Operations Management

Chapter 7 –
Location Decision

PowerPoint presentation to accompany
Heizer /Render, Operations Management, 12 th Ed.

Location Decision

- One of the most important decisions a firm makes
- Facility location is the process of determining a geographic site for a firm's operations. Managers of both service and manufacturing organizations must weigh many factors when assessing the desirability of a particular site.
- The selection of location is a strategic-decision as large investment is made in building plant and machinery. It is not advisable or not possible to change the location very often. So an improper location of plant may lead to waste of all the investments made in building and machinery, equipment.

Location Decision

The objective of location decision is to maximize the benefit of location to the firm

General procedure for location decision making

- ✓ Decide the criteria for evaluating location alternatives, ex: increased revenues, reduction of costs, community service
- ✓ Develop location alternatives
- ✓ Evaluate the alternatives and make a selection

Factors That Affect Location Decisions

- **Labor productivity**
  - Wage rates are not the only cost
  - Lower productivity may increase total cost

$$\frac{\text{Labor cost per day}}{\text{Productivity (units per day)}} = \text{Cost per unit}$$

Site 1

$$\frac{\$70}{60 \text{ units}} = \$1.17 \text{ per unit}$$

Site 2

$$\frac{\$25}{20 \text{ units}} = \$1.25 \text{ per unit}$$

Factors That Affect Location Decisions

- **Exchange rates and currency risks**
  - Can have a significant impact on cost structure
  - Rates change over time
- **Costs**
  - Tangible - easily measured costs such as utilities, labor, materials, taxes
  - Intangible - less easy to quantify and include education, public transportation, community, quality-of-life

Location decisions based on costs alone can create difficult ethical situations

Factors That Affect Location Decisions

- **Political risk, values, and culture**
  - National, state, local governments attitudes toward private and intellectual property, zoning, pollution, employment stability may be in flux
  - Worker attitudes towards turnover, unions, absenteeism
  - Globally cultures have different attitudes towards punctuality, legal, and ethical issues

Factors That Affect Location Decisions

- **Proximity to markets**
  - Very important to services
  - JIT systems or high transportation costs may make it important to manufacturers
- **Proximity to suppliers**
  - Perishable goods, high transportation costs, bulky products

Factors That Affect Location Decisions

- **Proximity to competitors**
  - Often driven by resources such as natural, information, capital, talent
  - Found in both manufacturing and service industries

Methods of Evaluation

1. Factor-Rating Method

2. Cost-Volume

3. Center-of-Gravity Method

4. Transportation Model

Factor-Rating Method

- Popular because a wide variety of factors can be included in the analysis
- Six steps in the method
  1. Develop a list of relevant factors called key success factors
  2. Assign a weight to each factor
  3. Develop a scale for each factor
  4. Score each location for each factor
  5. Multiply score by weights for each factor for each location
  6. **Recommend the location with the highest point score**

Factor-Rating Method

Example 1:

we are considering two different cities: Richmond, Birmingham for the location of a medium-sized Red Bakery Firm. The bakery will produce an assortment of bakery goods on site and will sell directly to retail customers as well as whole sale to grocery stores, restaurants, etc. The factors shown in Table-1 have been evaluated for two cites.

Table-1 Bakery Location Example

	Richmond	Birmingham
Supply of labor	Very good	Excellent
Labor and union relations	Good	Fair
Community attitudes	Excellent	Very good
Government regulations	Poor	Good
Quality of life	Very good	Good
Annual return on investment	9%	15%

Factor-Rating Method

The total score can be computed for each site. This is done by first converting the rating for each non-cost factor to a numerical score.

The conversion for the example is shown in Table-2 using a 10-point scale

Table-2 Computation of Location Score

Weight		Richmond	Birmingham
15	Supply of Labor	8	10
5	Labor and union relations	6	4
5	Community attitudes	10	8
5	Government regulations	2	6
10	Quality of life	8	6
60	Annual return on investment	6	10
100			

Excellent:10, Very good: 8, Good: 6, Fair:4 , Poor:2

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5	Government regulations	2	6
10	Quality of life	8	6
60	Annual return on investment	6	10
100			

Excellent:10, Very good: 8, Good: 6, Fair:4 , Poor:2

Factor-Rating Method

The location with the highest total score is then the best choice.

The total scores are as follows:

$S_1 = 15(8)+5(6)+5(10)+5(2)+10(8)+60(6)$

$S_2 = 15(10)+5(4)+5(8)+5(6)+10(6)+60(10)$

$S_1 = 650$ $\mathbf{S_2 = 900}$

This scoring system, therefore, indicates that alternative 2, Birmingham, is preferred.

Factor-Rating Method

Key Success Factor	Weight	Scores (out of 100) France	Scores (out of 100) Denmark	Weighted Scores France	Weighted Scores Denmark
Labor availability and attitude	.25	70	60	(.25)(70) = 17.5	(.25)(60) = 15.0
People-to-car ratio	.05	50	60	(.05)(50) = 2.5	(.05)(60) = 3.0
Per capita income	.10	85	80	(.10)(85) = 8.5	(.10)(80) = 8.0
Tax structure	.39	75	70	(.39)(75) = 29.3	(.39)(70) = 27.3
Education and health	.21	60	70	(.21)(60) = 12.6	(.21)(70) = 14.7
Totals	1.00			70.4	68.0

Factor-Rating Method

Example 3:

		SCORES (0 TO 100)		
LOCATION FACTOR	WEIGHT	*Site 1*	*Site 2*	*Site 3*
Labor pool and climate	.30	80	65	90
Proximity to suppliers	.20	100	91	75
Wage rates	.15	60	95	72
Community environment	.15	75	80	80
Proximity to customers	.10	65	90	95
Shipping modes	.05	85	92	65
Airport service	.05	50	65	90

Weighted Score for "Labor pool and climate" for Site 1 = (0.30)(80) = 24

Factor-Rating Method

WEIGHTED SCORES		
Site 1	*Site 2*	*Site 3*
24.00	19.50	27.00
20.00	18.20	15.00
9.00	14.25	10.80
11.25	12.00	12.00
6.50	9.00	9.50
4.25	4.60	3.25
2.50	3.25	4.50
77.50	**80.80**	**82.05**

Site 3 has the highest factor rating

Factor-Rating Method

Example 5:

- A photo-processing company intends to open a new branch store. The following table contains information on two potential locations. Which is better?

