# THE PRODUCTION, COST AND TECHNOLOGY OF HEALTH CARE

EE 474 Health Economics

Semester 2/2017

# Topics

- Production and the Possibilities for Substitution
- Costs in Theory and Practice
- Technical and Allocative Efficiency
- Productive Efficiency
- Frontier Analysis
- Health Care Technological Changes
    - Technological Changes and Costs
    - Price Adjustment When Technology Change Occurs
    - Diffusions of New Health Care Technologies

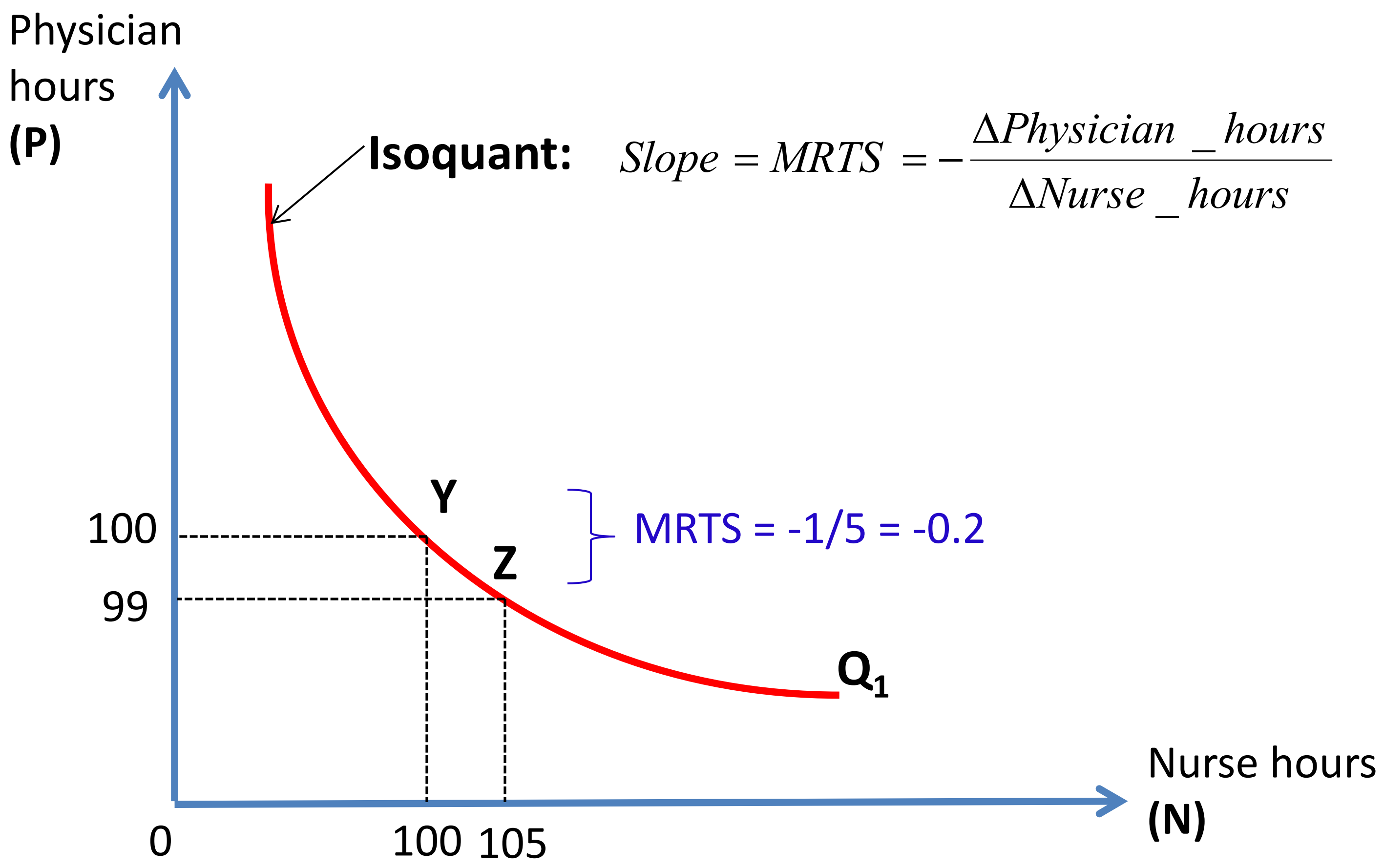
# Production

- Short-run production
  - A production in which *at least* one input cannot be modified within a given period of time.
  - Fixed inputs – fixed at all levels of output, e.g. capital, salary
  - Variable inputs – vary by the amount of output, e.g. labor
- Long-run production
  - A production in which *all inputs* can be changed over time

