MSBA 250 — Applied Business Analytics
Instructor: Dr. Xu

Chapter 1

Introduction to Business Analytics

Overview

(Business) Analytics is the use of:

- data,
- information technology,
- statistical analysis,
- quantitative methods, and
- mathematical or computer-based models

to help managers gain improved insight about their business operations and make better, fact-based decisions.

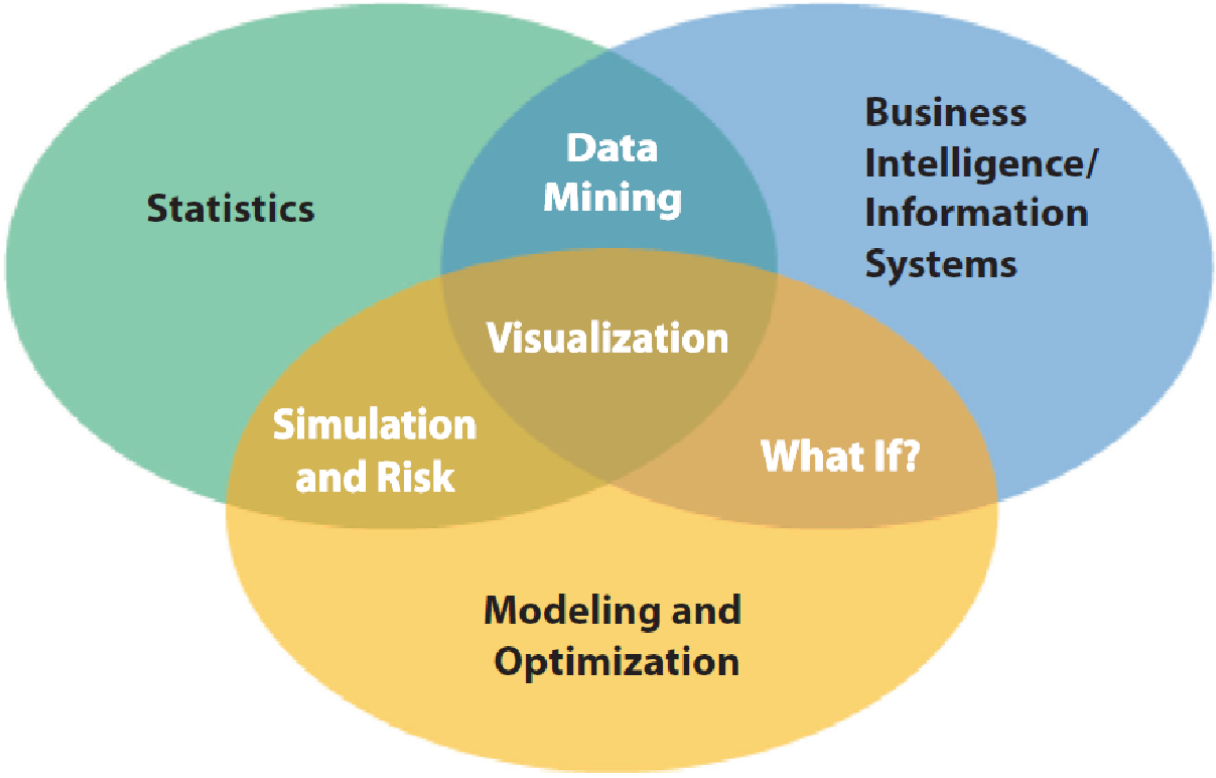
Examples of Applications

- Pricing
  - setting prices for consumer and industrial goods, government contracts, and maintenance contracts
- Customer segmentation
  - identifying and targeting key customer groups in retail, insurance, and credit card industries
- Merchandising
  - determining brands to buy, quantities, and allocations
- Location
  - finding the best location for bank branches and AT Ms, or where to service industrial equipment
- Supply Chain Design
  - determining the best sourcing and transportation options and finding the best delivery routes
- Staffing
  - ensuring appropriate staffing levels and capabilities, and hiring the right people
- Health care
  - scheduling operating rooms to improve utilization, improving patient flow and waiting times, purchasing supplies, and predicting health risk factors

