MANAGERIAL ECONOMICS CHAPTER 9

Application of Cost Theory

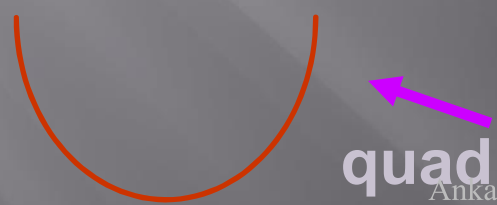
Ankara University, Faculty of Political Science, Department of Economics, Onur Özsoy

Applications of Cost Theory
Chapter 9

- Estimation of Cost Functions using regressions
  - **Short run** -- various methods including polynomial functions
  - **Long run** -- various methods including
    - Engineering cost techniques
    - Survivor techniques
- Break-even analysis and operating leverage
- Risk assessment
- Appendix 9A: The Learning Curve

Estimating Costs in the SR

- Typically use TIME SERIES data for a plant or firm.
- Typically use a functional form that "fits" the presumed shape.
- For TC, often CUBIC
- For AC, often QUADRATIC



Estimating Short Run Cost Functions

- Example: TIME SERIES data of total cost
- **Quadratic** Total Cost (to the power of two)

$$TC = C_0 + C_1 Q + C_2 Q^2$$

→

TC	*Q*	*Q²*
900	20	400
800	15	225
834	19	361
⇓		⇓
⇓		

Time Series Data

REGR c1 1 c2 c3

Regression Output:

Predictor	Coeff	Std Err	T-value
Constant	1000	300	3.3
Q	-50	20	**-2.5**
Q-squared	10	2.5	4.0

R-square = .91

Adj R-square = .90

N = 35

PROBLEMS: 1. **Write** the cost regression as an equation. 2. **Find** the AC and MC functions.

1. $TC = 1000 - 50\,Q + 10\,Q^{2}$
   (3.3) (-2.5) (4)

t-values in the parentheses

2. $AC = 1000/Q - 50 + 10\,Q$

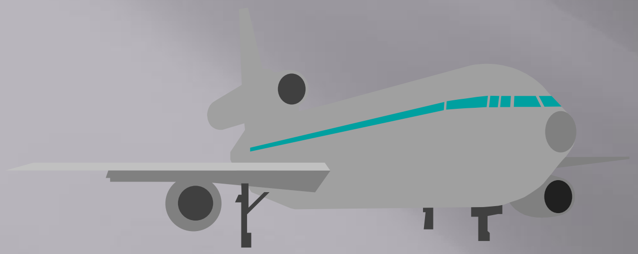
   $MC = -50 + 20\,Q$

NOTE: We can estimate TC either as quadratic or as **CUBIC**:

$$TC = C_1 Q + C_2 Q^2 + C_3 Q^3$$

If TC is CUBIC, then **AC** will be quadratic:

