Production, and Costs

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Outline

- The technology of production.
  - Long Run:
    - Isoquants.
    - Returns to scale.
  - Short Run:
    - Average and marginal product.
    - Law of diminishing returns.
- Costs.
  - Economic vs. Accounting:
    - Opportunity costs.
    - Sunk costs.
  - Cost minimization.
  - Cost functions:
    - Short run: fixed, variable, and marginal costs.
    - Long run: economies of scale.

Why Do We Care About Technology?

- Technology determines how products and services are produced.
- More importantly, together with the input prices, they determine the features of the costs of firms.
- Costs are the ultimate determinant of the number of firms in a industry, and how these firms react to changes in prices and production conditions.
- Technology determines whether some expenses are sunk costs and they are a critical element in driving firms' entry decisions.

M.Q. 2: Transport Service

This page has been left blank on purpose. Read the motivating question above and address it before coming to class. We will discuss them and I will post the solutions after the lecture.

Production Function

- It is a technological relation between the amount of inputs needed to produce outputs per unit of time.
  - In general a firm uses many inputs and may produce more than one output.
  - For presentation purposes, it suffice that we consider:
    - A single output: Q.
    - Two inputs: capital, K; and labor, L.

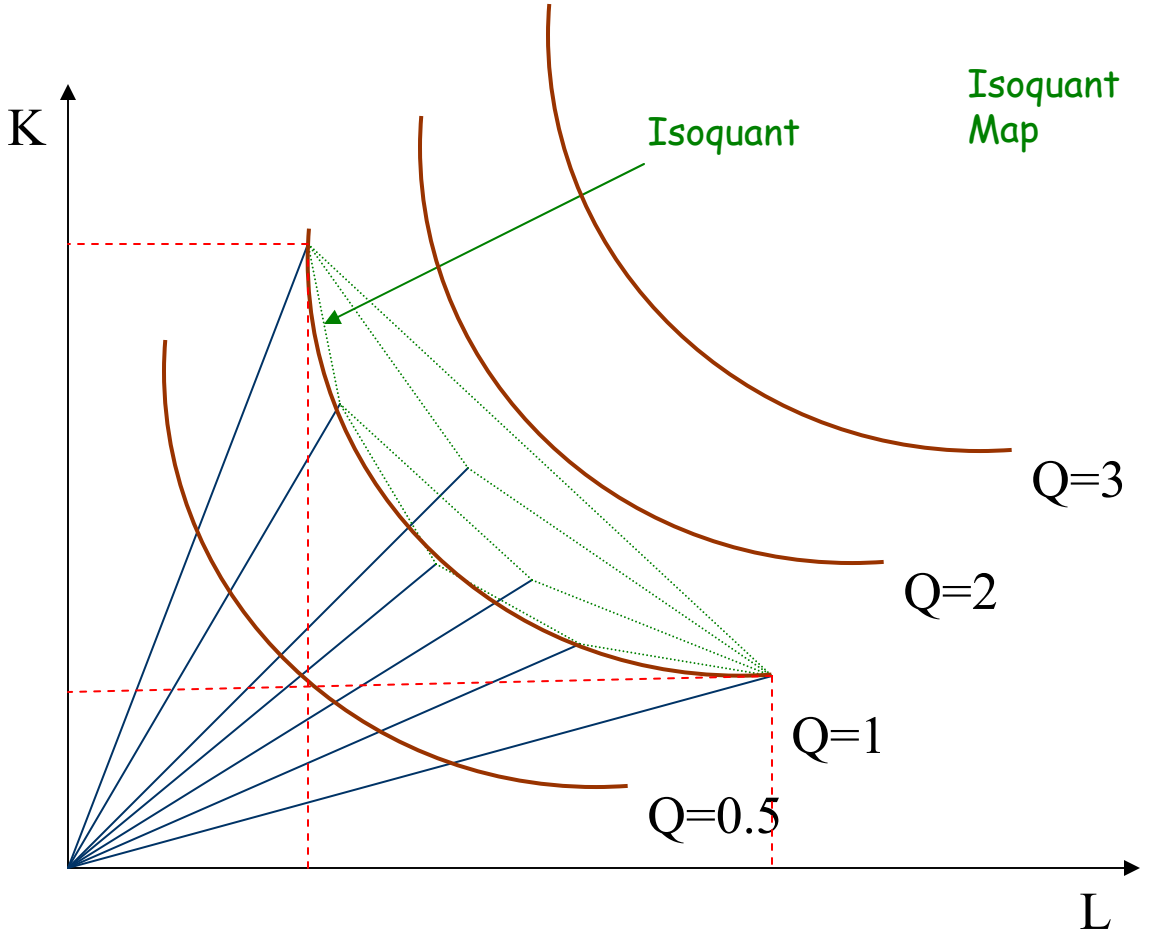
- Example: Cobb-Douglas Production Function:
  - A particular production function is just a way to represent the available technology to produce.
    - We will assume technological efficiency.
      - We rule out not being at the frontier that the production function represents.

