Introduction to Decision Analysis
Chapter 1

- Business executives and government policy makers struggle with difficult problems all the time.
- Why decisions are difficult?
- *First,* a decision can be difficult simply because its ***complexity.***
- *Second,* a decision can be difficulty because of the ***inherent uncertainty*** in the situation.
- *Third,* a decision maker may be interested in ***working toward multiple objectives.***
- *Fourth,* a problem may be difficulty if ***different perspective lead to different conclusions.***

Why study decision analysis?
Chapter 1, Continues…

- ***Why study decision analysis?***
- The obvious reason for studying decision analysis is that carefully ***applying quantitative and structured approaches can lead to a better decisions.***
- But, ***what is a good decision?***
- A simple answer is that gives ***the best outcome.***
- This answer, however, confuses the idea of a lucky outcome with a good decision.
- You can make a good decision but ***still have a unlucky outcome.***
- Decision analysis ***provides structure and guidance for systematic thinking in difficult situation***, it does not claim to recommend an alternative that must be ***blindly accepted.***

Subjective Judgments and Decision Making Chapter 1, Continues…

- Personal Judgments about uncertainty and values are important inputs for decision analysis.
- Managers and policy makers frequently complaint that analytical procedures from management science ignore subjective judgments.
- In fact, ***decision analysis requires personal judgments;*** they are important ingredients for making good decisions.
- ***Human beings are imperfect information processors.*** Personal insight about uncertainty can be limited and misleading.
- The sprit of the discussion is that understanding the problem people face and ***carefully applying decision-analysis techniques can lead to a better judgments*** and improved decisions.

The Decision-Analysis Process Chapter 1, Continues…

- The first step for the decision analysis process for the decision maker to identify the decision situation and to understand the objective in that situation.
- Then identity alternatives and decompose and model the problem:
  - *Model of problem*
  - *Model of Uncertainty*
  - *Model of Preference*
- Choose the best alternative
- Do the sensitivity analysis
- If further analysis needed then go to identity the ***decision node.***
- If not then ***implement the chosen alternative.***

Where is Decision Analysis Used? Chapter 1, Continues…

- Decision analysis is widely used in business and government decision making.
- Managing Research and development programs, negotiating oil and gas leases, ***forecasting sales for new products***, developing a ways to ***respond to environmental risks*** the name the few.
- Decision Analysis can ***create a competitive advantage for a firm.***
- Another important area of application for ***decision analysis has been medicine***. Decision analysis has helped doctors make specific diagnoses and individuals to understand the risks of different treatments.
- This discussion is by no means exhaustive; the intent is to give you a feel for the breath of possible applications of decision analysis.

Where Are we Going from Here? Chapter 1, Continues…

- The course is divided into three main sections. The first section is ***"Modeling Decisions"*** and it introduces influence diagrams and decision trees
- The second section is ***"Modeling Uncertainty".*** We delve into the use of probability for modeling uncertainty in decision problems. We review basic probability concepts
- The last section is ***"Modeling Preferences".*** The development of a mathematical representations of a decision maker's preferences.
- During the course of this course you will learn basic techniques and concepts that are central to the practice of modern decision analysis.
- This understanding and application of methods allow you to make better decisions ***in difficult and complex business situations.***
- That is what the objective is this course is all about – making difficult decisions in an uncertain, dynamic global business environment.

Elements of Decision Problems
Chapter 2

Given a complex and complicated decision problems, how and where we begin?

- ***First,*** identity the elements of the situation.
- ***Second,*** Classify various elements into order below:

  - Values and objectives
  - Decisions to make
  - Uncertain events
  - Consequences

Values and Objectives
Chapter 2, Continuous…

- Lets define the meaning of values and objectives in the context of decision analysis:

- ***Values:*** In general terms it refers to things that matter to you. An example would be, a manager wants to earn extra profit or you may want to learn to speak fluent English.
- ***Objectives:*** an objective is a specific thing that you want to achieve. An individual's objective taken together make up his/her values. They define what is important to that person in making decisions.

- Without objectives, it would not be possible to tell which alternative would be the best choice.

Making Money, A special Objective Chapter 2, Continuous…

- Money is important because it allows us to eat, afford housing clothing, travel, engage in activities, and give comfortable.
- Many people spend money on insurance because they have an objective of avoiding risk.
- Money’s role as a trading mechanism in our economy puts in a special role. For corporations, money is often a ***primary objective***.
- Money making is an ultimate objective but it is important to realize that many situations require ***trade-off between making money and some other objective.***
- In many cases, you can price out the value of different objectives, an example; when buying a car how much would you pay for A/C

Decisions to Make Chapter 2, Continuous…

- First step in decision making process, the decision maker can begin identify to specific elements of a decision. Which the decision must be made with the available information.
- Many situations have central issue a decisions that must be made right away. There would be two alternative – ***Go and No Go.***
- No model of the decision situation can be build ***without knowing exactly what the decision problem at hand is.***
- Some decisions will have a specific alternatives while others may involve choosing a specific value out of a ***range of possible values***.
- It is also important to think possible alternatives.

Uncertain Events
Chapter 2, Continuous…

- Many decisions have to be made without knowing what will happen in the future or what the ultimate outcome will be.
- The possible things that can happen in the resolution of an event are called ***outcomes.***
- Many different uncertain events might be considered in a decision situation, but only some are relevant.
- The relevancy is: The outcome of the event must have some impact on at least one of your objectives.
- A decision situation usually involves more than one uncertain event.
- The large number of uncertain events, the more complicated the decision. Also some uncertain events depends on others.

Consequences Chapter 2, Continuous…

- After the last decision has been made, the decision maker's fate is ***finally determined.*** It may be a matter of profit/loss or some other non monetary gain/loss.
- One of the fundamental issues with which a decision maker must look into is the time horizon, ***how far into the future to look.***
- Once the planning horizon has been determined, the next step is to figure out ***how to value the consequences***. In many cases it will be done in ***monetary terms.***
- Many decisions , especially government policy decisions***, are complicated by trade offs.***
- Personal decisions require a decision maker to think difficult about the trade offs involved.

Time Value of Money
Chapter 2, Continuous…

- Many business and/or personal ***decisions involves money, a cash flow.***
- There is a special kind of trade-off; spending dollars today to obtain dollars tomorrow.
- If a dollar today were worth the same as a dollar next year, there would be no problem.
- The trade-offs between current and future dollars depends on when it is available to decision maker.
- This is referred as a ***Time Value of Money.***
- Investing \$1,000.00 with 10% interest, \$1,000.00 X 1.1 = \$1,100.00 at the end of the year.

Overview of Descriptive and Inferential Statistics Chapter 2, Continuous…

- Statistics itself, is divided into two branches, both of which are applicable to managing business operations.
- ***Descriptive statistics:***
  - Focuses on collecting, summarizing and presenting a set of DATA.
  - Descriptive statistics has roots in the record keeping needs of large political and social organizations.
- ***Inferential statistics:***
  - Uses sample data to draw conclusions about a population.
  - The foundation of Inferential Statistics is based on mathematics of probability theory. Inferential methods used sample DATA to calculate statistics that provide estimates of the characteristics of the entire population.

Ethics in Decision Making Chapter 2, Continuous…

- ***Ethical behavior is commanding increased attention from Management at all levels.*** It requires structured, quantitative approaches in making better decisions. Furthermore, even managers with the best intentions will sometime make mistakes. Therefore openness and transparency is important.
- ***If mistakes do occur, managers should act responsibility*** to correct those mistakes as quickly as possible, and to advert any negative consequences and impacts on the stakeholders.
- One of the themes dominant throughout this course, as well as in the business world today, is one of the ethics. ***You should not act unethically and this tenet should serve you during your career.***
- Most importantly managers have the ***responsibility to make ethical decisions.***
- ***<u>Remember, integrity should be your most important asset!</u>***

Structuring Decisions
Chapter 3

- Creating a decision model requires three fundamental steps:
  - ***First,*** Identifying and structuring the values and objectives
  - ***Second,*** structuring the elements of the decision situation into a logical framework. To do this we have two tools:
    - Influence Diagrams
    - Decision Trees

    These two approaches have different advantages, both valuable and they complement each other.
  - ***Third,*** Refinement and precise definition of all the elements of the decision model. What the uncertain events are, how to measure the consequences in terms of objectives that have been specified.

Structuring Values
Chapter 3, Continuous…

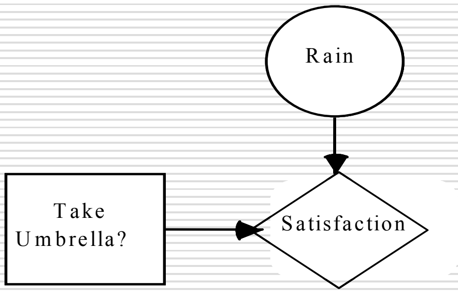
- In many cases, a ***single objective drives the decision***; a manager might want to maximize profit next quarter or an investor might want to ***maximize the financial return*** on an investment portfolio.
- Often, the multiple objectives will conflict each other, manager might want to maximize profits but at the same time minimize the change of loosing money.
- For many decisions the real ***problem lies in balancing multiple conflicting objectives.***
- First step in dealing with such situation is to ***understand just what the objectives are.***
- Specifying objectives is not always a simple matter.