$$AC = C_1 + C_2 Q + C_3 Q^2$$

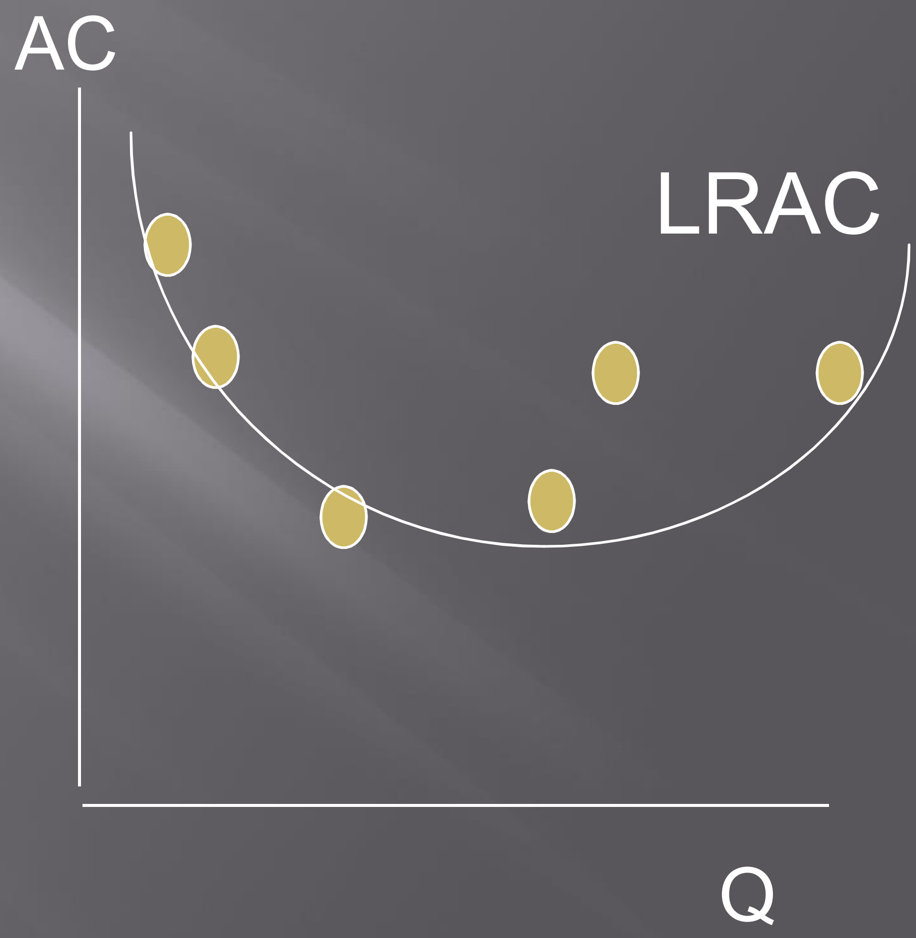


What Went Wrong With Boeing?

- **Airbus** and **Boeing** both produce large capacity passenger jets
- Boeing built each 747 to order, one at a time, rather than using a common platform
  - Airbus began to take away Boeing's market share through its lower costs.
- As Boeing shifted to mass production techniques, cost fell, but the price was still below its marginal cost for wide-body planes

Estimating LR Cost Relationships

- Use a CROSS SECTION of firms
  - SR costs usually uses a time series
- Assume that firms are near their lowest average cost for each output



Log Linear LR Cost Curves

- One functional form is Log Linear
- **Log TC = a + b• Log Q + c•Log W + d•Log R**
- Coefficients are elasticities.
- "b" is the output elasticity of TC
  - IF b = 1, then CRS long run cost function
  - IF b < 1, then IRS long run cost function
  - IF b > 1, then DRS long run cost function

Example: Electrical Utilities →

Sample of 20 Utilities
Q = megawatt hours
R = cost of capital on rate base, W = wage rate

Electrical Utility Example

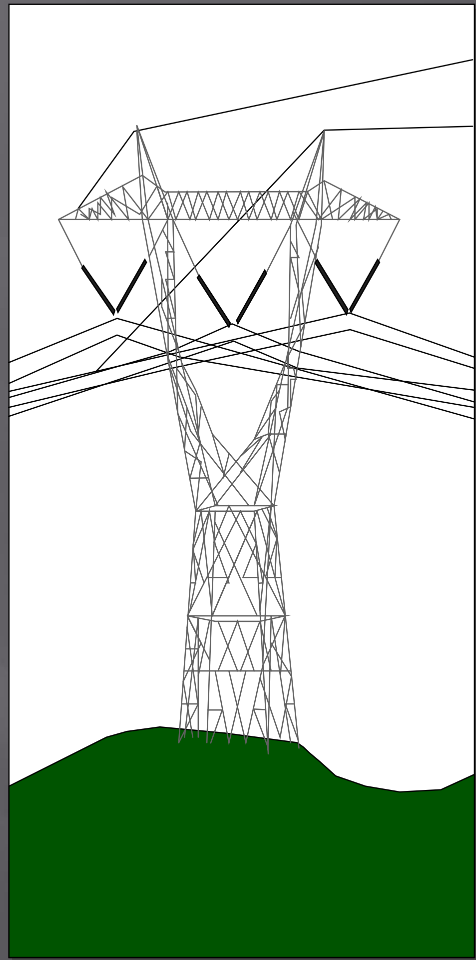
- Regression Results:

Log TC = -.4 +.83 Log Q + 1.05 Log(W/R)

(1.04) (.03) (.21)

R-square = .9745

Std-errors are in the parentheses



QUESTIONS:

1. Are utilities constant returns to scale?
2. Are coefficients statistically significant?
3. Test the hypothesis:

   H_o: b = 1.