$$Q = f(K, L) \Rightarrow AK^{\alpha}L^{\beta}$$

Short vs. Long Run

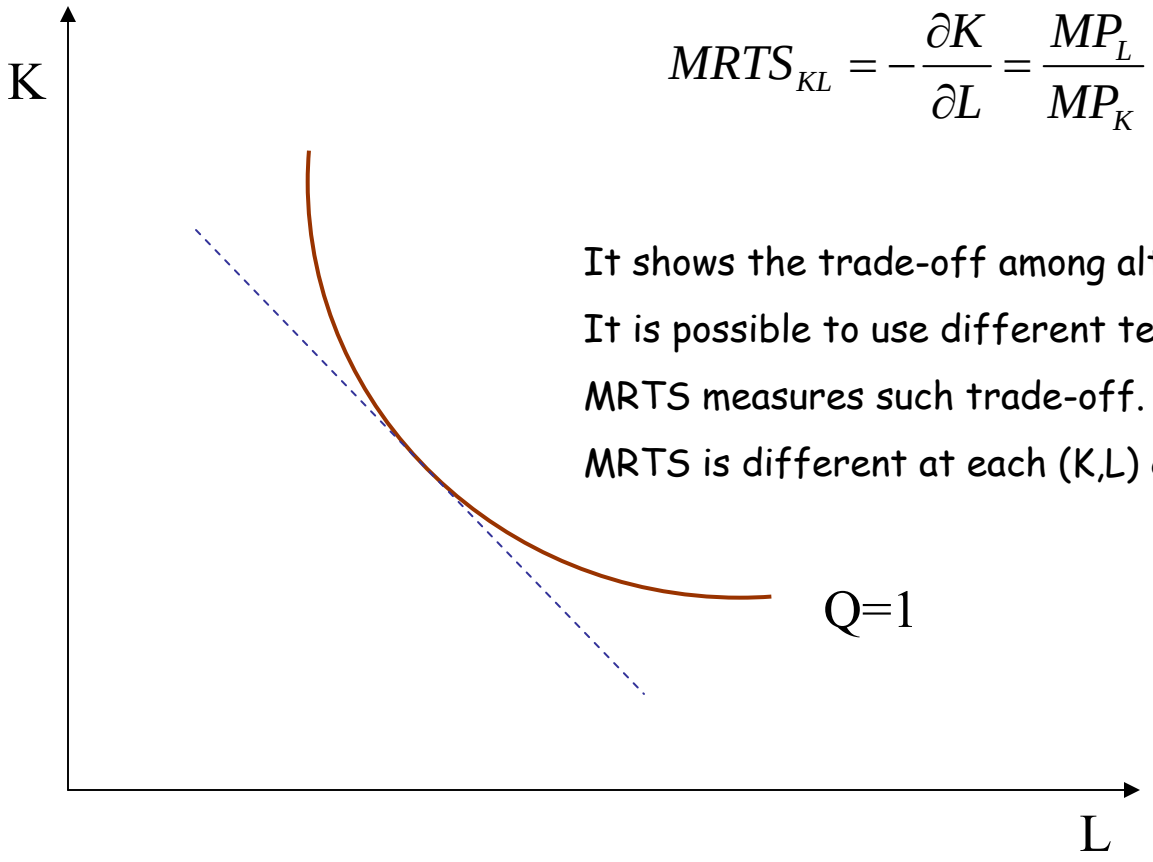
- The length of time needed to go from short to long run is different for each industry, and indeed irrelevant for economic analysis.
- In the short run at least one input remain fixed.
- In the long run all inputs are variable.
- I will focus in the long run to derive the economically relevant features of production functions.

Activity Analysis



Isoquants are Downward Sloping

$$MRTS_{KL} = -\frac{\partial K}{\partial L} = \frac{MP_L}{MP_K} = \frac{\frac{\partial Q}{\partial L}}{\frac{\partial Q}{\partial K}}$$



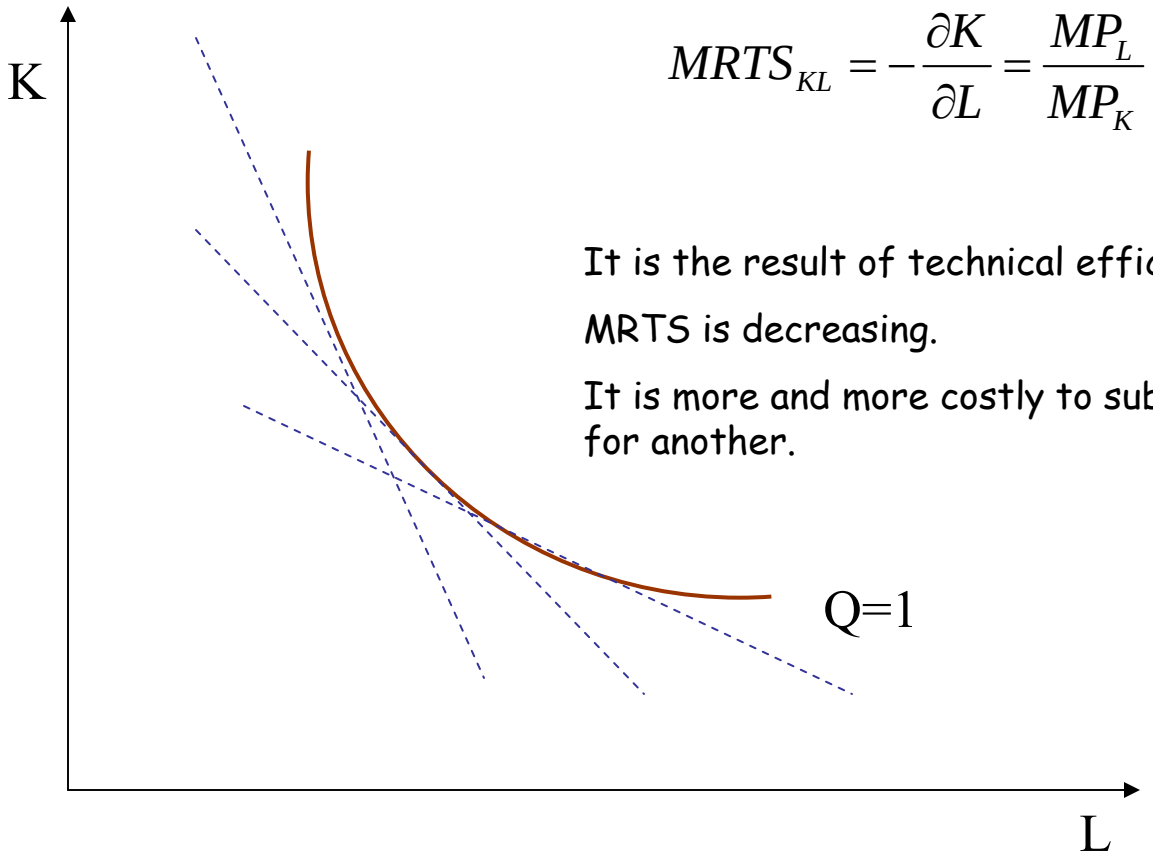
It shows the trade-off among alternative inputs.

It is possible to use different techniques.

MRTS measures such trade-off.

MRTS is different at each (K,L) combination.

