Chapter-17

Theory of Production

After reading this lesson, you would be able to:

1. Define production function, isoquants, marginal product, price discrimination, monopsonist and the all-or-nothing demand curve.
2. Define increasing, decreasing and constant returns to scale.
3. Distinguish between income and substitution effects.
4. Distinguish between an individual buyer's demand curve and the industry demand, and between industry demand and the demand curve facing an individual seller.
5. Compute marginal revenue from the demand curve of the seller when that demand curve is given in the form of a table.
6. Compute marginal resource cost from the supply curve of the buyer when supply curve is given in the form of a table.
7. Explain why marginal resource cost equals price for a buyer who is a price taker.
8. Explain why marginal revenue equals price for a seller who is a price taker, and why marginal revenue is less than price for a seller who is a price maker.
9. Explain what the law of diminishing returns is and under what conditions it holds.
10. Explain why the demand curve, the supply curve for resources and the production function can be treated as boundaries.

Though economists are interested in many cases of unintended consequences yet the unintended consequences that involve businessmen seeking their own gain have been at the heart of economic analysis. Smith noted that, "It is not from the benevolence of the butcher, the brewer, or the baker, that we expect our dinner, but from their regard to their own interests. We address ourselves, not to their humanity but to their self love, and never talk to them of our necessities but of their advantages."

Since Smith, a great deal of intellectual effort has gone into exploring the question that under what conditions the interests of society will be served by businessmen seeking to make a profit. This question is, infact, the core of microeconomics. The reading selections present background material to this exploration by explaining a large number of technical terms that economists use and also by looking at a few of the simplifying assumptions they generally invoke.

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Overview

I. Production Analysis
- Total Product, Marginal Product, Average Product
- Isoquants
- Isocosts
- Cost Minimization

II. Cost Analysis
- Total Cost, Variable Cost, Fixed Costs
- Cubic Cost Function
- Cost Relations

III. Multi-Product Cost Functions

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Production Analysis

- Production Function
  - Q = F(K,L)
  - The maximum amount of output that can be produced with K units of capital and L units of labor
- Short-Run vs. Long-Run Decisions
- Fixed vs. Variable Inputs

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Production functions

Example-- Calvin has expanded his operation. Taking his lemonade profits, he has integrated upstream, buying the local supplier of lemonade cups. His engineer (former management consultant Hobbes) has given Calvin a table of output and input combinations which is as follows:

capital \ labor	0	5	10	15	20	25	30	35	40
0	0	0	0	0	0	0	0	0	0
5	0	20	46	73	101	129	156	182	206
10	0	31	70	111	150	188	223	255	284
15	0	40	90	140	187	231	269	**302**	329
20	0	49	107	164	217	263	**302**	333	356
25	0	56	122	185	241	289	327	354	370
30	0	63	135	203	262	310	345	366	374
35	0	69	148	220	280	327	358	373	370
40	0	75	159	234	295	340	366	373	360
45	0	80	169	247	309	351	372	370	345
50	0	86	179	259	320	359	374	363	325
55	0	91	188	270	331	365	373	352	301
60	0	96	197	281	339	370	370	338	274

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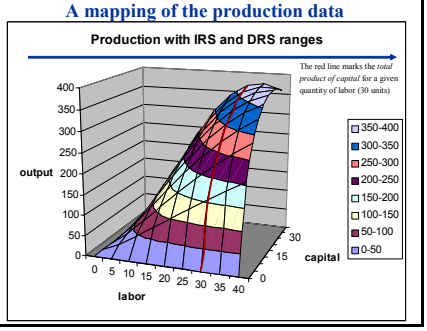
A mapping of the production data



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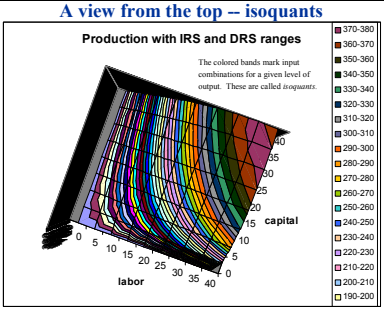
A view from the top -- isoquants



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Mathematical relationships

- The production function relates output to inputs

$$Q = f(K, L)$$

$$\frac{\partial f}{\partial L}, \frac{\partial f}{\partial K} > 0$$

- The marginal product relates changes in output to changes in one input by holding the other constant

$$MP_L = \frac{\partial f}{\partial L}(locally)$$

$$= \frac{\Delta Q}{\Delta L}$$

- The total product of labor is the relationship between labor input and quantity output, given capital

$$TP_L = f(L, \overline{K})$$

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Total Product

- Cobb-Douglas Production Function
- Example-- $Q = F(K,L) = K^{.5} L^{.5}$
  - K is fixed at 16 units
  - Short run production function:
    $Q = (16)^{.5} L^{.5} = 4 L^{.5}$
  - Production when 100 units of labor are used
    $Q = 4 (100)^{.5} = 4(10) = 40$ units