Answers

1. The coefficient on Log Q is less than one. A 1% increase in output lead only to a .83% increase in TC -- It's **Increasing Returns to Scale!**
2. The t-values are **coeff / std-errors**: t = .83/.03 = **27.7** is Sign. & t = 1.05/.21 = **5.0** which is Significant.
3. The t-value is (.83 - **1**)/.03 = - 0.17/.03 = **- 5.6** which is significantly different than CRS.

Cement Mix Processing Plants

- 13 cement mix processing plants provided data for the following cost function. Test the hypothesis that cement mixing plants have constant returns to scale?
- **Ln TC = .03 + .35 Ln W + .65 Ln R + 1.21 Ln Q**

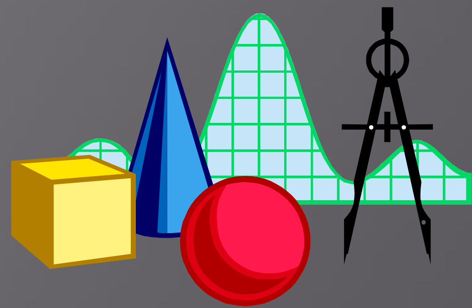
  (.01) (.24) (.33) (.08)

  R^2 = .563
- parentheses contain standard errors

Discussion

- Cement plants are Constant Returns if the coefficient on Ln Q were 1
- 1.21 is more than 1, which appears to be Decreasing Returns to Scale.
- **TEST**: t = (1.21 -1) / .08 = **2.65**
- Small Sample, d.f. = 13 - 3 -1 = **9**
- critical t = 2.262
- We reject constant returns to scale.

