Location

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PPU426

Location decisions

Location decisions affect processes and departments

- Marketing
- Human resources
- Accounting and finance
- Operations
- International operations

Location decisions

Many factors

- Sensitive to location
- High impact on the company's ability to meet its goals
- Divide location factors
  - Dominant
  - secondary

Location decisions

Dominant factors in manufacturing

- Favorable labor climate
- Proximity to markets
- Impact on environment
- Quality of life
- Proximity to suppliers and resources
- Proximity to the parent company’s facilities
- Utilities, taxes, and real estate costs
- Other factors

Location decisions

- **Dominant factors in services**
- **Impact of location on sales and customer satisfaction**
  - Proximity to customers
  - Transportation costs and proximity to markets
  - Location of competitors
  - Site-specific factors

Locating a single facility

Expand onsite, build another facility, or relocate to another site?

- Onsite expansion
- Building a new plant or moving to a new retail or office space

Selecting a new facility

Step 1: Identify the important location factors and categorize them as dominant or secondary

Step 2: Consider alternative regions; then narrow to alternative communities and finally specific sites

Step 3: Collect data on the alternatives

Step 4: Analyze the data collected, beginning with the *quantitative* factors

Step 5: Bring the *qualitative* factors pertaining to each site into the evaluation

Weighted scores

EXAMPLE 11.1

A new medical facility, Health-Watch, is to be located in Erie, Pennsylvania. The following table shows the location factors, weights, and scores (1 = poor, 5 = excellent) for one potential site. The weights in this case add up to 100 percent. A weighted score (*WS*) will be calculated for each site. What is the *WS* for this site?

Location Factor	Weight	Score
Total patient miles per month	25	4
Facility utilization	20	3
Average time per emergency trip	20	3
Expressway accessibility	15	4
Land and construction costs	10	1
Employee preferences	10	5

Weighted scores

SOLUTION

The *WS* for this particular site is calculated by multiplying each factor's weight by its score and adding the results:

Location Factor	Weight	Score
Total patient miles per month	25	4
Facility utilization	20	3
Average time per emergency trip	20	3
Expressway accessibility	15	4
Land and construction costs	10	1
Employee preferences	10	5

$$\boldsymbol{WS = (25 \times 4) + (20 \times 3) + (20 \times 3) + (15 \times 4) + (10 \times 1) + (10 \times 5)}$$
$$\boldsymbol{= 100 + 60 + 60 + 60 + 10 + 50 = 340}$$

The total *WS* of 340 can be compared with the total weighted scores for other sites being evaluated.

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Weighted scores

Example:

Management is considering three potential locations for a new ball bearing factory. They have assigned scores shown below to the relevant factors on a 0 to 10 basis (10 is best). Using the preference matrix, which location would be preferred?

Location Factor	Weight	Eastland	Westland	Northland
Material Supply	0.1	5	9	8
Quality of Life	0.2	9	8	4
Mild Climate	0.3	10	6	8
Labor Skills	0.4	3	4	7

Weighted scores

Example:

Management is considering three potential locations for a new ball bearing factory. They have assigned scores shown below to the relevant factors on a 0 to 10 basis (10 is best). Using the preference matrix, which location would be preferred?

Location Factor	Weight	Eastland		Westland		Northland	
Material Supply	0.1 ×	5 =	0.5	9	0.9	8	0.8
Quality of Life	0.2	9	1.8	8	1.6	4	0.8
Mild Climate	0.3	10	3.0	6	1.8	8	2.4
Labor Skills	0.4	3	1.2	4	1.6	7	2.8
			6.5		5.9		6.8

Load-Distance (ld) method

- **Identify and compare candidate locations**
  - Like weighted-distance method
  - Select a location that *minimizes* the sum of the loads multiplied by the distance the load travels
  - Time may be used instead of distance

Load-Distance (ld) method

- **Calculating a load-distance score**
  - Varies by industry
  - Use the actual distance to calculate *ld* score
  - Use Rectilinear or Euclidean distances
  - Different measures for distance
  - Find one acceptable facility location that minimizes the *ld* score

Formula for the *ld* score:

$$ld = \sum_i l_i d_i$$

Load-Distance (ld) method

Example:

What is the distance between (20, 10) and (80, 60)?