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Marginal Product of Labor

- $MP_L = \Delta Q/\Delta L$
- Measures the output produced by the last worker
- Slope of the production function

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Average Product of Labor

- $AP_L = Q/L$
- Measures the output of an "average" worker

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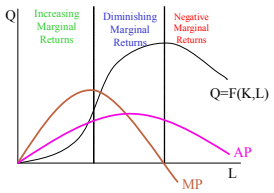
Stages of Production



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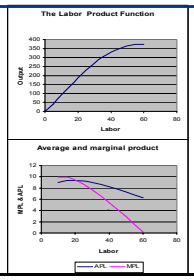
With Lemonade, we have a similar pattern



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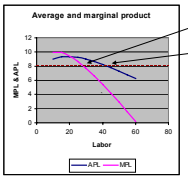
Time frames

- To maximize profit when only labor is variable, there is a need to set MRP=wage rate
- To break even, one needs to set ARP=wage rate



Profit maximizing point

Break-even point

Here, assume P=1, and w=8

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Isoquant

- The combinations of inputs (K, L) that yield the producer the same level of output
- The shape of an isoquant reflects the ease with which a producer can substitute among inputs while maintaining the same level of output

L

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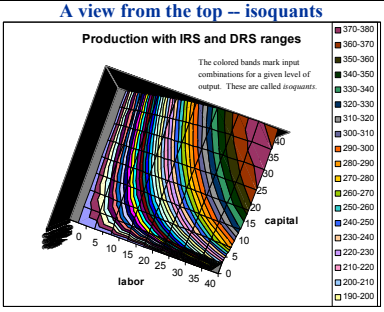
A view from the top -- isoquants



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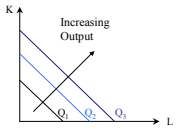
Linear Isoquants

- Capital and labor are perfect substitutes



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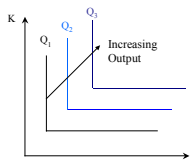
Leontief Isoquants

- Capital and labor are perfect complements
- Capital and labor are used in fixed-proportions



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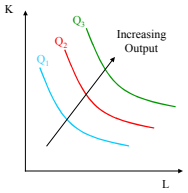
Cobb-Douglas Isoquants

- Inputs are not perfectly substitutable
- Diminishing marginal rate of technical substitution
- Most of the production processes have isoquants of this shape



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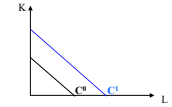
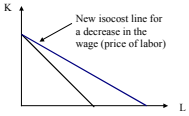
Isocost

- The combinations of inputs that cost the producer the same amount of money
- For given input prices, isocosts farther from the origin are associated with higher costs
- Changes in input prices change the slope of the isocost line





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Cost Minimization

- Marginal product per dollar spent should be equal for all inputs

$$\frac{MP_L}{w} = \frac{MP_K}{r}$$

- Expressed differently

$$MRTS_{KL} = \frac{w}{r}$$

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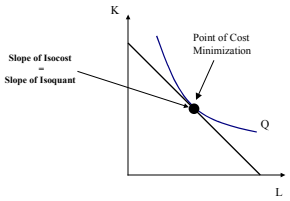
Cost Minimization



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Cost Analysis

- Types of Costs
  - Fixed costs (FC)
  - Variable costs (VC)
  - Total costs (TC)
  - Sunk costs

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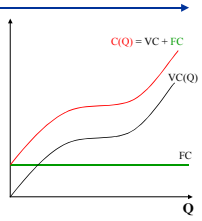
Total and Variable Costs

C(Q)-- Minimum total cost of producing alternative levels of output:

C(Q) = VC + FC

VC(Q)-- Costs that vary with output

FC-- Costs that do not vary with output



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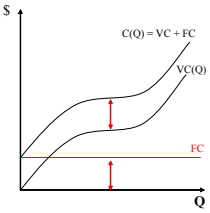
Fixed and Sunk Costs

FC: Costs that do not change as output changes

Sunk Cost: A cost that is forever lost after it has been paid



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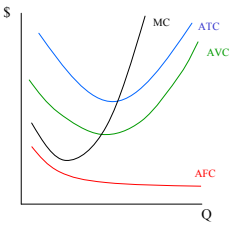
Some Definitions

Average Total Cost
ATC = AVC + AFC
ATC = C(Q)/Q

Average Variable Cost
AVC = VC(Q)/Q

Average Fixed Cost
AFC = FC/Q

Marginal Cost
MC = ΔC/ΔQ



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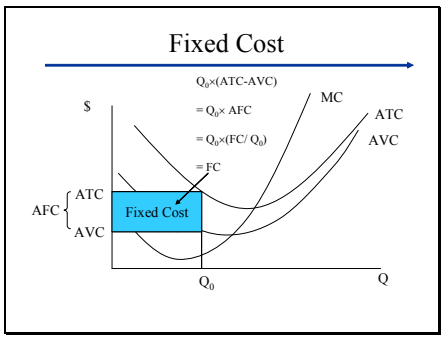