Isoquants are Convex



$$MRTS_{KL} = -\frac{\partial K}{\partial L} = \frac{MP_L}{MP_K} = \frac{\frac{\partial Q}{\partial L}}{\frac{\partial Q}{\partial K}}$$

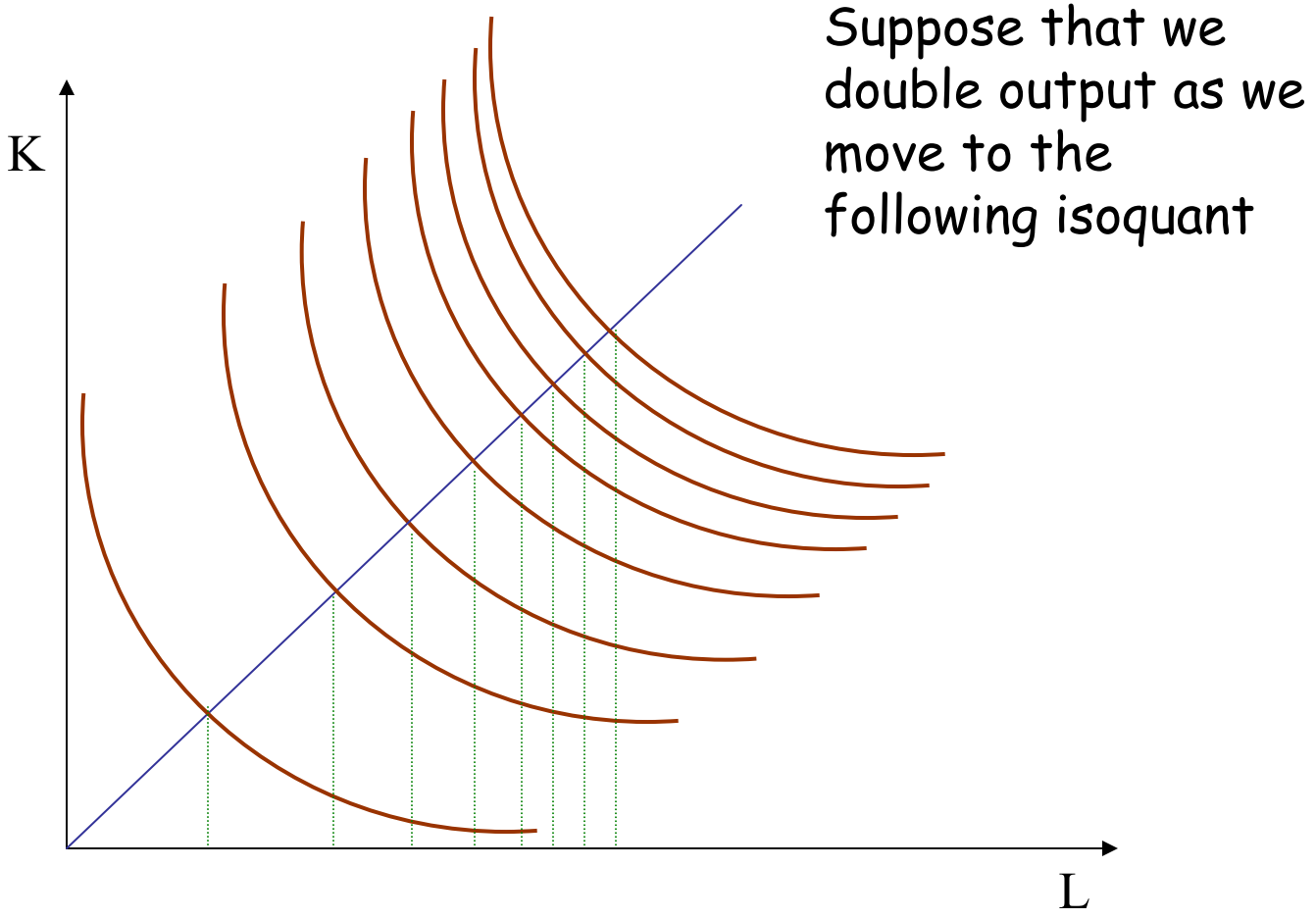
It is the result of technical efficiency.

MRTS is decreasing.

It is more and more costly to substitute one input for another.

Returns to Scale

- It is the way to characterize production functions in the long run.
- The idea is to hold the proportion of inputs constant and vary all of them simultaneously (i.e., moving along a technique).
- Then, we observe IRS, CRS, or DRS depending on whether the output increase more, equal, or less than the scale of the firm.



Suppose that we double output as we move to the following isoquant

- Example: Returns to Scale of a Cobb-Douglas Production Function:
  - Mathematically, this corresponds to homogeneous functions of degree more, equal, or less than one.
  - For instance for IRS below, $\alpha+\beta > 1$:

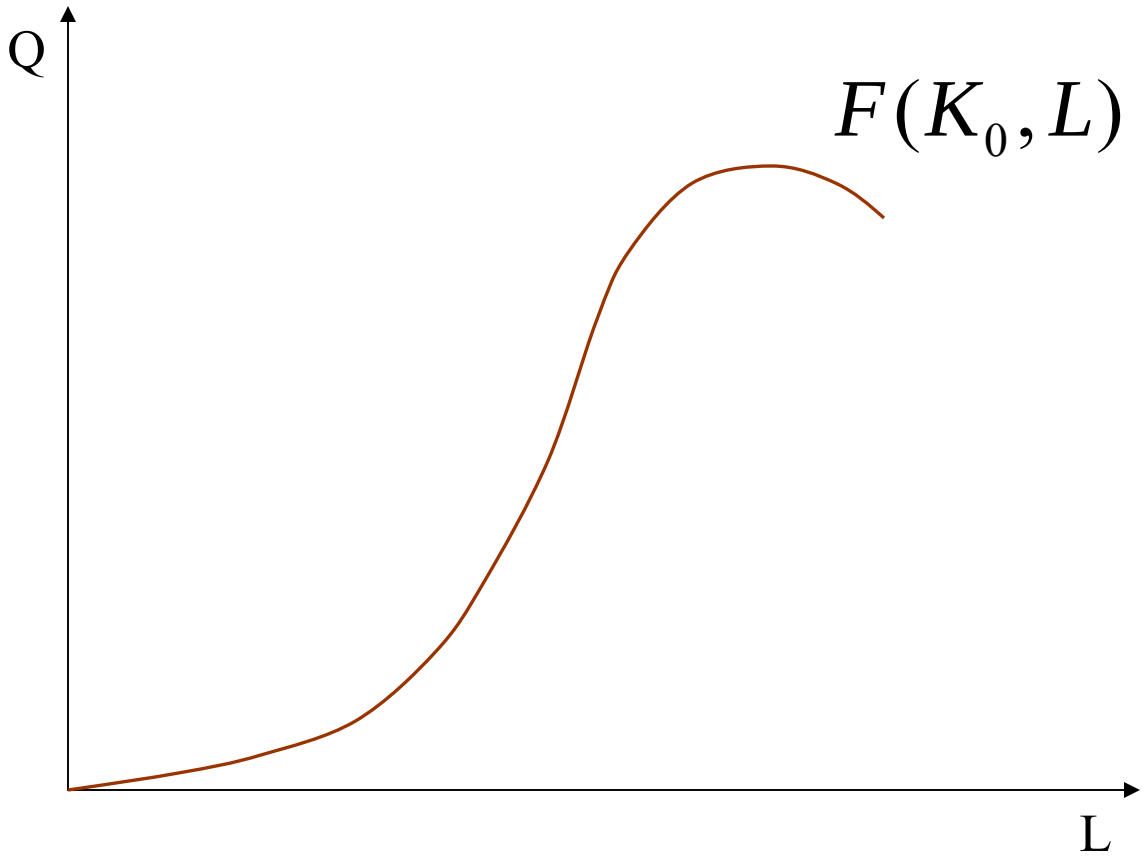
$$f(tK,tL) > tQ \Rightarrow A(tK)^{\alpha}(tL)^{\beta} = t^{(\alpha+\beta)}AK^{\alpha}L^{\beta} = t^{(\alpha+\beta)}Q$$