		Scores (Out of 100)	
Factor	Weight	Alt 1	Alt 2
Proximity to existing source	.10	100	60
Traffic volume	.05	80	80
Rental costs	.40	70	90
Size	.10	86	92
Layout	.20	40	70
Operating Cost	.15	80	90
	1.00		

Factor-Rating Method

		Scores (Out of 100)		Weighted Scores	
Factor	Weight	Alt 1	Alt 2	Alt 1	Alt 2
Proximity to existing source	.10	100	60	.10(100) = 10.0	.10(60) = 6.0
Traffic volume	.05	80	80	.05(80) = 4.0	.05(80) = 4.0
Rental costs	.40	70	90	.40(70) = 28.0	.40(90) = 36.0
Size	.10	86	92	.10(86) = 8.6	.10(92) = 9.2
Layout	.20	40	70	.20(40) = 8.0	.20(70) = 14.0
Operating Cost	.15	80	90	.15(80) = 12.0	.15(90) = 13.5
	1.00			70.6	82.7

Alt 2 has the highest factor rating

Cost-Volume Analysis

- An economic comparison of location alternatives
- Three steps in the method
  1. Determine fixed and variable costs for each location
  2. Plot the cost for each location
  3. Select location with lowest total cost for expected production volume

Cost-Volume Analysis

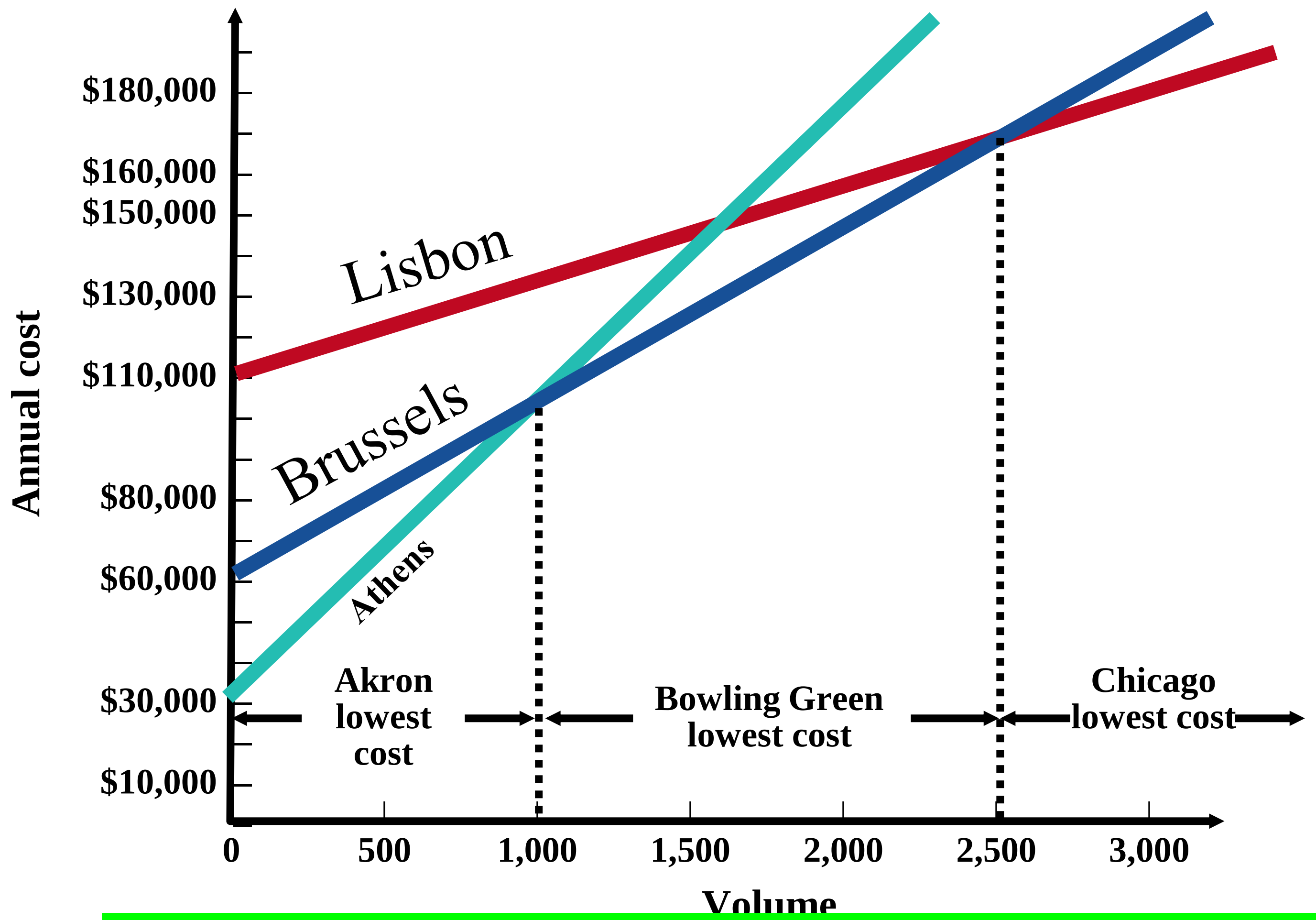
Exemple 1:

Three locations:

What is the best location at an Expected volume = 2,000 units

City	Fixed Cost	Variable Cost	Total Cost
Athens	$30,000	$75	$180,000
Brussels	$60,000	$45	$150,000
Lisbon	$110,000	$25	$160,000