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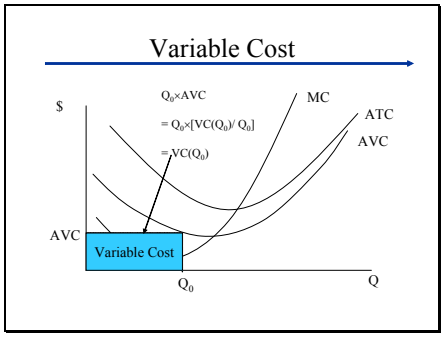

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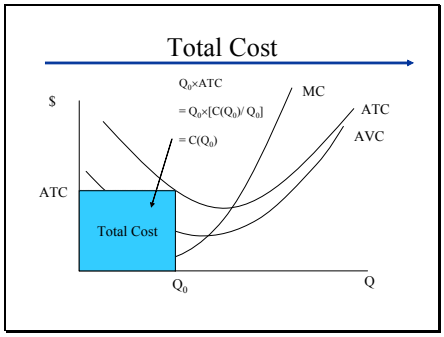

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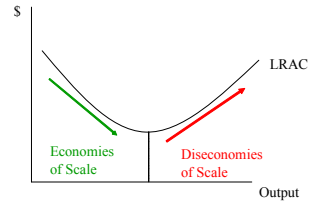
Economies of Scale



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Economies of scale

If average costs fall with output, the marginal cost is less than average cost. A measure of this is the cost disadvantage ratio:

$$CDR = \frac{AC - MC}{AC}$$

Declining average costs reflect economies of scale.

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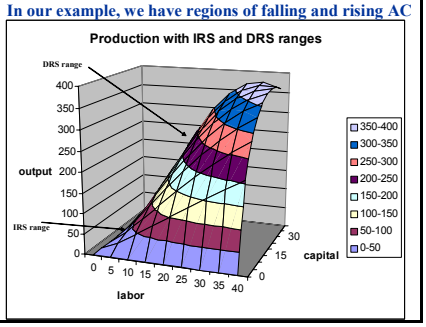
In our example, we have regions of falling and rising AC



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An Example

- Total Cost-- $C(Q) = 10 + Q + Q^2$
- Variable cost function:
  $VC(Q) = Q + Q^2$
- Variable cost of producing 2 units:
  $VC(2) = 2 + (2)^2 = 6$
- Fixed costs:
  $FC = 10$
- Marginal cost function:
  $MC(Q) = 1 + 2Q$
- Marginal cost of producing 2 units:
  $MC(2) = 1 + 2(2) = 5$

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Multi-Product Cost Function

- $C(Q_1, Q_2)$: Cost of producing two outputs jointly

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Economies of scope

- Scope economies imply that joint production costs are lower than separate costs
- This means integrated production is more cost efficient

It is measured as follows:

$$S = \frac{TC(Q_1) + TC(Q_2) - TC(Q_1, Q_2)}{TC(Q_1, Q_2)}$$

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Economies of Scope

- $C(Q_1, Q_2) < C(Q_1, 0) + C(0, Q_2)$
- It is cheaper to produce the two outputs jointly instead of separately

Examples

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Cost Complementarities

- The marginal cost of producing good 1 declines as more of good two is produced:

$$\Delta MC_1/\Delta Q_2 < 0.$$

Examples

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A Numerical Example

- $C(Q_1, Q_2) = 90 - 2Q_1Q_2 + (Q_1)^2 + (Q_2)^2$
- Cost Complementarity

  Since $a = -2 < 0$

  $MC_1(Q_1, Q_2) = -2Q_2 + 2Q_1$
- Economies of scope

  Since $90 > -2Q_1Q_2$
- Implications for merger

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Relevant cost components

- Accounting costs often reflect historical cost. In addition, they are incomplete
- Relevant costs for maximization of profits are both explicit costs and implicit costs (i.e. the cost of lost opportunities or the opportunity cost of a project)
- Economic profit is then any return net of explicit and implicit costs
- Costs include sunk costs (past costs that can no longer be affected) and also incremental costs
- Marginal costs are a special case of incremental costs
- In the short-run, one makes decisions vis-à-vis variable costs

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Operating Leverage

- Firms are highly leveraged when fixed costs are a high relative to variable costs
- High leverage means profit will rise(fall) faster in upswings(downswings)
- This can be measured by the profit elasticity

$$E_{\pi} = \frac{d\pi}{dQ} \cdot \frac{Q}{\pi} = \frac{Q(P - AVC)}{Q(P - AVC) - TFC}$$