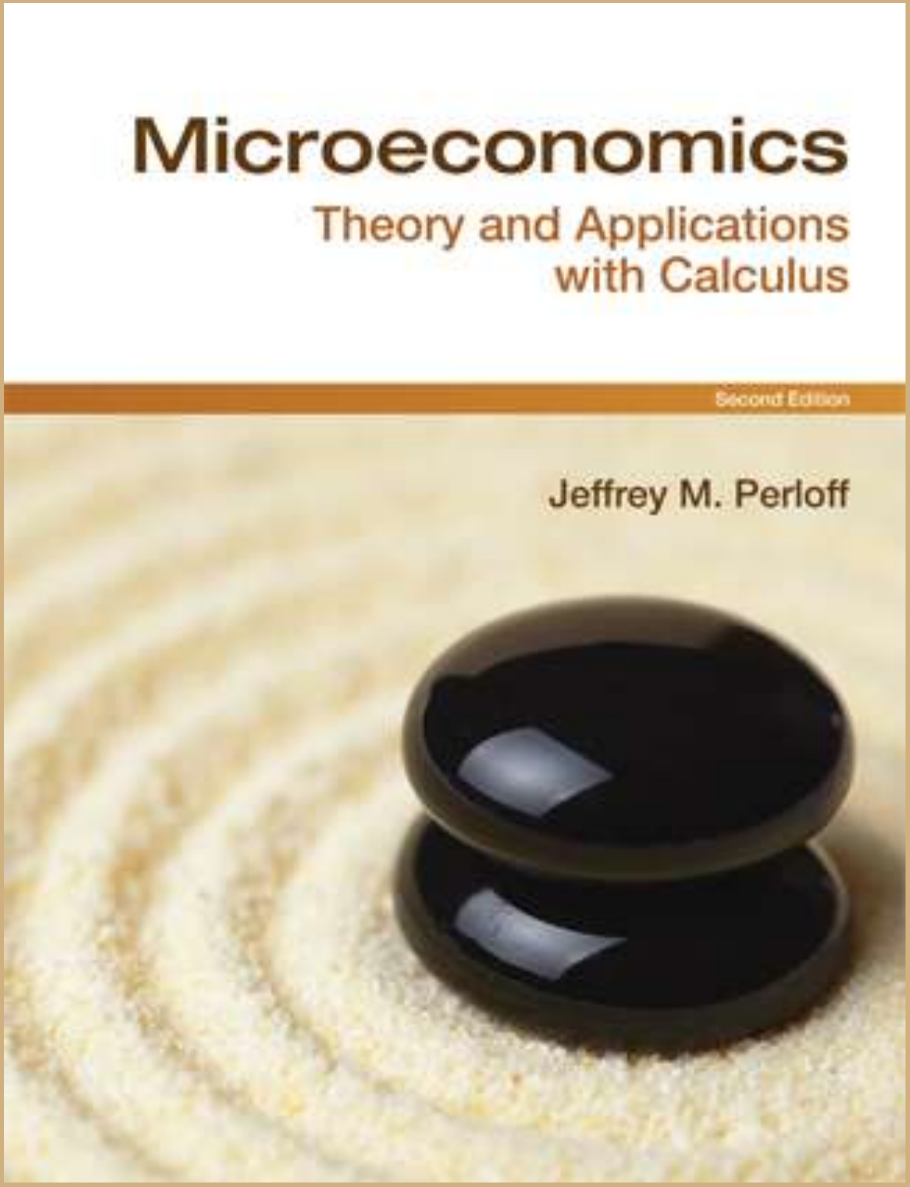
# Chapter 6

# Firms and Production

*Hard work never killed anybody, but why take a chance?*

Charlie McCarthy

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# Chapter 6 Outline

# 6.1 Ownership & Management of Firms

- A ***firm*** is an organization that converts inputs (labor, materials, and capital) into outputs.
- Firm types:
  1. Private (for-profit) firms: owned by individuals or other non-governmental entities trying to earn a profit (e.g. Toyota, Walmart). Responsible for 77% of GDP.
  2. Public firms: owned by governments or government agencies (e.g. Amtrak, public schools). Responsible for 11% of GDP.
  3. Not-for-profit firms: owned by organizations that are neither governments nor intended to earn a profit, but rather pursue social or public interest objectives (e.g. Salvation Army, Greenpeace). Responsible for 12% of GDP.