Cost-Volume Analysis



Cost-Volume Analysis

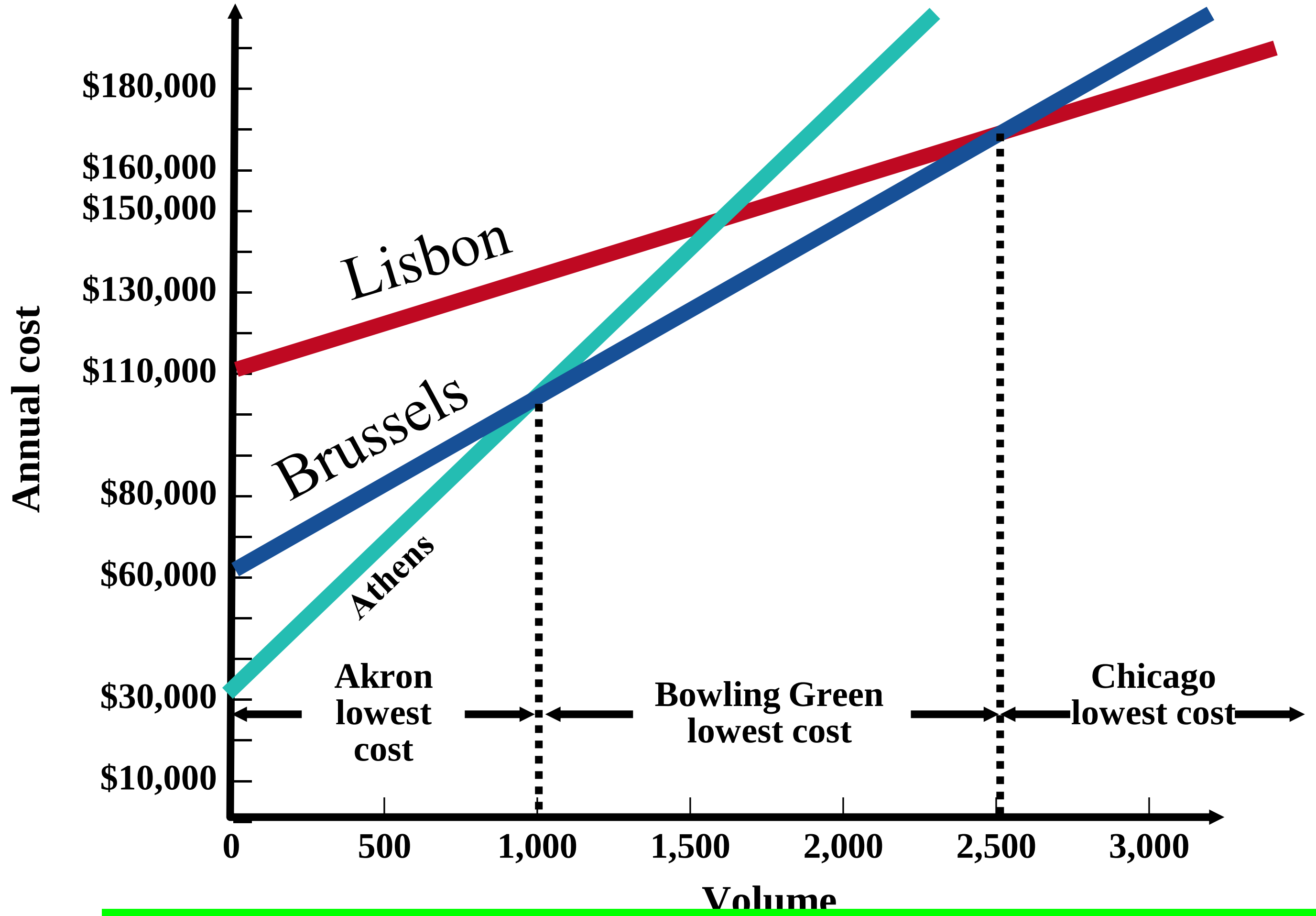
Crossover point – Athens/Brussels

$$30{,}000 + 75(x) = 60{,}000 + 45(x)$$
$$30(x) = 30{,}000$$
$$(x) = 1{,}000$$

Crossover point – Brussels/Lisbon

$$60{,}000 + 45(x) = 110{,}000 + 25(x)$$
$$20(x) = 50{,}000$$
$$(x) = 2{,}500$$

Cost-Volume Analysis



Cost-Volume Analysis

Example 3:

- Fixed and variable costs for four potential plant locations are shown below:

Location	Fixed Cost per Year	Variable Cost per Unit
A	$250,000	$11
B	$100,000	$30
C	$150,000	$20
D	$200,000	$35