Engineering Cost Approach

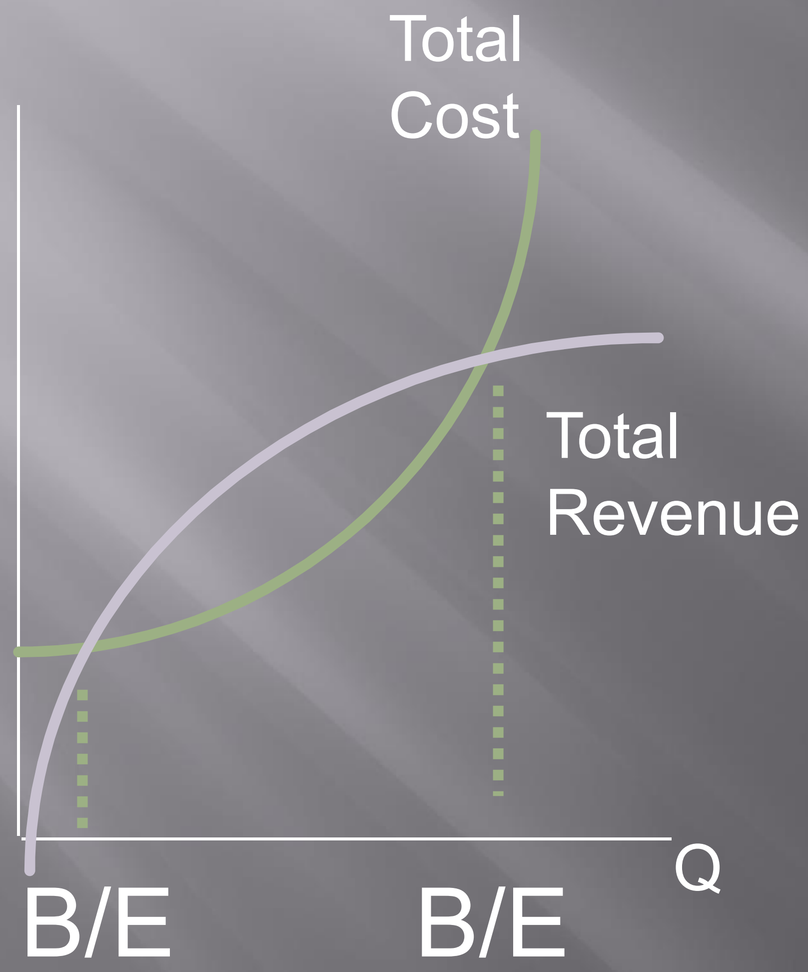


- *Engineering Cost Techniques* offer an alternative to fitting lines through historical data points using regression analysis.
- It uses knowledge about the efficiency of machinery.
- Some processes have pronounced economies of scale, whereas other processes (including the costs of raw materials) do not have economies of scale.
- Size and volume are mathematically related, leading to engineering relationships. Large warehouses tend to be cheaper than small ones per cubic foot of space.

Survivor Technique

- The *Survivor Technique* examines what size of firms are tending to succeed over time, and what sizes are declining.
- This is a sort of Darwinian survival test for firm size.
- Presently many banks are merging, leading one to conclude that small size offers disadvantages at this time.
- Dry cleaners are not particularly growing in average size, however.

Break-even Analysis & D.O.L

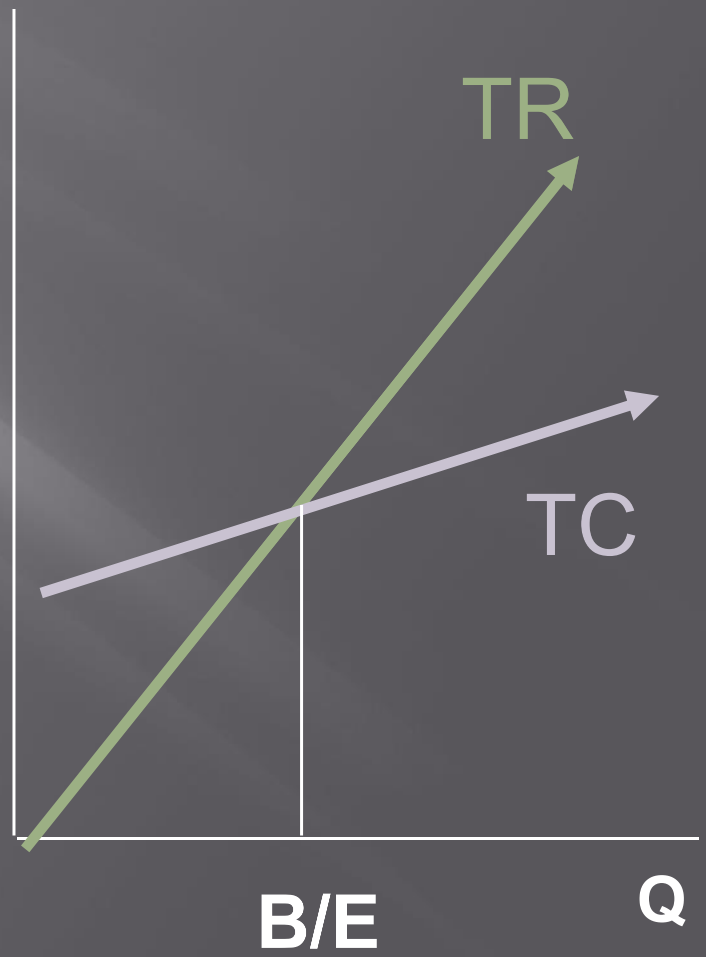


- Can have multiple B/E points
- If linear total cost and total revenue:
  - TR = P•Q
  - TC = F + v•Q
    - where v is Average Variable Cost
    - F is Fixed Cost
    - Q is Output
- *cost-volume-profit analysis*

The Break-even Quantity: $Q_{B/E}$

- At break-even: TR = TC
  - So, $P \bullet Q = F + v \bullet Q$
- $Q_{B/E} = F / (P - v) = F/CM$
  - where contribution margin is: $CM = (P - v)$

PROBLEM: As a garage contractor, find $Q_{B/E}$
if: P = $9,000 per garage
v = $7,000 per garage
& F = $40,000 per year



Answer: Q = 40,000/(2,000)= 40/2 = 20 garages at the break-even point.