SOLUTION

Euclidean distance:

$$d_{AB} = \sqrt{(x_A - x_B)^2 + (y_A - y_B)^2} = \sqrt{(20 - 80)^2 + (10 - 60)^2} = 78.1$$

Rectilinear distance:

$$d_{AB} = |x_A - x_B| + |y_A - y_B| = |20 - 80| + |10 - 60| = 110$$

Load-Distance (ld) method

Example:

Management is investigating which location would be best to position its new plant relative to two suppliers (located in Cleveland and Toledo) and three market areas (represented by Cincinnati, Dayton, and Lima). Management has limited the search for this plant to those five locations. The following information has been collected. Which is best, assuming rectilinear distance?

Location	*x,y* coordinates	Trips/year
Cincinnati	(11,6)	15
Dayton	(6,10)	20
Cleveland	(14,12)	30
Toledo	(9,12)	25
Lima	(13,8)	40

Load-Distance (ld) method

SOLUTION

Calculations:

Location	*x,y* coordinates	Trips/year
Cincinnati	(11,6)	15
Dayton	(6,10)	20
Cleveland	(14,12)	30
Toledo	(9,12)	25
Lima	(13,8)	40

Cincinnati = 15(0) + 20(9) + 30(9) + 25(8) + 40(4) = 810

Dayton = 15(9) + 20(0) + 30(10) + 25(5) + 40(9) = 920

Cleveland = 15(9) + 20(10) + 30(0) + 25(5) + 40(5) = 660

Toledo = 15(8) + 20(5) + 30(5) + 25(0) + 40(8) = 690

Lima = 15(4) + 20(9) + 30(5) + 25(8) + 40(0) = 590

Center of Gravity Method

- **A good starting point**
  - Find x coordinate, x^*, by multiplying each point's x coordinate by its load (l_t), summing these products $\Sigma l_i x_i$, and dividing by Σl_i
  - The center of gravity's y coordinate y^* found the same way
  - Generally not the optimal location

$$x^* = \frac{\sum_i l_i x_i}{\sum_i l_i} \qquad y^* = \frac{\sum_i l_i y_i}{\sum_i l_i}$$

Center of Gravity Method

EXAMPLE 11.2

A supplier to the electric utility industry produces power generators; the transportation costs are high. One market area includes the lower part of the Great Lakes region and the upper portion of the southeastern region. More than 600,000 tons are to be shipped to eight major customer locations as shown below:

Customer Location	Tons Shipped	x, y Coordinates
Three Rivers, MI	5,000	(7, 13)
Fort Wayne, IN	92,000	(8, 12)
Columbus, OH	70,000	(11, 10)
Ashland, KY	35,000	(11, 7)
Kingsport, TN	9,000	(12, 4)
Akron, OH	227,000	(13, 11)
Wheeling, WV	16,000	(14, 10)
Roanoke, VA	153,000	(15, 5)

Finding the Center of Gravity

What is the center of gravity for the electric utilities supplier? Using rectilinear distance, what is the resulting load–distance score for this location?

Customer Location	Tons Shipped	x, y Coordinates
Three Rivers, MI	5,000	(7, 13)
Fort Wayne, IN	92,000	(8, 12)
Columbus, OH	70,000	(11, 10)
Ashland, KY	35,000	(11, 7)
Kingsport, TN	9,000	(12, 4)
Akron, OH	227,000	(13, 11)
Wheeling, WV	16,000	(14, 10)
Roanoke, VA	153,000	(15, 5)

SOLUTION

The center of gravity is calculated as shown below:

$$\sum_i l_i = 5 + 92 + 70 + 35 + 9 + 227 + 16 + 153 = 607$$

$$\sum_i l_i x_i = 5(7) + 92(8) + 70(11) + 35(11) + 9(12) + 227(13) + 16(14) + 153(15) = 7{,}504$$

$$x^* = \frac{\sum_i l_i x_i}{\sum_i l_i} = \frac{7{,}504}{607} = 12.4$$

Finding the Center of Gravity

What is the center of gravity for the electric utilities supplier? Using rectilinear distance, what is the resulting load–distance score for this location?