Impacts of Analytics

- Benefits
  - …reduced costs, better risk management, faster decisions, better productivity and enhanced bottom-line performance such as profitability and customer satisfaction.
- Challenges
  - …lack of understanding of how to use analytics, competing business priorities, insufficient analytical skills, difficulty in getting good data and sharing information, and not understanding the benefits versus perceived costs of analytics studies.
- Evolution of Business Analytics
- Analytic Foundations
  - Business Intelligence (BI)
  - Information Systems (IS)
  - Statistics
  - Operations Research/Management Science (OR/MS)
- Modern Business Analytic
  - Data mining
  - Simulation and risk analysis
  - Decision Support Systems (DSS)
  - Visualization

A Visual Perspective of Business Analytics



Software Support and Spreadsheet Technology

- Commercial software
  - IBM Cognos Express
  - SAS Analytics
  - Tableau
- Spreadsheets
  - Widely used
  - Effective for manipulating data and developing and solving models
  - Support powerful commercial add-ons
  - Facilitate communication of results
  - Analytic Solver (online supplements)

Descriptive, Predictive, and Prescriptive Analytics

- Descriptive analytics: the use of data to understand past and current business performance and make informed decisions

- Predictive analytics: predict the future by examining historical data, detecting patterns or relationships in these data, and then extrapolating these relationships forward in time.

- Prescriptive analytics: identify the best alternatives to minimize or maximize some objective

Example 1.1: Retail Markdown Decisions

- Most department stores clear seasonal inventory by reducing prices.

- *Key question*: When to reduce the price and by how much to maximize revenue?

- Potential applications of analytics in retail:
  - Descriptive analytics: examine historical data for similar
  - Predictive analytics: predict sales based on price
  - Prescriptive analytics: find the best sets of pricing and advertising to maximize sales revenue

Data for Business Analytics

- Data: numbers or textual data that are collected through some type of measurement process
- Information: result of analyzing data; that is, extracting meaning from data to support evaluation and decision making

Examples of Data Sources and Uses

- Annual reports
- Accounting audits
- Financial profitability analysis
- Economic trends
- Marketing research
- Operations management performance
- Human resource measurements
- Web behavior
  - page views, visitor's country, time of view, length of time, origin and destination paths, products they searched for and viewed, products purchased, what reviews they read, and many others

Big Data

- Big data refers to massive amounts of business data (*volume*) from a wide variety of sources (*variety*), much of which is available in real time (*velocity*), and much of which is uncertain or unpredictable (*veracity*).

- "The effective use of big data has the potential to transform economies, delivering a new wave of productivity growth and consumer surplus. Using big data will become a key basis of competition for existing companies, and will create new competitors who are able to attract employees that have the critical skills for a big data world." - McKinsey Global Institute, 2011

Data Reliability and Validity

- Reliability - data are accurate and consistent.
- Validity - data correctly measures what it is supposed to measure.

Data Reliability and Validity Examples

A tire pressure gage that consistently reads several pounds of pressure below the true value is not reliable, although it is valid because it does measure tire pressure.

Data Reliability and Validity Examples

A survey question that asks a customer to rate the quality of the food in a restaurant may be neither reliable (because different customers may have conflicting perceptions) nor valid (if the intent is to measure customer satisfaction, as satisfaction generally includes other elements of service besides food).

Models in Business Analytics

- Model - an abstraction or representation of a real system, idea, or object.
  - Captures the most important features
  - Can be a written or verbal description, a visual representation, a mathematical formula, or a spreadsheet.

Example 1.2: Three Forms of a Model

The sales of a new product, such as a first-generation iPad or 3D television, often follow a common pattern.

- Verbal description: The rate of sales starts small as early adopters begin to evaluate a new product and then begins to grow at an increasing rate over time as positive customer feedback spreads. Eventually, the market begins to become saturated and the rate of sales begins to decrease.

