

THE PRODUCTION, COST AND TECHNOLOGY OF HEALTH CARE

EE 474 Health Economics

Semester 1/2013

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

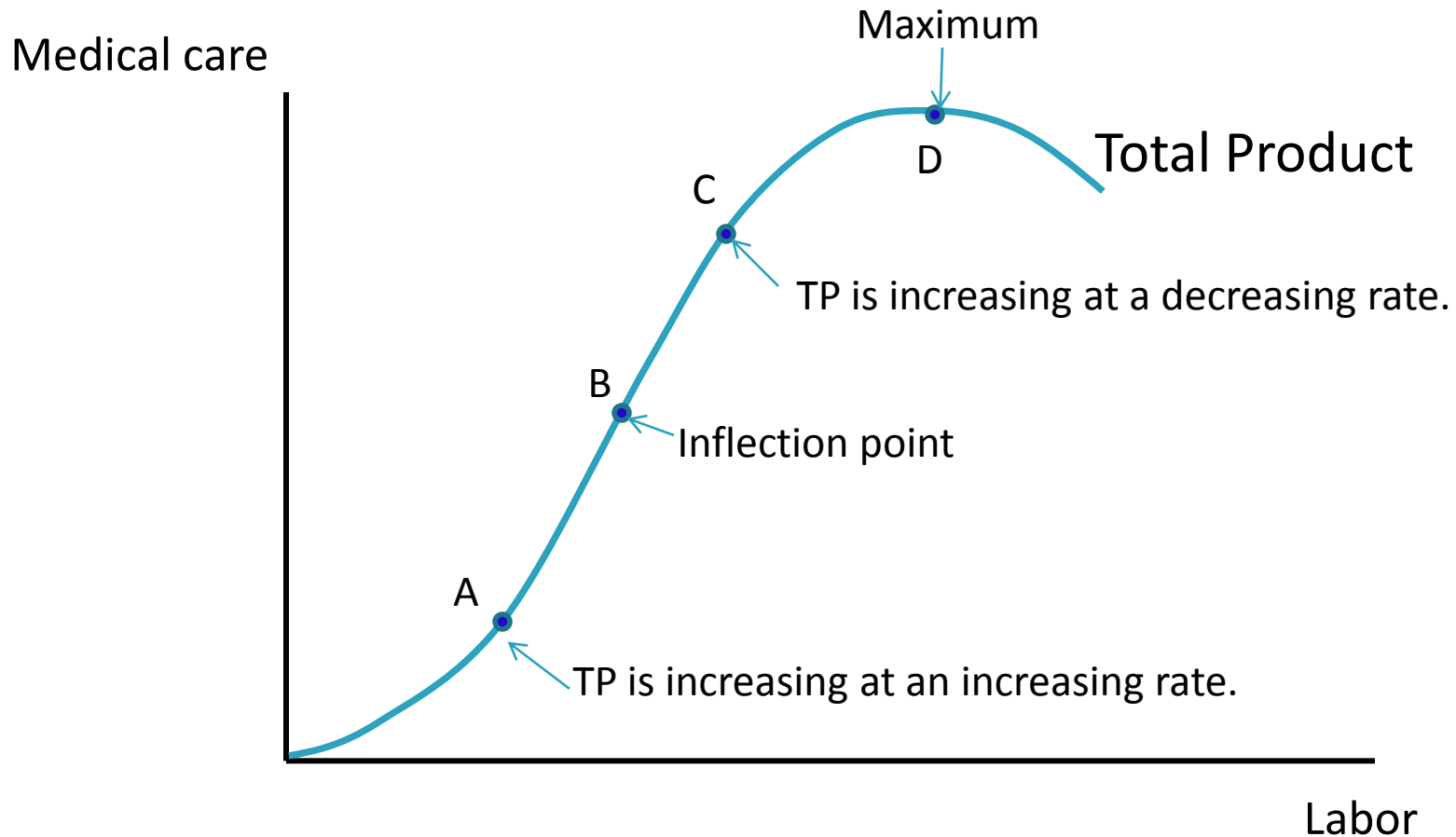
- Short-run production

- 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

Recall: Short-run Production



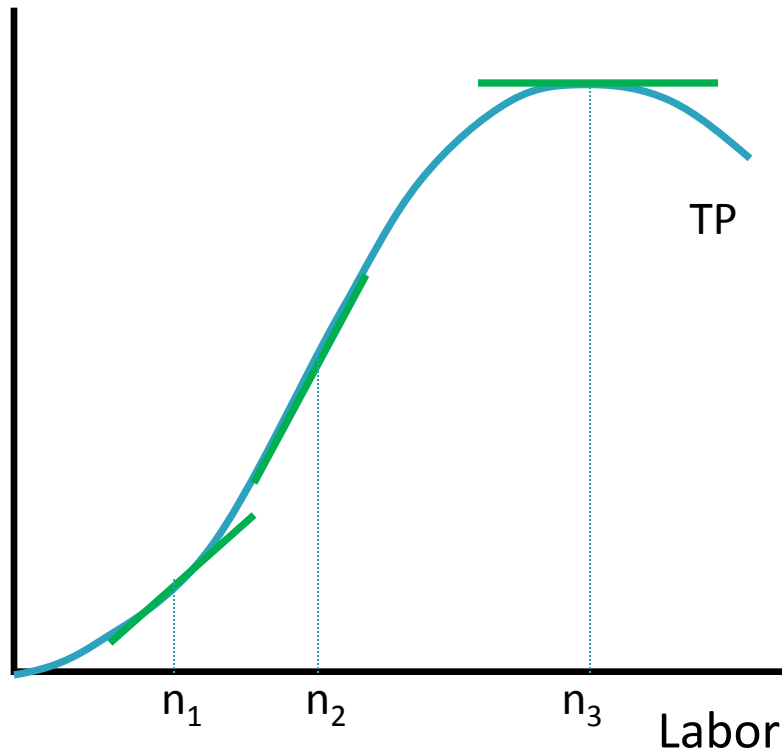
Marginal Product

- Economists are concerned about **efficiency** and **optimization**.