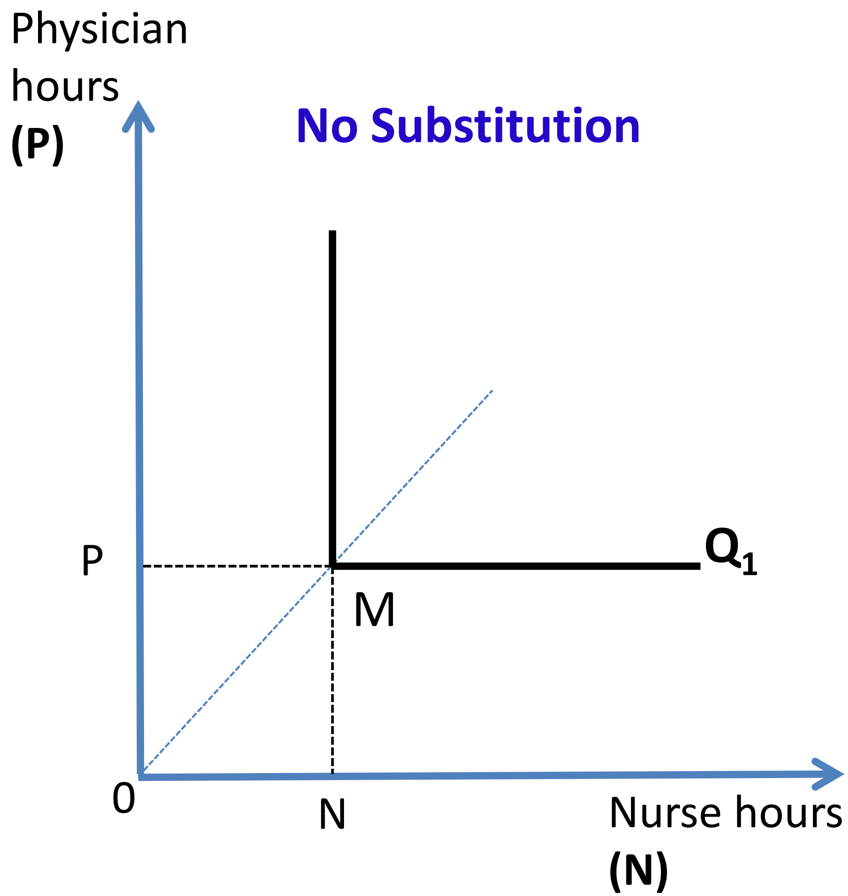
# Possibilities for Substitution

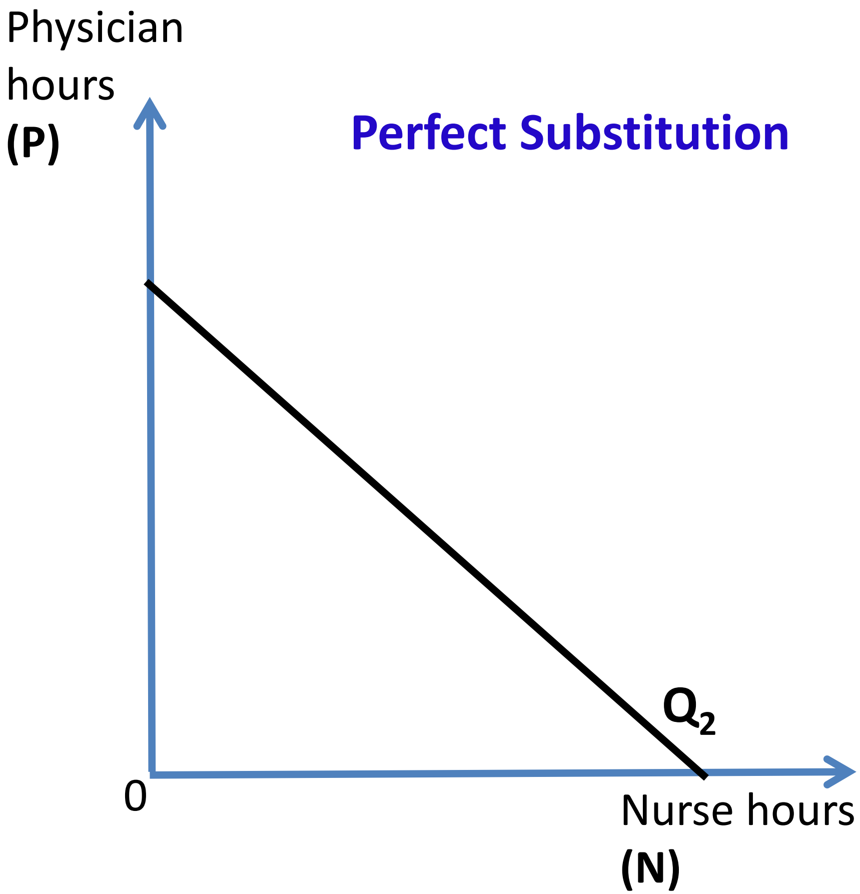
- Now, consider the production with *more than two variable inputs* (e.g. physicians and nurses).
- We are interested in the ability to substitute one input (e.g. physicians) for another input (e.g. nurses) while maintaining the same level of output.
- The degree to which one input can be replaced by another input, while output remains constant, is measured by the *slope of the isoquant*, which is equal to the marginal rate of technical substitution (MRTS).

# Substitution between Physicians and Nurses



# Substitution: Extreme Cases




Question: Would these two cases be possible in the real world?

# Elasticities of Input Substitution

- If an input price changes, a cost-minimizing firm would respond by shifting away from the *costlier* input to the *cheaper* input.
- The new input combination is determined by the elasticity of substitution of inputs.
- The elasticity of substitution ($E_S$) measures the responsiveness of a cost-minimizing firm to changes in relative input prices:

$$E_s = \frac{\text{Percentage change in factor input ratio}}{\text{Percentage change in factor price ratio}}$$

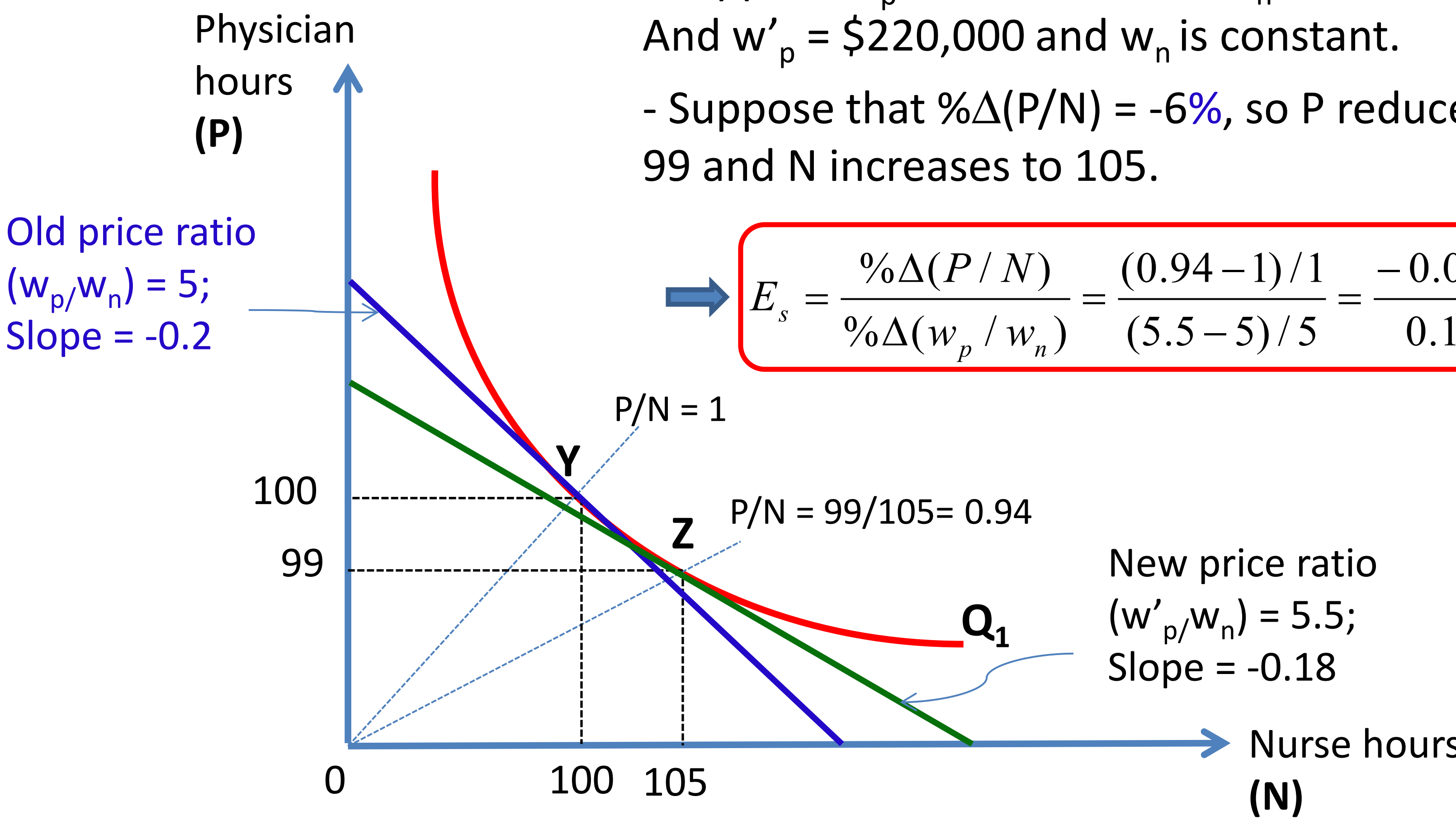
- Example: Suppose M = f(P, N), and factor prices are Wp and Wn.