# 6.1 Ownership & Management of Firms

- Legal forms of organization:
  1. Sole proprietorship: firms owned by a single individual who is personal liable for the firm's debts.
     - 72% of firms, but responsible for 4% of sales.
  2. General partnership: businesses jointly owned and controlled by two or more people who are personally liable for the firm's debts.
     - 9% of firms, but responsible for 13% of sales.
  3. Corporation: firms owned by shareholders in proportion to the number of shares or amount of stock they hold.
     - 19% of firms, but responsible for 83% of sales.
     - Corporation owners have limited liability; they are not personally liable for the firm's debts even if the firm goes into bankruptcy.

# 6.1 What Owners Want

- We focus on for-profit firms in the private sector in this course.
- We assume these firms' owners are driven to maximize profit.
  - Profit is the difference between revenue (R), what it earns from selling its product, and cost (C), what it pays for labor, materials, and other inputs.

    $\pi = R - C$ where $R = pq$.
- To maximize profits, a firm must produce as efficiently as possible, where ***efficient production*** means it cannot produce its current level of output with fewer inputs.

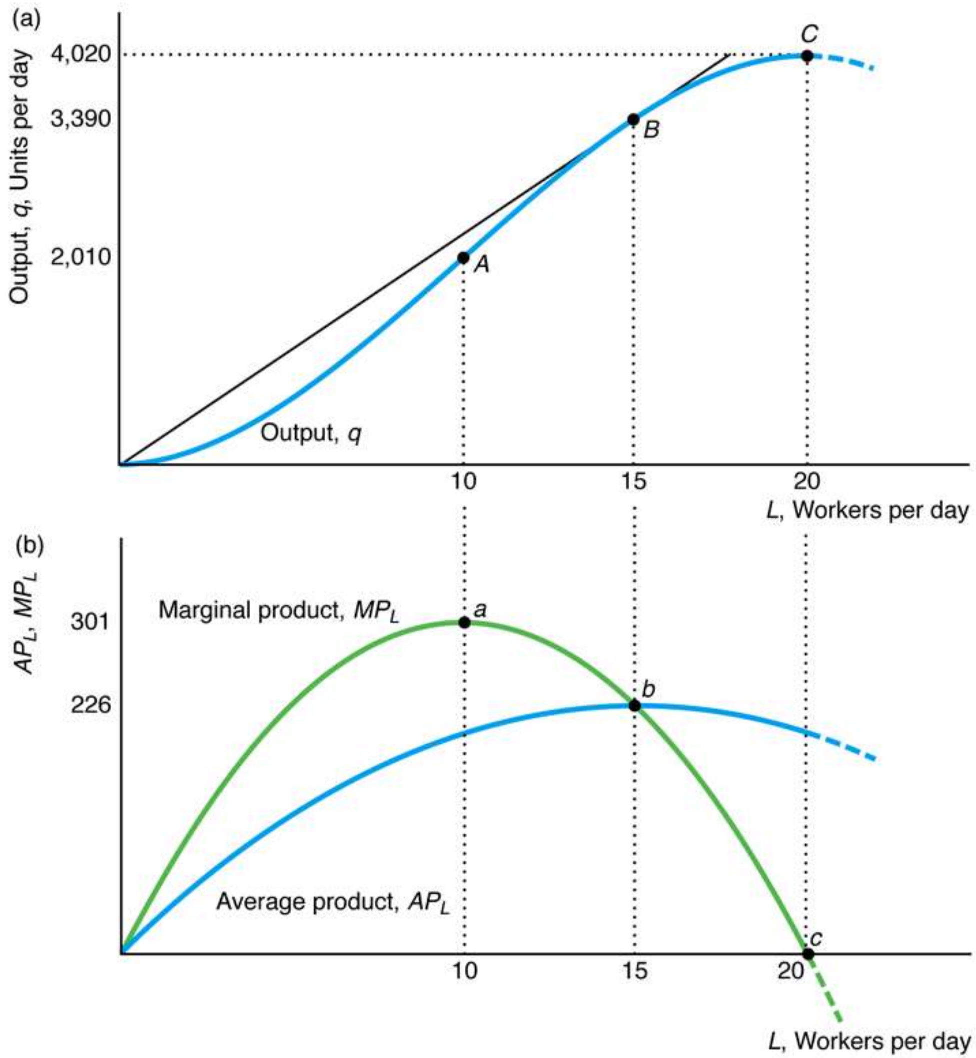
# 6.2 Production and Variability of Inputs