Techniques for Identifying Objectives Chapter 3, Continuous…

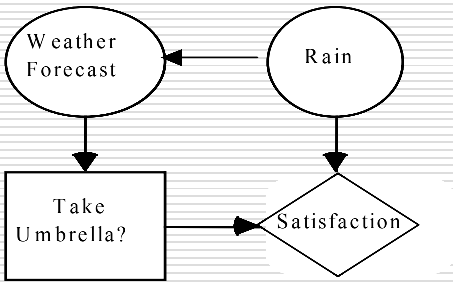
- ***Develop a wish list:*** What do you want? What do you value?
- ***Identify alternatives:*** What is the perfect alternative, a terrible alternative?
- ***Consider problems and shortcomings:*** What is right or wrong with your organization?
- ***Predict consequences:*** What has occurred that was good or bad?
- ***Identify goals, constraints, and guidelines:*** What are your aspiration? What limitations are placed on you?
- ***Consider different perspectives:*** What would your competitor be concerned about?
- ***Determine strategic objectives:*** What are the ultimate objectives?
- ***Determine generic objectives:*** What objectives do you have for others?

Influence Diagrams
Chapter 3, Continuous…

- Influence diagram can provide simple graphical representation of decision situations.
- Different decision elements show up in the influence diagram as different shapes. These shapes then linked with arrows to show the relationships among the elements.
- Rectangles represents decisions, ovals represents change events, and diamonds represents the final consequences.



(B) Basic Risky Decision



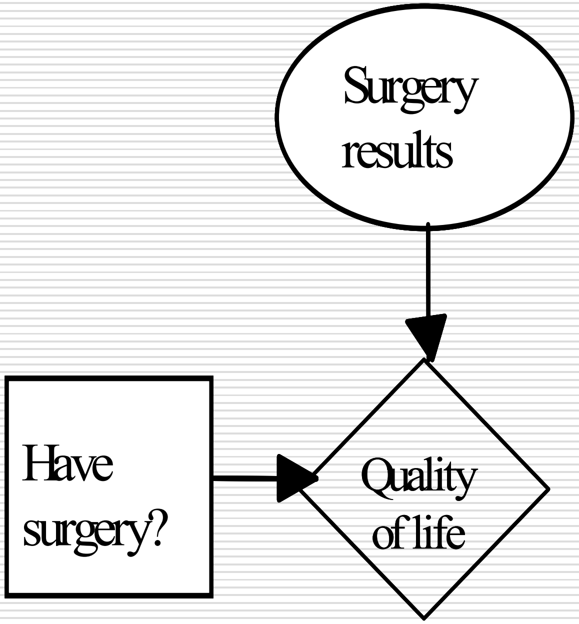
(C) Imperfect Information

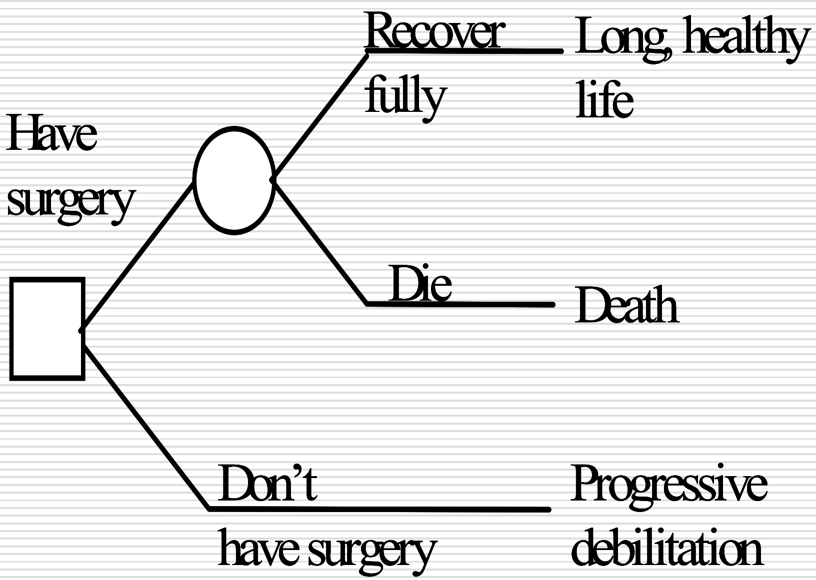
Decision Trees
Chapter 3, Continuous…

- Influence diagrams are excellence for displaying a decision's basic structure but they hide many of the details.
- To display more of the details, we use a ***Decision Tree***
- ***<u>The interpretations of decision tree requires explanations.</u>***
- ***First,*** the options are represented by branches from the decision mode.
- ***Second,*** each change mode must have branches that correspond to a set of mutually exclusive and collectively exhaustive outcomes.
  - *Mutually exclusive means*: that only one of the outcome can happen.
  - *Collectively exhaustive means*: no other possibilities exists.
- ***Third,*** it begins on the left side of the tree, followed by change events.

Decision Trees
Chapter 3, Continuous…

These are the influence diagrams and decision trees.





Decision Trees and Influence Diagrams Compared Chapter 3, Continuous…

- Should you use ***decision tree*** or ***influence diagrams***?
- Both are worthwhile, and they complement each other well.
- The ultimate decision should not depend on the presentation, because influence diagrams and decision trees are ***isomorphic.***
- Influence diagrams can be converted in to a decision tree and vice versa.
- Influence diagrams and decision trees provide two approaches for modeling a decision. Both have advantages, one may be more appropriate then the other.
- Using both approaches together may prove useful; the goal is to make sure that the model accurately represent the decision situation.

Defining Elements of the Decision Chapter 3, Continuous…

- Much of the difficulty in decision making arises when different people have different ideas regarding some aspects of the decision.
- The solution is to refine the events and variables associated with decisions enough so that it can be made.
- How do we know when we have refined enough?
- The ***Clarity Test*** (Howard 1988) provides a simple and understandable answer it requires absolutely clear definition of events and variables in quantitative terms in specifically defined terms.
- At this point, the problem should clear enough so that people involved in the decision are thinking in exactly the same way.

Making Choices
Chapter 4

- In this Chapter we will learn how to use the details in a structured problem to find a preferred alternatives.

- ***"Using the details" means analysis:*** making calculations, creating graphs, and examining the results so as to gain insight into the decision.

- We also introduce ***risk profiles and dominance considerations***, ways to make decisions without doing all those calculations.

Decision Environment
Chapter 4, continues…

- Decision environment are classified according to the degree of certainty present, there are three basic categories: *Certainty, risk and uncertainty.*

- ***Certainty:*** means that relevant parameters such as cost, capacity, and demand have known values.

- ***Risk:*** means that certain parameters have probabilistic outcomes.

- ***Uncertainty:*** means that it is impossible to assess the likelihood of various possible future events.

Causes of Bad Decisions Chapter 4, Continues…

- Despite the best efforts of a manager, a ***decision occasionally turns out poorly due to unforeseeable circumstances.***
- Luckily, such circumstances are not common.
- Often, failures can be traced to a combination of mistakes in the decision process, to ***bounded rationally*** or to ***suboptimization.***
- ***Manager's ego can be factor,*** this happens when manager has experienced a series of successes – important decision that turned out right.
- ***Some managers then get the impression that they can do no wrong.***
- But they soon run into trouble, ***which usually enough them bring down to earth.***

Decision Making Under Uncertainty Chapter 4, continues…

- All the opposite extreme is complete uncertainty: No information is available on how likely the state of nature are.

  The approaches can be defined as follows:

- ***Maximin:*** Determines the worst possible payoff for each alternative, and choose the alternative that has the “best worst”.

- ***Maximax:*** Determine the best possible payoff.

- ***Laplace:*** Determine the average payoff of each alternative, and choose the alternative with the best average.

- ***Minimax regret:*** Determine the worst regret for each alternative, and choose the alternative with the “best worst”.

Decision Trees
Chapter 4, Continues…

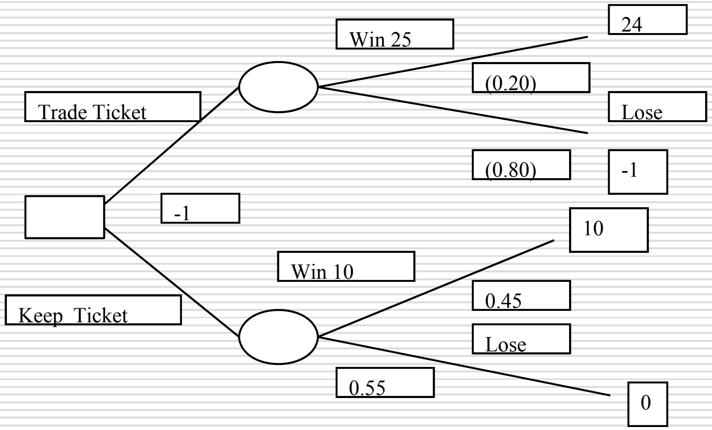
- Composed of
  - ***Nodes***
    - Decisions – *represented by square nodes*
    - Chance events – *represented by circular nodes*
  - ***Branches***
    - Alternatives– *branches leaving a square node*
    - Chance events– *branches leaving a circular node*
- Analyze from right to left
  - For each decision, **choose the alternative *that will yield the greatest return***
  - If chance events follow a decision, ***choose the alternative that has the highest expected monetary value.***

Decision Trees and Expected Monetary Value Chapter 4, Continues…

- Between two extremes of certainty and uncertainty lies the case of risk. The probability of occurrence for each state of nature is known, because the sates are mutually exclusive and collectively exhaustive, these probabilities must add to 1.00.
- One way to choose risky alternatives is to pick the alternative with the ***highest expected value (EV).***
- When the decision's consequences involve only money, we can calculate the ***expected monetary value (EMV).*** It determines the expected payoff of each alternative, and choose the alternative that hast the best expected payoff.