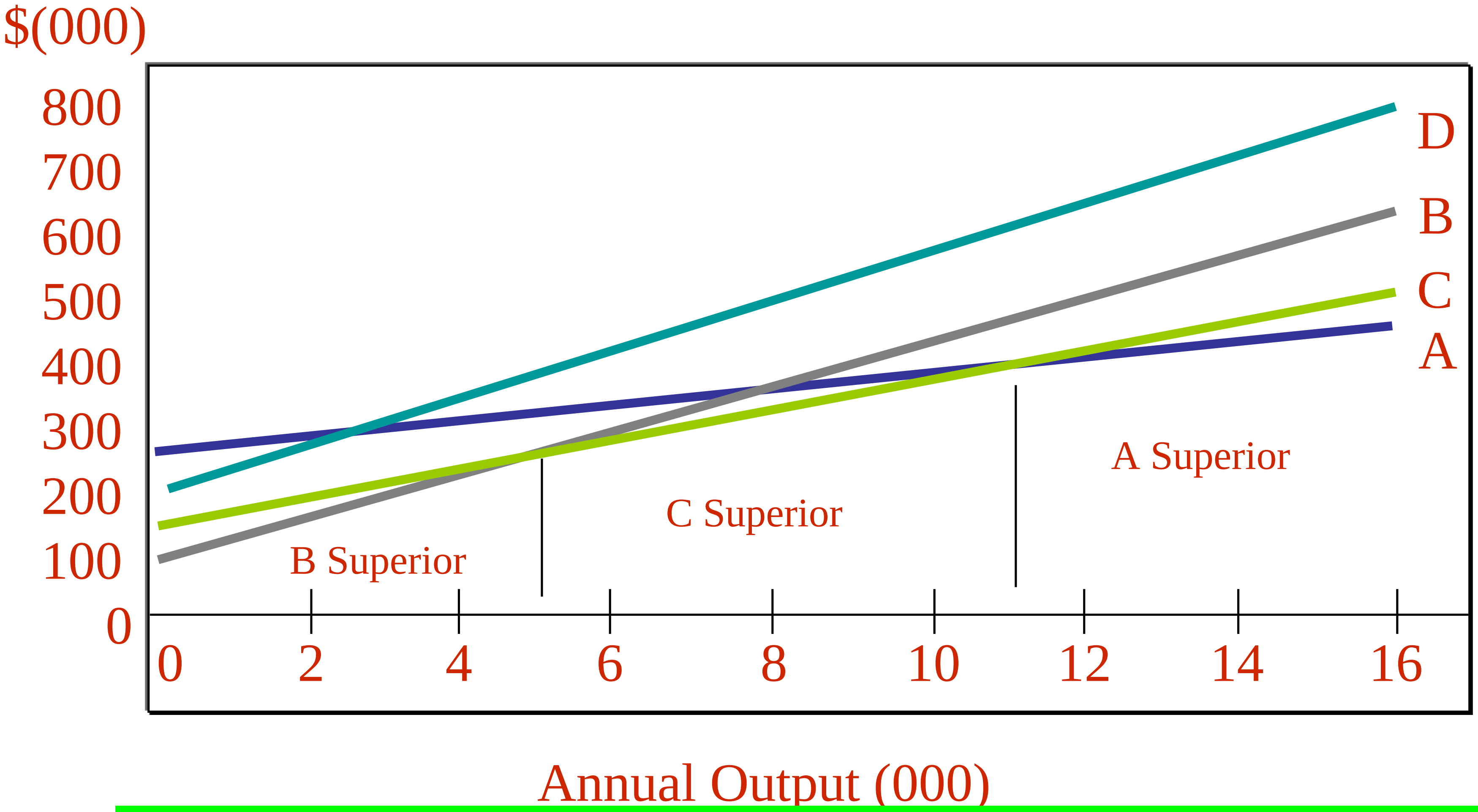
Cost-Volume Analysis

Example 2: Solution

	Fixed Costs	Variable Costs	Total Costs
A	$250,000	$11(10,000)	$360,000
B	100,000	30(10,000)	400,000
C	150,000	20(10,000)	350,000
D	200,000	35(10,000)	550,000

Cost-Volume Analysis

Example 2: Solution



Cost-Volume Analysis

- **Range approximations**
  - B Superior (up to 4,999 units)

$$\text{Total Cost of C} = \text{Total Cost of B}$$
$$150{,}000 + 20Q = 100{,}000 + 30Q$$
$$50{,}000 = 10Q$$
$$Q = 5{,}000$$

  - C Superior (>5,000 to 11,111 units)

$$\text{Total Cost of A} = \text{Total Cost of C}$$
$$250{,}000 + 11Q = 150{,}000 + 20Q$$
$$100{,}000 = 9Q$$
$$Q = 11{,}111.11$$

  - A superior (11,112 units and up)

Center-of-Gravity Method

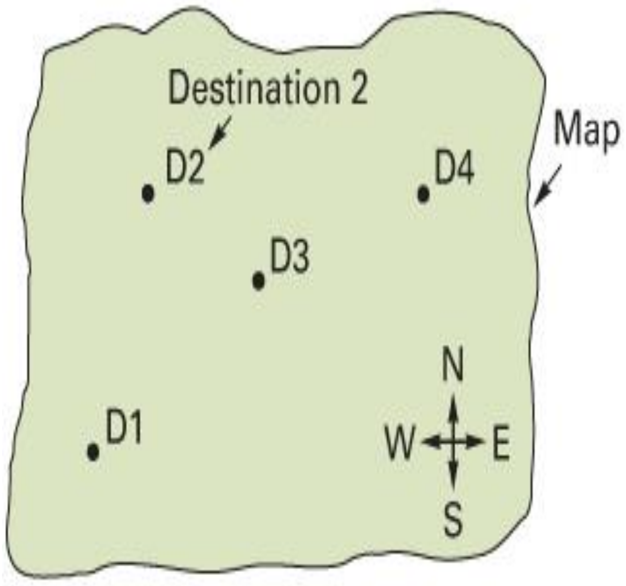
- Finds location of distribution center that minimizes distribution costs
- Considers
  - Location of markets
  - Volume of goods shipped to those markets
  - Shipping cost (or distance)

Center-of-Gravity Method

- Place existing locations on a coordinate grid

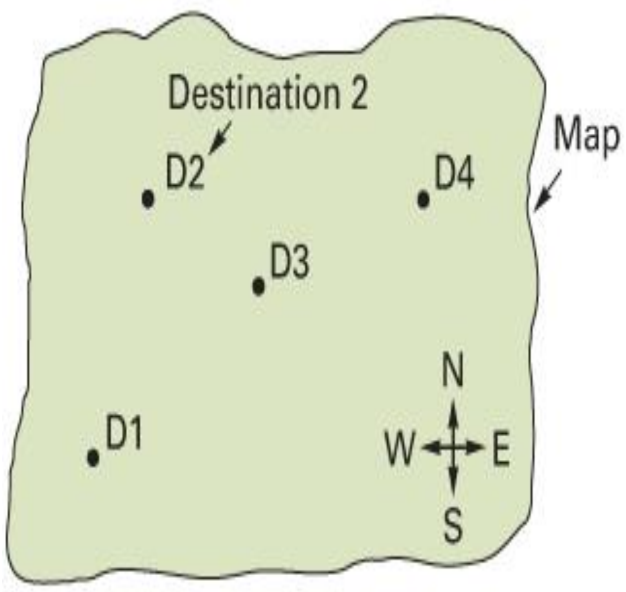
- Calculate X and Y coordinates for ‘center of gravity’
  - Assumes cost is directly proportional to distance and volume shipped