- The various ways that a firm can transform inputs into the maximum amount of output are summarized in the ***production function***.
  - Assuming labor (L) and capital (K) are the only inputs, the production function is $q = f(L, K)$ .
- A firm can more easily adjust its inputs in the long run than in the short run.
  - The ***short run*** is a period of time so brief that at least one factor of production cannot be varied (the fixed input).
  - The ***long run*** is a long enough period of time that all inputs can be varied.

# 6.3 Short Run Production

- In the short run (SR), we assume that capital is a fixed input and labor is a variable input.
  - SR Production Function: $$q = f\left(L, \bar{K}\right)$$
  - *q* is output, but also called ***total product***; t*he* short run production function is also called the ***total product of labor***
  - The ***marginal product of labor*** is the additional output produced by an additional unit of labor, holding all other factors constant. $$MP_L = \frac{\partial q}{\partial L} = \frac{\partial f\left(L, K\right)}{\partial L}$$
  - The ***average product of labor*** is the ratio of output to the amount of labor employed. $$AP_L = \frac{q}{L}$$

# 6.3 SR Production with Variable Labor



# 6.3 SR Production with Variable Labor

- Interpretations of the graphs:
  - Total product of labor curve shows output rises with labor until L=20.
  - $AP_L$ and $MP_L$ both first rise and then fall as L increases.
    - Initial increases due to specialization of activities; more workers are a good thing
    - Eventual declines result when workers begin to get in each other's way as they struggle with having a fixed capital stock
  - $MP_L$ curve first pulls $AP_L$ curve up and then pulls it down, thus, $MP_L$ intersects $AP_L$ at its maximum.

# 6.3 Law of Diminishing Marginal Returns (LDMR)

- The law holds that, if a firm keeps increasing an input, holding all other inputs and technology constant, the corresponding increases in output will eventually becomes smaller.
  - Occurs at L=10 in previous graph
- Mathematically:

$$\partial MP_L/\partial L = \partial(\partial q/\partial L)/\partial L = \partial^2 q/\partial L^2 = \partial^2 f(L, K)/\partial L^2 < 0$$

- Note that when $MP_L$ begins to fall, *TP* is still increasing.
- LDMR is really an empirical regularity more than a law.
  - Application: Malthus and the Green Revolution.

# 6.4 Long Run Production

- In the long run (LR), we assume that both labor and capital are variable inputs.
- The freedom to vary both inputs provides firms with many choices of *how* to produce (labor-intensive vs. capital-intensive methods).
- Consider a Cobb-Douglas production function where *A*, *a*, and *b* are constants:

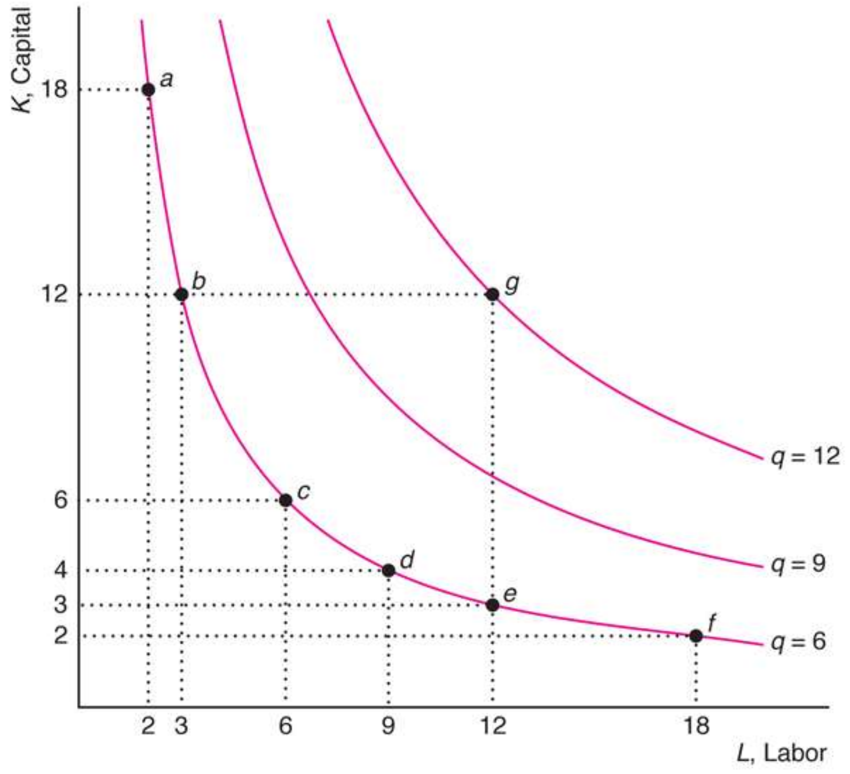
$$q = AL^a K^b$$

- Hsieh (1995) estimated such a production function for a U.S. electronics firm:

$$q = L^{0.5} K^{0.5}$$

# 6.4 LR Production Isoquants

- A production ***isoquant*** graphically summarizes the efficient combinations of inputs (labor and capital) that will produce a specific level of output.

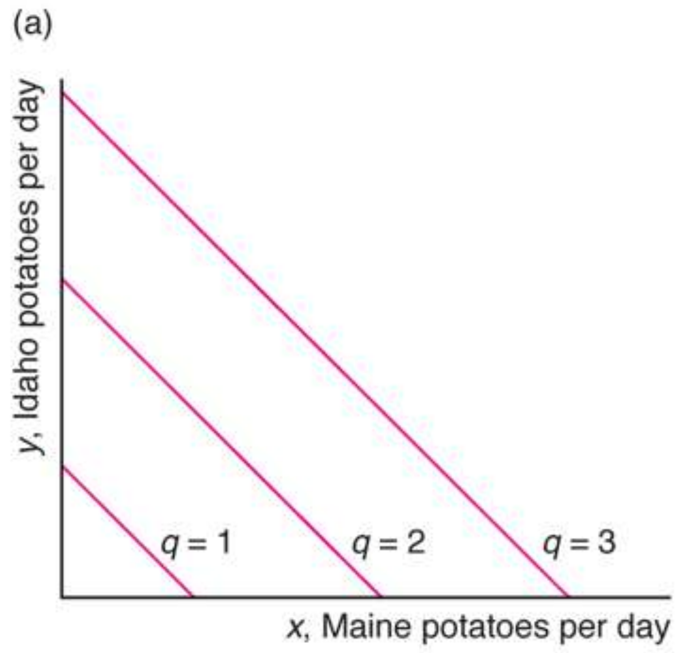


# 6.4 LR Production Isoquants

- Properties of isoquants:
  1. The farther an isoquant is from the origin, the greater the level of output.
  2. Isoquants do not cross.
  3. Isoquants slope downward.
  4. Isoquants must be thin.
- The shape of isoquants (curvature) indicates how readily a firm can substitute between inputs in the production process.

