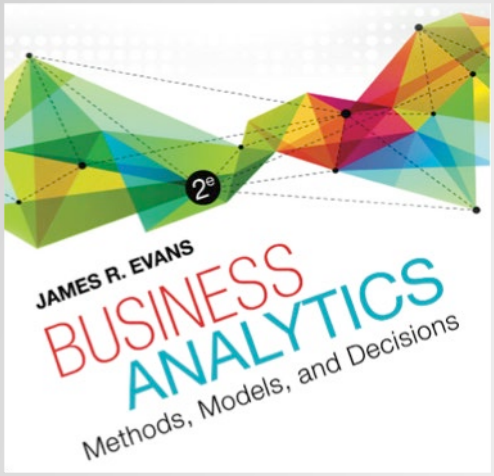


Chapter 1 Introduction to Business Analytics

Case Example

- Cincy zoo – increase revenue from visitors, membership, food & retails – truly transformed customer experience: look at visitors' behavior, tailor operations to their preferences → increase attendance, boost membership, maximize sales through technical solutions (IBM) and real-time information (analytics, weather forecast) → 411% ROI:

- Targeting visitors through ZIP codes
- Offering a mix of products on sale, especially during peak times
- Cutting costs by eliminating ineffective campaigns

Why analytics are so important?

- Similarly, have you watched the Moneyball movie? Visit https://datasciencedegree.wisconsin.edu/blog/moneyball-proves-importance-big-data-big-ideas/ to get a better idea.

- Analytics are important to help managers make business decisions based on real data, not just assumptions and experience. Analytics help organizations to not only understand historical data and to predict future tendencies, but to also prevent problems such as financial frauds.

Business Analytics

(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.