  - In practice most production functions show CRS.

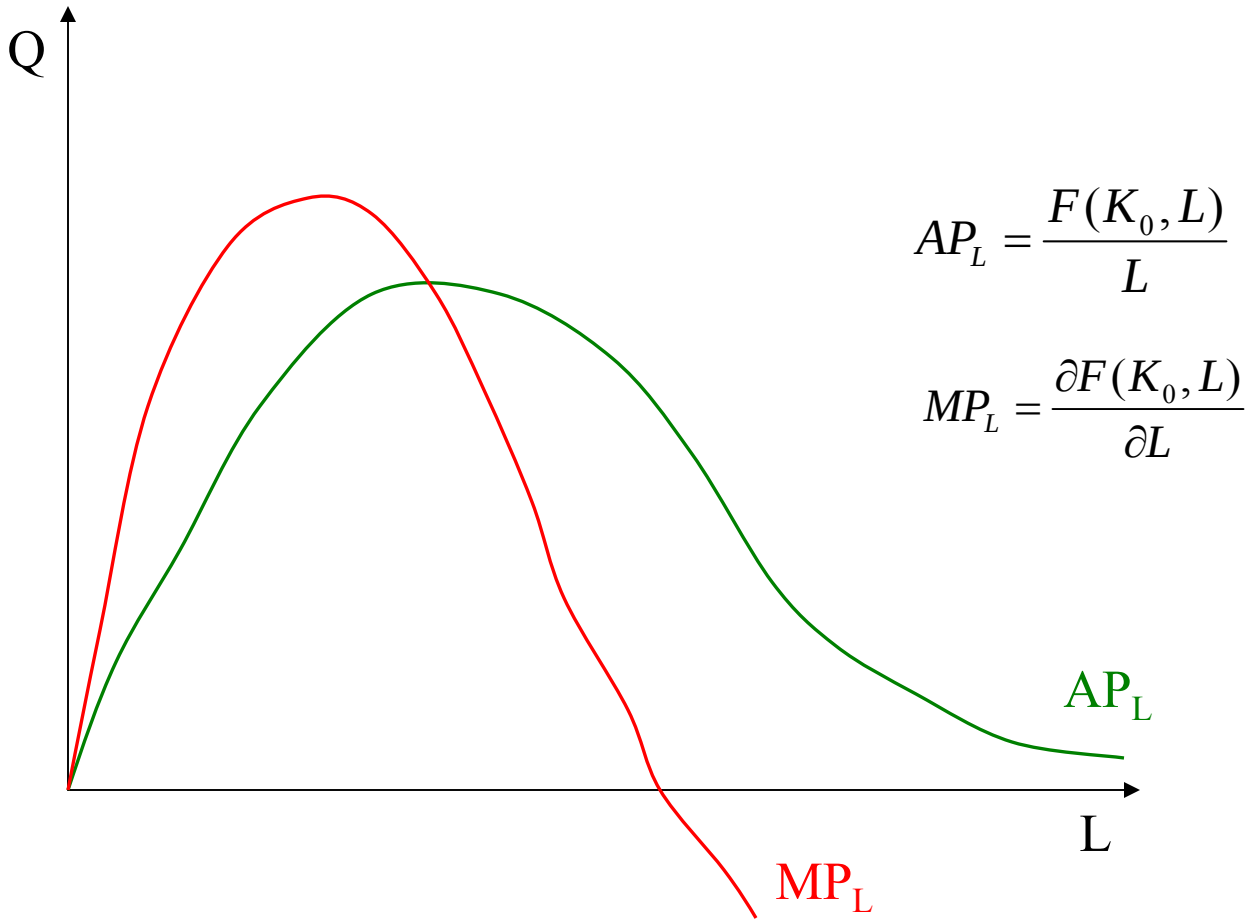
Factor Output Elasticities and Returns to Scale

INDUSTRY	Capital	Production Workers	Nonproduction Workers	Returns to Scale
Furniture	0.205	0.802	0.102	1.110
Chemicals	0.200	0.553	0.336	1.089
Printint	0.459	0.045	0.574	1.078
Food and Beverages	0.555	0.439	0.076	1.070
Rubber and Plastics	0.481	1.033	-0.458	1.056
Instruments	0.205	0.819	0.020	1.044
Lumber	0.392	0.504	0.145	1.041
Apparel	0.128	0.437	0.477	1.041
Leather	0.076	0.441	0.523	1.040
Stone, Clay, etc.	0.632	0.032	0.366	1.030
Fabricated Metals	0.151	0.512	0.364	1.027
Electrical Machinery	0.368	0.429	0.229	1.026
Transport Equipment	0.234	0.749	0.041	1.024
Nonelectrical Machinery	0.404	0.228	0.389	1.021
Textiles	0.121	0.549	0.334	1.004
Paper and Pulp	0.420	0.367	0.197	0.984
Primary Metals	0.371	0.077	0.509	0.957
Petroleum	0.308	0.546	0.093	0.947

Short Run Production Function



Average and Marginal Product



$$AP_L = \frac{F(K_0, L)}{L}$$

$$MP_L = \frac{\partial F(K_0, L)}{\partial L}$$

Cost Concepts

- Measuring costs properly is necessary to allocate scarce resources efficiently.

- Economic vs. technical efficiency.
  - It does not matter how can we combine inputs to produce a product or service but finding out the less expensive way to do it.

- What should we consider when deciding how much to produce?
  - Explicit costs: wages, cost of raw materials, rent on capital,…
  - All cost should value the employed inputs at their opportunity cost.