$$E_S = \frac{\%\Delta(P/N)}{\%\Delta(W_p/W_n)} = \frac{\Delta(P/N)}{P/N} \times \frac{W_p/W_n}{\Delta(W_p/W_n)}$$

# Substitution between Physicians and Nurses

- Suppose $w_p$ = \$200,000 and $w_n$ = \$40,000 And $w'_p$ = \$220,000 and $w_n$ is constant.
- Suppose that %Δ(P/N) = -6%, so P reduces to 99 and N increases to 105.

$$E_s = \frac{\%\Delta(P/N)}{\%\Delta(w_p/w_n)} = \frac{(0.94-1)/1}{(5.5-5)/5} = \frac{-0.06}{0.1} = -0.6$$



# Input Substitution: Application

- $E_s$ = -0.6 means that, as input price ratio increases by 1%, the input ratio would decrease by 0.6%.
- The absolute values of $E_s$ range between 0 and ∞.
  - $E_s$ =0 ➔ No substitutability
  - Larger $E_s$ ➔ Greater potential for substitutability
- The concept of input substitution can be applied particularly to the *long-run production*, where all inputs are flexible.
- Other examples of input substitution:
  - Substitution between health workers and new technology
  - Substitution between local physicians and foreign physicians (Think about AEC integration in 2015!)

# Deriving Cost Curve

- Hospital's cost minimization problem:

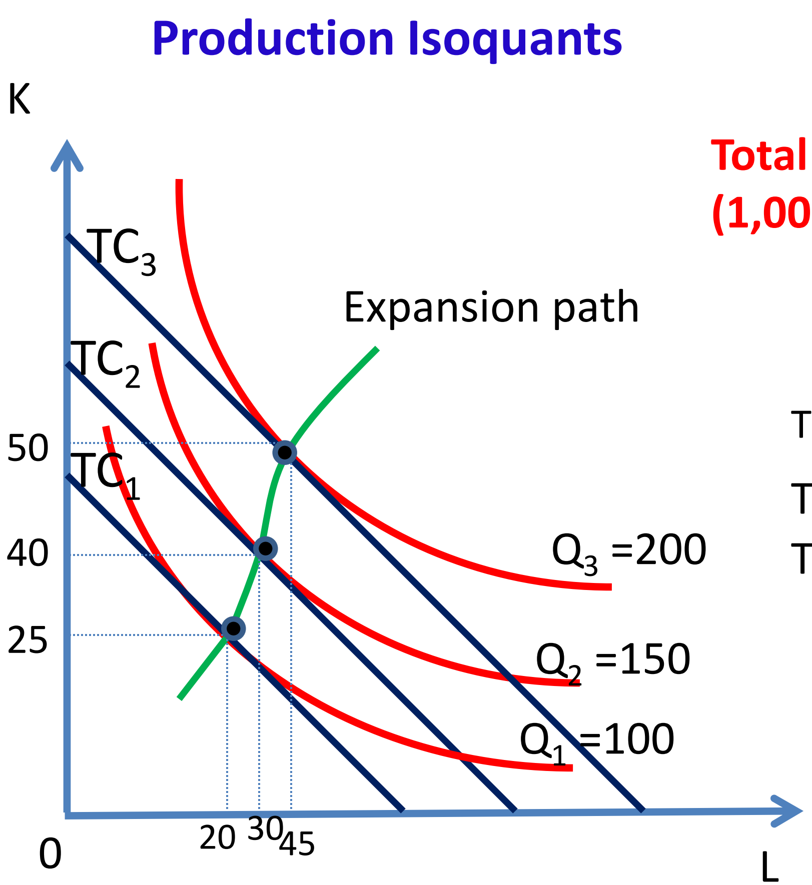
  Min TC = rK + wL

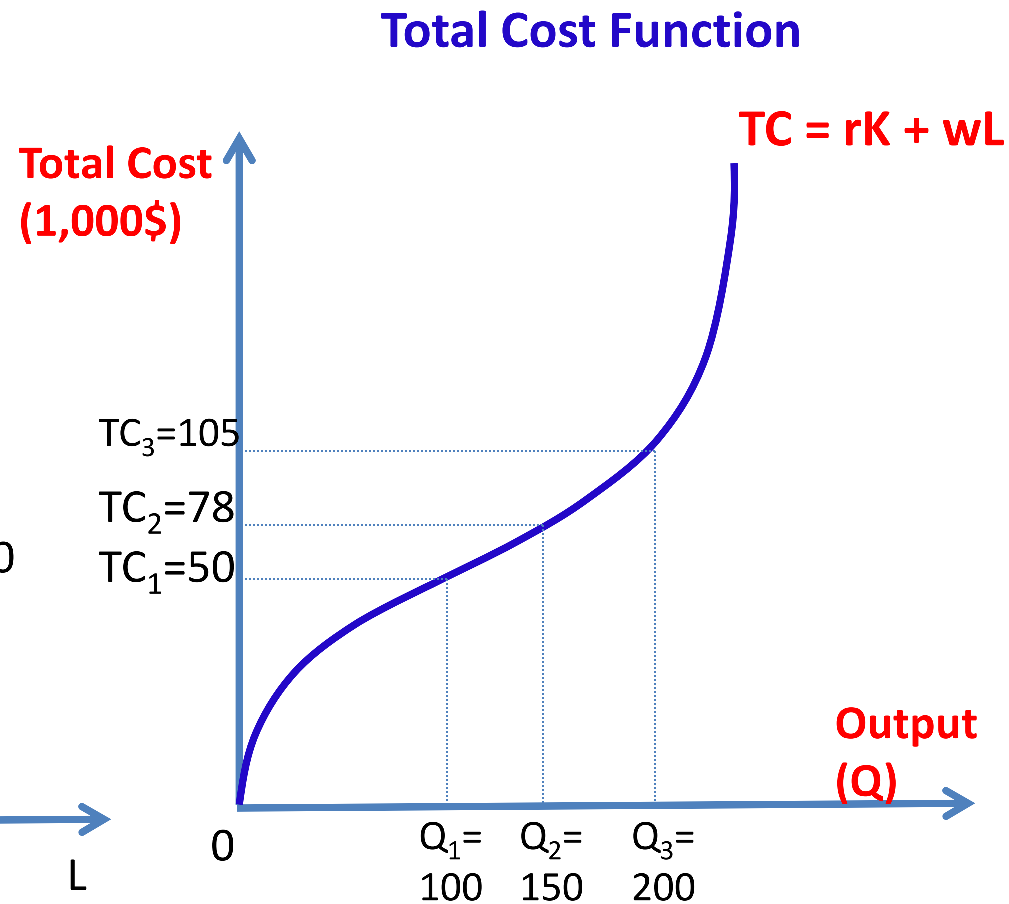
  Subject to Q*=Q(K, L)