Center-of-Gravity Method



a) Map showing destinations

Center-of-Gravity Method



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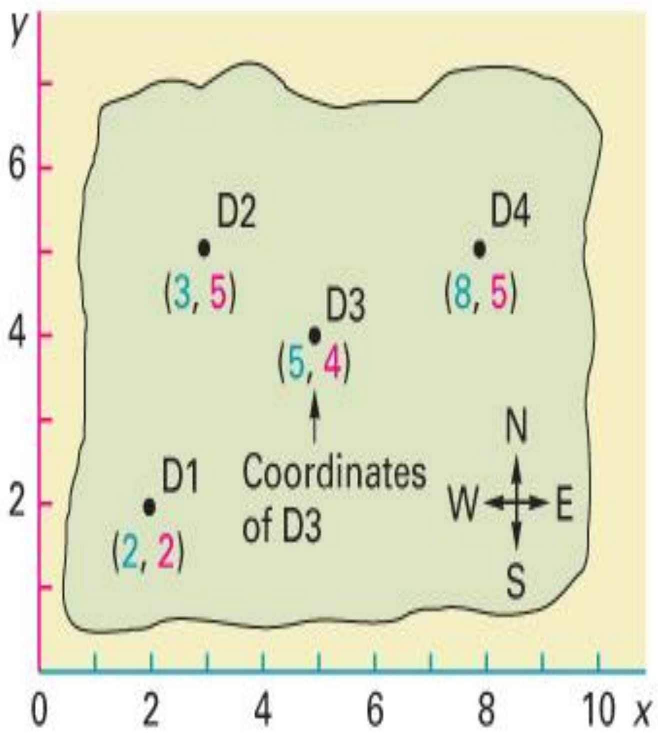


b) Coordinate system added

Center-of-Gravity Method

- If quantities to be shipped to every location are equal, you can obtain the coordinates of the center of gravity by finding the average of the *x*-coordinates and the average of the *y*-coordinates

$$\bar{x} = \frac{\sum x_i}{n}$$

$$\bar{y} = \frac{\sum y_i}{n}$$

where

$x_i = x$ coordinate of destination i

$y_i = y$ coordinate of destination i

$n =$ Number of destinations

Center-of-Gravity Method

Example 1:

Suppose you are attempting to find the center of gravity for the problem depicted in previous Figure

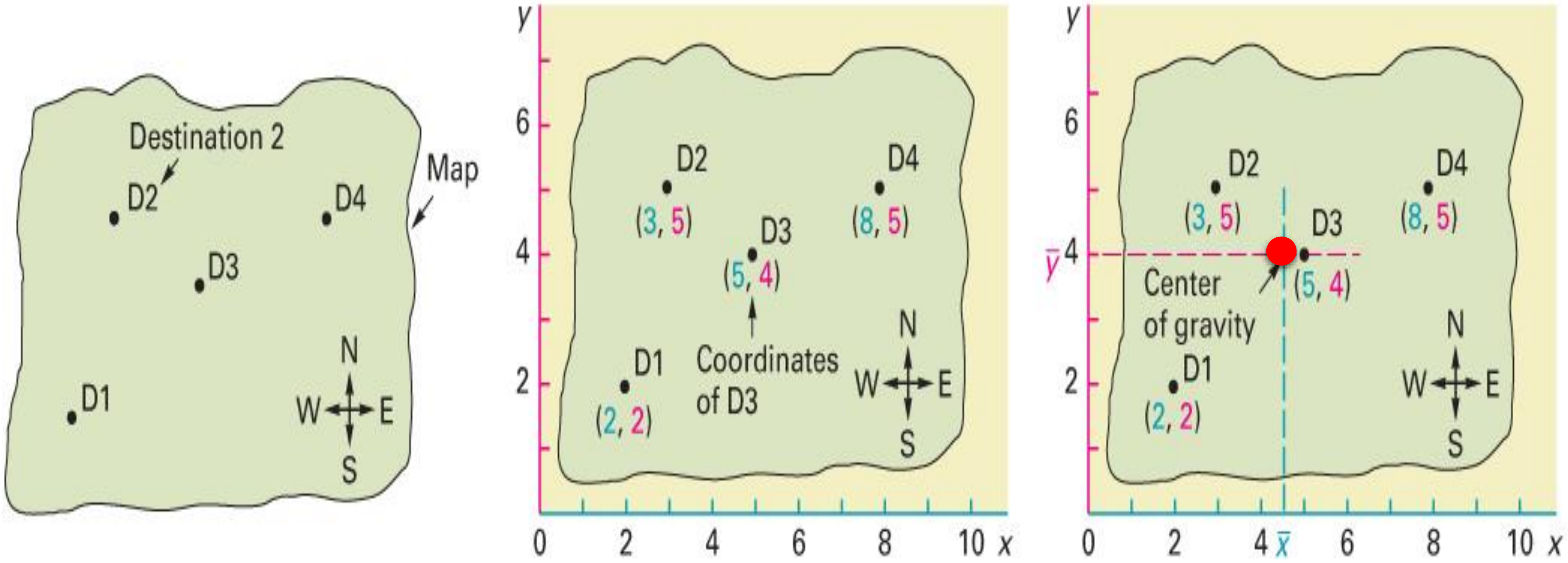
Destination	x	y
D1	2	2
D2	3	5
D3	5	4
D4	8	5
	18	16

$$\bar{x} = \frac{\sum x_i}{n} = \frac{18}{4} = 4.5$$

$$\bar{y} = \frac{\sum y_i}{n} = \frac{16}{4} = 4$$

Here, the center of gravity is (4.5,4). This is slightly west of D3 from last Figure

Center-of-Gravity Method



a) Map showing destinations **b) Coordinate system added** **c) Center of gravity**

Center-of-Gravity Method

When the quantities to be shipped to every location are unequal, you can obtain the coordinates of the center of gravity by finding the weighted average of the *x*-coordinates and the average of the *y*-coordinates

$$\bar{x} = \frac{\sum x_i Q_i}{\sum Q_i}$$

$$\bar{y} = \frac{\sum y_i Q_i}{\sum Q_i}$$

where

Q_i = Quantity to be shipped to destination i

x_i = x coordinate of destination i

y_i = y coordinate of destination i

Center-of-Gravity Method

Example 2:

- Suppose the shipments for the previous problem are not all equal. Determine the center of gravity based on the following information.