Example 1.2 Continued

- Visual model: A sketch of sales as an S-shaped curve over time
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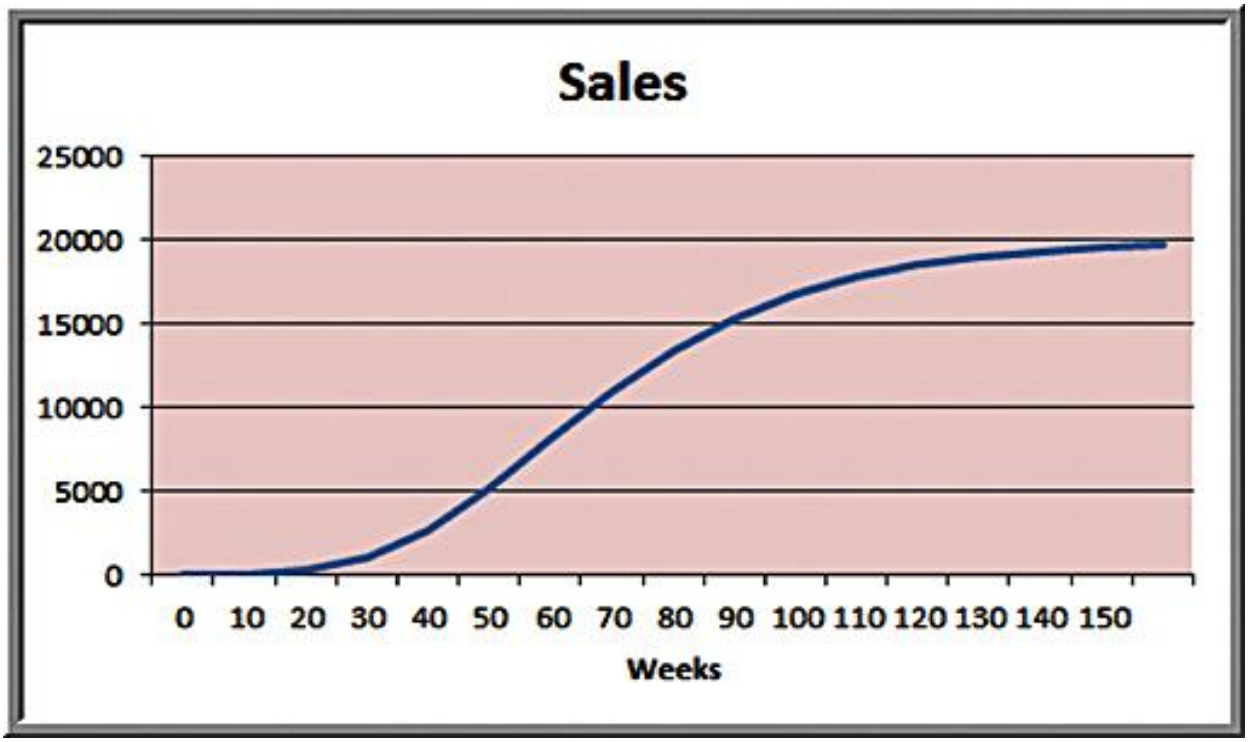


Example 1.2 Continued

- Mathematical model:

$$S = ae^{be^{ct}}$$

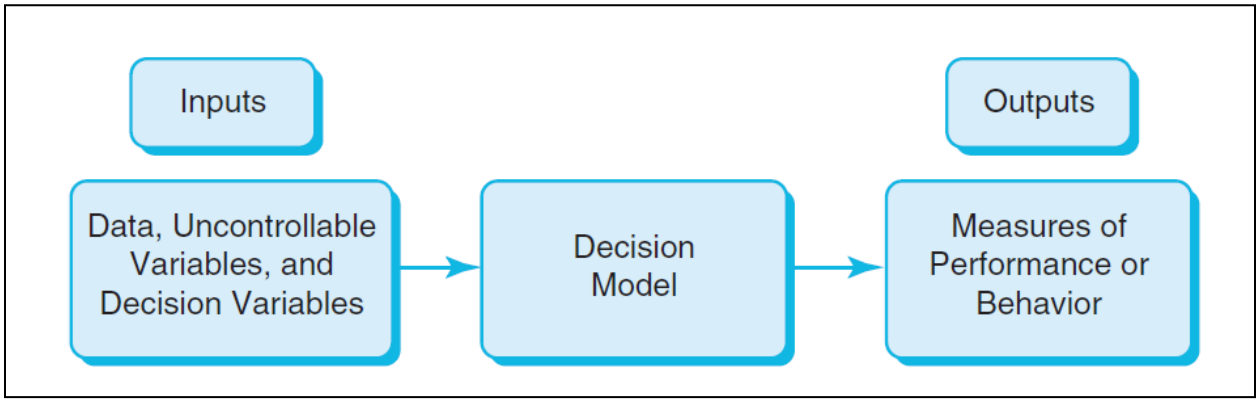
where S is sales, t is time, e is the base of natural logarithms, and a, b and c are constants