Decision Trees and Expected Monetary Value Chapter 4, Continues…

- To solve the decision tree using EMV, begin calculating the expected value of alternatives. ***See page 116, Figure 4.3***
- This expected value is simple the weighted average of possible outcomes. The weights being the changes with which the outcomes occur.



EMV (Keep Ticket) = 0.45(10) + 0.55(0) = \$4.50

EMV (Trade Ticket) = 0.20(24) + 0.80(-1) = \$4.00

Sensitivity Analysis
Chapter 5

- It can be useful for the decision maker to have some indication of how sensitive the choice of an alternative is to changes in one or more of these values.

- Sensitivity analysis provide a range of probability over which the choice of alternatives would remain the same. It involves constructing a graph and then using an algebra to determine a range of probabilities for each given solution is best.

- The ***graph provides a visual indication*** and the ***algebra provides exact value*** of the end points of the range.

Payoff Tables
Chapter 5, Continues…

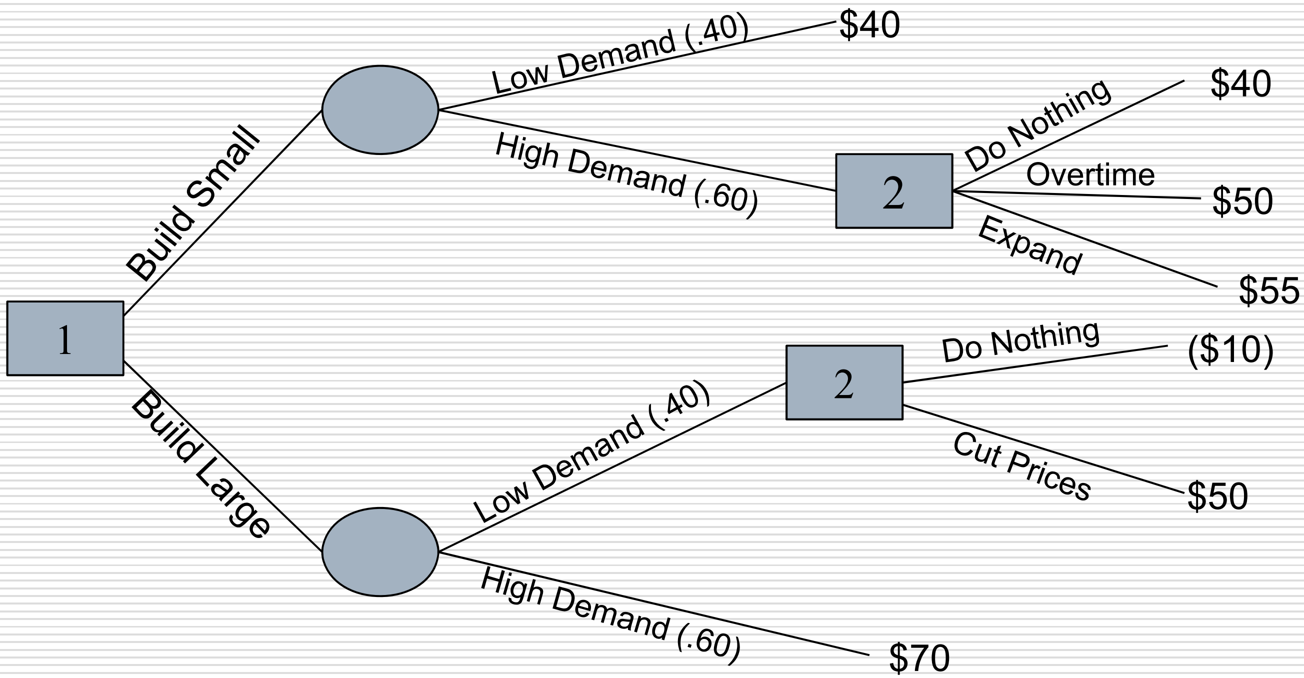
- The information for a decision is often summarized in a payoff table, which shows the ***expected payoffs for each alternative*** under the various possible state of nature.
- These tables are helpful in choosing among alternatives because they ***facilitate comparison of alternatives***.

Alternatives	**Low (.30)**	**Moderate (.50)**	**High (.20)**
Small Facility	$10	$10	$10
Medium Facility	$7	$12	$12
Large Facility	$-4	$2	$16

Present value in $ millions

Transforming Payoff Tables to Decision Trees Chapter 5, Continues…

A manager must decide on the size of a video arcade to construct. The manager has narrowed the choices to two: large or small. Information has been collected on payoffs, and a decision tree has been constructed.

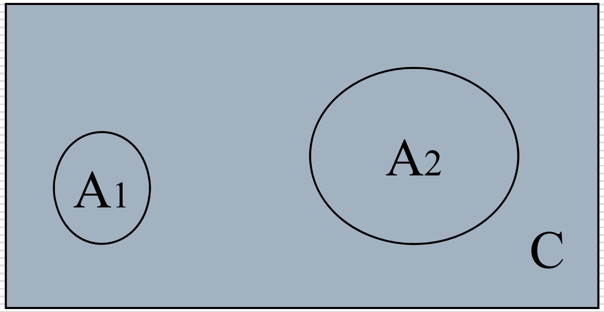


Probability Basics
Chapter 7

- A probability is the numeric value representing the chance, likelihood, or possibility of particular event will occur, ***such as the outcome five in one toss of a die.***
- The principles of probability ***help bridge the worlds of descriptive statistics and inferential statistics.***
- Probabilities must satisfy the following three requirements:
  - Probabilities must lie between 0 and 1, An event no chance of occurring has a probability of “0”.An event sure to occur has a probability of 1.
  - Probabilities must add up - For example the DOW have a chance of going up 30% and a change of staying the same is 45% - ***It can not do both at once***, the probability of going up or staying the same is 75% (30% + 45%).
  - Total probability must equal to 1.

Venn Diagrams
Chapter 7, continues…

Venn diagrams provide a graphical presentations of Probability.



Venn diagram in which two outcomes, A1 and A2, are displayed.

Because area A1 and A2 are not overlap, A1 and A2 cannot occur at the same time; they are mutually exclusive thus, the probability of A1 and A2 occurring must be just the sum of the probability of A1 plus the probability of A2.

Probability Basics
Chapter 7, continues…

<u>The Consumer Electronics Company</u>

- Probability models will answers some of the questions below and provide better decision making in consumer's purchasing behavior.
  - What is the ***probability that a household is planning to purchase*** a flat screen TV?
  - What is the probability that a household ***will actually purchase*** a flat screen TV?
  - What is the probability that a household ***planning to purchase*** a flat screen TV and ***actually purchases*** a flat screen TV?
  - Given that the household is planning to purchase a flat screen TV, ***what is the probability that the purchase is made.***
  - What is the probability that a household that purchases a flat screen TV ***will be satisfied with their purchase***?

Probability Basics
Chapter 7, continues…

Results of the sample of 1,000 households in terms of purchase behavior for flat screen TV.

ACTUALLY PURCHASED

PLANNED TO PURCHASE	***YES***	***NO***	***TOTAL***
YES	200	50	250
NO	100	650	750
TOTAL	***300***	***700***	***1,000***

Simple events are ***"planned to purchase," did not plan to purchase," "purchase," and "did not purchase"***. The event ***"planned to purchase and actually purchase"*** is a joint event because the responded must plan to purchase the flat screen TV and actually purchase it.

Probability Basics
Chapter 7, continues…

- ***Simple Probability***

  Refers to the probability of occurrences of a simple event, P(A).

  Probability of Occurrences = X/T

  P (planed to purchase) = $\dfrac{\text{number who planned to purchase}}{\text{total number of households.}}$

  = 250/1,000 = 0.25

  Thus, there is a 0.25 (or 25%) chance that a household planned to purchase a flat screen TV.

Probability Basics
Chapter 7, continues…

- ***Joint Probability***

  Refers to the probability of occurrences of an occurrence of ***two or more events***. An examples the probability that you will get heads on the first toss and heads on the second toss of coin.

  P (planed to purchase and actually purchased) =

$$\frac{\textit{planned to purchase and actually purchased}}{\textit{total number of responded.}}$$

P = 200/1,000 = 0.20

Thus, there is a 0.20 (or 20%) chance that a 200 respondent planned to purchase a flat screen TV.

Probability Basics
Chapter 7, continues…

- ***General Addition Rule***

  The general addition rule consists of taking the probability of A and adding to the probability of B, and then subtracting the joint event of A and B from the total.

$$P(A \text{ and } B) = P(A) + P(B) – P(A \text{ and } B)$$

P (planed to purchase and actually purchased) =
P (planned to purchase) + P(actually purchased) - P (planed to purchase and actually purchased)

$P = 250/1{,}000 + 3/1{,}000 – 200/1{,}000$
$P = 350/1{,}000 = 0.35$

Thus, there is a 0.35 (or 35%) chance that a respondent planned to purchase and actually purchased a flat screen TV.