Customer Location	Tons Shipped	x, y Coordinates
Three Rivers, MI	5,000	(7, 13)
Fort Wayne, IN	92,000	(8, 12)
Columbus, OH	70,000	(11, 10)
Ashland, KY	35,000	(11, 7)
Kingsport, TN	9,000	(12, 4)
Akron, OH	227,000	(13, 11)
Wheeling, WV	16,000	(14, 10)
Roanoke, VA	153,000	(15, 5)

$$\sum_i l_i y_i = 5(13) + 92(12) + 70(10) + 35(7) + 9(4) + 227(11) + 16(10) + 153(5) = 5{,}572$$

$$y^* = \frac{\sum_i l_i y_i}{\sum_i l_i} = \frac{5{,}572}{607} = 9.2$$

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Finding the Center of Gravity

What is the center of gravity for the electric utilities supplier? Using rectilinear distance, what is the resulting load–distance score for this location?

Customer Location	Tons Shipped	x, y Coordinates
Three Rivers, MI	5,000	(7, 13)
Fort Wayne, IN	92,000	(8, 12)
Columbus, OH	70,000	(11, 10)
Ashland, KY	35,000	(11, 7)
Kingsport, TN	9,000	(12, 4)
Akron, OH	227,000	(13, 11)
Wheeling, WV	16,000	(14, 10)
Roanoke, VA	153,000	(15, 5)

The resulting load-distance score is:

$$ld = \sum_i l_i d_i = 5(5.4 + 3.8) + 92(4.4 + 2.8) + 70(1.4 + 0.8) + 35(1.4 + 2.2) + 9(0.4 + 5.2) + 227(0.6 + 1.8) + 16(1.6 + 0.8) + 153(2.6 + 4.2)$$

$$= 2662,4$$

where $d_i = |x_i - x^*| + |y_i - y^*|$

x*=12,4
y*=9,2

Break-Even analysis

Compare location alternatives on the basis of quantitative factors expressed in total costs

1. Determine the variable costs and fixed costs for each site
2. Plot total cost lines
3. Identify the approximate ranges for which each location has lowest cost
4. Solve algebraically for break-even points over the relevant ranges

Break-Even analysis for location

EXAMPLE 11.3

An operations manager narrowed the search for a new facility location to four communities. The annual fixed costs (land, property taxes, insurance, equipment, and buildings) and the variable costs (labor, materials, transportation, and variable overhead) are as follows:

Community	Fixed Costs per Year	Variable Costs per Unit
A	$150,000	$62
B	$300,000	$38
C	$500,000	$24
D	$600,000	$30

Break-Even analysis for location

Step 1: Plot the total cost curves for all the communities on a single graph. Identify on the graph the approximate range over which each community provides the lowest cost.

Step 2: Using break-even analysis, calculate the break-even quantities over the relevant ranges. If the expected demand is 15,000 units per year, what is the best location?

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Break-Even analysis for location

SOLUTION step 1

To plot a community's total cost line, let us first compute the total cost for two output levels: $Q = 0$ and $Q = 20{,}000$ units per year. For the $Q = 0$ level, the total cost is simply the fixed costs. For the $Q = 20{,}000$ level, the total cost (fixed plus variable costs) is as follows:

Community	Fixed Costs	Variable Costs (Cost per Unit)(No. of Units)	Total Cost (Fixed + Variable)
A	$150,000		
B	$300,000		
C	$500,000		
D	$600,000		