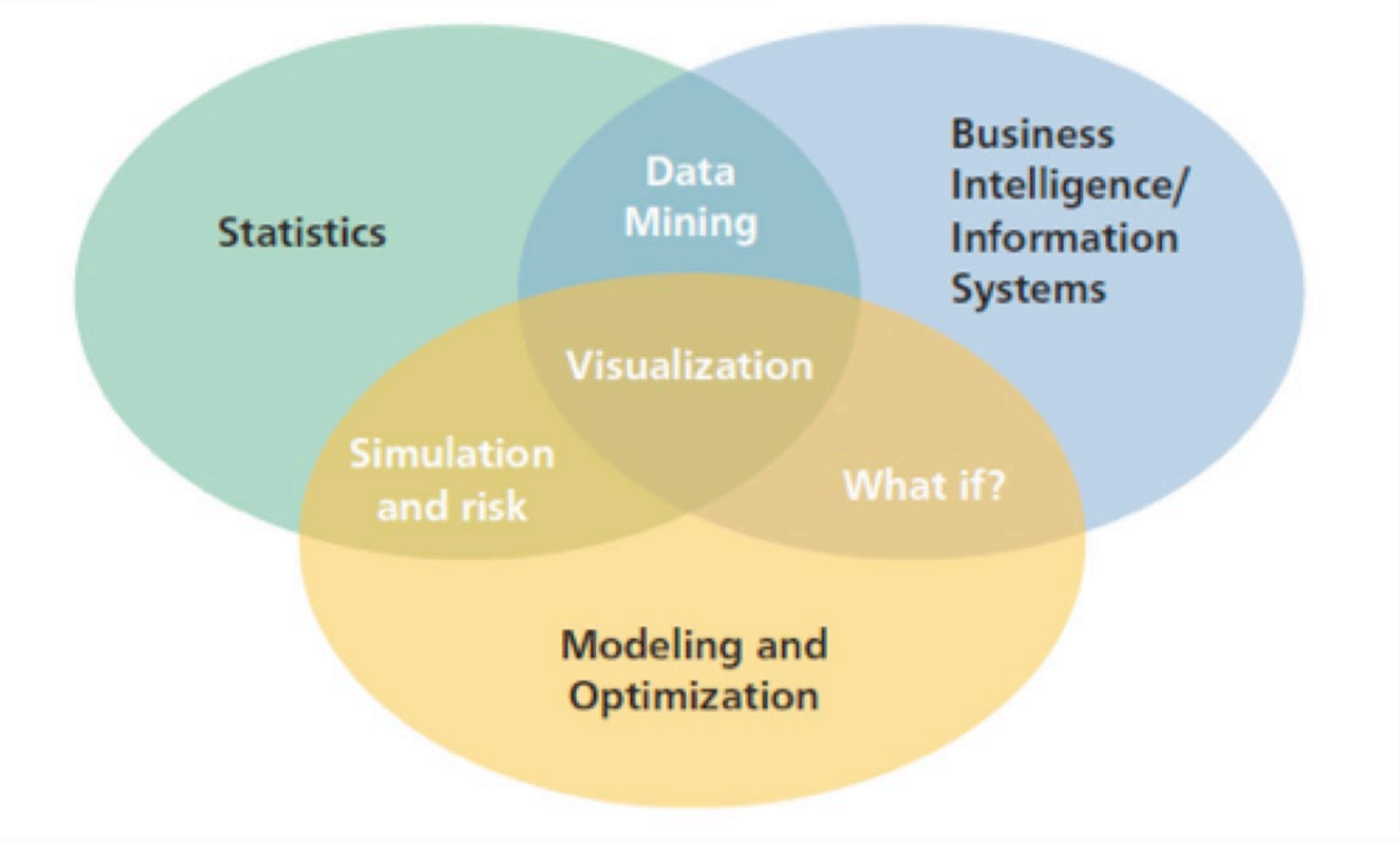
Examples of Applications

- **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 ATMs, or where to service industrial equipment
- **Social Media**
  - understand trends and customer perceptions; assist marketing managers and product designers

Evolution of Business Analytics

- Business intelligence
- Information Systems
- Statistics
- Operations research/Management science
- Decision support systems

A Visual Perspective of Business Analytics



Impacts and Challenges

- **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.

Scope of Business 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

Tools

- Database queries and analysis
- Dashboards to report key performance measures
- Data visualization
- Statistical methods
- Spreadsheets and predictive models
- Scenario and “what-if” analyses
- Simulation
- Forecasting
- Data and text mining
- Optimization
- Social media, web, and text analytics

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:
  - Descriptive analytics: examine historical data for similar products (prices, units sold, advertising, …)
  - Predictive analytics: predict sales based on price
  - Prescriptive analytics: find the best sets of pricing and advertising to maximize sales revenue

Software Support

- IBM Cognos Express
  - An integrated business intelligence and planning solution designed to meet the needs of midsize companies, provides reporting, analysis, dashboard, scorecard, planning, budgeting and forecasting capabilities.
- SAS Analytics
  - Predictive modeling and data mining, visualization, forecasting, optimization and model management, statistical analysis, text analytics, and more.
- Tableau Software
  - Simple drag and drop tools for visualizing data from spreadsheets and other databases.

Data for Business Analytics

- **Data**: numerical or textual facts and figures 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.

Data Sets and Databases

- **Data set** - a collection of data.
  - Examples: Marketing survey responses, a table of historical stock prices, and a collection of measurements of dimensions of a manufactured item.
- **Database** - a collection of related files containing records on people, places, or things.
  - A database file is usually organized in a two-dimensional table, where the columns correspond to each individual element of data (called *fields*, or *attributes*), and the rows represent records of related data elements.

Example 1.2: A Sales Transaction Database File

	A	B	C	D	E	F	G	H
1	**Sales Transactions: July 14**							
2								
3	**Cust ID**	**Region**	**Payment**	**Transaction Code**	**Source**	**Amount**	**Product**	**Time Of Day**
4	10001	East	Paypal	93816545	Web	$20.19	DVD	22:19
5	10002	West	Credit	74083490	Web	$17.85	DVD	13:27
6	10003	North	Credit	64942368	Web	$23.98	DVD	14:27
7	10004	West	Paypal	70560957	Email	$23.51	Book	15:38
8	10005	South	Credit	35208817	Web	$15.33	Book	15:21
9	10006	West	Paypal	20978903	Email	$17.30	DVD	13:11
10	10007	East	Credit	80103311	Web	$177.72	Book	21:59
11	10008	West	Credit	14132683	Web	$21.76	Book	4:04
12	10009	West	Paypal	40128225	Web	$15.92	DVD	19:35
13	10010	South	Paypal	49073721	Web	$23.39	DVD	13:26

Records

Entities

Fields or Attributes

Big Data

- **Big data** to refer to massive amounts of business data from a wide variety of sources, much of which is available in real time, and much of which is uncertain or unpredictable. IBM calls these characteristics **volume**, **variety**, **velocity,** and **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

Metrics and Data Classification

- **Metric** - a unit of measurement that provides a way to objectively quantify performance.
- **Measurement** - the act of obtaining data associated with a metric.
- **Measures** - numerical values associated with a metric.