- ***<u>Conditional Probability</u>***

  Refers to the probability of event A, given information about the occurrence of another event B.

  Event A = planned to purchase Event B = actually purchased

  P(B/A) = P(A and B)/P(A)

  P (planed to purchase / actually purchased) =

  $$\frac{\textit{planned to purchase and actually purchased}}{\textit{planned to purchase}}$$

  P = 200/250 = 0.80

  It consists of only those households that planned to purchase flat screen TV. Of 250 such households, 200 actually purchased flat screen TV.

  Thus, there is a 0.80 (or 80%) chance that a 250 households planned to purchase, actually purchased a flat screen TV.

Bayesian statistics Chapter 7, continues…

- Bayes' theorem is used to revise previously calculated probabilities when we have new information. Developed by the Rev. Thomas Bayes in the eighteen century.
- The Consumer Electronic Company is considering marketing new flat screen TV. The marketing research has issued a favorable report.
- What is the probability that the new flat screen TV will be successful?

Event (S) = successful TV launch
Event (S')= unsuccessful TV launch

Event (F)= favorable report
Event (F')= unfavorable report

Event (S) = 0.40
Event (S')=0.60

Event (F/S)= 0.80
Event (F/S')= 0.30

$$P(B/A)=P(A \text{ and } B)/P(A) = P(A/)P(B)/P(A)$$

Bayesian statistics
Chapter 7, continues…

$$P(S/F) = \frac{P(F/S)P(S)}{P(F/S)P(S) + P(F/S')P(S')}$$

$$P(S/F) = \frac{(0.80)(0.40)}{(0.80)(0.40) + (0.30)(0.60)}$$

$$P(S/F) = \frac{0.32}{0.32 + 0.18} = 0.64$$

- The probability of a successful TV launch, given a favorable report was received is 0.64. (64 %). Thus the probability of an unsuccessful TV launch is 1-0.64=0.36 (36%).

Bayesian statistics Chapter 7, continues…

Bayer's Statistics Calculation for the flat screen TV marketing example.

	Prior Probability	***Conditional Probability***	***Joint Probability***	***Revised Probability***
Event Si	$P(S_i)$	$P(F/S_i)$	$P(F/S_i)P(S_i)$	$P(S_i/F)$
S=successful flat screen TV launch	0.40	0.80	0.32	0.32/0.50=0.64=P(S/F)
S'=unsuccessful flat screen TV launch	0.60	0.30	0.18	0.18/0.50=0.36=P(S'/F)
TOTAL			0.50	

Subjective Probability and its Interpretation Chapter 8

- You are uncertain about the outcome because we don't know the outcome was ; the uncertainty is in your mind. When we think of uncertainty and probability in this way, we are adapting a ***subjective interpretation.***
- With a probability representing an individual's degree of believe that a particular outcome will occur.
- Personal decisions also involve high stakes and uncertainty.
- Personal ***investment decisions and career decisions*** are two kinds of decision that ***involve substantial uncertainty.***
- Decision analysis requires number for probabilities, not phrases such as ***"common, "unusual," "toss up," or "rare".***

Experts and Probability Assessment Chapter 8, continues…

- In complex problems, ***expert risk assessment*** plays a major role in the decision-making process.
- The process by which the expert information was acquired must stand up to ***professional scrutiny***, and thus individuals who acquire and use expert information must be able to ***document the assessment process***.
- Every ***assessment protocol*** should include the following steps:
  - *Background*
  - *Identification and Recruitment of Experts*
  - *Motivating Experts*
  - *Structuring and Decomposition*
  - *Probability - Assessment Training*
  - *Probability Elicitation and Verification*
  - *Aggregation of Experts' Probability Distributions.*

Theoretical Probability Models
Chapter 9

- The subjective assessment of probabilities as a method of modeling uncertainty in a decision problem.
- An alternative source of probabilities is it use theoretical probability models and their associated distributions.
- One approach is to assess a subjective probability distribution and then find a standard distribution that provides a close "fit" to those subjective probabilities.
- A decision maker might do this simply to make the probability and expected- value calculations easier.
- How important are theoretical probability distributions for decision making? Consider the following applications:

Theoretical Probability Models
Chapter 9, continues…

- ***Educational Testing:*** Many educational and intelligent tests generate distribution of scores that can be represented by the normal Distribution, with bell-shaped curve.
- ***Market Research:*** Whether a potential customer prefers one product over another.
- ***Quality Control:*** How many defect are acceptable in a finished product. Or a life expectancy of a light bulb.
- ***Capacity Planning:*** How to provide adequate service when the arrival of customer is uncertain, the number of customer arriving within a period of time can be modeled using "Poisson Distribution".
- ***Environmental Risk Analysis:*** In modeling the level of pollutants in the environment, scientists use normal distribution, this way it is possible to analyze pollution-control policies.

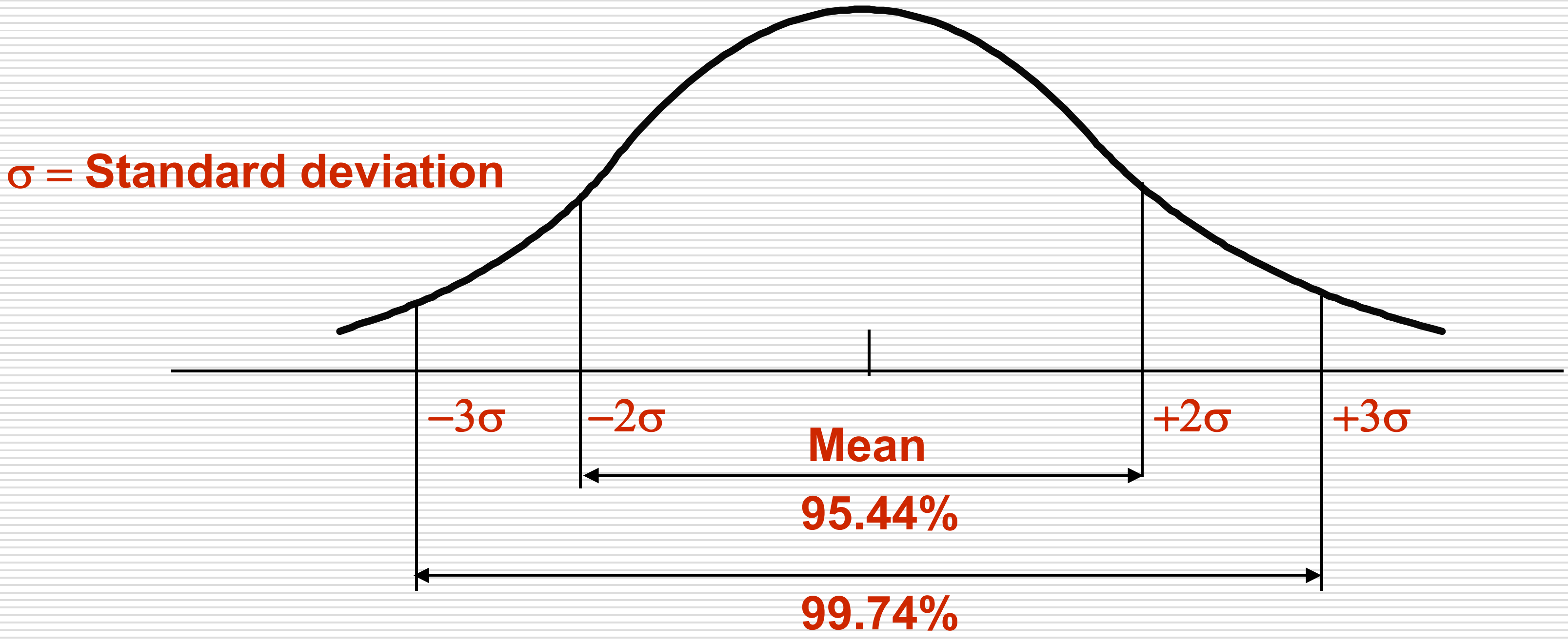
Theoretical Probability, The Normal Distribution Chapter 9, continues…

- The normal distribution sometime referred to as ***Gaussian Distribution*** is the most common continues distribution used in statistics.
- The normal distribution is presented by the ***bell-shape,***
- In the normal distribution, decision maker can calculate the probability that various values occur within certain ranges or intervals.

  The normal distribution has several important theoretical properties:
  - *It is bell-shaped, and thus symmetrical in its appearance.*
  - *Its measure of central tendency (mean. Median, and mode) are all identical.*
  - *Its "middle-fifty" is equal to 1.33 standard divination.*
  - *Has an infinite range (- infinite < X < infinite)*

The Normal Distribution
Chapter 9, continues…

- ***The normal distribution is presented by the bell-shape.***



The Normal Distribution Chapter 9, continues…

- Example: Light bulb manufacturing faculty. Quality control manager needs to know the following: What is the probability that a 40Watt light bulb will last less than 1410 hours in a production run of 10,000 light bulbs.
- Quality control manager gathered Data on the life expectancy of 40 Watt light bulbs, the life expectancy were normally distributed with a mean of 1500 hours and a standard deviation of 75 hours.