  ➔ (K*,L*) is the input combination that gives the least cost at a given output level.

- The set of all possible points of tangency between the isocost curves and the isoquants is called the expansion path.
  - This curve tells the relationship between a given output level and its minimum cost.

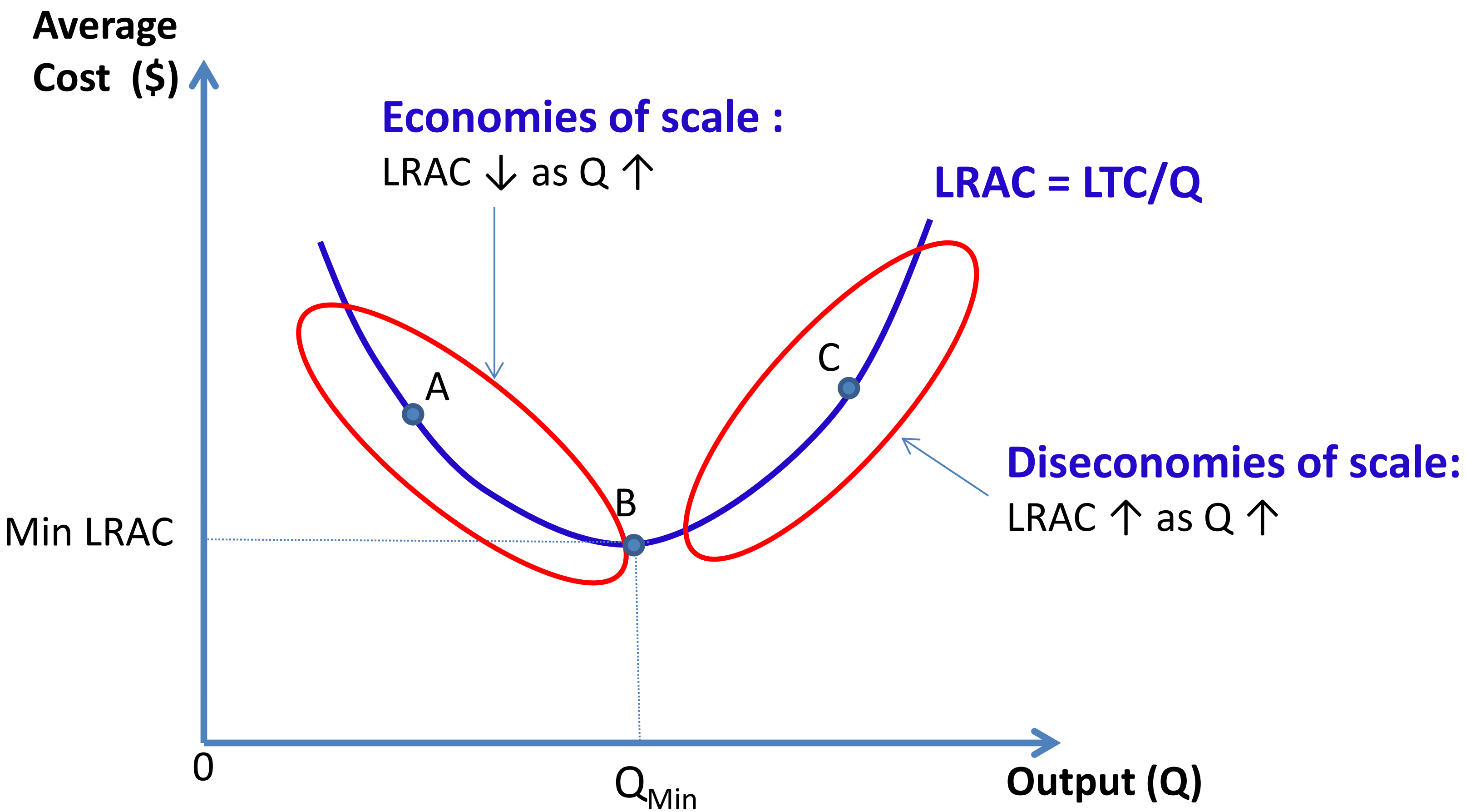
# Cost Function




Suppose input prices are r = \$1,200 and w = \$1,000.

# Economies of Scale



# Economies of Scope

- Definition:

For a multiproduct firm, economies of scope occur whenever it is possible to produce two or more goods jointly more cheaply than they can be produced separately.

- Mathematically, suppose a firm has 2 outputs $Q_1$ and $Q_2$. Economies of scope exists if:

$$TC(Q_1, Q_2) > TC(Q_1, 0) + TC(0, Q_2)$$

where $TC(Q_1,Q_2)$ = the joint cost of producing both outputs together

$TC(Q_1,0)$ = the cost of producing output 1 only

$TC(0,Q_2)$ = the cost of producing output 2 only

# Significance of Economies of Scale and Economies of Scope

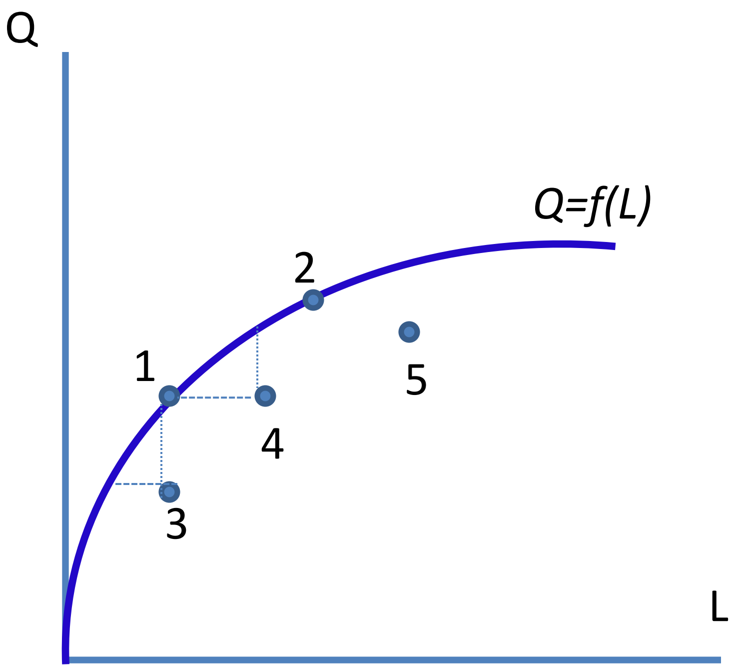
- Both concepts can provide implications to public policy and to managerial policy.
- Economies of scale:
  - Profit-maximizing firm
    - Prefers to produce where AC is still decreasing
  - Society's perspective
    - Prefers lowest average costs (not necessary where it max π)
- Economies of scope:
  - Provision of different departments in the same hospital
  - Subsidization in teaching hospitals

# Efficiency

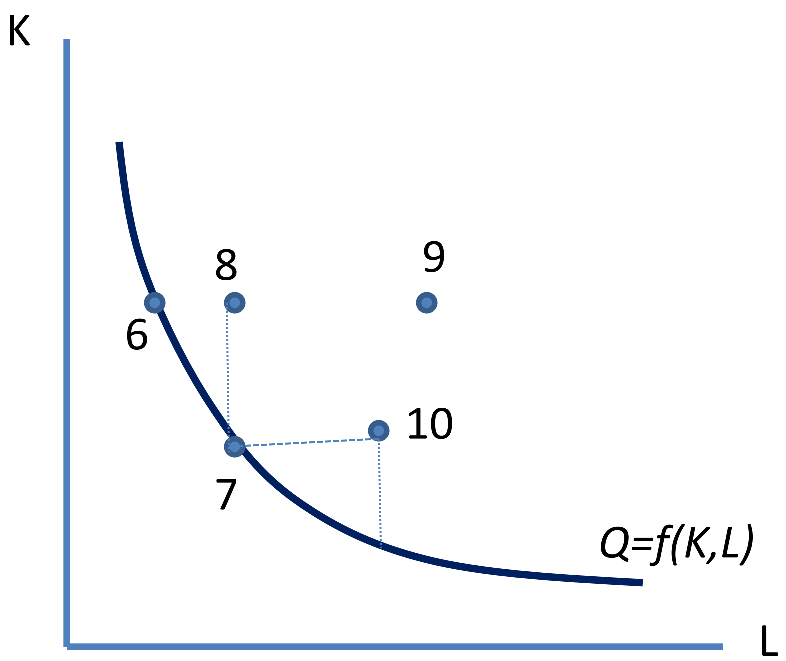
- Technical efficiency
  - Applies to production within a given firm
  - Technical efficiency is achieved when a maximum output is being produced from a given input combination.
- Allocative efficiency
  - Requires the efficient allocation of inputs between firms and between outputs.
  - Allocative efficiency is achieved when inputs are put into their best uses so that no further gains in output are possible.
- Productive efficiency
  - There could be many different levels of output that are allocative efficient (i.e. total costs are minimized).
  - Of all the least cost levels of output, the “most least cost” level of output is productively efficient.

# 1. Technical Efficiency

- 1 Input




- 2 Inputs



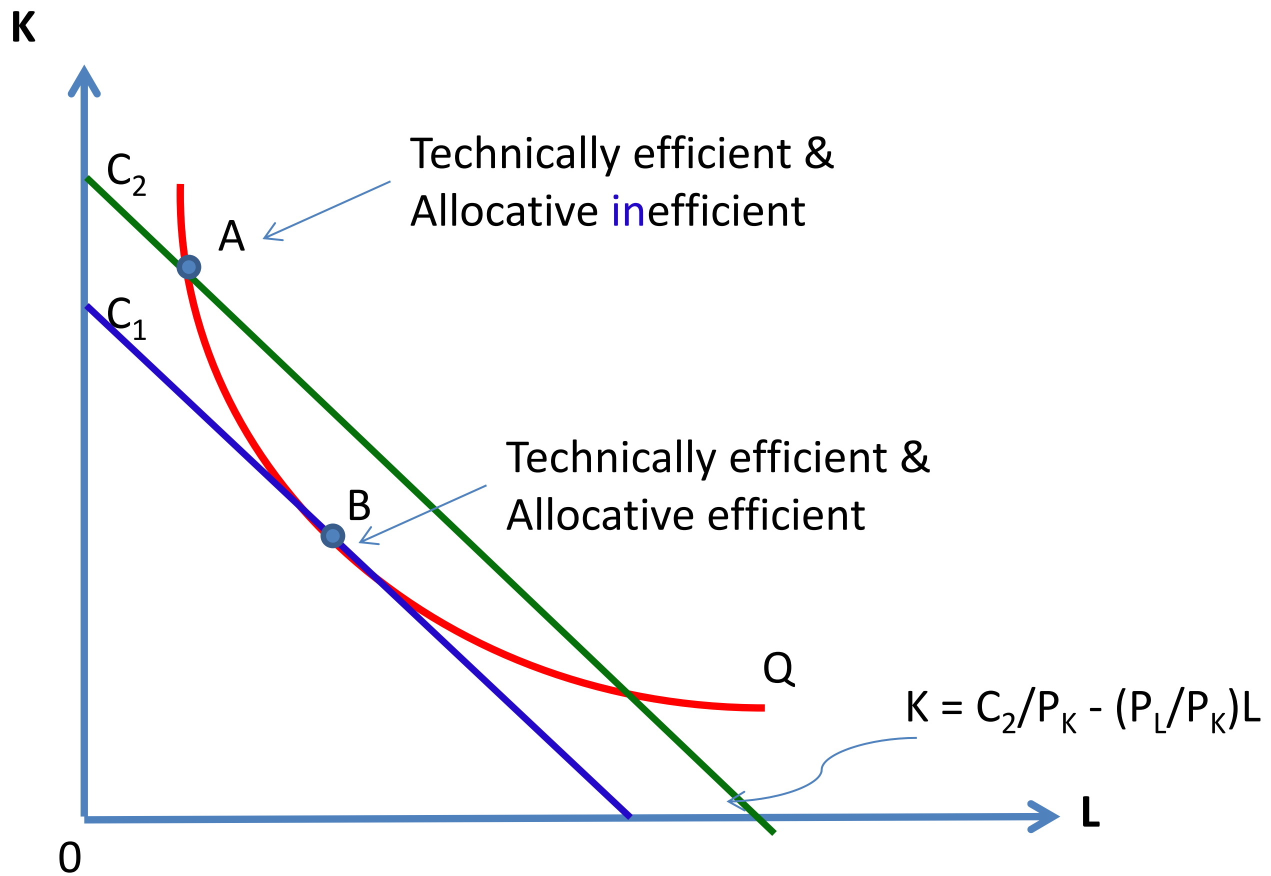

Technical inefficiency results when a firm uses more resources than necessary to produce a given level of output.