Types of Metrics

- **Discrete metric** - one that is derived from counting something.
  - For example, a delivery is either on time or not; an order is complete or incomplete; or an invoice can have one, two, three, or any number of errors. Some discrete metrics would be the proportion of on-time deliveries; the number of incomplete orders each day, and the number of errors per invoice.
- **Continuous metrics** are based on a continuous scale of measurement.
  - Any metrics involving dollars, length, time, volume, or weight, for example, are continuous.

Measurement Scales

- **Categorical (nominal) data** - sorted into categories according to specified characteristics.
- **Ordinal data** - can be ordered or ranked according to some relationship to one another.
- **Interval data** - ordinal but have constant differences between observations and have arbitrary zero points.
- **Ratio data** - continuous and have a natural zero.

Example 1.3: Classifying Data Elements

	A	B	C	D	E	F	G	H	I	J
1	**Purchase Orders**									
2										
3	**Supplier**	**Order No.**	**Item No.**	**Item Description**	**Item Cost**	**Quantity**	**Cost per order**	**A/P Terms (Months)**	**Order Date**	**Arrival Date**
4	Hulkey Fasteners	Aug11001	1122	Airframe fasteners	$ 4.25	19,500	$ 82,875.00	30	08/05/11	08/13/11
5	Alum Sheeting	Aug11002	1243	Airframe fasteners	$ 4.25	10,000	$ 42,500.00	30	08/08/11	08/14/11
6	Fast-Tie Aerospace	Aug11003	5462	Shielded Cable/ft.	$ 1.05	23,000	$ 24,150.00	30	08/10/11	08/15/11
7	Fast-Tie Aerospace	Aug11004	5462	Shielded Cable/ft.	$ 1.05	21,500	$ 22,575.00	30	08/15/11	08/22/11
8	Steelpin Inc.	Aug11005	5319	Shielded Cable/ft.	$ 1.10	17,500	$ 19,250.00	30	08/20/11	08/31/11
9	Fast-Tie Aerospace	Aug11006	5462	Shielded Cable/ft.	$ 1.05	22,500	$ 23,625.00	30	08/20/11	08/26/11
10	Steelpin Inc.	Aug11007	4312	Bolt-nut package	$ 3.75	4,250	$ 15,937.50	30	08/25/11	09/01/11
11	Durrable Products	Aug11008	7258	Pressure Gauge	$ 90.00	100	$ 9,000.00	45	08/25/11	08/28/11
12	Fast-Tie Aerospace	Aug11009	6321	O-Ring	$ 2.45	1,300	$ 3,185.00	30	08/25/11	09/04/11
13	Fast-Tie Aerospace	Aug11010	5462	Shielded Cable/ft.	$ 1.05	22,500	$ 23,625.00	30	08/25/11	09/02/11
14	Steelpin Inc.	Aug11011	5319	Shielded Cable/ft.	$ 1.10	18,100	$ 19,910.00	30	08/25/11	09/05/11
15	Hulkey Fasteners	Aug11012	3166	Electrical Connector	$ 1.25	5,600	$ 7,000.00	30	08/25/11	08/29/11

Categorical
Ordinal
Categorical
Categorical
Ratio
Ratio
Ratio
Ratio
Interval
Interval

Data Reliability and Validity

- **Reliability** - data are accurate and consistent.
- **Validity** - data correctly measures what it is supposed to measure.
- 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.
  - The number of calls to a customer service desk might be counted correctly each day (and thus is a reliable measure) but not valid if it is used to assess customer dissatisfaction, as many calls may be simple queries.
  - 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.