 - How much output is generated by each additional unit of an input
 - Want to know *how much input to buy*
- **Marginal product** measures the amount of output (q) increased from using an additional unit of input (L).
 - MP is the **slope** of the production function.

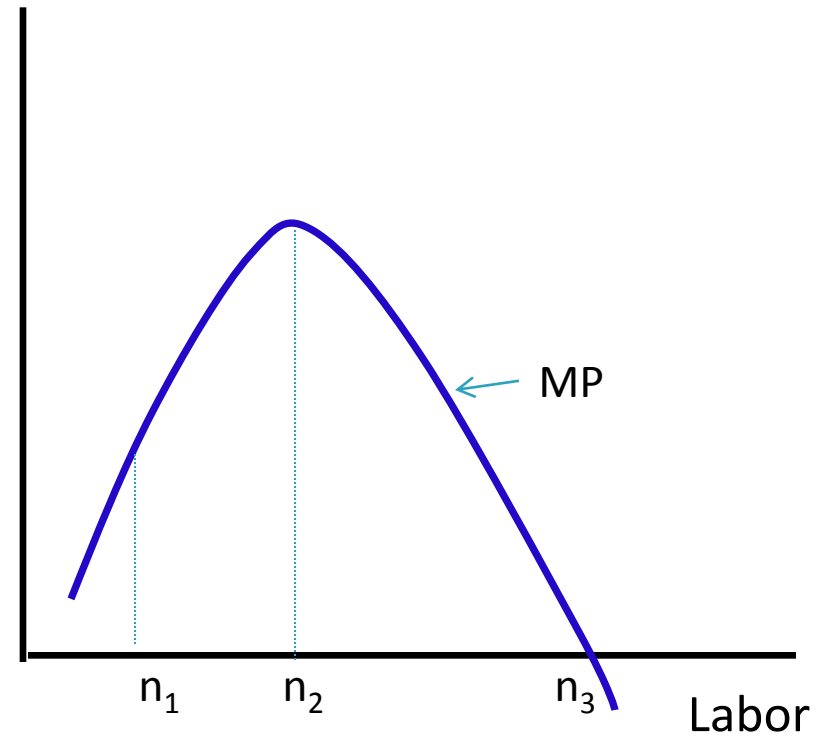
$$MP_L = \frac{\Delta \text{Output}}{\Delta \text{Labor Input}} = \frac{\Delta q}{\Delta L}$$