Decision Models

- Decision Model - a logical or mathematical representation of a problem or business situation that can be used to understand, analyze, or facilitate making a decision

- Inputs:
  - *Data* – assumed to be constant
  - *Uncontrollable inputs* – quantities that can change but cannot be controlled
  - *Decision options* – controllable and selected at the discretion of the decision maker

Nature of Decision Models



- Descriptive Models
- Descriptive models explain behavior and allow users to evaluate potential decisions by asking “what-if?” questions.

Example 1.3: Gasoline Usage Model

- G = gallons of fuel consumed per month
- m = miles driven per day to and from work or school
- d = number of driving days per month
- f = fuel economy in miles per gallon (mpg)
- a = additional miles for leisure and household activities per month

Example 1.3 Continued

- Use dimensions for logical consistency:

(m miles/day) x (d days/month) = m x d miles/month

- Total miles driven per month = m x d + a

- Gallons consumed per month
  = (m x d + a miles/month)/(f miles/gallon)
  = (m x d + a)/f gallons/month

Example 1.4: An Outsourcing Decision Model

- Production cost: $125/unit plus fixed cost of $50,000
- Outsourcing cost: $175/unit
- *Q* = production volume

- TC (manufacturing) = $50,000 + $125 x *Q*
- TC (outsourcing) = $175 x *Q*

- Breakeven Point: TC (manufacturing) = TC (outsourcing)

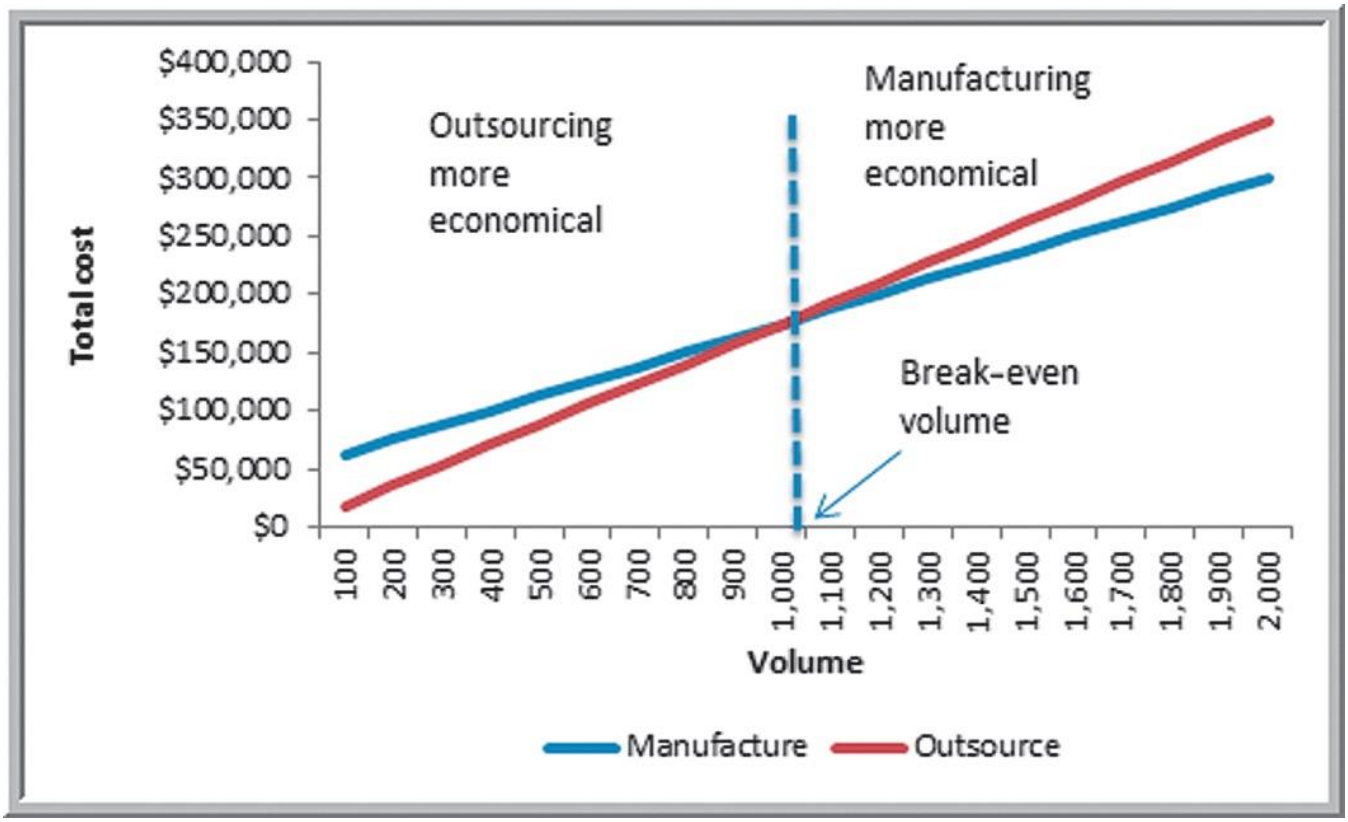
$$\$50{,}000 + \$125 \times Q = \$175 \times Q$$