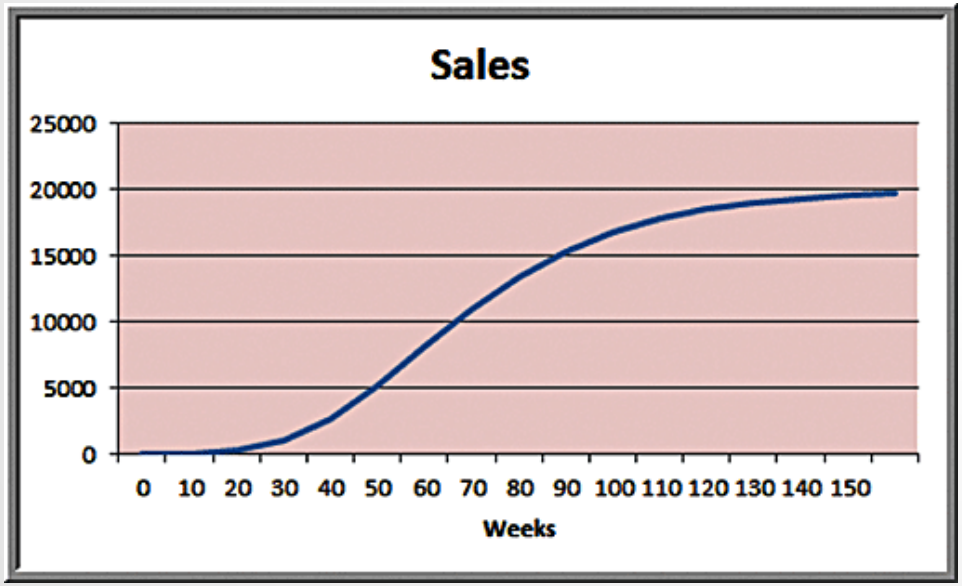
Example 1.4: Three Forms of a Model

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

1. **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 1.4 (continued)

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



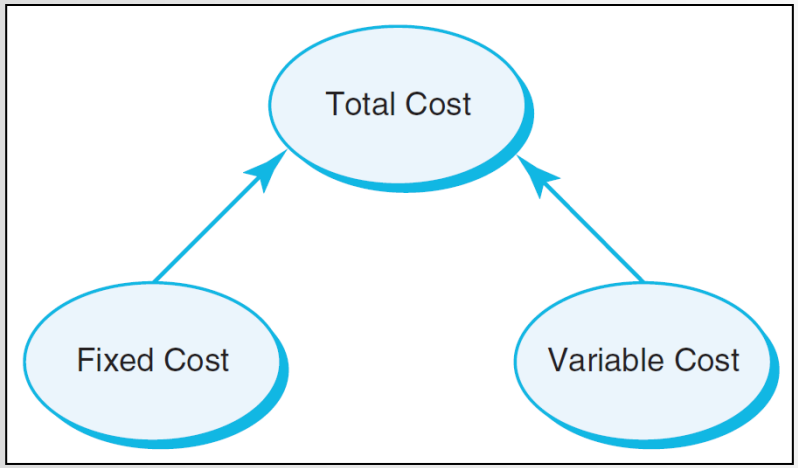
Example 1.4 (continued)

3. **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.

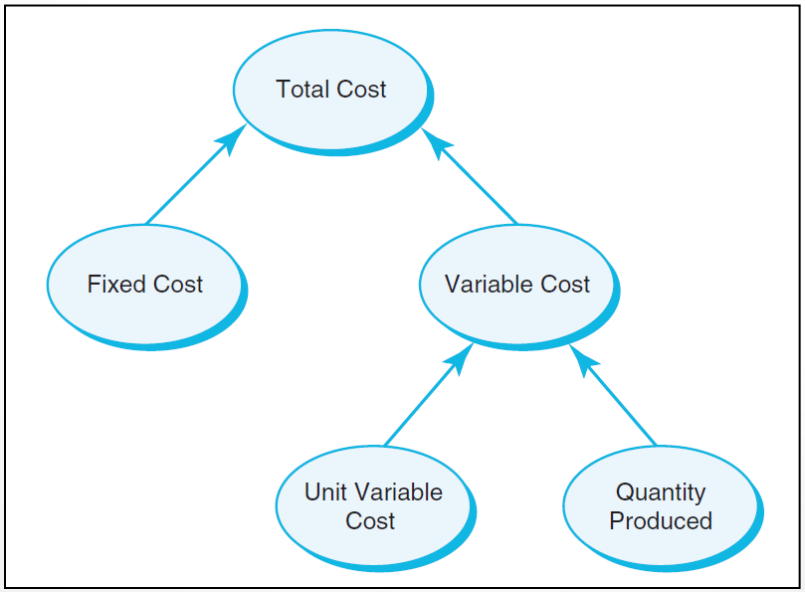
Influence Diagrams

- **Influence diagram** - a visual representation of a descriptive model that shows how the elements of the model influence, or relate to, others.
  - An influence diagram is a useful approach for conceptualizing the structure of a model and can assist in building a mathematical or spreadsheet model.