# Technical and Allocative Efficiencies

| Technology | K | L |
|---|---|---|
| A | 3 | 4 |
| B | 4 | 2 |
| C | 3 | 3 |

- Which technology is technically inefficient?
  - Technology A.
- Which technology is allocative inefficient?
  - We can't tell whether B or C costs less until we have prices.

# 2. Allocative Efficiency

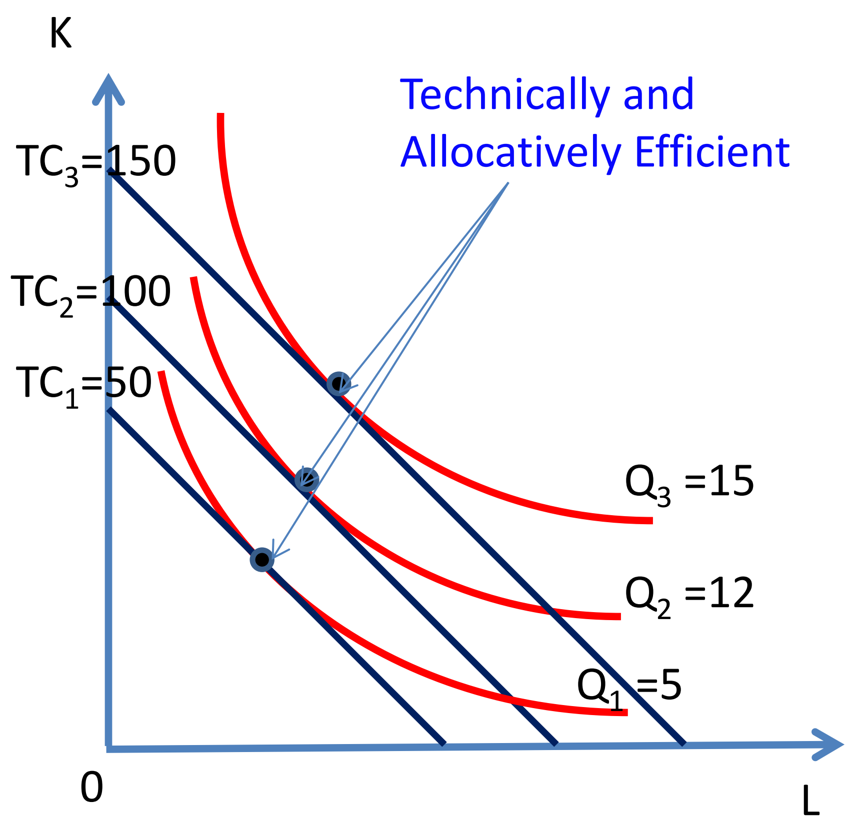


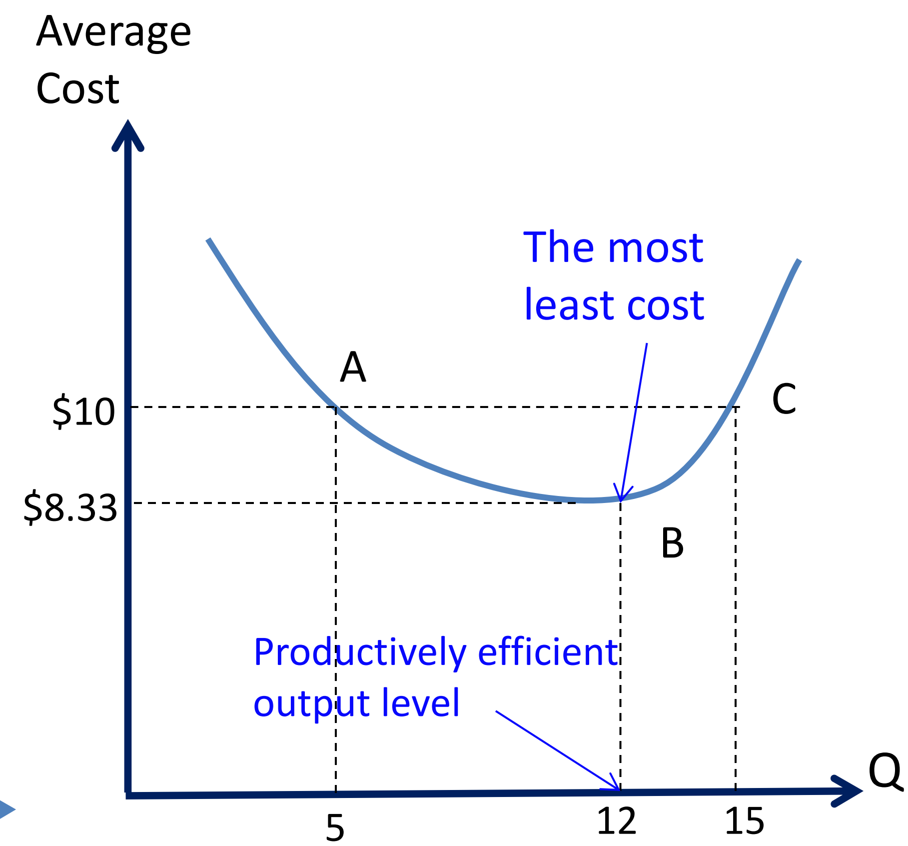
# Technical and Allocative Efficiencies

| Technology | K | L | Cost (if $P_K$=10, $P_L$=5) |
|---|---|---|---|
| A | 3 | 4 | $50 |
| B | 4 | 2 | $50 |
| C | 3 | 3 | $45 |

- Suppose $P_K$ = 10 and $P_L$= 5, which technology is allocatively efficient?