$$\$50{,}000 = 50 \times Q$$

$$Q = 1{,}000$$

- If Q < 1,000, outsourcing is cheaper.

Example 1.4 Continued



Predictive Models

- Predictive models focus on what will happen in the future.

- Many predictive models are developed by analyzing historical data and assuming that the past is representative of the future.

Example 1.5: A Sales-Promotion Decision Model

In the grocery industry, managers typically need to know how best to use pricing, coupons, and advertising strategies to influence sales. Grocers often study the relationship of sales volume to these strategies by conducting controlled experiments to identify the relationship between them and sales volumes. That is, they implement different combinations of pricing, coupons, and advertising, observe the sales that result, and use analytics to develop a predictive model of sales as a function of these decision strategies.

Example 1.5 Model

Week	Price ($)	Coupon (0,1)	Advertising ($)	Store 1 Sales (Units)	Store 2 Sales (Units)	Store 3 Sales (Units)
1	$6.99	0	$0	501	510	481
2	$6.99	0	$150	772	748	775
3	$6,99	1	$0	554	528	506
4	$6.99	1	$150	838	785	834
5	$6.49	0	$0	521	519	500
6	$6.49	0	$150	723	790	723
7	$6.49	1	$0	510	556	520
8	$6.49	1	$150	818	773	800
9	$7.59	0	$0	479	491	486
10	$7.59	0	$150	825	822	757
11	$7.59	1	$0	533	513	540
12	$7.59	1	$150	839	791	832
13	$5.49	0	$0	484	480	508
14	$5.49	0	$150	686	683	708
15	$5.49	1	$0	543	531	530
16	$5.49	1	$150	767	743	779

Model:

Total Sales = 1105.55 + 56.18 x Price + 123.88 x Coupon + 5.25 x Advertising

If the price is $6.99, no coupons are offered, and no advertising is done (the experiment corresponding to week 1), the model estimates sales as
Total Sales = 1105.55 + 56.18 x 6.99 + 123.88 x 0 + 5.25 x 0 = 1,498.25 units

Prescriptive Models

- Prescriptive models help decision makers identify the best solution to a decision problem.

- Optimization - finding values of decision variables that minimize (or maximize) something such as cost (or profit)
  - Objective function - the equation that minimizes (or maximizes) the quantity of interest
  - Optimal solution - values of the decision variables at the minimum (or maximum) point

Example 1.6: A Prescriptive Pricing Model

- A firm wishes to determine the best pricing for one of its products in order to maximize revenue.