(this is the single, most important slide of the day)

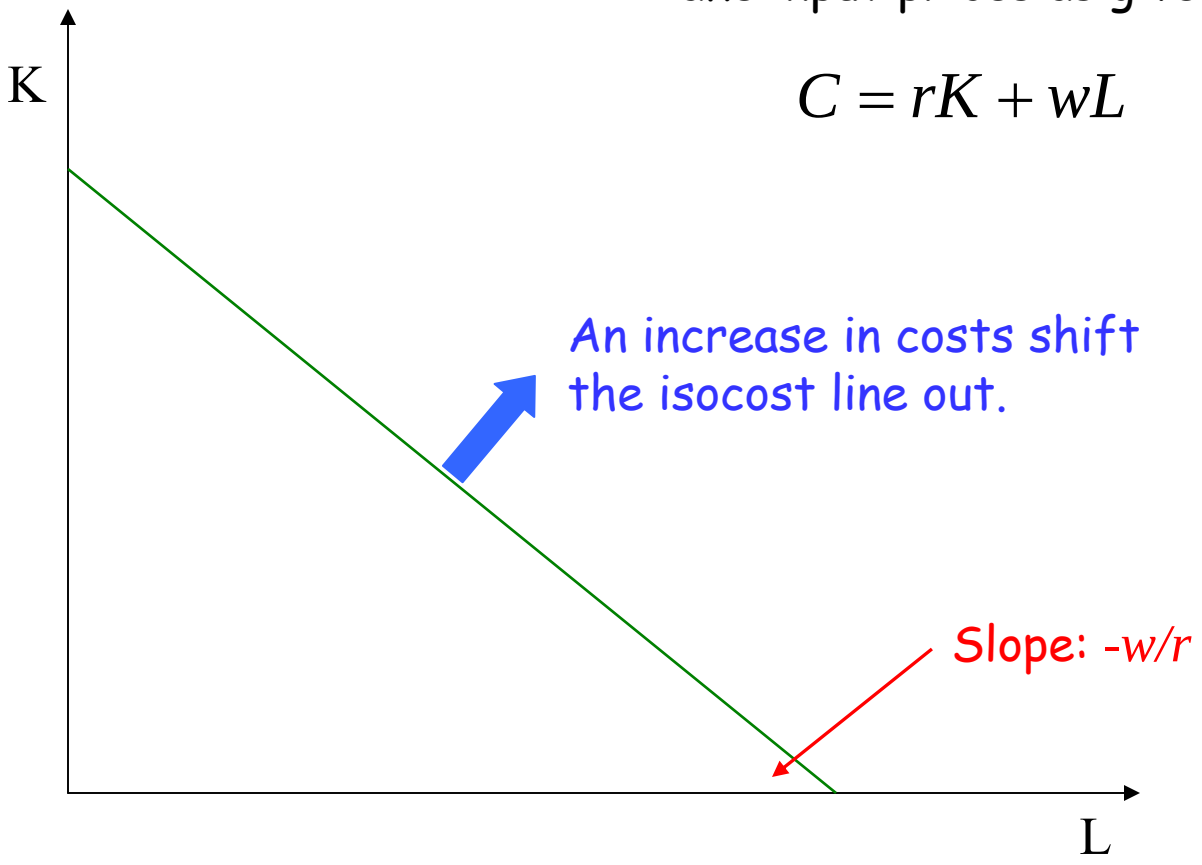
- What are opportunity costs?
  - It is the economic (not accounting) measure of cost.
  - Costs should be measured by their foregone opportunity.
    - Include own-wages if self-employed.
    - Include rent on land if owned.
    - Include the "normal rate of return" on investment for own capital employed (instead of some arbitrary rule for accounting for depreciation of machinery).

- We should exclude sunk costs.
  - These are irreversible expenses without any alternative use once they have been made.
  - Their opportunity cost is zero.
  - Example: Fixed cost incurred to enter an industry are important to decide whether to enter an industry, not to determine the pricing decisions of the firm.