Destination	x	y	Weekly Quantity
D1	2	2	800
D2	3	5	900
D3	5	4	200
D4	8	5	100
	18	16	2,000

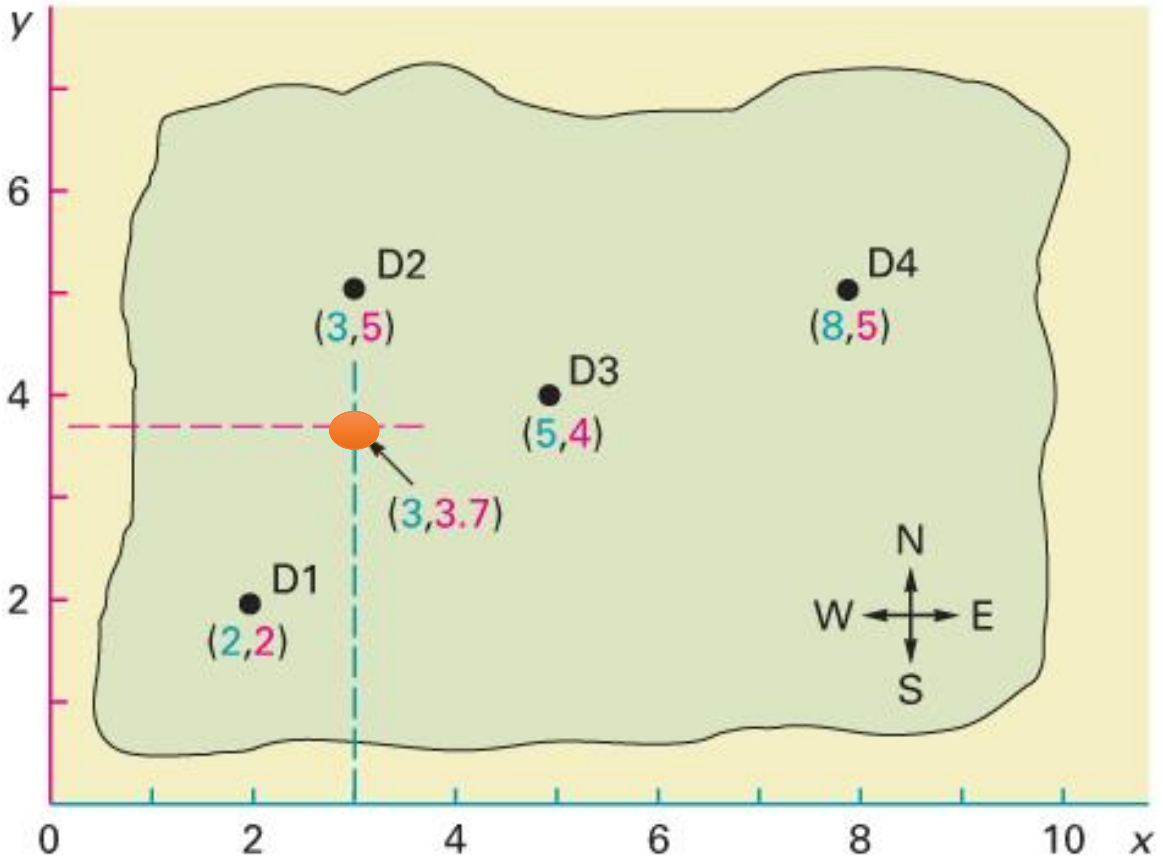
Center-of-Gravity Method

$$\bar{x} = \frac{\sum x_i Q_i}{\sum Q_i} = \frac{2(800)+3(900)+5(200)+8(100)}{2{,}000} = \frac{6{,}100}{2{,}000} = 3.05$$

$$\bar{y} = \frac{\sum y_i Q_i}{\sum Q_i} i = \frac{2(800)+5(900)+4(200)+5(100)}{2{,}000} = \frac{7{,}400}{2{,}000} = 3.7$$

The coordinates for the center of gravity are (3.05, 3.7). You may round the x-coordinate down to 3.0, so the coordinates for the center of gravity are (3.0, 3.7). This is south of destination D2 (3, 5).

Center-of-Gravity Method



Center-of-Gravity Method

Example 3:

Store Location	Number of Containers Shipped per Month
Chicago (30, 120)	2,000
Pittsburgh (90, 110)	1,000
New York (130, 130)	1,000
Atlanta (60, 40)	2,000