Marginal Product Curve

TP



MP

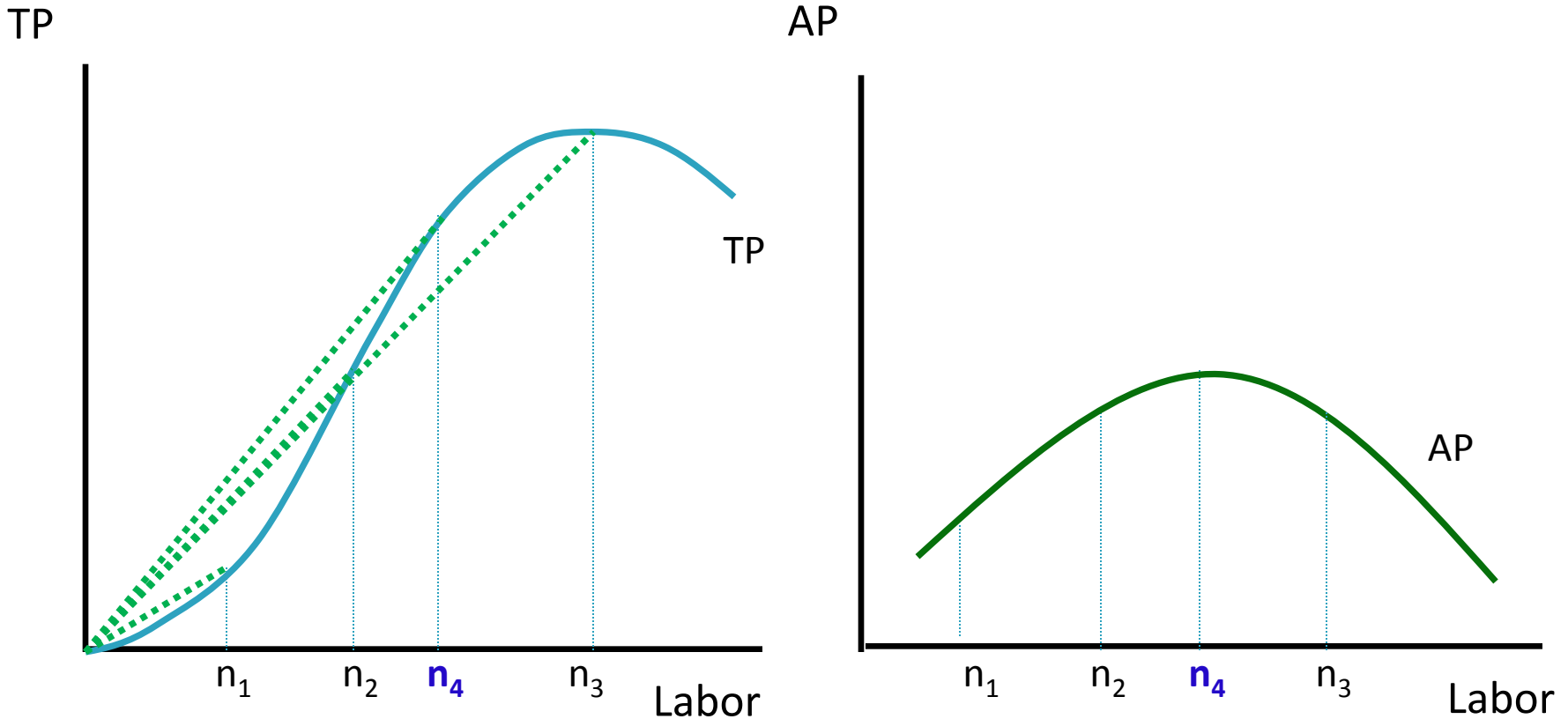


Average Product

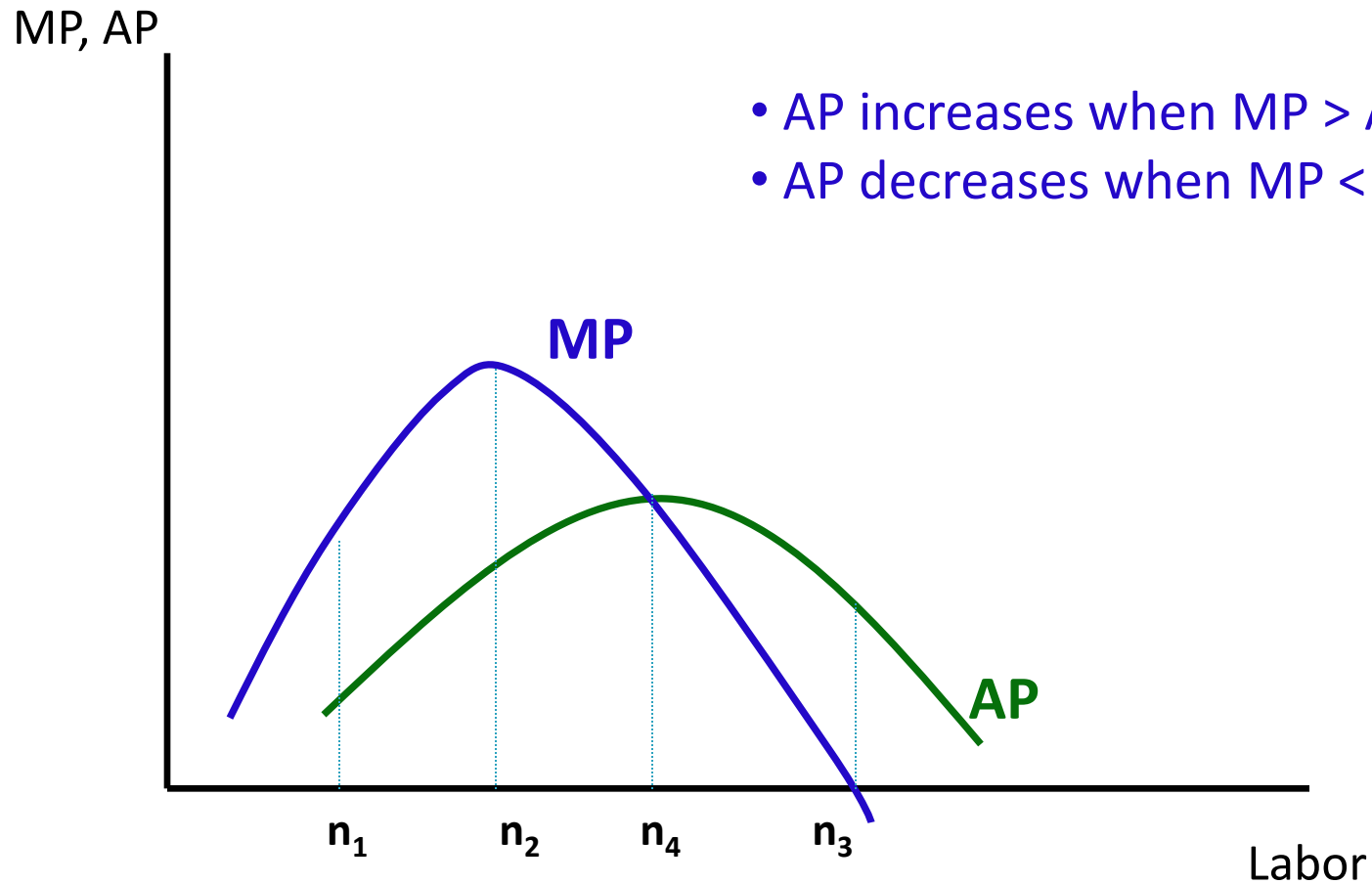
- The **average product (AP)** is the amount of output that is produced on average per unit of input.
 - AP varies with the level of input.
 - AP is the slope of a ray from the origin to a point on the production function.