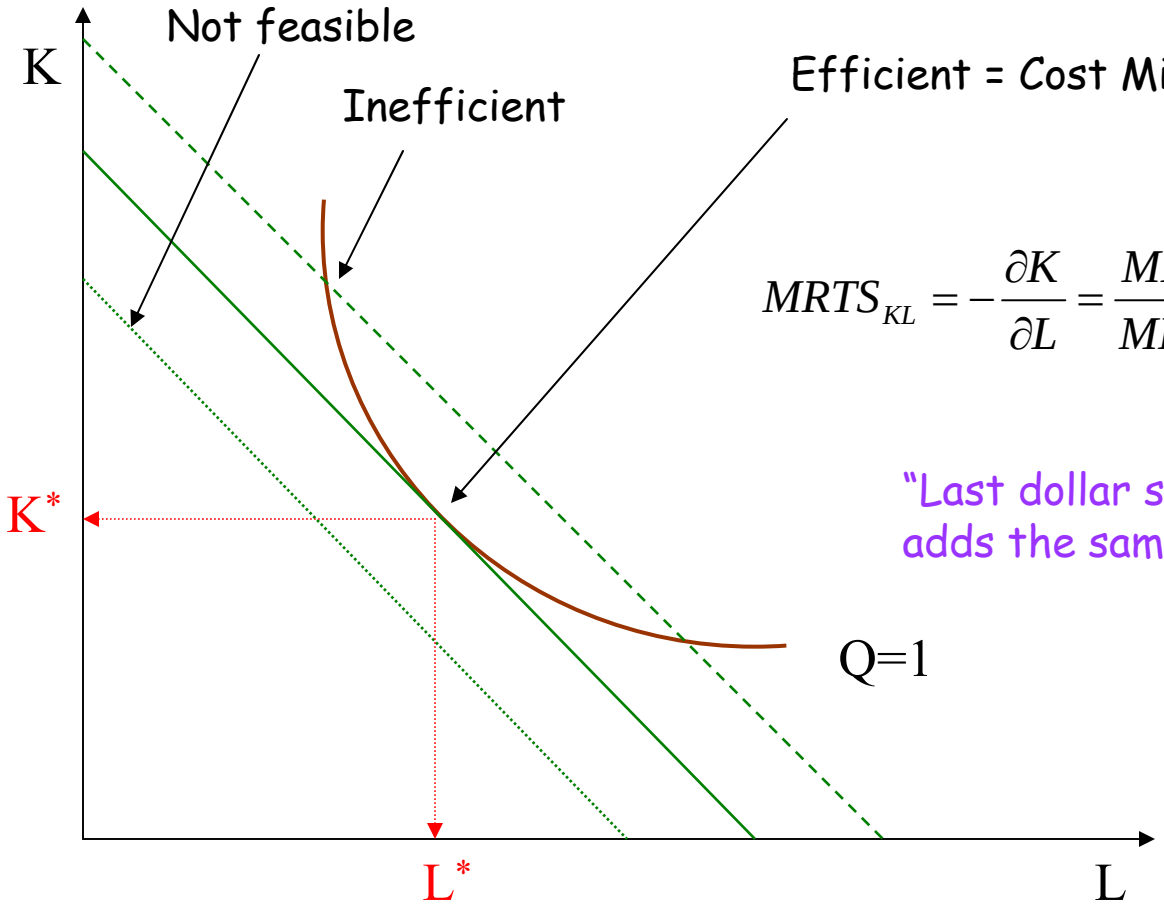
Isocost Line

Take input prices as given:

$$C = rK + wL$$

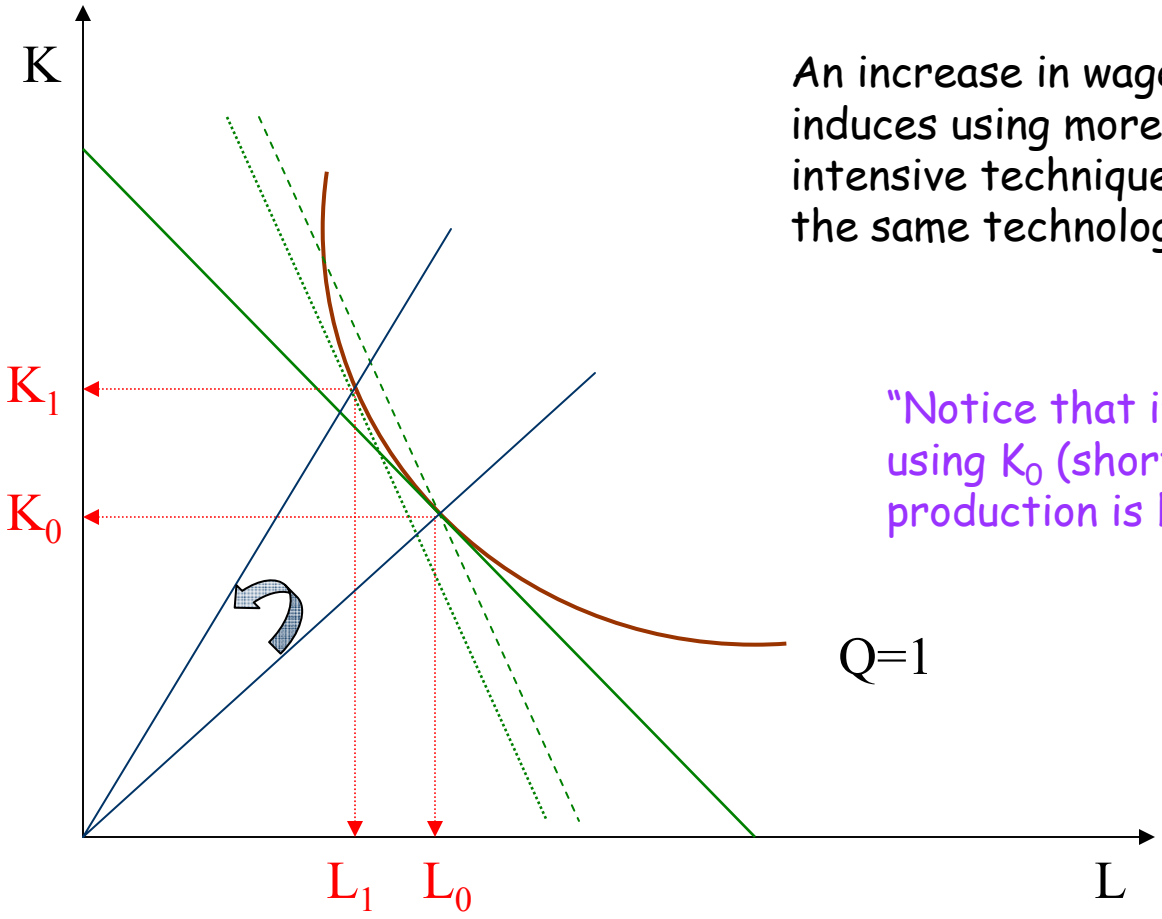


Cost Minimization (for Q=1)



$$MRTS_{KL} = -\frac{\partial K}{\partial L} = \frac{MP_L}{MP_K} = \frac{\frac{\partial Q}{\partial L}}{\frac{\partial Q}{\partial K}} = \frac{w}{r}$$

