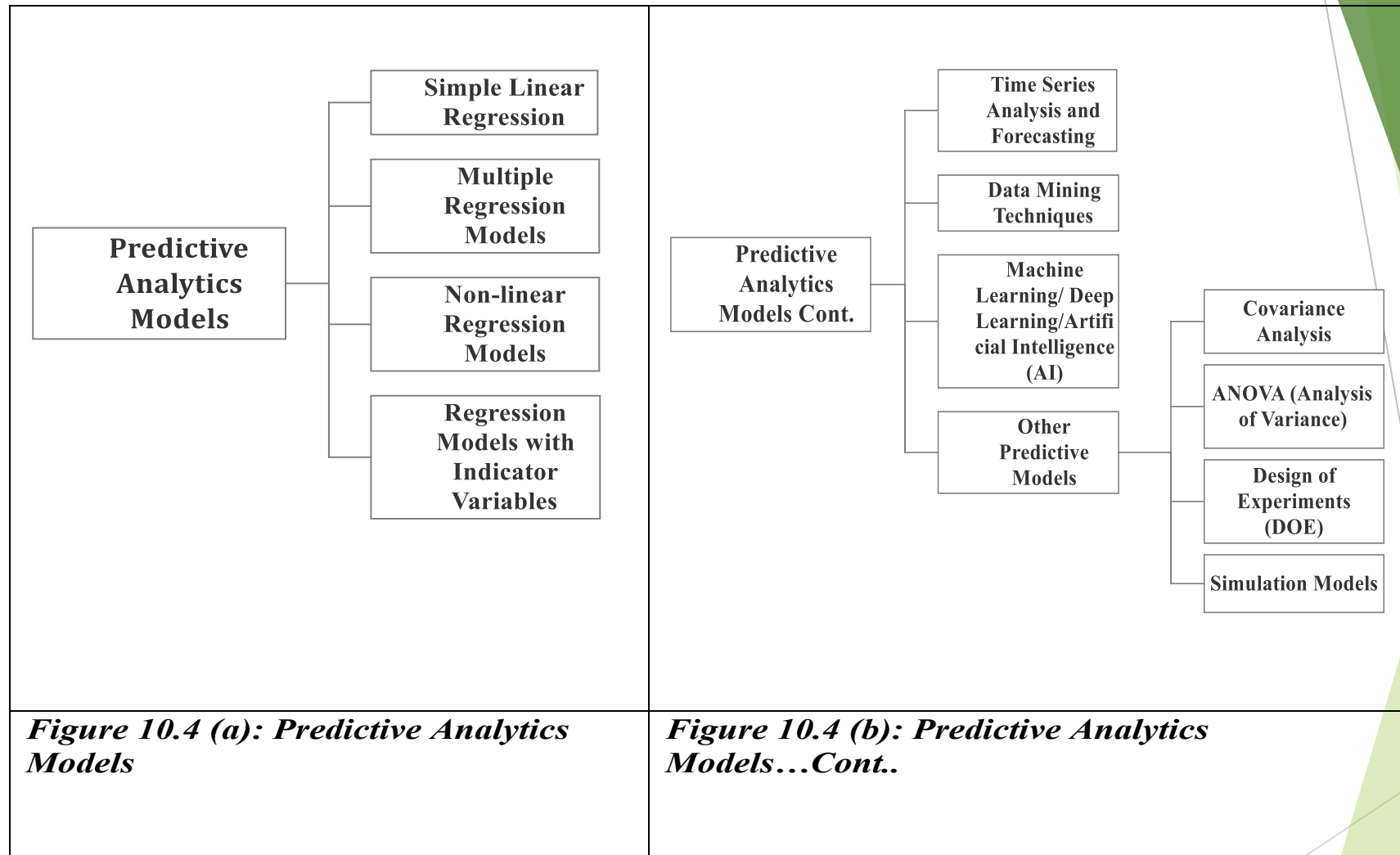
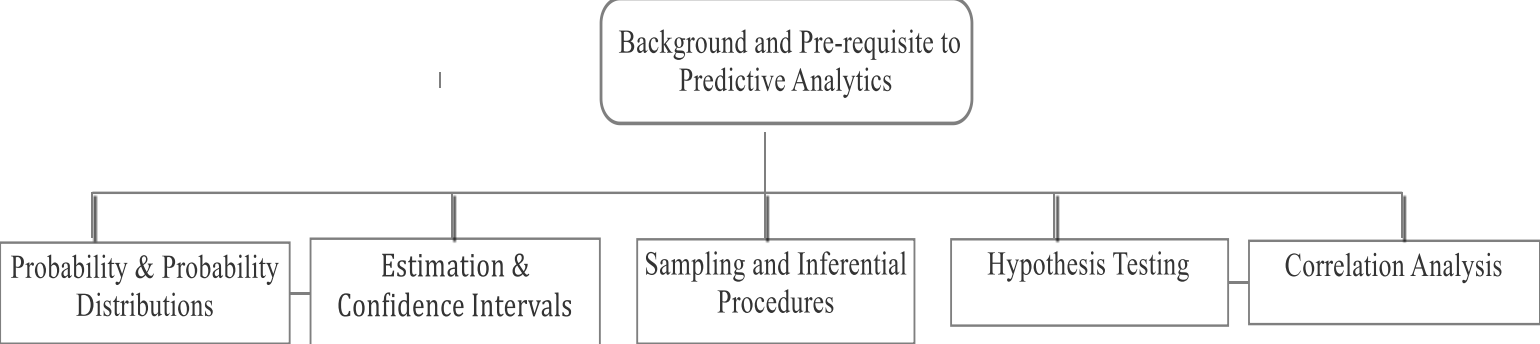


Figure 10.5: Background and Pre-requisites to Predictive Analytics



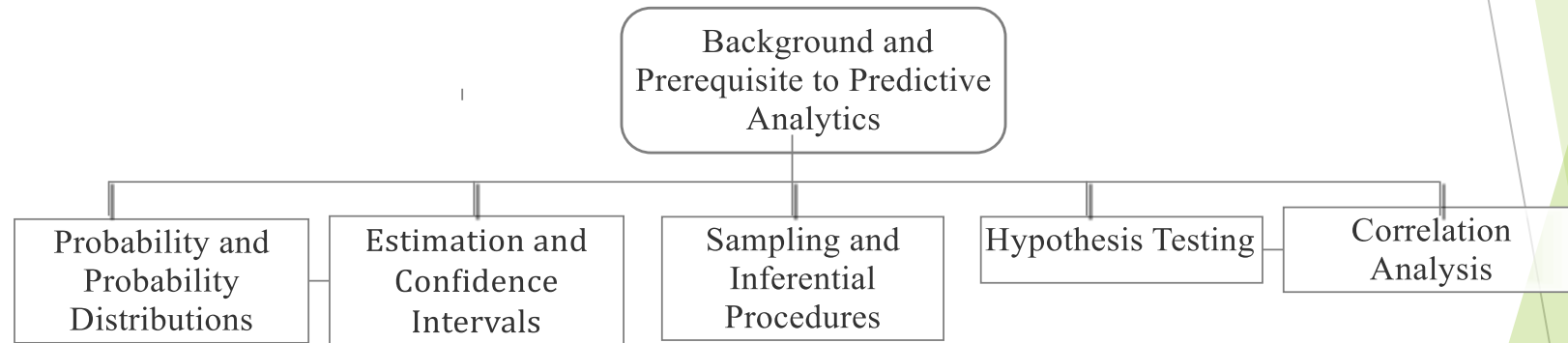


Figure 10.6: Prescriptive Analytics Models