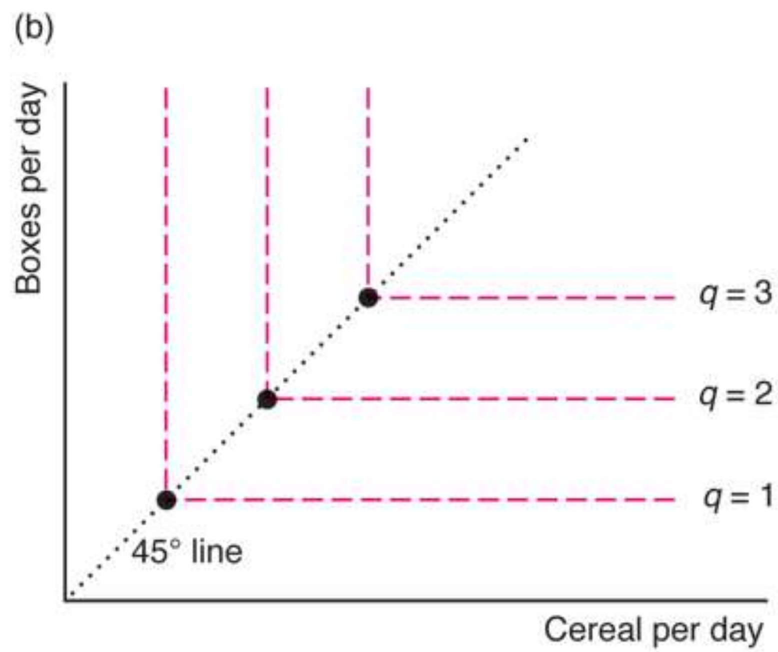
# 6.4 LR Production Isoquants

- Types of isoquants:
  1. Perfect substitutes (e.g. $q = x + y$)



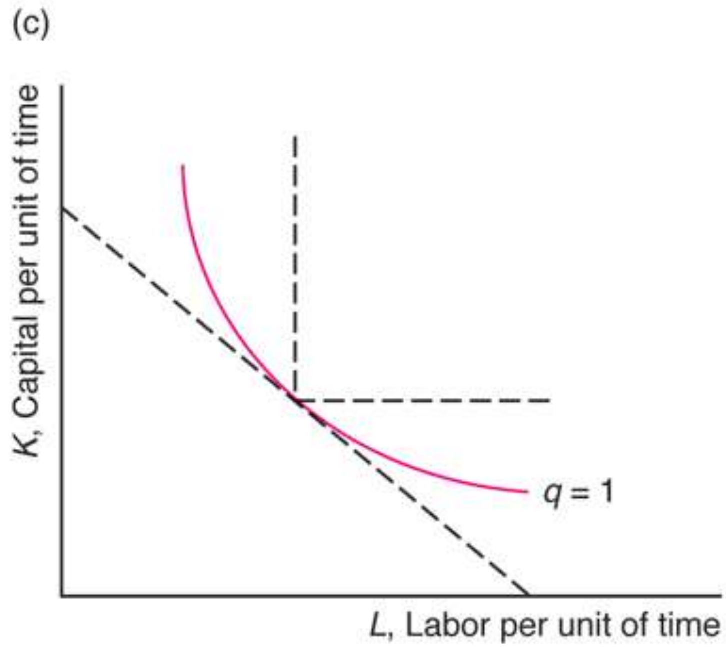
# 6.4 LR Production Isoquants

- Types of isoquants:
  2. Fixed-proportions (e.g. $q = \min\{g, b\}$ )



# 6.4 LR Production Isoquants

- Types of isoquants:
  3. Convex (e.g. $q = L^{0.5}K^{0.5}$ )



# 6.4 Substituting Inputs

- The slope of an isoquant shows the ability of a firm to replace one input with another (holding output constant).
- ***Marginal rate of technical substitution*** (***MRTS***) is the slope of an isoquant at a single point.

$$MRTS = \frac{\text{change in capital}}{\text{change in labor}} = \frac{\Delta K}{\Delta L} = \frac{dK}{dL}$$

  - MRTS tells us how many units of K the firm can replace with an extra unit of L (*q* constant)

$$\frac{d\bar{q}}{dL} = 0 = \frac{\partial f}{\partial L} + \frac{\partial f}{\partial K}\frac{dK}{dL} = MP_L + MP_K \frac{dK}{dL}$$