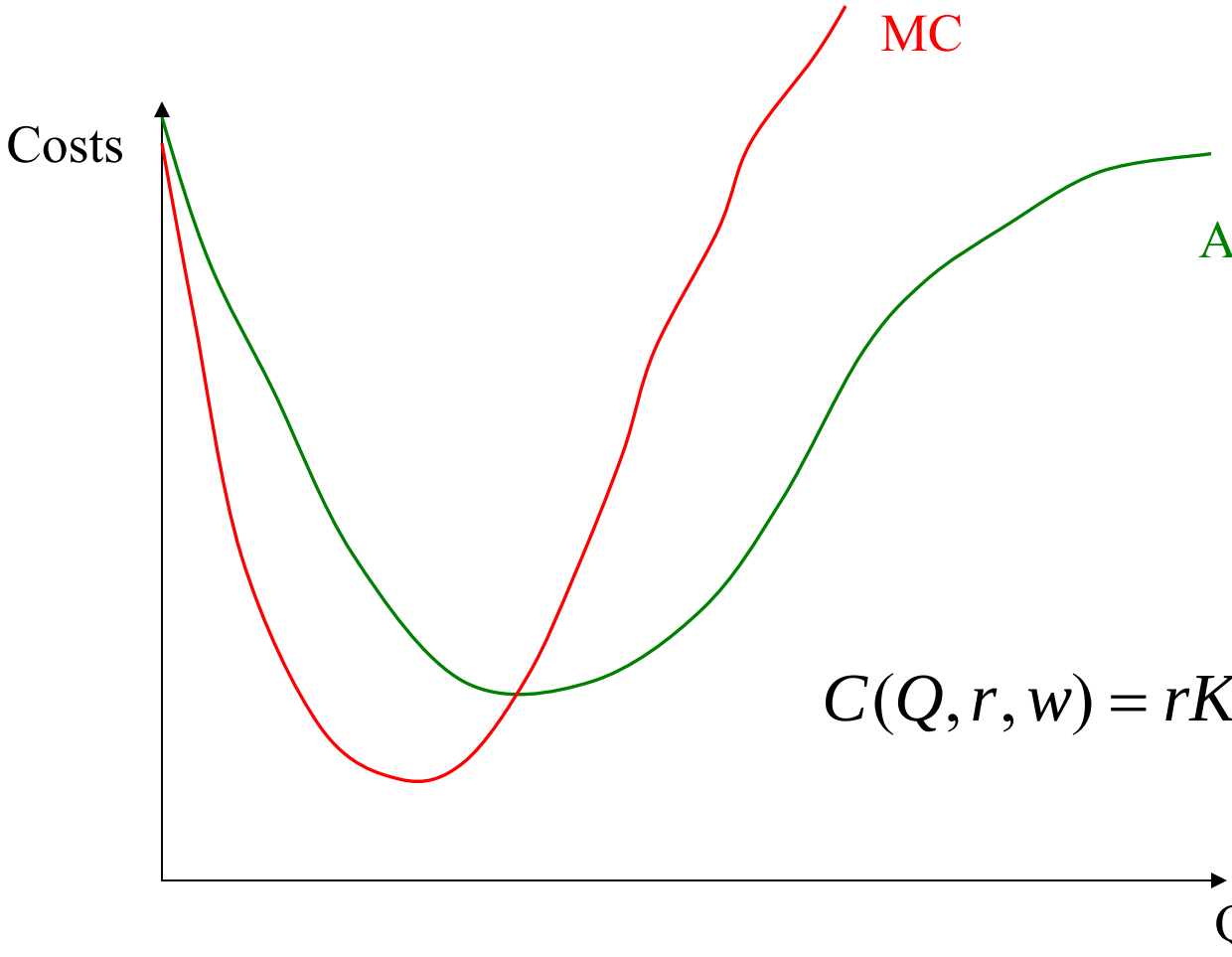
"Last dollar spent in any input adds the same output level."



An increase in wage induces using more capital intensive techniques (with the same technology).

"Notice that if we insist in using K_0 (short run) cost of production is higher."