Break-even Sales Volume

- Amount of sales revenues that breaks even
- $P \bullet Q_{B/E} = P \bullet [F/(P-v)]$

$= F / [1 - v/P]$

Variable Cost Ratio

Ex: At **Q = 20**,
B/E Sales Volume is
$9,000•20 =
$180,000 Sales Volume

Target Profit Output

- Quantity needed to attain a target profit
- If π is the target profit,

$$Q_{target\ \pi} = [F + \pi] / (P-v)$$

Suppose want to attain $50,000 profit, then,

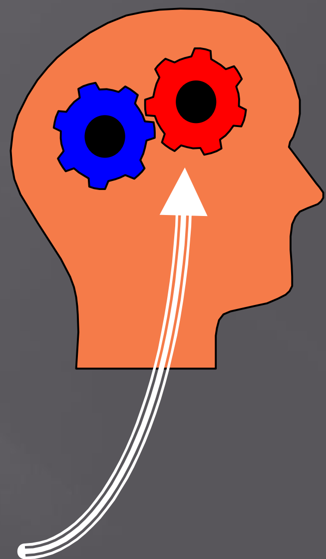
$$Q_{target\ \pi} = (\$40,000 + \$50,000)/\$2,000$$

$$= \$90,000/\$2,000 = 45 \text{ garages}$$

Degree of Operating Leverage or Operating Profit Elasticity

- $DOL = E_{\pi}$
  - sensitivity of operating profit (EBIT) to changes in output
- Operating π = TR-TC = $(P-v) \bullet Q - F$
- Hence, DOL = $\partial \pi / \partial Q \bullet (Q/\pi)$ =

$(P-v) \bullet (Q/\pi) = (P-v) \bullet Q / [(P-v) \bullet Q - F]$



A measure of the **importance of Fixed Cost** or **Business Risk** to fluctuations in output

Suppose a contractor builds 45 garages. What is the D.O.L?

- $DOL = \dfrac{(9000-7000) \bullet 45}{\{(9000-7000) \bullet 45 - 40000\}}$

  $= 90{,}000 \;/\; 50{,}000 = 1.8$
- A 1% INCREASE in Q → **1.8%** INCREASE in operating profit.
- At the break-even point, DOL is INFINITE.
  - A small change in Q increase EBIT by astronomically large percentage rates

DOL as *Operating Profit Elasticity*

DOL = [(P - v)Q] / { [(P - v)Q] - F }

- We can use empirical estimation methods to find operating leverage
- Elasticities can be estimated with double log functional forms
- Use a time series of data on operating profit and output
  - **Ln EBIT = a + b• Ln Q**, where b is the DOL
  - then a 1% increase in output increases EBIT by **b**%
  - b tends to be greater than or equal to 1