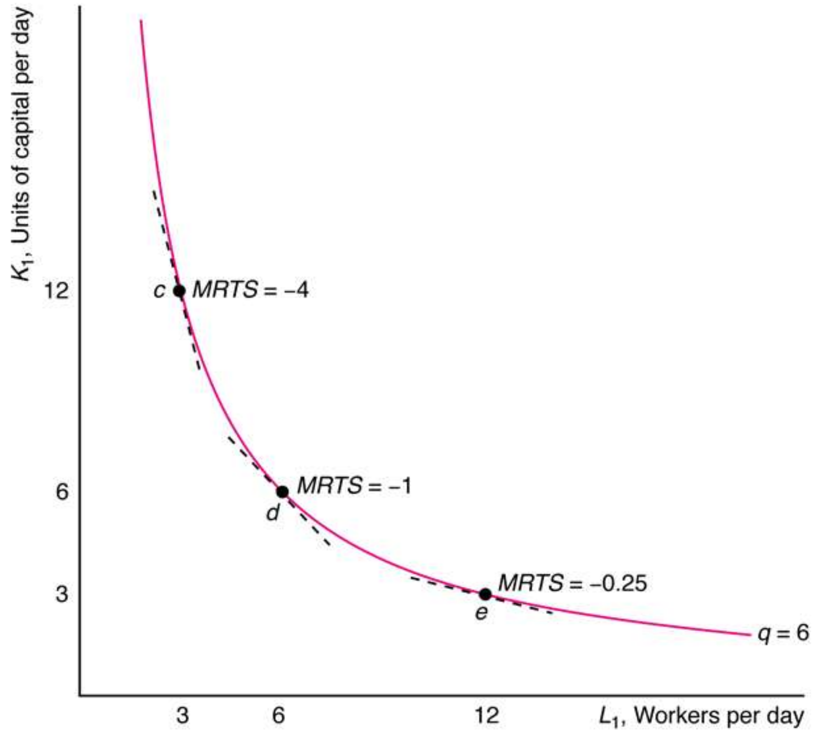
    - $MP_L$ = marginal product of labor; $MP_K$ = marginal product of capital

- Thus,

$$MRTS = \frac{dK}{dL} = -\frac{MP_L}{MP_K}$$

# 6.4 Substituting Inputs

- MRTS diminishes along a convex isoquant
  - The more L the firm has, the harder it is to replace K with L.



# 6.4 Elasticity of Substitution

- ***Elasticity of substitution*** measures the ease with which a firm can substitute capital for labor.

$$\sigma = \frac{\frac{d(K/L)}{K/L}}{\frac{dMRTS}{MRTS}} = \frac{d(K/L)}{dMRTS}\frac{MRTS}{K/L}$$

- Can also be expressed as a logarithmic derivative:

$$\sigma = \frac{d\ln(K/L)}{d\ln|MRTS|}$$

  - Example: CES production function, $q = \left(aL^{\rho} + bK^{\rho}\right)^{\frac{d}{\rho}}$

$$q = \left(L^{\rho} + K^{\rho}\right)^{\frac{1}{\rho}} \qquad MRTS = -\left(\frac{L}{K}\right)^{\rho-1}$$

Constant elasticity: $\sigma = \dfrac{1}{1-\rho}$

# 6.5 Returns to Scale

- How much does output change if a firm increases all its inputs proportionately?