Break-Even analysis for location

SOLUTION step 1

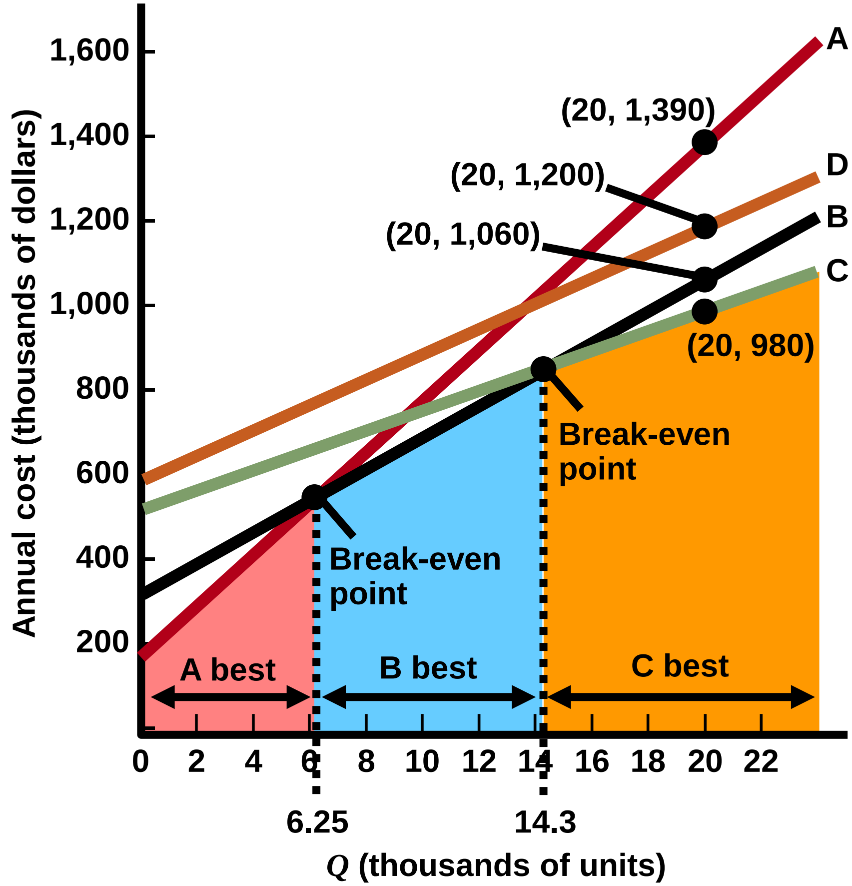
To plot a community's total cost line, let us first compute the total cost for two output levels: Q = 0 and Q = 20,000 units per year. For the Q = 0 level, the total cost is simply the fixed costs. For the Q = 20,000 level, the total cost (fixed plus variable costs) is as follows:

Community	Fixed Costs	Variable Costs (Cost per Unit)(No. of Units)	Total Cost (Fixed + Variable)
A	$150,000	$62(20,000) = $1,240,000	$1,390,000
B	$300,000	$38(20,000) = $760,000	$1,060,000
C	$500,000	$24(20,000) = $480,000	$980,000
D	$600,000	$30(20,000) = $600,000	$1,200,000

Break-Even analysis for location

The figure shows the graph of the total cost lines.

The line for community A goes from (0, 150) to (20, 1,390). The graph indicates that community A is best for low volumes, B for intermediate volumes, and C for high volumes. We should no longer consider community D, because both its fixed and its variable costs are higher than community C's.



Break-Even analysis for location

Step 2: The break-even quantity between A and B lies at the end of the first range, where A is best, and the beginning of the second range, where B is best. We find it by setting both communities' total cost equations equal to each other and solving:

(A)	(B)
$\$150{,}000 + \$62Q =$	**$\$300{,}000 + \$38Q$**
$Q = 6{,}250$ units	

Community	Fixed Costs	VARIABLE COSTS (Cost per Unit) (No. of Units)	TOTAL COST (Fixed + Variable)
A	$150,000	$62(20,000) = $1,240,000	$1,390,000
B	$300,000	$38(20,000) = $ 760,000	$1,060,000
C	$500,000	$24(20,000) = $ 480,000	$ 980,000
D	$600,000	$30(20,000) = $ 600,000	$1,200,000

Break-Even analysis for location

The break-even quantity between B and C lies at the end of the range over which B is best and the beginning of the final range where C is best. It is

(B)	(C)
\$300,000 + \$38*Q* =	**\$500,000 + \$24*Q***
***Q* = 14,286 units**	

Community	Fixed Costs	VARIABLE COSTS (Cost per Unit) (No. of Units)	TOTAL COST (Fixed + Variable)
A	\$150,000	\$62(20,000) = \$1,240,000	\$1,390,000
B	\$300,000	\$38(20,000) = \$ 760,000	\$1,060,000
C	\$500,000	\$24(20,000) = \$ 480,000	\$ 980,000
D	\$600,000	\$30(20,000) = \$ 600,000	\$1,200,000

Break-Even analysis for location

No other break-even quantities are needed. The break-even point between A and C lies above the shaded area, which does not mark either the start or the end of one of the three relevant ranges.

(A)	(B)
$150,000 + $62*Q* =	$300,000 + $38*Q*
Q = 6,250 units	

(B)	(C)
$300,000 + $38*Q* =	$500,000 + $24*Q*
Q = 14,286 units	

Relevant book chapters

- Chapter: “Locating facilities”

Thank you!

Questions?

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Next part of the lecture:

Transportation method