Regression Output

- Dependent Variable: Ln EBIT uses 20 quarterly observations N = 20

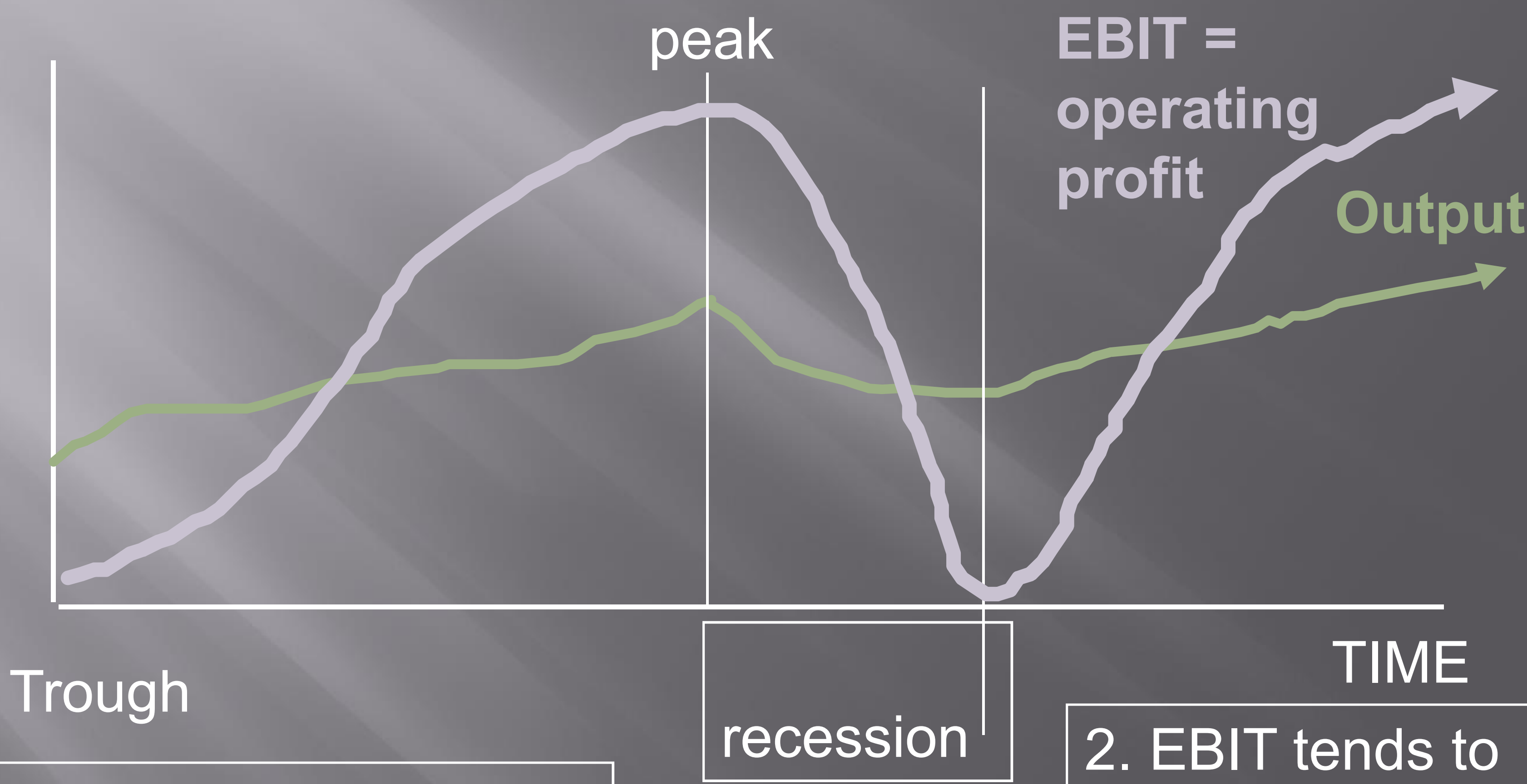
The log-linear regression equation is
Ln EBIT = - .75 + 1.23 Ln Q

Predictor	**Coeff**	**Stdev**	**t-ratio**	**p**
Constant	-.7521	0.04805	-15.650	0.001
Ln Q	1.2341	0.1345	9.175	0.001

s = 0.0876 R-square= **98.2%** R-sq(adj) = 98.0%

The DOL for this firm, 1.23. So, a 1% increase in output leads to a 1.23% increase in operating profit

Operating Profit and the Business Cycle



1. EBIT is more volatile that output over cycle

2. EBIT tends to collapse late in recessions

Learning Curve: Appendix 9A

- "Learning by doing" has wide application in production processes.
- Workers and management become more efficient with experience.
- the cost of production declines as the accumulated past production, $Q = \Sigma q_t$, increases, where q_t is the amount produced in the t^{th} period.
- Airline manufacturing, ship building, and appliance manufacturing have demonstrated the learning curve effect.

- Functionally, the learning curve relationship can be written **$C = a \cdot Q^b$**, where C is the input cost of the Qth unit:
- Taking the (natural) logarithm of both sides, we get: **$\log C = \log a + b \cdot \log Q$**
- The coefficient b tells us the extent of the learning curve effect.
  - If the **b**=0, then costs are at a constant level.
  - If $b > 0$, then costs rise in output, which is exactly opposite of the learning curve effect.
  - If $b < 0$, then costs decline in output, as predicted by the learning curve effect.