# 3. Productive Efficiency



# Example: Productive Efficiency

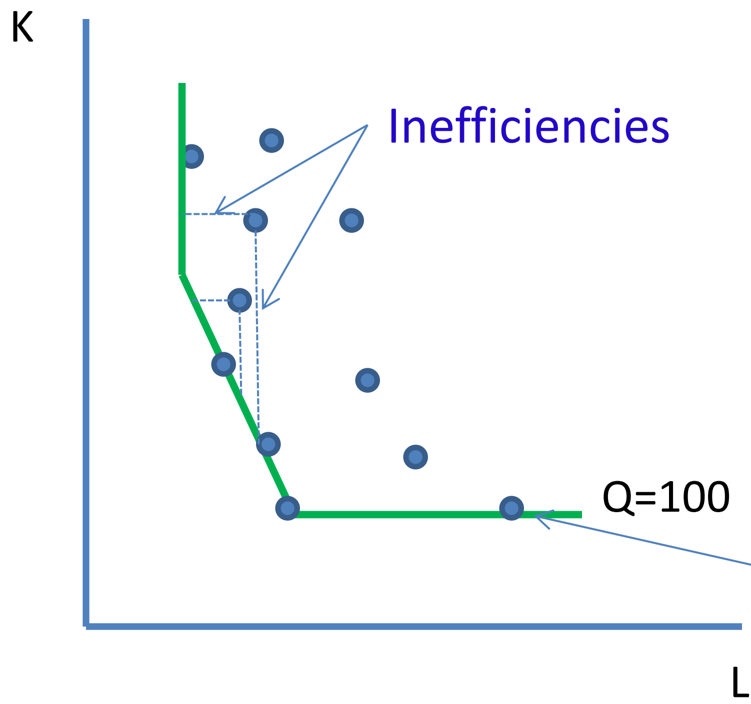
- Consider another example

| Quantity (Unit) | Total Cost ($) | Average Cost |
|---|---|---|
| 100 | 50,000 | 500 |
| 150 | 78,000 | 520 |
| 200 | 105,000 | 525 |

- Which quantity level is productively efficient?

➔ Q = 100 (because at this quantity, AC is the least).

# Frontier Analysis: Data Envelope Analysis

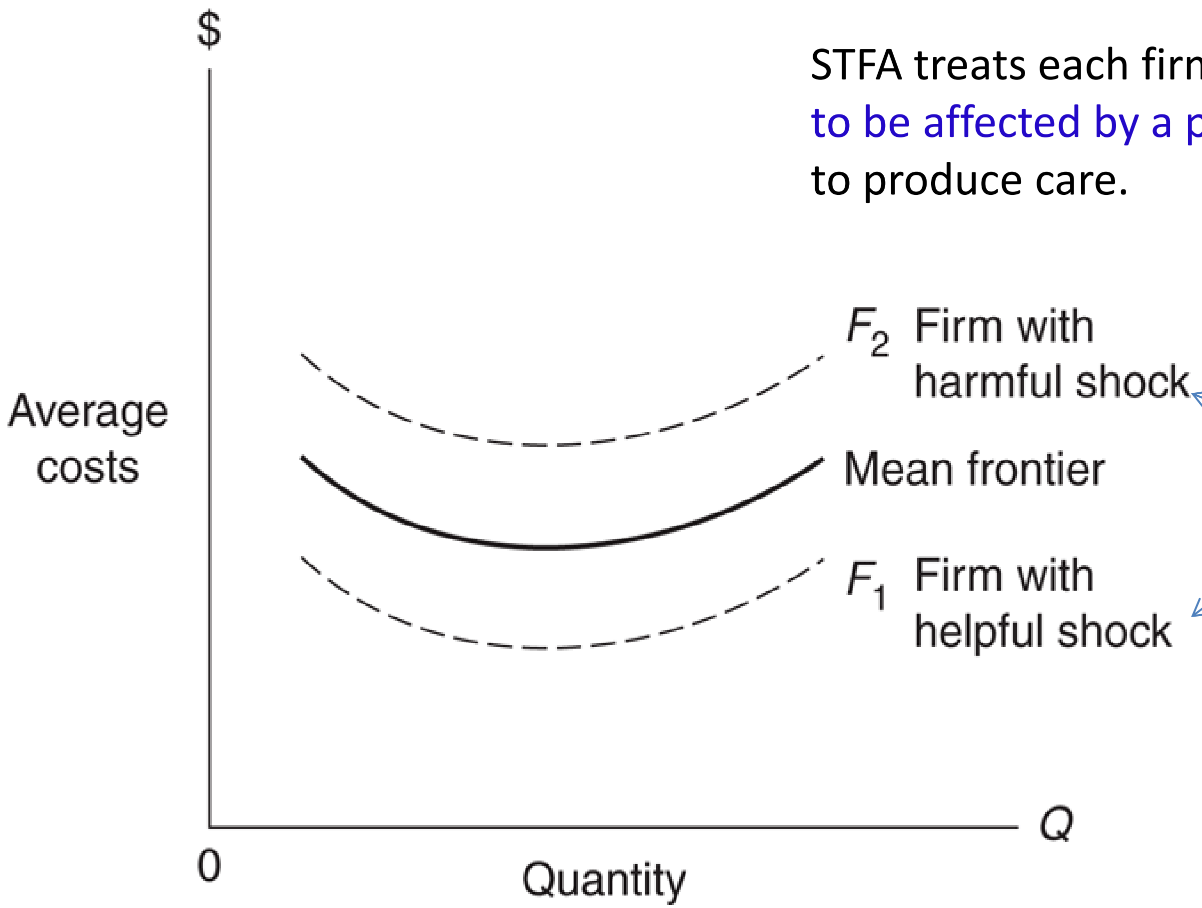



The Data Envelope Analysis (DEA) identifies the efficient outer shell enveloping the data.

Deterministic frontier (found by using linear programming)

# Frontier Analysis: Stochastic Frontier Analysis (STFA)

STFA treats each firm uniquely by assuming it to be affected by a potential shock to its ability to produce care.




Frontier is stochastic.

*Inefficiency* score is calculated from the residuals obtained from SCF model.