Example 1.5: An Influence Diagram for Total Cost



Basic



Expanded

Example 1.6: Building a Mathematical Model

- total cost = fixed cost + variable cost (1.1)
- variable cost = unit variable cost × quantity produced (1.2)
- total cost = fixed cost + variable cost
  = fixed cost + unit variable cost × quantity produced (1.3)

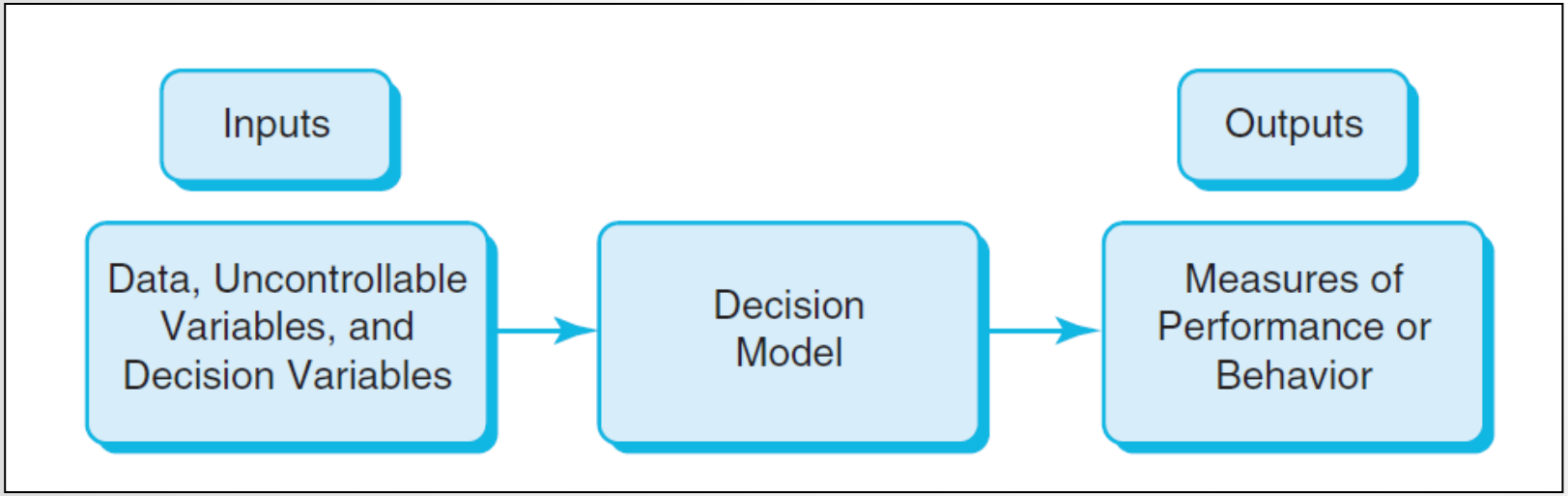
Mathematical model:

- TC = Total Cost
- F = Fixed cost
- V = Variable unit cost
- Q = Quantity produced
- $TC = F + VQ$ (1.4)

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*, which are assumed to be constant for purposes of the model.
  - *Uncontrollable variables*, which are quantities that can change but cannot be directly controlled by the decision maker.
  - *Decision variables*, which are controllable and can be selected at the discretion of the decision maker.