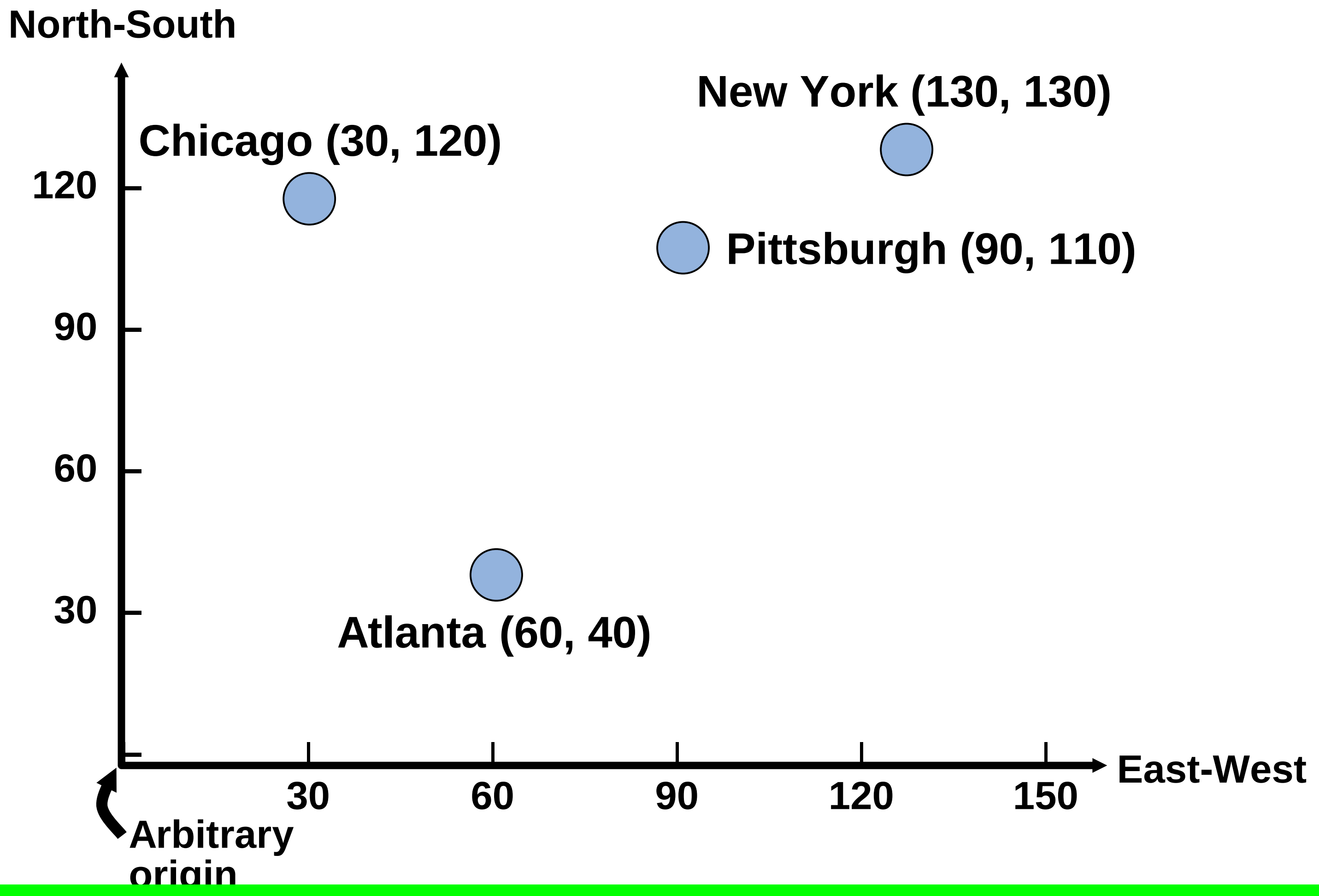
$$x\text{-coordinate} = \frac{(30)(2000) + (90)(1000) + (130)(1000) + (60)(2000)}{2000 + 1000 + 1000 + 2000}$$

$$= 66.7$$

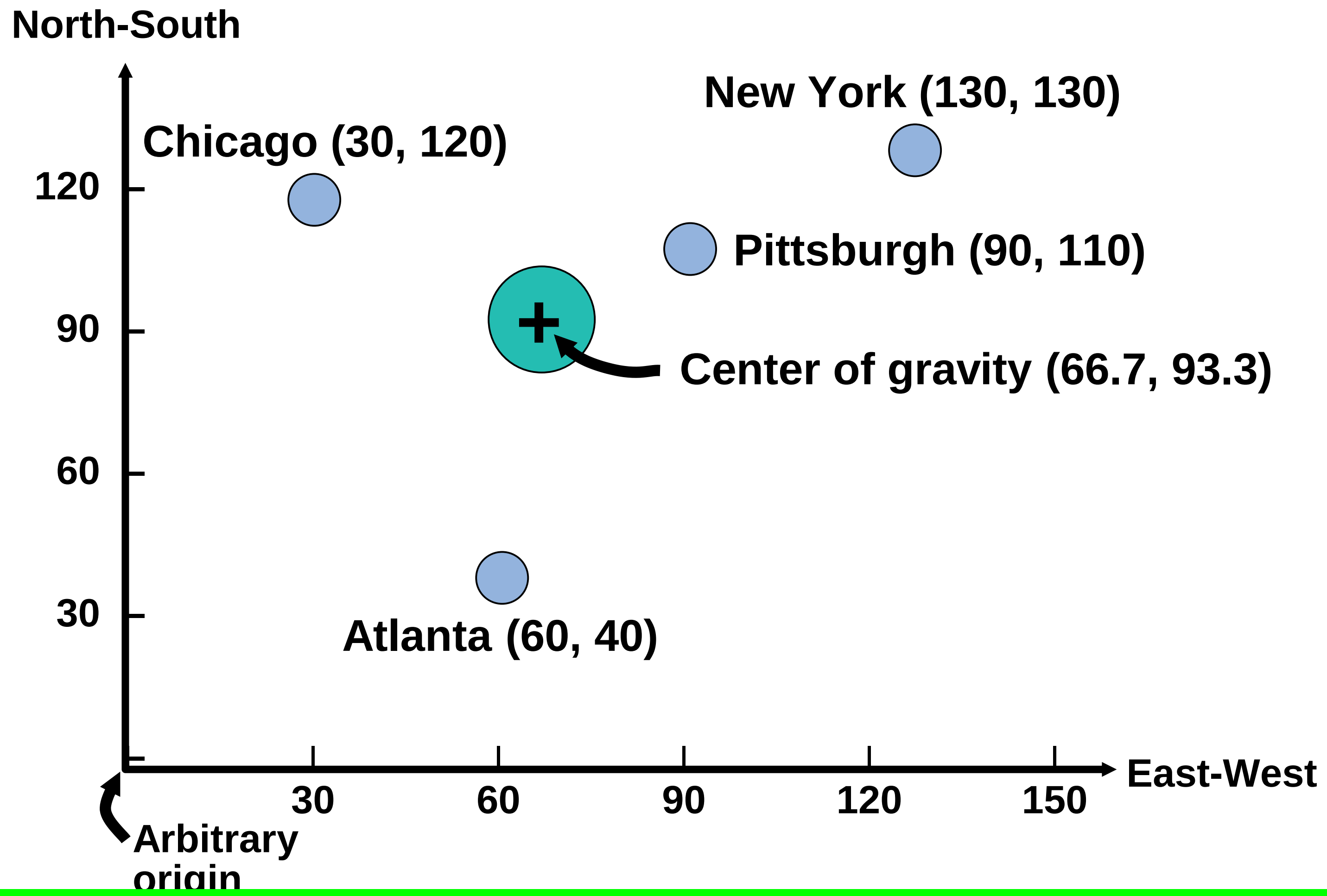
$$y\text{-coordinate} = \frac{(120)(2000) + (110)(1000) + (130)(1000) + (40)(2000)}{2000 + 1000 + 1000 + 2000}$$