# Case Study:
# Efficiency of Public Hospitals in Thailand

(Source: Patamasiriwat, 2011)

- Examined cost efficiency of 3 different types of public hospitals in Thailand:
  - Regional hospitals (23)
  - Provincial hospitals (58)
  - Community hospitals (629)
- Focused on technical efficiency and looked at the cost side
  - Costs: Wage, personal compensations, operating expenses, material costs, utilities, others
- Estimated cost function: $C = f(OP, IP) = OP^a x IP^b$
  - Regional hospitals: constant returns to scale (i.e. $a+b = 1$)
  - Community & Provincial hospitals: decreasing cost (i.e. $a+b <1$)

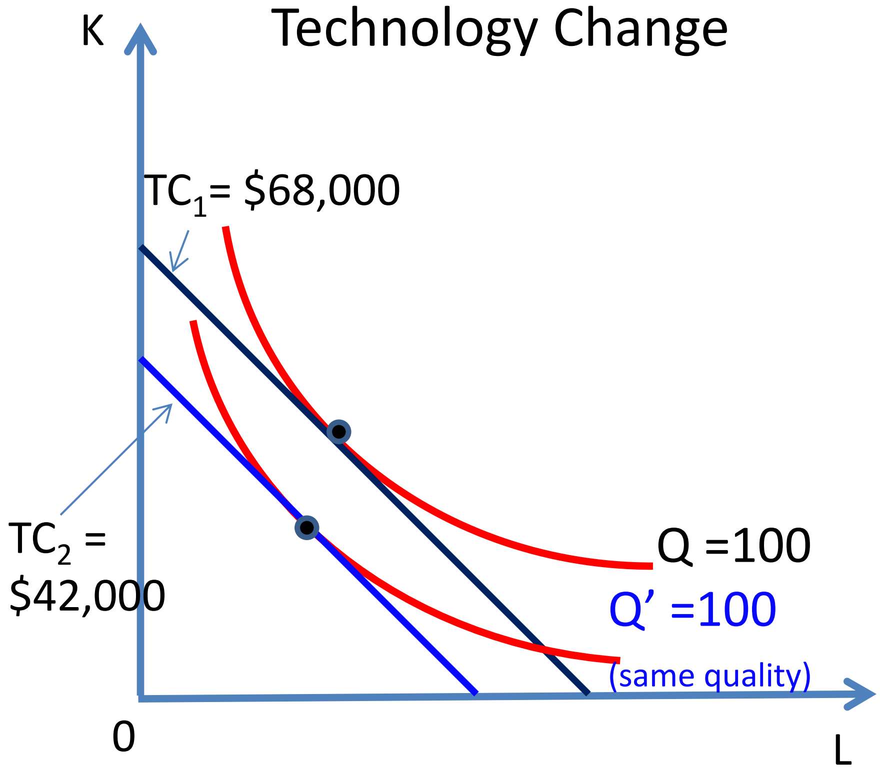
# Case Study: Efficiency of Public Hospitals in Thailand

(Source: Patamasiriwat, 2011)

- 2 Methods to determine efficiency: DEA and STFA
  - Regional hospitals: Efficiency score = 0.94 (i.e. "output slack" =6%)
  - Provincial hospitals: Efficiency score = 0.64
  - Community hospitals: Inefficiency score=0.186 → Efficiency score = 0.814
- Limitations:
  - Ignore other types of hospital outputs (teaching, research, health promotion)
  - Did not consider quality of care or severity of different health care cases
- Discussion:
  - ➢ Provincial and community hospitals might operate at less than full capacity
  - ➢ There were signs of resource underutilization.

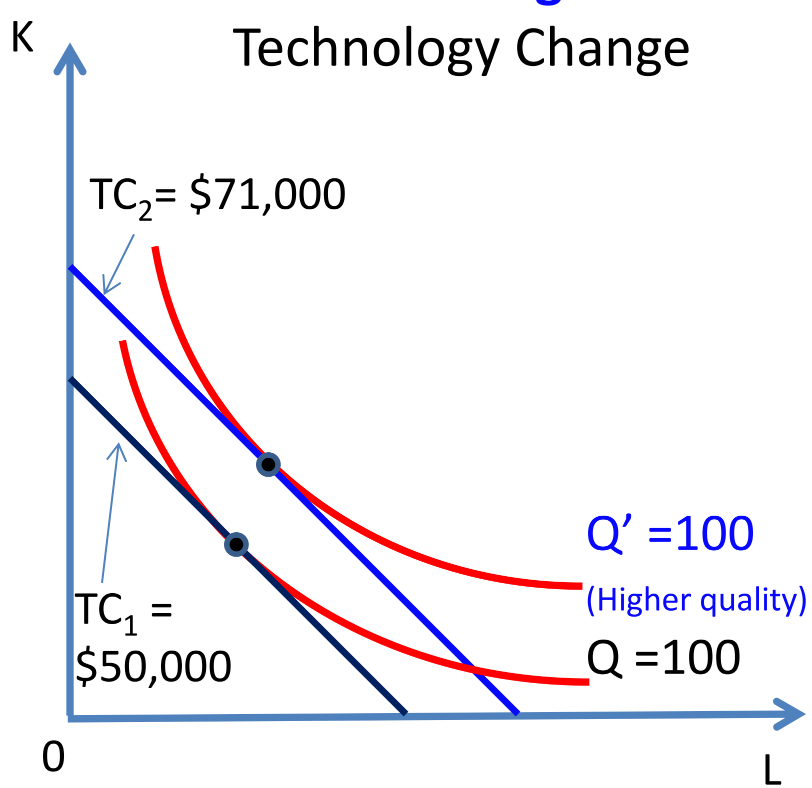
# Technological Changes and Costs

**Cost-Decreasing** due to Technology Change




Technology change increases the productivity of health resources.

**Cost-Increasing** due to Technology Change




Technology change improves quality of care or introduce costlier products.

# Health Care Prices with Technological Change Occurs

- Question: Whether technological changes really cause the inflation in the health care sector?

➢ Not necessarily!

  - ➢ New treatments are *not* included in the fixed basket when calculating CPI.
  - ➢ Improvement in the treatment effectiveness could be omitted.
    - Example: New treatments reduce the length of hospital stay. By putting more weight on the room charge, the price index is overestimated.
  - ➢ Not taken into account the improvement in quality of life of the patients.

# Adjustment in Health Care Prices

- <u>Example</u>: Cutler et al (1999) developed two quality adjusted price indexes of myocardial infarction treatment

| Unadjusted Indexes | Avg. Price Changes | Quality-Adjusted Indexes | Avg. Price Changes |
|---|---|---|---|
| Official MCPI | 3.4% | Quality (extra years of life) | -1.5% |
| Heart attack episode approach | 2.8% | Quality (extra QALYs) | -1.7% |

- ➢ Technological change has *improved the quality of treatment*.
- ➢ The quality adjustment can prove that the heart attack treatment *price* is actually *declining* (price deflation).

# Diffusion of New Health Care Technologies

- Two basic principles guide adopters:

1. Profit channels:
   - Example: Physicians tend to adopt a new surgical technique if they expect to *increase their revenues*.
     - ➢Enhancing their prestige
     - ➢Improving the well-being of their patients.
2. Information channels:
   - Derived originally from sociology discipline
   - Emphasizes the role of friends, colleagues, journals, etc., in informing and encouraging the adoption decision.

- Other factors affecting diffusion patterns: regulation and timing of the adoption.