Nature of Decision Models



Example 1.7 A Break-Even Decision Model

TC(manufacturing) = $50,000 + $125*Q*

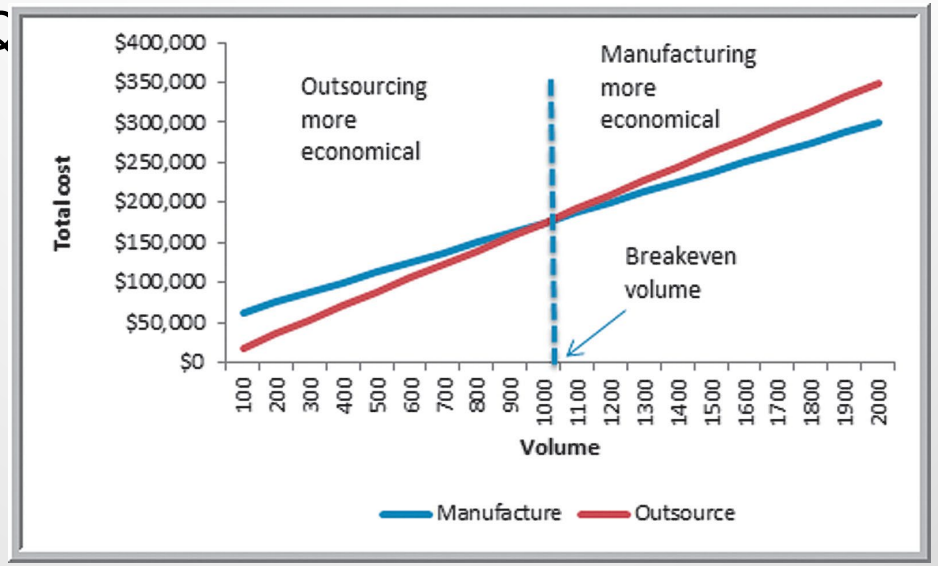
TC(outsourcing) = $175*Q*

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

$50,000 + $125 × *Q* = $175 × *Q*

$50,000 = 50 × *Q*

Q = 1,000



- **General Formula**

F + *VQ* = *CQ*

Q = *F*/(*C* - *V*) (1.5)

Example 1.8: 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 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

Sales = 500 – 0.05(price) + 30(coupons) + 0.08(advertising) + 0.25(price)(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

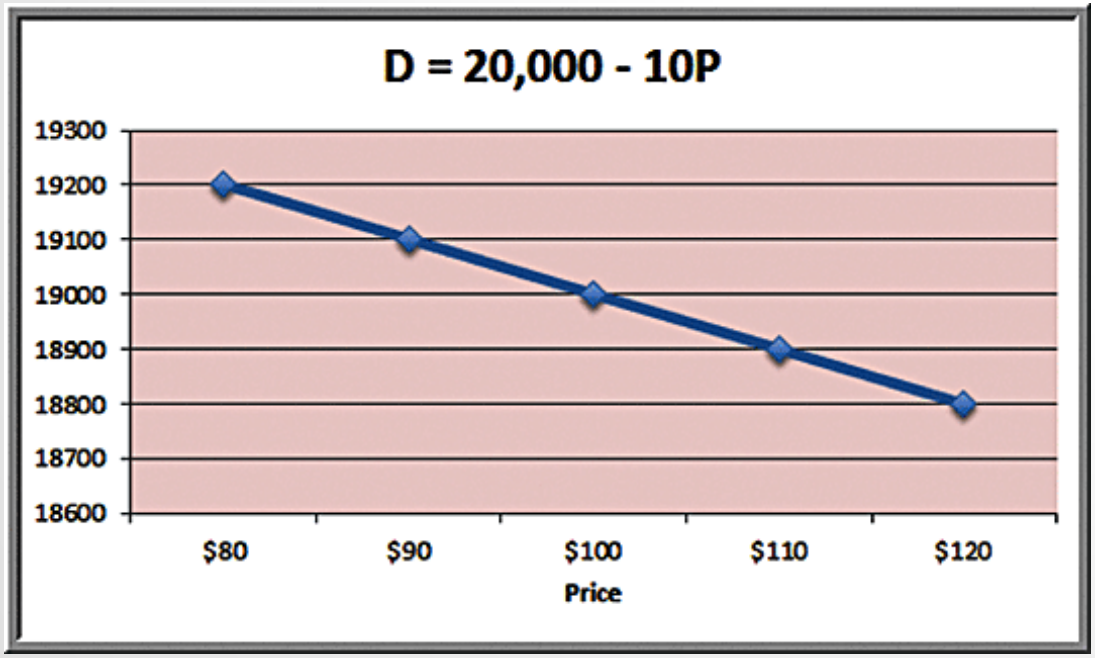
Sales = 500 - 0.05 × $6.99 + 30 × 0 + 0.08 × 0 + 0.25 × $6.99 × 0 = 500 units

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.
- 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).