$$= 93.3$$

Center-of-Gravity Method



Center-of-Gravity Method

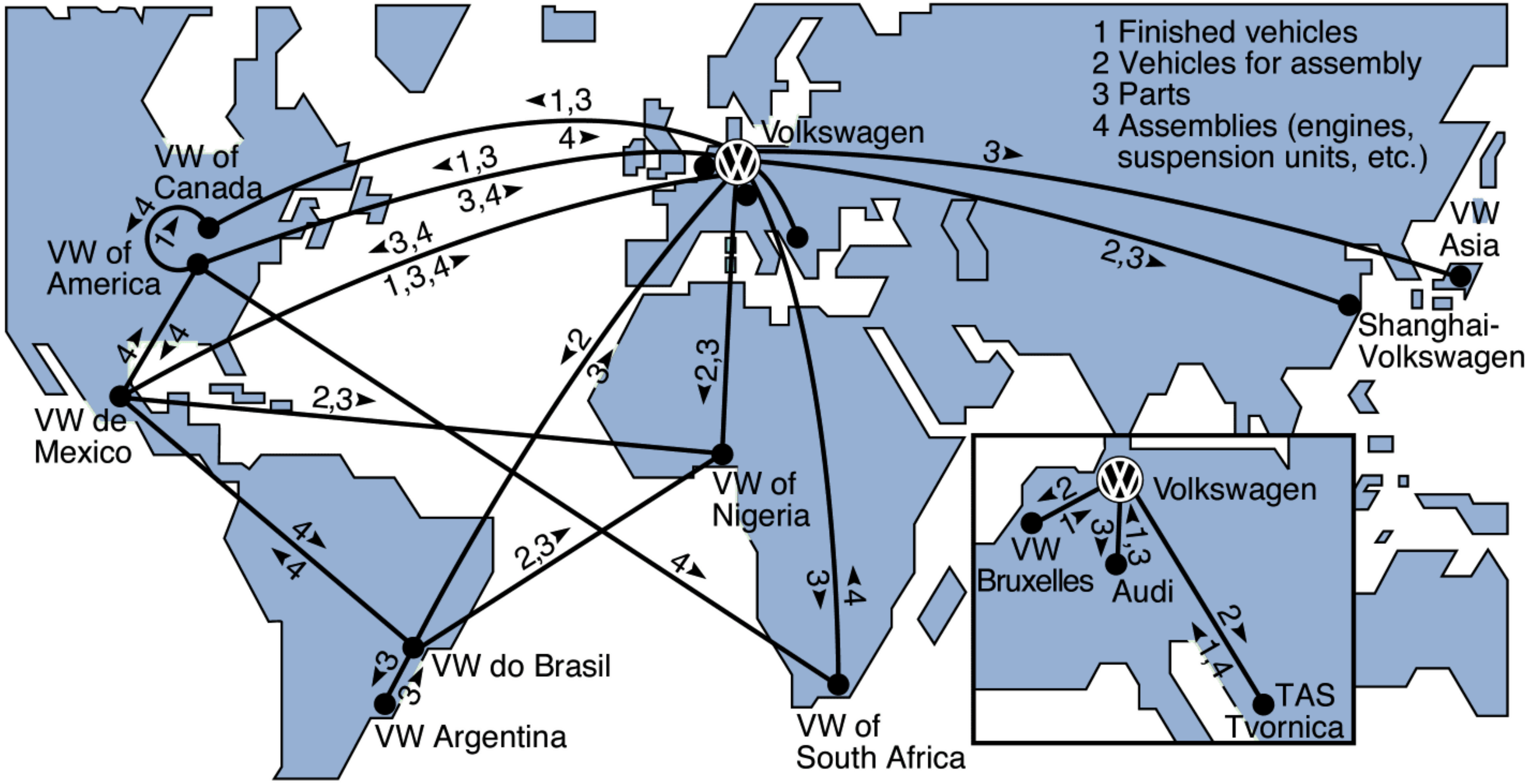


Transportation Model

- Finds amount to be shipped from several points of supply to several points of demand
- Solution will minimize total production and shipping costs
- A special class of linear programming problems

Transportation Model

Worldwide Distribution of Volkswagens and Parts



Transportation Model

Transportation Linear Programming

Transportation adds no value to a product other than place utility.

However, the transportation costs for raw materials and finished goods are often significant and merit special analysis.

Before deciding on a plant location, management may want to know which plants will be used to produce what quantities and to which distribution warehouses all quantities should be shipped.

The location problem can be formulated as one of minimizing a transportation cost, subject to satisfying overall supply and demand requirements.

Transportation Model

- To use the transportation linear-programming format, the demand requirements and supply availabilities are formulated in a rectangular matrix.
- The transportation costs between the supply and demand points are placed in the upper corner of each cell.
- Supply is allocated to meet demand.
- The solution procedure is an iterative one that begins which an initial solution that is feasible but not necessarily optimal.
- The solution is progressively tested and improved upon until an optimal solution is reached.

Transportation Model

Example

From	Supply
1.Cincinati	300
2.Atlanta	200
3.Pittsburg	200

To	Demand
A.New York	150
B.Dallas	250
C.Detroit	300

	Unit Cost Table		
	A	B	C
1	$16	$18	$11
2	$14	$12	$13
3	$13	$15	$17

Transportation Model

Linear Programming Model

X_{ij} $i=1,2,3$ $j=A,B,C$

Objective Function

Minimize

$$Z=16X_{1A}+18X_{1B}+11X_{1C}+14X_{2A}+12X_{2B}+13X_{2C}+13X_{3A}+15X_{3B}+17X_{3C}$$

Subject to:

$X1A+X1B+X1C \leq 300$

$X2A+X2B+X2C \leq 200$ Supply Constraints

$X3A+X3B+X3C \leq 200$

Transportation Model

$X1A+X2A+X3A=150$

$X1B+X2B+X3C=250$ Demand Constraints

$X1C+X2C+X3C=300$

$X_{ij} \geq 0$

Transportation Model

Final Thought

The ideal location for many companies in the future will be a floating factory ship that will go from port to port, from country to country – wherever cost per unit is lowest.