The formula ***<u>Z = X - Mean/Standard Deviation</u>***

Z = 1410-1500/75 = -1.2

Z = -1.2 from the Z tables = 0.3849

= 0.5000-0.3849

= 0.1151 or 11.51 %

The probability of 40 Watt light bull lasting less the 1410 hours is 11.51% or 1151 light bulbs from 10,000 light bulbs production run.

The Normal Distribution
Chapter 9, continues…

- What is the probability that a 40Watt light bulb will last between 1485 hours and 1500 hours?

<u>Z = X - Mean/Standard Deviation</u>

Z = 1485- 1500/75 = - 0.2

Z = -0.2 from the Z tables = 0.5793

= 0.5000 - 0.5793

= 0.0793 or 7.93 %

The probability of 40 Watt light bull lasting between 1485 hours and 1500 hours is 7.93% or 793 light bulbs from the 10,000 light bulb production run.

The Normal Distribution Chapter 9, continues…

- What is the probability that a 40Watt light bulb will last between 1563 hours and 1648 hours?

<u>Z = X - Mean/Standard Deviation</u>

Z = 1563- 1500/75 = 0.84

Z = 0.84 from the Z tables = 0.2995

Z = 1648- 1500/75 = 1.97

Z = 1.97 from the Z tables = 0.4756

= 0.4756 – 0.2995 = 0.1761

= 0.1761 or 17.61 %

The probability of 40 Watt light bull lasting between 1563 hours and 1648 hours is 17.61% or 1761 light bulbs from the 10,000 light bulb production run.

The Binomial Distribution Chapter 9, continues…

- ***A fixed number of observations, n***
  - e.g., 15 tosses of a coin; ten light bulbs taken from a warehouse

- ***Two mutually exclusive and collectively exhaustive categories***
  - e.g., head or tail in each toss of a coin; defective or not defective light bulb
  - Generally called ***"success" and "failure"***
  - Probability of success is p, probability of failure is $1 - p$

- ***Constant probability for each observation***
  - e.g., Probability of getting a tail is the same each time we toss the coin

The Binomial Distribution Chapter 9, continues…

- ***Observations are independent***
  - The outcome of one observation does not affect the outcome of the other
- ***Two sampling methods***
  - Infinite population without replacement
  - Finite population with replacement

<u>Possible Binomial Distribution Settings</u>

- A manufacturing plant labels items as ***either defective or acceptable***
- A firm bidding for contracts will either ***get a contract or not***
- A marketing research firm receives survey responses of ***"yes I will buy" or "no I will not"***
- New job applicants either ***accept the offer or reject it.***

Binomial Distribution Formula Chapter 9, continues…

$$P(X) = \frac{n!}{X!(n-X)!} p^X (1-p)^{n-X}$$

P(X) = probability of **X** successes in **n** trials, with probability of success **p** on each trial

X = number of 'successes' in sample, (X = 0, 1, 2, ..., n)

n = sample size (number of trials or observations)

p = probability of "success"

Example: Flip a coin four times, let x = # heads:

$n = 4$

$p = 0.5$

$1 - p = (1 - 0.5) = 0.5$

$X = 0, 1, 2, 3, 4$

Calculating Binomial Probability Chapter 9, continues…

What is the probability of one success in five observations if the probability of success is 0.1?

$X = 1$, $n = 5$, and $p = 0.1$

$$P(X = 1) = \frac{n!}{X!\,(n - X)!} p^{X} (1 - p)^{n - X}$$

$$= \frac{5!}{1!\,(5 - 1)!} (0.1)^{1} (1 - 0.1)^{5 - 1}$$

$$= (5)(0.1)(0.9)^{4}$$

$$= 0.32805$$

The Poisson Distribution Chapter 9, continues…

- ***Apply the Poisson Distribution when:***
  - Decision maker wishes to count the number of times an event occurs in a given area of opportunity
  - The probability that an event occurs in one area of opportunity is the same for all areas of opportunity
  - The number of events that occur in one area of opportunity is independent of the number of events that occur in the other areas of opportunity
  - The probability that two or more events occur in an area of opportunity approaches zero as the area of opportunity becomes smaller
  - The average number of events per unit is λ (lambda)

Poisson Distribution Formula
Chapter 9, continues…

$$P(X) = \frac{e^{-\lambda}\lambda^{x}}{X!}$$

Where:

X = number of events in an area of opportunity

λ = expected number of events

e = base of the natural logarithm system (2.71828...)

Poisson Distribution Characteristics Chapter 9, continues…

- **Mean**

$$\boxed{\mu = \lambda}$$

- **Variance and Standard Deviation**

$$\boxed{\sigma^2 = \lambda}$$

$$\boxed{\sigma = \sqrt{\lambda}}$$

- **Where: λ = expected number of events**

The Poisson Distribution Table Chapter 9, continues…

X	λ 0.10	0.20	0.30	0.40	**0.50**	0.60	0.70	0.80	0.90
0	0.9048	0.8187	0.7408	0.6703	0.6065	0.5488	0.4966	0.4493	0.4066
1	0.0905	0.1637	0.2222	0.2681	0.3033	0.3293	0.3476	0.3595	0.3659
2	0.0045	0.0164	0.0333	0.0536	***0.0758***	0.0988	0.1217	0.1438	0.1647
3	0.0002	0.0011	0.0033	0.0072	0.0126	0.0198	0.0284	0.0383	0.0494
4	0.0000	0.0001	0.0003	0.0007	0.0016	0.0030	0.0050	0.0077	0.0111
5	0.0000	0.0000	0.0000	0.0001	0.0002	0.0004	0.0007	0.0012	0.0020
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002	0.0003
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

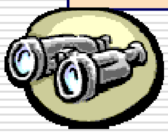
Example: Find P (X = 2) if λ = 0.50

$$P(X = 2) = \frac{e^{-\lambda}\lambda^{X}}{X!} = \frac{e^{-0.50}(0.50)^{2}}{2!} = 0.0758$$

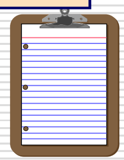
Using Data and Data Sources
Chapter 10

Primary Sources
Data Collection

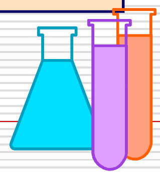
- Observation



- Survey

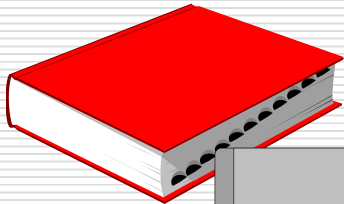


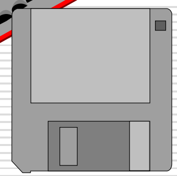
- Experimentation



Secondary Sources
Data Compilation

- Print or Electronic





Data Collecting Techniques and Tips Chapter 10, Continuous…

The Data collection process can be long and cumbersome and it is the most time consuming part of the process.

- Begin thinking about the type of Data you want to collect, Interviews, Questionnaires, Government Surveys?
- Where you will be getting the Data?
- Make sure that the Data collection forms you use are clear and easy to use.
- Duplicate copy of the Data files.
- Do not rely on other people to collect and transfer Data, Unless you have personally trained them.

Data Collecting Techniques and Tips Chapter 10, Continuous…

- Plan a detailed schedule of when and where you will be collecting Data.
- Do it as soon as possible, there maybe other groups doing the same Data collection.
- Try to follow up on subject who missed their testing session or interview.
- Never discard the original Data, Interview notes, Questionnaires and others.
- Follow the previous steps.

Business Forecasting
Chapter 10, continues…

Business Forecasting:

Statement about the future, value of a variable of interest, such as demand.

Forecasting is not an exact science, but structured and quantitative approaches, decision maker can predict the future with some degree of accuracy

Forecasting is used to make informed decisions.

- Short-range
- Long-range

Business Forecasting
Chapter 10, continues…

- Forecasts affect decisions and activities throughout an organization
  - Accounting, finance
  - Human resources
  - Marketing
  - MIS
  - Operations
  - Product / service design

Business Forecasting
Chapter 10, continues…

- No single technique works in every situation
- Two most important factors
  - *Cost*
  - *Accuracy*

- Other factors include the availability of:
  - *Historical data*
  - *Computers*
  - *Time needed to gather and analyze the data*
  - *Forecast horizon*