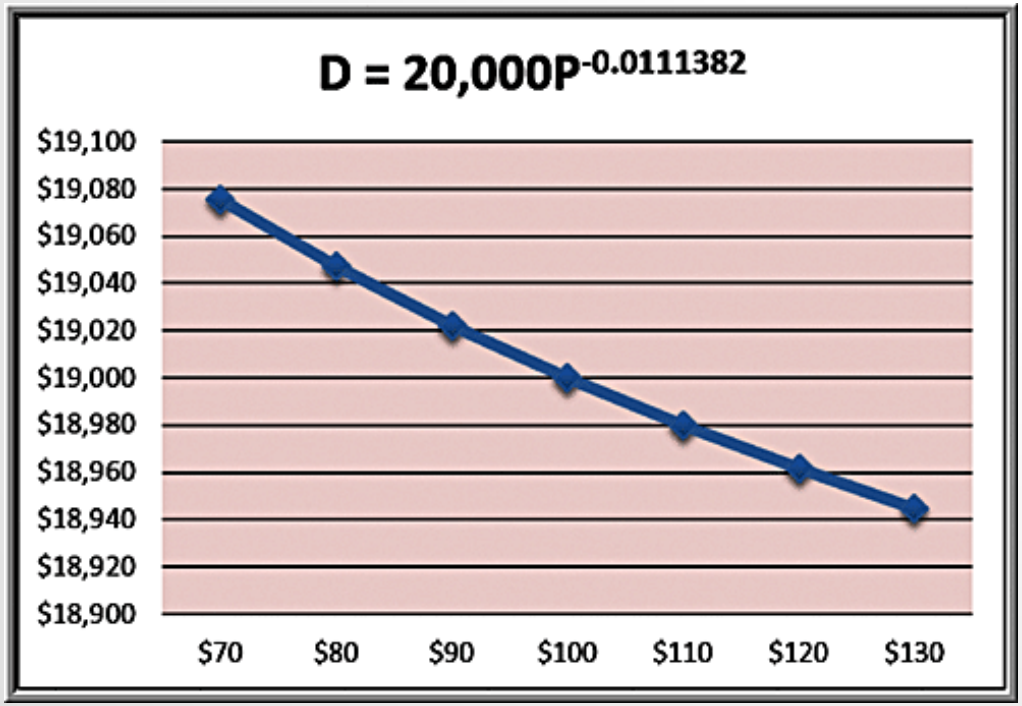
Example 1.9: A Linear Demand Prediction Model

As price increases, demand falls.



Example 1.10 A Nonlinear Demand Prediction Model

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



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

Prescriptive Decision Models

- **Prescriptive decision models** help decision makers identify the best solution.
- **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.
  - **Constraints** - limitations or restrictions.
  - **Optimal solution** - values of the decision variables at the minimum (or maximum) point.

Example 1.11: 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(price) + 3240.9

  Total revenue = (price)(sales)

  $= \text{price} \times (-2.9485 \times \text{price} + 3240.9)$

  $= 22.9485 \times \text{price}^2 + 3240.9 \times \text{price}$

- Identify the price that maximizes total revenue, subject to any constraints that might exist.

Types of Prescriptive Models

- **Deterministic model** – all model input information is known with certainty.
- **Stochastic model** – some model input information is uncertain.
  - For instance, suppose that customer demand is an important element of some model. We can make the assumption that the demand is known with certainty; say, 5,000 units per month (deterministic). On the other hand, suppose we have evidence to indicate that demand is uncertain, with an average value of 5,000 units per month, but which typically varies between 3,200 and 6,800 units (stochastic).

Problem Solving With Analytics

1. Recognizing a problem
2. Defining the problem
3. Structuring the problem
4. Analyzing the problem
5. Interpreting results and making a decision
6. 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.

Setting up Google Analytics

- If you have not done so, please email me (albert.kalim@asbury.edu) your Gmail address so I can add you to access a real-world analytics dashboard that is part of the course project/assignment.

Homework 1 – Email the answers to me (albert.kalim@asbury.edu) by Sunday, 5/22/22, by 11:59 p.m. ET 10 points total (2.5 points each)

- 1. Suggest some metrics that a teacher might want to collect about their students.
- 2. Suggest some metrics that a megachurch might want to collect about their attendees.
- 3. Suggest some metrics that TikTok might want to collect about their users.
- 4. Suggest some metrics that Amazon.com might want to collect about their customers.