- Analysts determined the following model:

  Sales = -2.9485 x Price + 3,240.9

  Total Revenue = Price x Sales
  = Price x (-2.9485 x Price + 3,240.9)
  = -2.9485 x Price^2 + 3,240.9 x Price

- Identify the price that maximizes total revenue.

Model Assumptions

- Assumptions are made to
  - simplify a model and make it more tractable; that is, able to be easily analyzed or solved.
  - better characterize historical data or past observations.

- The task of the modeler is to select or build an appropriate model that best represents the behavior of the real situation.

Model Assumptions - Example

- Economic theory tells us that demand for a product is negatively related to its price. Thus, as prices increase, demand falls, and vice versa (modeled by price elasticity — the ratio of the percentage change in demand to the percentage change in price).

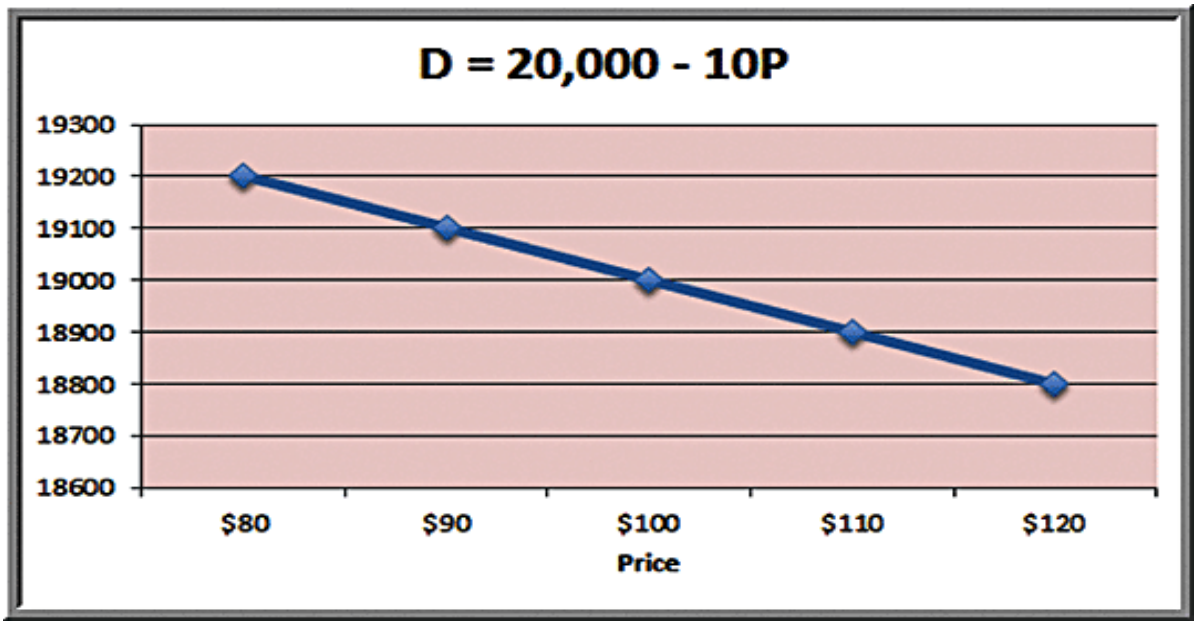
- A key assumption in developing a model is the type of relationship between demand and price.

Example 1.7: A Linear Demand Prediction Model

As price increases, demand falls. A simple model is:

$$D = a - bP$$

where D is the demand, P is the unit price, a is a constant that estimates the demand when the price is zero, and b is the slope of the demand function.