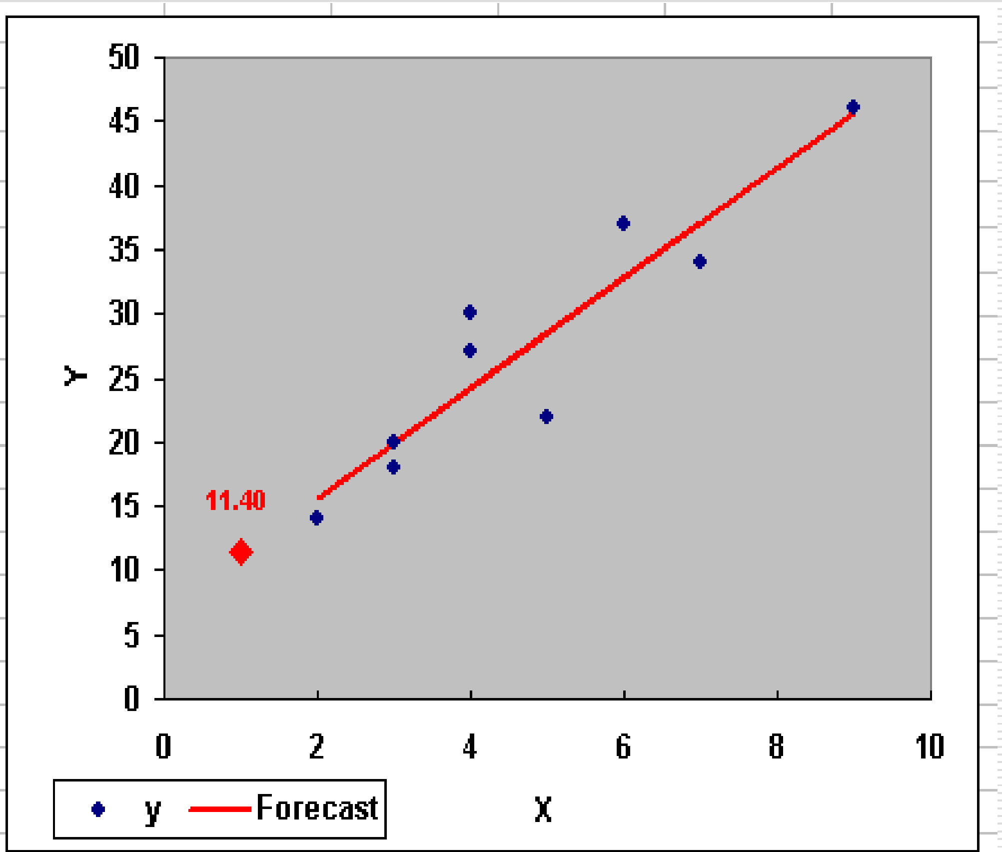
Simple Linear Regression Analysis
Chapter 10, continues…

Simple Linear Regression

Clear

Slope =	4.2753	r =	0.9276226
Intercept =	7.1292135	r^2 =	0.8604837

x	y	Forecast	Error
9	46	45.606742	0.3932584
3	18	19.955056	-1.9550562
3	20	19.955056	0.0449438
5	22	28.505618	-6.505618
4	27	24.230337	2.7696629
7	34	37.05618	-3.0561798
2	14	15.679775	-1.6797753
6	37	32.780899	4.2191011
4	30	24.230337	5.7696629



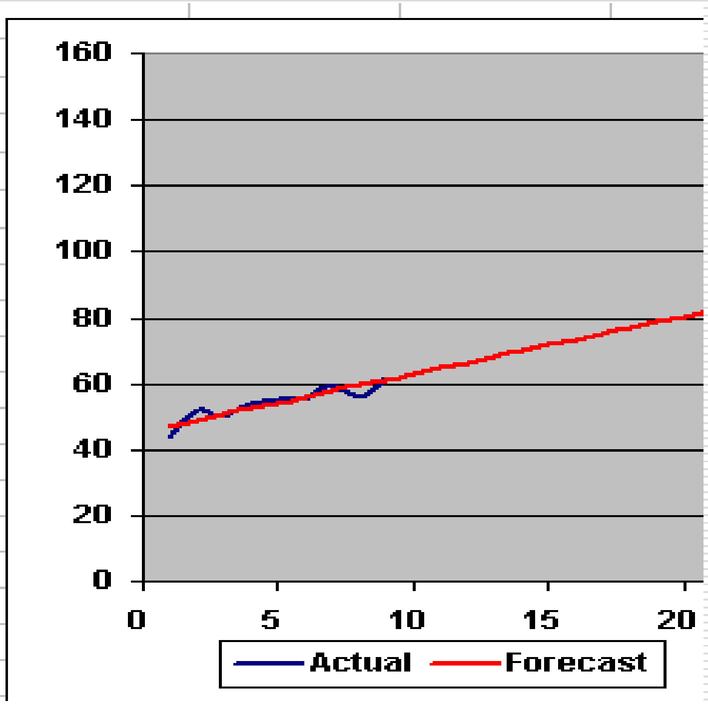
Linear Trend Equation Analysis Chapter 10, continues…

Linear Trend Equation

Clear

Slope =	1.7500	MAD =	1.86
Intercept =	45.472222	MSE =	5.23

Period	Actual	Forecast	Error
1	44	47.222222	-3.2222222
2	52	48.972222	3.0277778
3	50	50.722222	-0.7222222
4	54	52.472222	1.5277778
5	55	54.222222	0.7777778
6	55	55.972222	-0.9722222
7	60	57.722222	2.2777778
8	56	59.472222	-3.4722222
9	62	61.222222	0.7777778



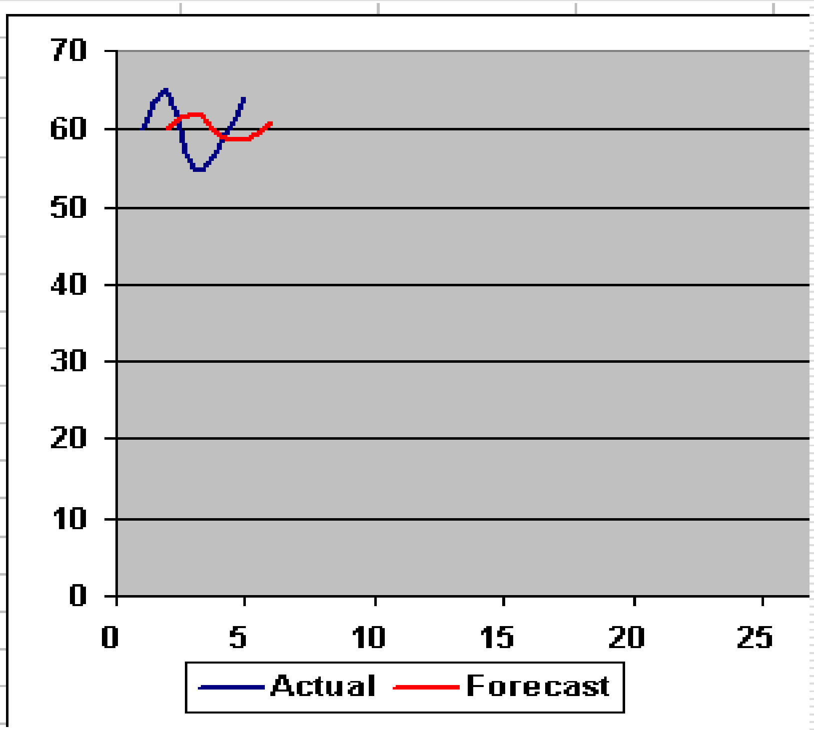
Exponential Smoothing, Business Forecasting Chapter 10, continues…

Exponential Smoothing

Clear

α =	0.4	MAD =	4.62
Δα =	0.1	MSE =	34.44

Period	Actual	Forecast	Error
1	60		
2	65	60	5
3	55	62	-7
4	58	59.2	-1.2
5	64	58.72	5.28
6		60.832	



Linear Programming, Optimization Problems Chapter 10, continues…

- Used to obtain optimal solutions to problems that involve restrictions or limitations, such as:

    - *Materials*
    - *Budgets*
    - *Labor*
    - *Machine time*

Linear Programming, Optimization Problems Chapter 10, continues…

Linear programming (LP) techniques consist of a sequence of steps that will lead to an optimal solution to problems, in cases where an optimum exists:

Objective Function: mathematical statement of profit or cost for a given solution

***Decision variables*:** amounts of either inputs or outputs

***Feasible solution space*:** the set of all feasible combinations of decision variables as defined by the constraints

***Constraints*:** limitations that restrict the available alternatives

***Parameters*:** numerical values

Linear Programming, Optimization Problems Chapter 10, continues…

Linearity: the impact of decision variables is linear in constraints and objective function

Divisibility: noninteger values of decision variables are acceptable

Certainty: values of parameters are known and constant

Nonnegativity: negative values of decision variables are unacceptable

Linear Programming, Optimization Problems
Chapter 10, continues…

Graphical method for finding optimal solutions to two-variable problems

1. Set up objective function and constraints in mathematical format
2. Plot the constraints
3. Identify the feasible solution space
4. Plot the objective function
5. Determine the optimum solution