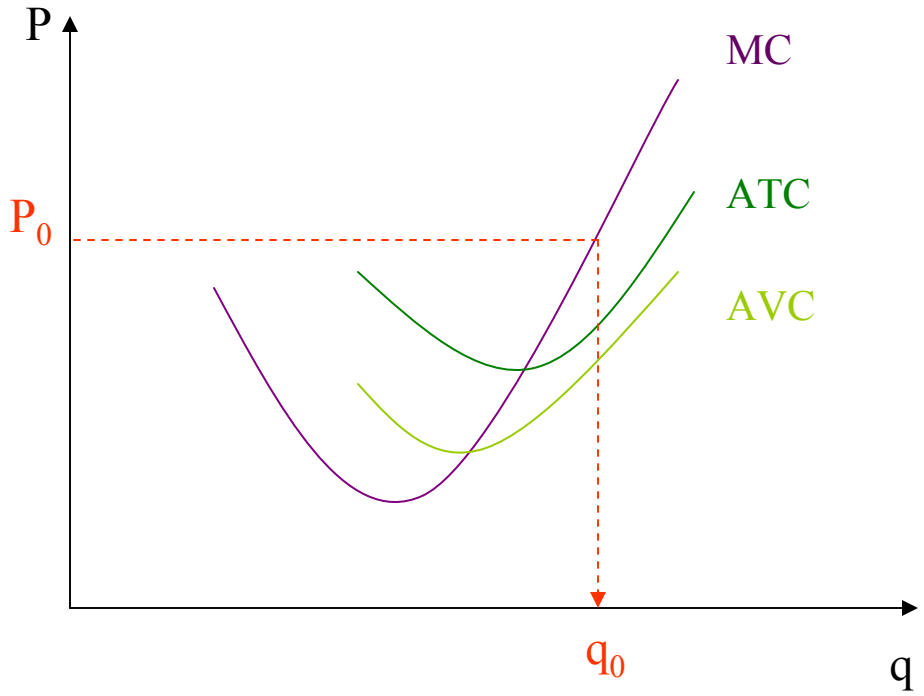
Average and Marginal Costs



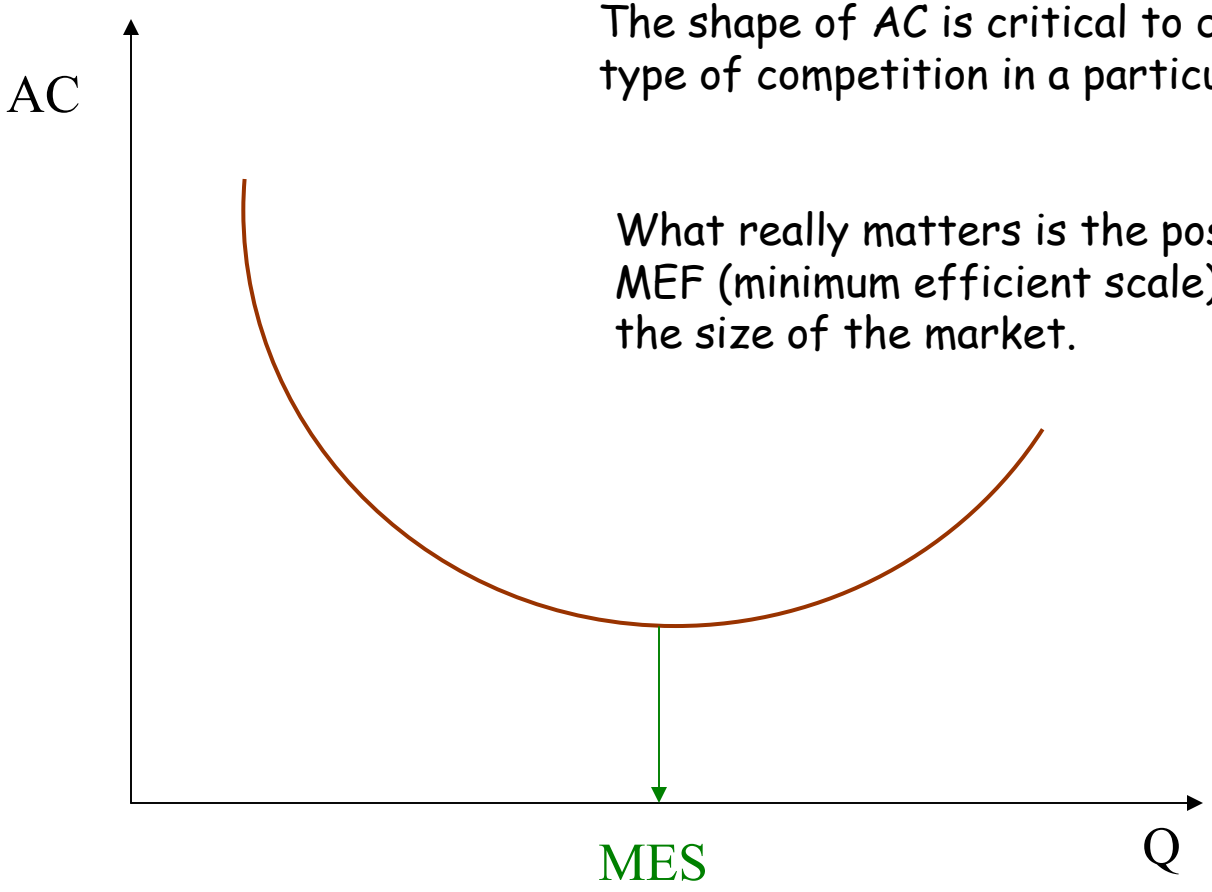
$$C(Q,r,w) = rK(Q) + wL(Q)$$

Costs in the Short Run

- In the short run we need to distinguish between fixed and variable costs:



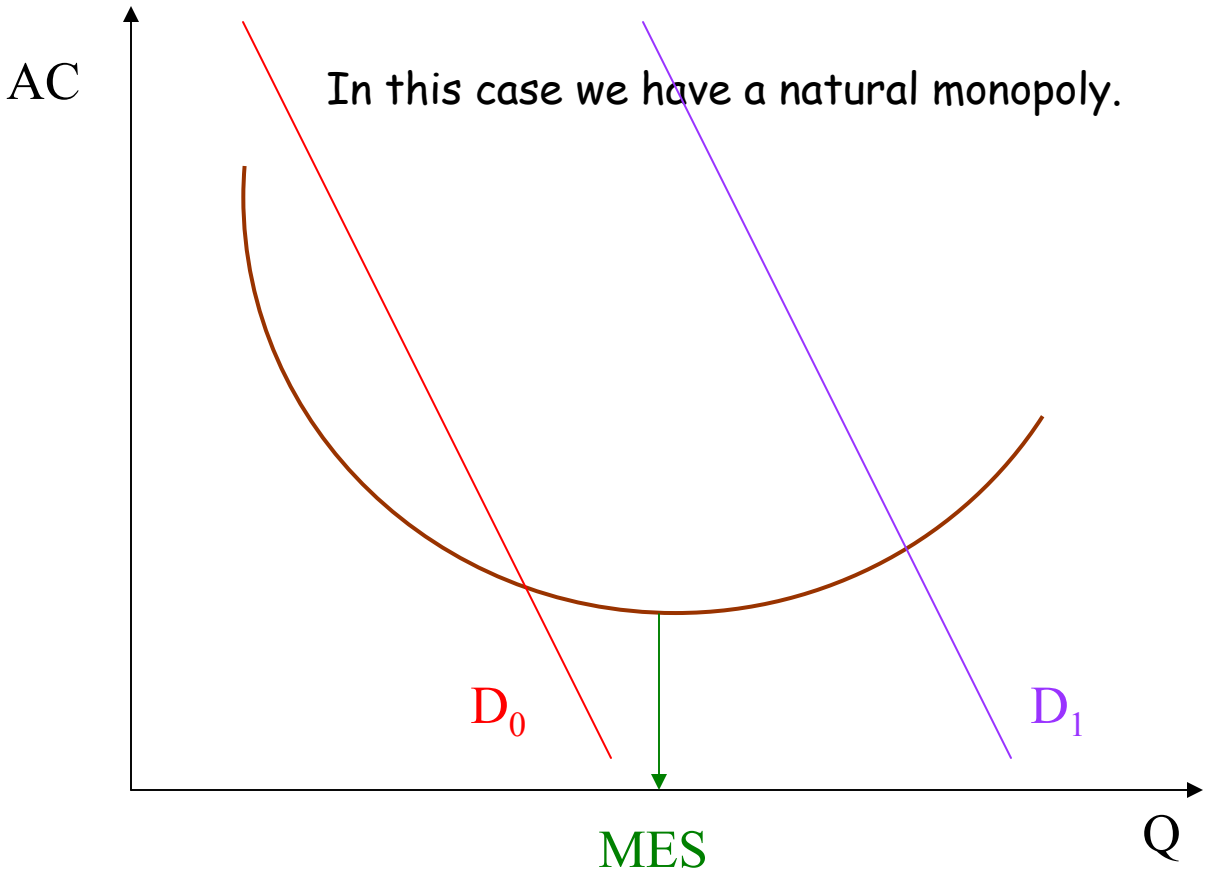
Economies of Scale



The shape of AC is critical to determine the type of competition in a particular industry.

What really matters is the position of the MEF (minimum efficient scale) relative to the size of the market.

While here competition is possible.



Factor Output Elasticities and Returns to Scale

Minimum Efficient Scale of Plants and Firms as Percentage of U.S. National Market, 1967

Industry	Minimum Efficient Scale Plant as Percentage of Total Market	Minimum Efficient Scale Firm as Percentage of Total Market	Four-Firm Concentration Ratio
Beer Brewing	3.4	10–14	40
Cigarettes	6.6	6–12	81
Cotton Synthetic Fabrics	0.2	1	36
Paints, Varnishes, and Lacquers	1.4	1.4	22
Petroleum Refining	1.9	4–6	33
Shoes, Except Rubber	0.2	1	26
Glass Containers	1.5	4–6	60
Cement	1.7	2	29
Steel Works	2.6	3	48
Ball and Roller Bearings	1.4	4–7	54
Refrigerators and Freezers	14.1	14–20	73
Storage Batteries	1.9	2	61

Source: F. M. Scherer, A. Beckenstein, E. Kaufer, and R. D. Murphy, *The Economics of Multi-Plant Operation: An International Comparison Study* (Cambridge, Mass.: Harvard University Press, 1975).