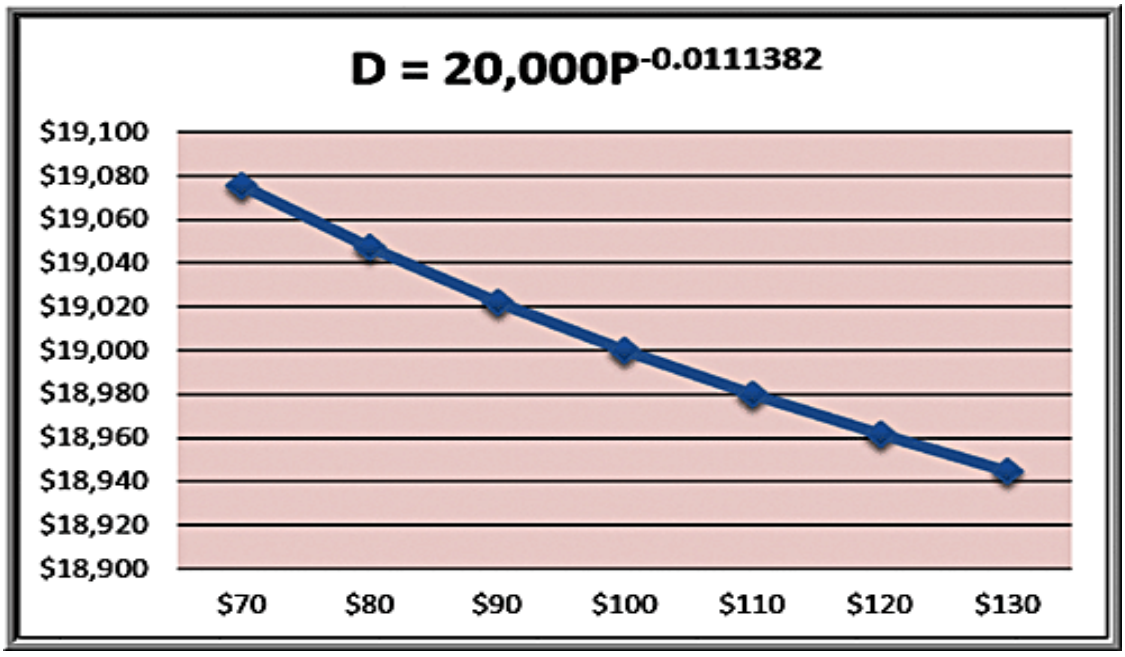


Example 1.8: A Nonlinear Demand Prediction Model

Assumes price elasticity is constant (constant ratio of % change in demand to % change in price):

$$D = cP^{-d}$$

where c is the demand when the price is 0 and $d > 0$ is the price elasticity.



Uncertainty and Risk

- Uncertainty is imperfect knowledge of what will happen in the future.

- Risk is associated with the consequences of what actually happens.

- "*To try to eliminate risk in business enterprise is futile. Risk is inherent in the commitment of present resources to future expectations. Indeed, economic progress can be defined as the ability to take greater risks. The attempt to eliminate risks, even the attempt to minimize them, can only make them irrational and unbearable. It can only result in the greatest risk of all: rigidity*."
  – Peter Drucker

Problem Solving with Analytics

- Recognizing a problem
- Defining the problem
- Structuring the problem
- Analyzing the problem
- Interpreting results and making a decision
- Implementing the solution

Recognizing a Problem

Problems exist when there is a gap between what is happening and what we think should be happening.

- For example, costs are too high compared with competitors.

Defining the Problem

- Clearly defining the problem is not a trivial task.

- Complexity increases when the following occur:
  - large number of courses of action
  - the problem belongs to a group and not an individual
  - competing objectives
  - external groups are affected
  - problem owner and problem solver are not the same person
  - time limitations exist

Structuring the Problem

- Stating goals and objectives
- Characterizing the possible decisions
- Identifying any constraints or restrictions

Analyzing the Problem

- Analytics plays a major role.
- Analysis involves some sort of experimentation or solution process, such as evaluating different scenarios, analyzing risks associated with various decision alternatives, finding a solution that meets certain goals, or determining an optimal solution.

Interpreting Results and Making a Decision

- Models cannot capture every detail of the real problem.
- Managers must understand the limitations of models and their underlying assumptions and often incorporate judgment into making a decision.

Implementing the Solution

- Translate the results of the model back to the real world.

- Requires providing adequate resources, motivating employees, eliminating resistance to change, modifying organizational policies, and developing trust.