Linear Programming, an Example Chapter 10, continues…

- ***Objective – profit***

  Maximize $Z=60X_1 + 50X_2$

- ***Subject to (constraints)***

  Assembly $4X_1 + 10X_2 <= 100$ hours

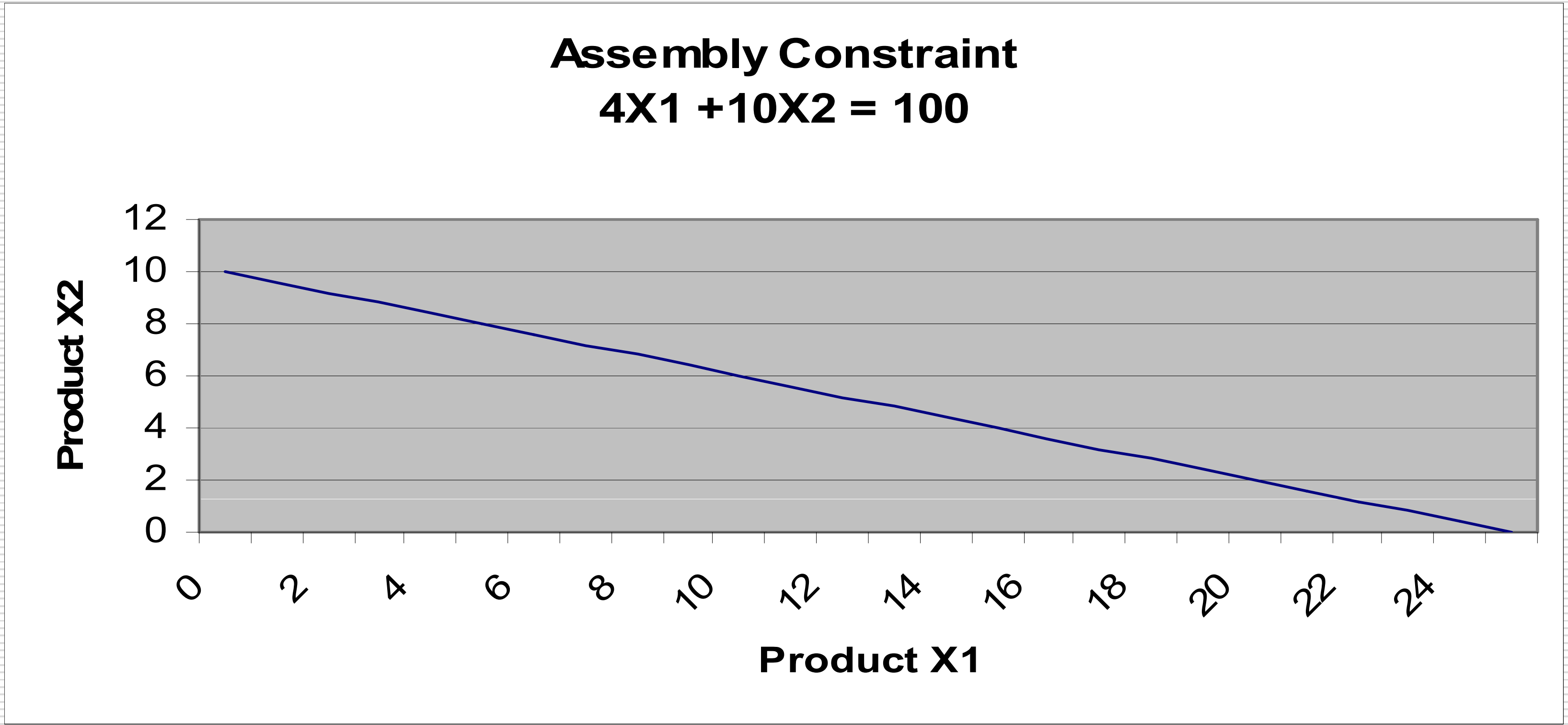
  Inspection $2X_1 + 1X_2 <= 22$ hours

  Storage $3X_1 + 3X_2 <= 39$ cubic feet

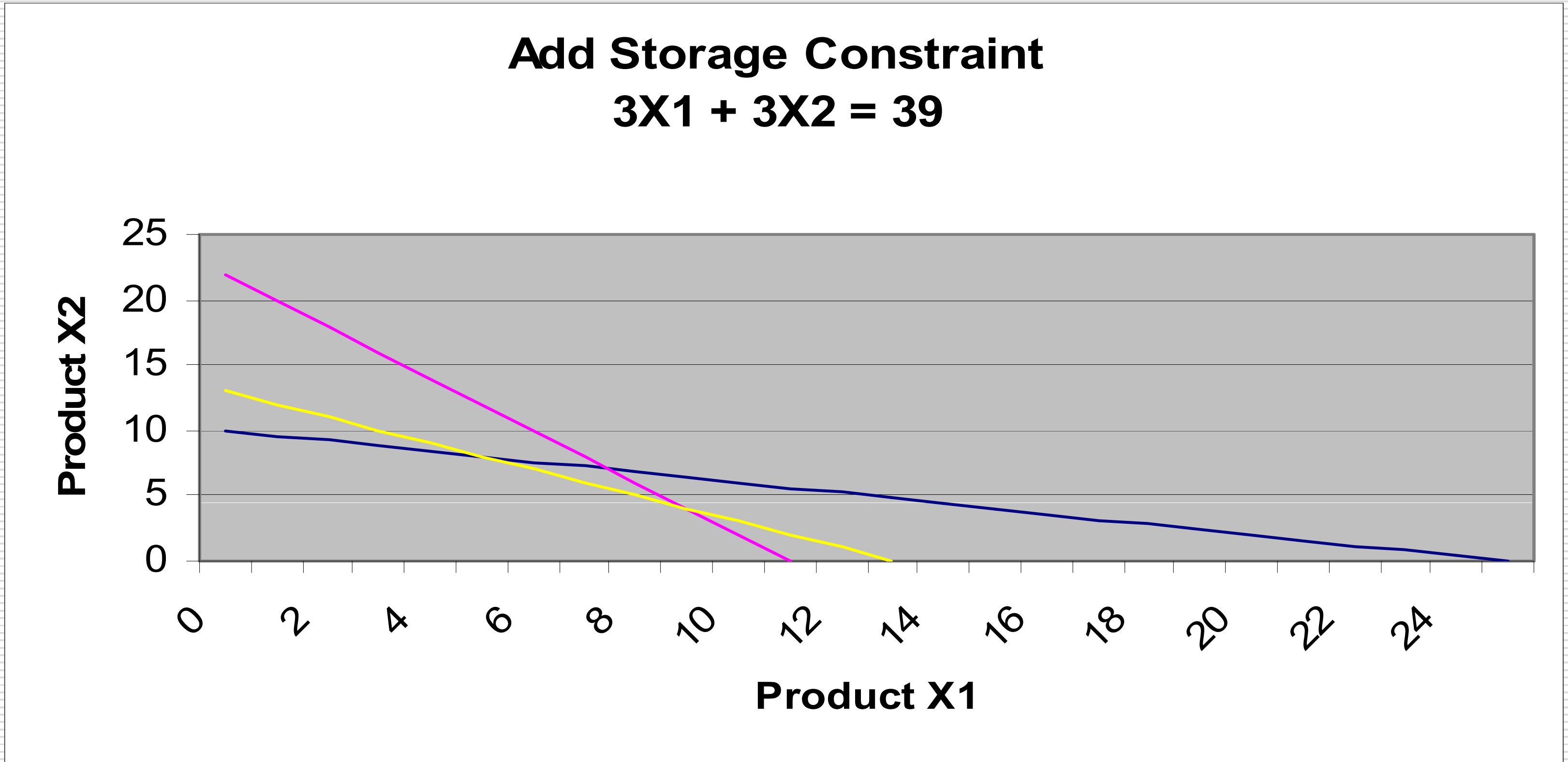
  - ***Non-negativity***

    $X_1, X_2 >= 0$

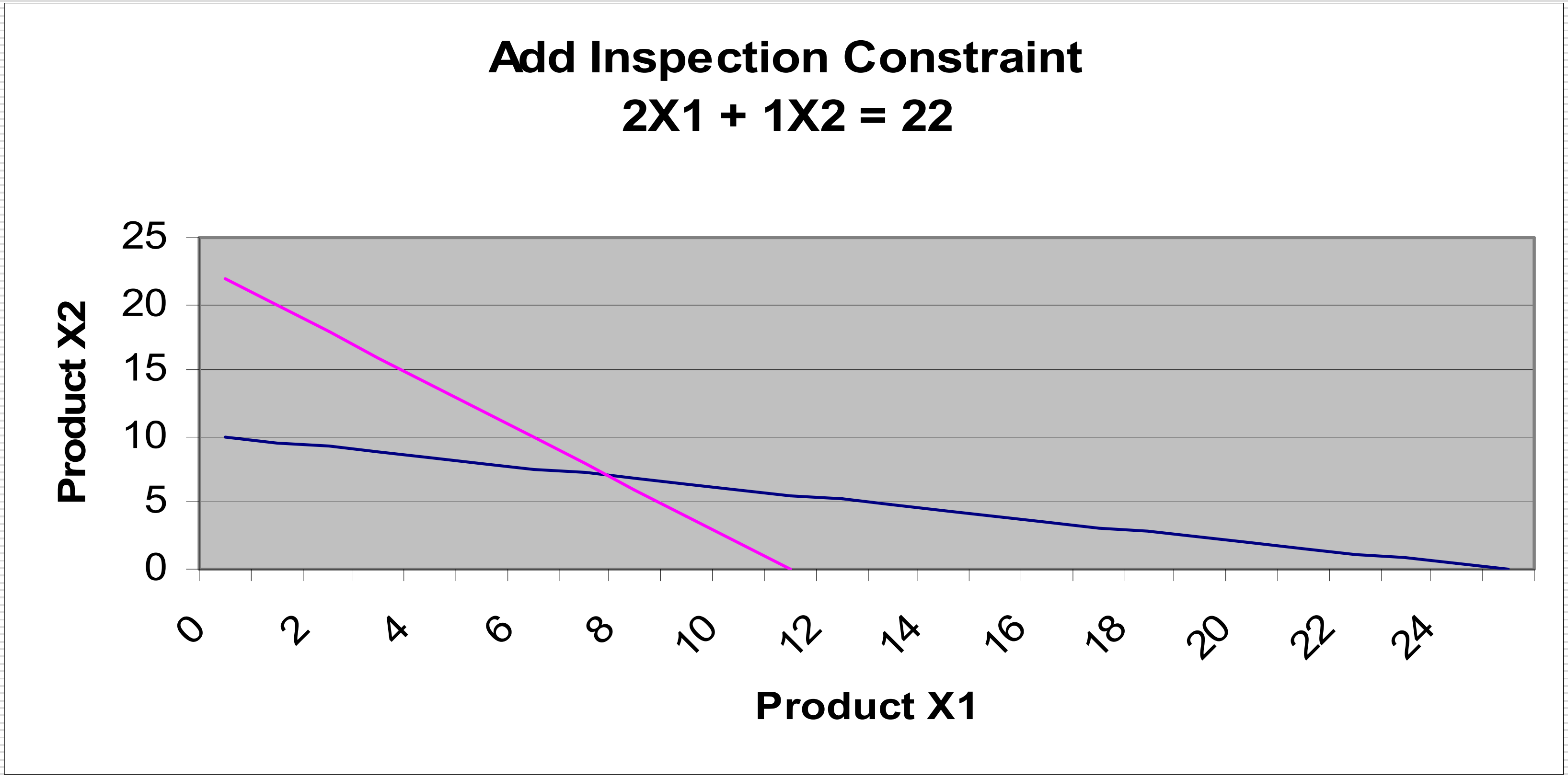
Linear Programming, an Example Chapter 10, continues…