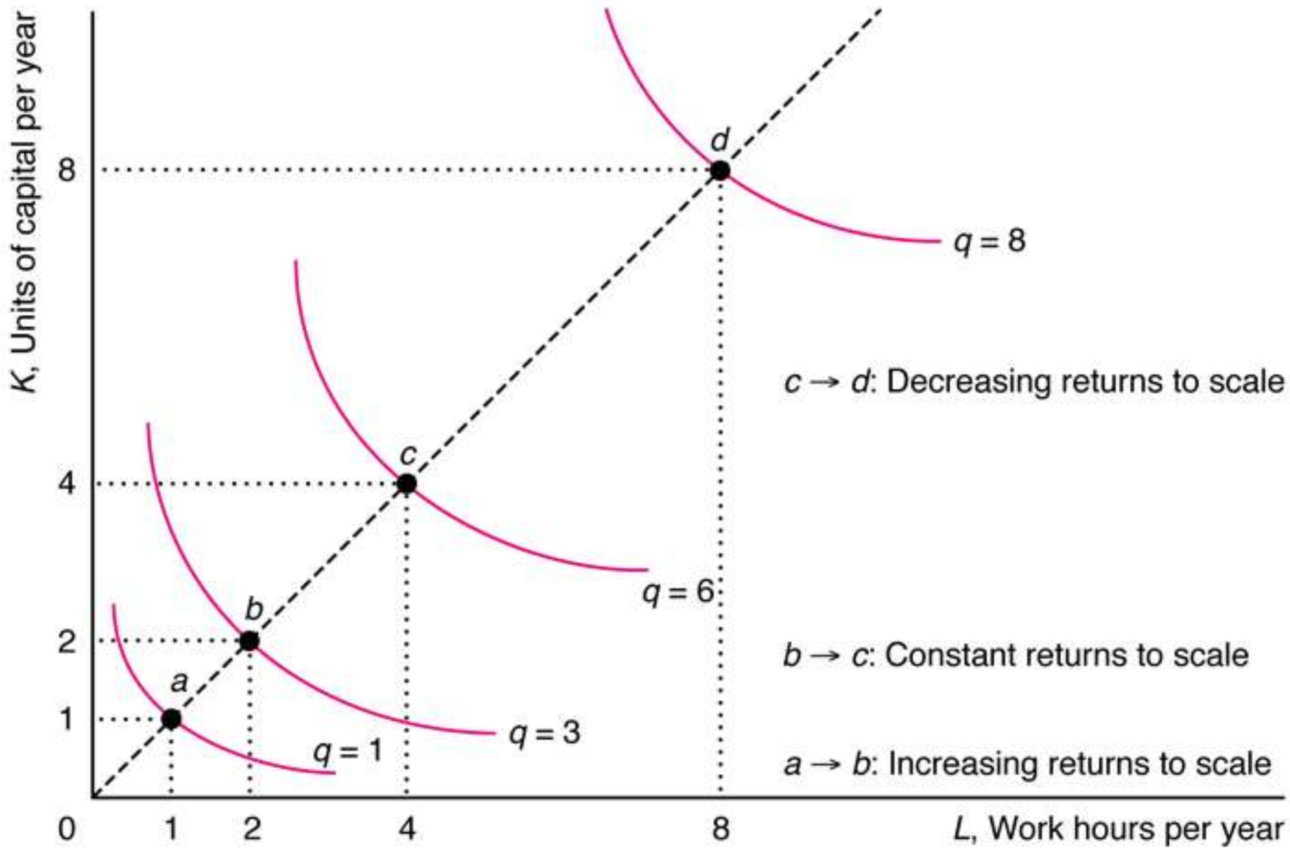
- Production function exhibits ***constant returns to scale*** when a percentage increase in inputs is followed by the same percentage increase in output.
  - Doubling inputs, doubles output → $f(2L, 2K) = 2f(L, K)$

- More generally, a production function is homogeneous of degree $\gamma$ if $f(xL, xK) = x^{\gamma}f(L, K)$ where $x$ is a positive constant.

# 6.5 Returns to Scale

- Production function exhibits ***increasing returns to scale*** when a percentage increase in inputs is followed by a **larger** percentage increase in output.
  - $f(2L, 2K) > 2f(L, K)$
  - Occurs with greater specialization of L and K; one large plant more productive than two small plants
- Production function exhibits ***decreasing returns to scale*** when a percentage increase in inputs is followed by a **smaller** percentage increase in output.
  - $f(2L, 2K) < 2f(L, K)$
  - Occurs because of difficulty organizing and coordinating activities as firm size increases.

# 6.5 Varying Returns to Scale



# 6.6 Productivity and Technical Change

- Even if all firms are producing efficiently (an assumption we make in this chapter), firms may not be equally ***productive***.
- ***Relative productivity*** of a firm is the firm's output as a percentage of the output that the most productive firm in the industry could have produced with the same inputs.
  - Relative productivity depends upon:
    1. Management skill/organization
    2. Technical innovation
    3. Union-mandated work rules
    4. Work place discrimination
    5. Government regulations or other industry restrictions
    6. Degree of competition in the market

# 6.6 Productivity and Technical Change

- An advance in firm knowledge that allows more output to be produced with the same level of inputs is called ***technical progress***.
  - Example: Nano by Tata Motors
  - *Neutral technical change* involves more output using the same ratio of inputs.
  - *Non-neutral technical change* involves altering the proportion in which inputs are used to produce more output.
- Organizational change may also alter the production function and increase output.
  - Examples: automated production of Gillette razor blades, mass production of Ford automobiles