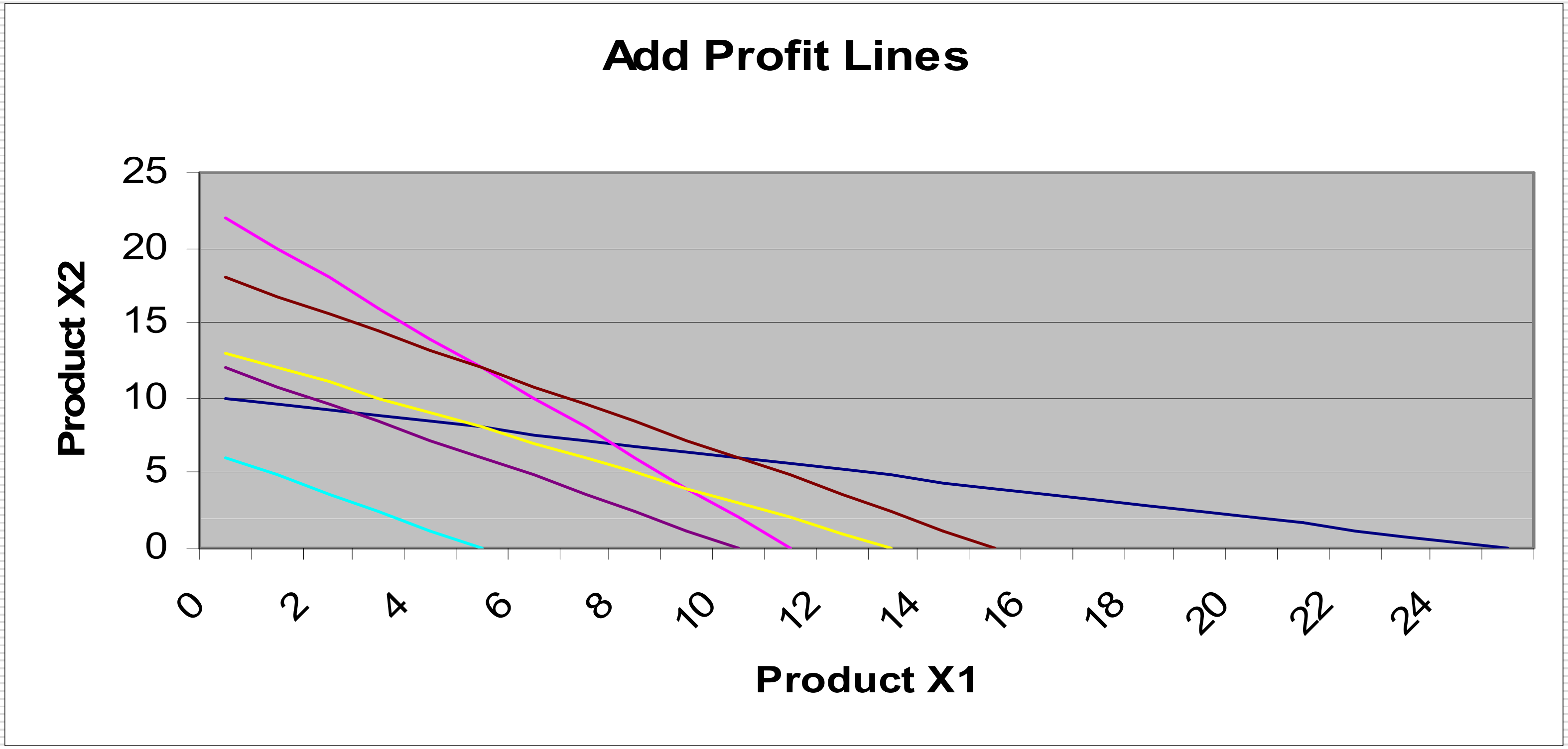
Linear Programming, an Example Chapter 10, continues…



Linear Programming, an Example Chapter 10, continues…



Linear Programming, an Example
Chapter 10, continues…



Linear Programming, the Solution Chapter 10, continues…

- The intersection of inspection and storage
- Solve two equations in two unknowns

$$2X1 + 1X2 = 22$$

$$3X1 + 3X2 = 39$$

$$X1 = 9$$

$$X2 = 4$$

$$Z = \$740$$

- Feasible solution space is usually a polygon
- Solution will be at one of the corner points
- ***Enumeration approach***: Substituting the coordinates of each corner point into the objective function to determine which corner point is optimal.

Value of Information Chapter 12, continues…

- Decision makers who faces uncertain prospects often gather information with the intention of reducing uncertainty.

  Information gathering includes

  - Consulting experts,
  - Conducting surveys
  - Performing mathematical and statistical analysis
  - Doing research
  - Or simply reading books, journals and newspaper.

Value of Information
Chapter 12, continues…

This Chapter addresses below questions:

- What does it mean for an expert to provide perfect information?
- How does probability relates to the idea of information?
- What is an appropriate basis on which to evaluate information in a decision situation.

Probability and Perfect Information Chapter 12, continues…

An Expert's information is said to be perfect if it is always correct. We can use conditional probabilities to model perfect information.

P(Expert says "Market up" / Market Really Does Go up) = 1

Because the probabilities must add to 1, we also must have:

P(Expert Says " Market Will Stay the Same or Fall"/Market Really Will Go Up) = 0

Probability and Perfect Information Chapter 12, continues…

Market Up = The market really goes up

Market Down = The market really stays flat or goes down

Experts says "Up" = The experts will say the market will go up

Experts says "Down" = The experts says the market will stay flat or go down.

Now we can apply Bayer's theorem:

P(Market Up/Experts Say "Up")

=P(Experts Says "Up"/Market Up)P(Market Up)

[P(Experts Says "Up"/Market Up)P(Market Up) + P(Expert Says "Up"/Market Down)P(Market Down

1 P(Market Up)

1 P(Market Up) + 0 P (Market Down)

= 1 (one)

Utility Axioms, Paradoxes, and Implications Chapter 12, continues…

- For the basis of a few behavioral axioms, it is possible to establish logically that people who behave according to the axioms should make choices consistent with ***the maximization of expected utility.***

Evaluation of the behavioral assumptions that for the basis for expected utility.

1. ***Ordering and transitivity:*** A decision maker can order any to alternative, and the ordering is transitive. Example: which cities to live; If that person prefers Amsterdam to London and London to Paris, the she prefer Amsterdam to Paris.
2. ***Reduction of compound certain events:*** A decision maker is indifferent between a compound uncertain events, gambling and Lottery
3. ***Continuity:*** A decision maker is indifferent between a consequences of winning $100 and some uncertain event involving two basic consequences.

Utility Axioms, Paradoxes, and Implications Chapter 12, continues…

4. ***Substitutability:*** A decision maker is indifferent between any original uncertain events that includes outcome A and one formed by substituting for A an uncertain event that is judged to be its equivalent
5. ***Monotonicity:*** Given two preferences gambles with the same possible outcomes, a decision maker prefers the one with the higher probability of winning the preferred outcome.
6. ***Invariance:*** All that is needed to determine a decision maker's preferences among uncertain events are the payoffs and the associated probabilities.
7. ***Finiteness:*** No consequences are considered infinitely bad or infinitely good.

Paradoxes and Implications Chapter 12, continues…

- The axioms of expected utility theory appears to be compelling but ***people do not necessarily make choices in accordance with them***.
- "Framing effect" are among the most pervasive paradoxes in choice behavior.
- ***Individual's risk attitude*** can change depending on the ways the decision problem posed.
- The difficulty is that the same decision problem usually can be expressed in different frames.
- ***People do not always behave according to the behavioral axioms.***
- This fact has distinct implications for the practice of decision analysis.

Paradoxes and Implications Chapter 12, continues…

- Perhaps the one intriguing are the implications for managers and policy makers whose jobs depend on ***how people actually make decisions.***

- It may be important for such managers to ***consider some of the above-described behavioral phenomena.***

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