$$AP_L = \frac{\text{Output}}{\text{Labor Input}} = \frac{q}{L}$$

Average Product Curve



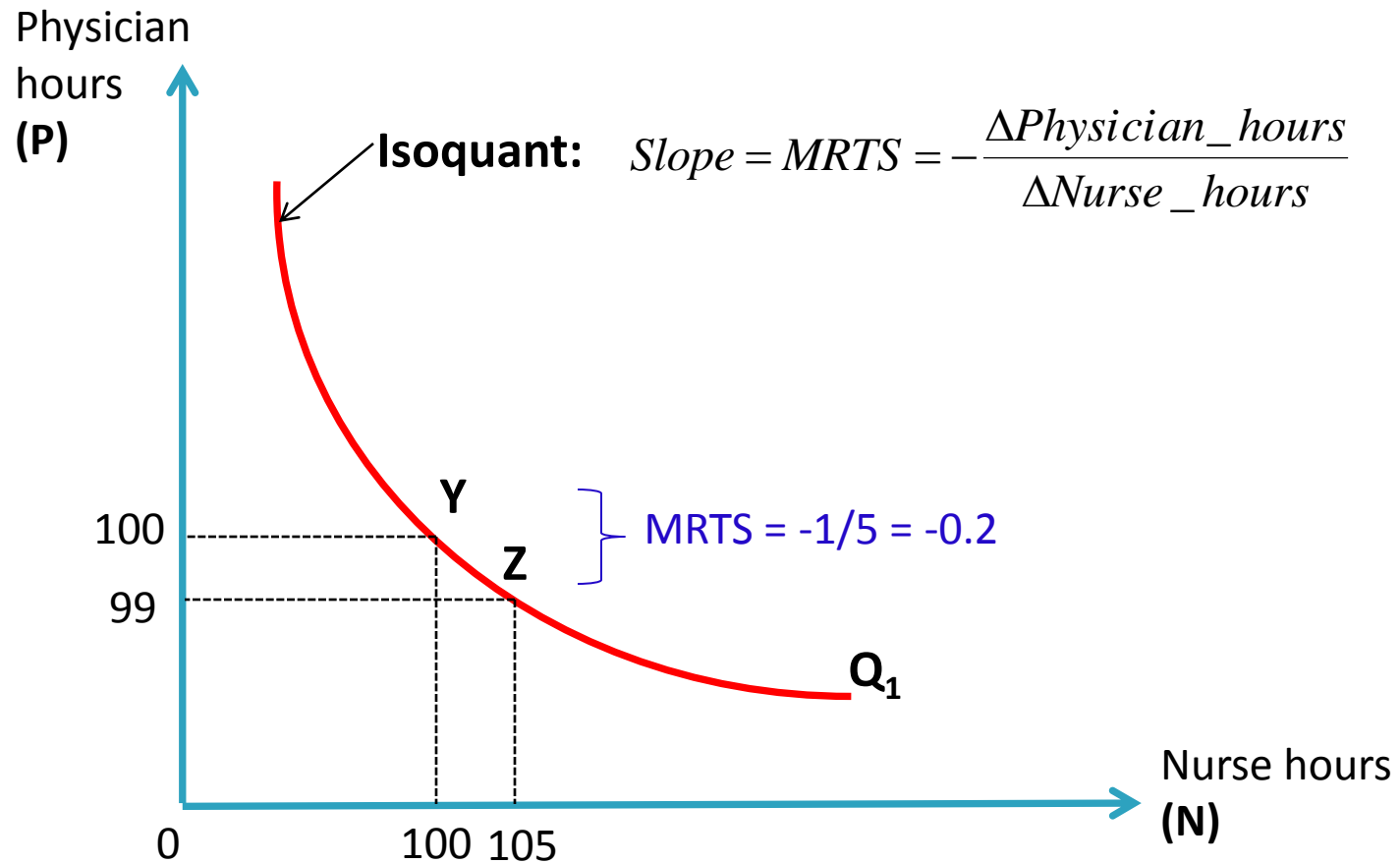
MP and AP Curves



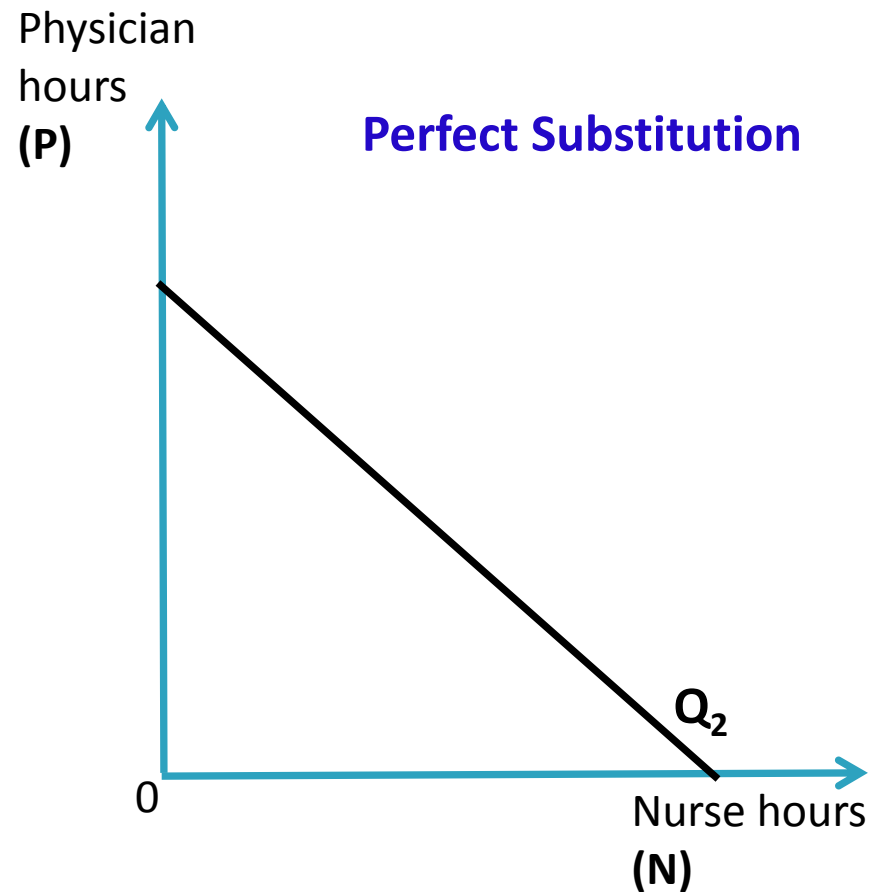
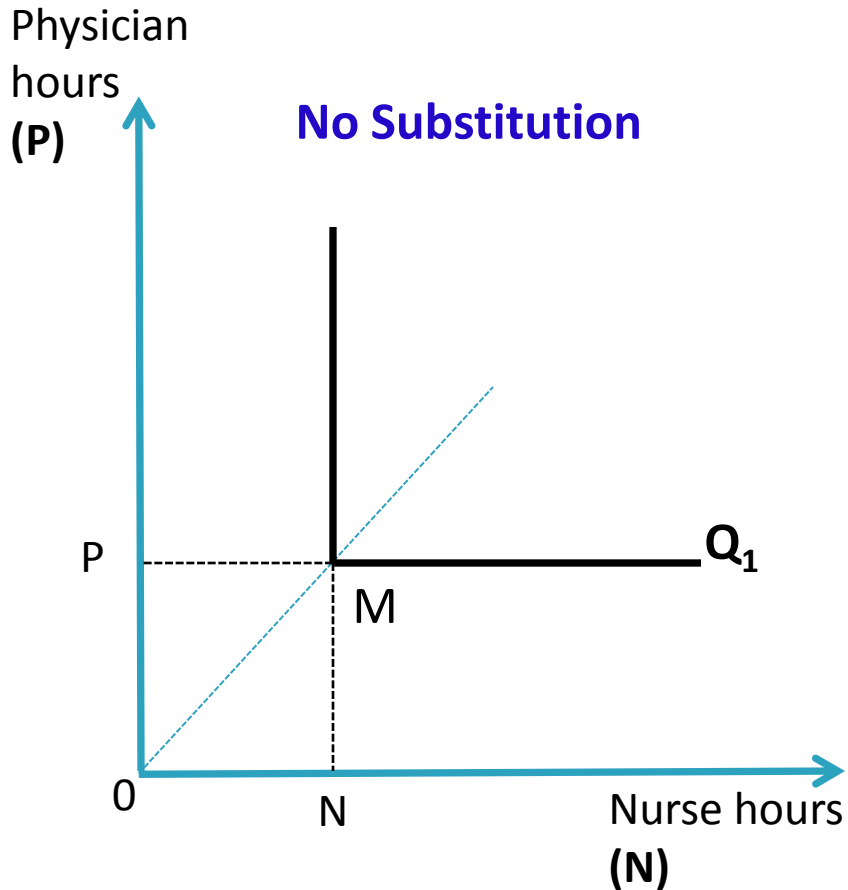
Possibilities for Substitution

- Now, consider the production with *more than two variable inputs* (e.g. physicians and nurses) in the short run.
- We are interested in the **ability to substitute one input (e.g. physicians) for another input (e.g. nurses)** while maintaining the 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

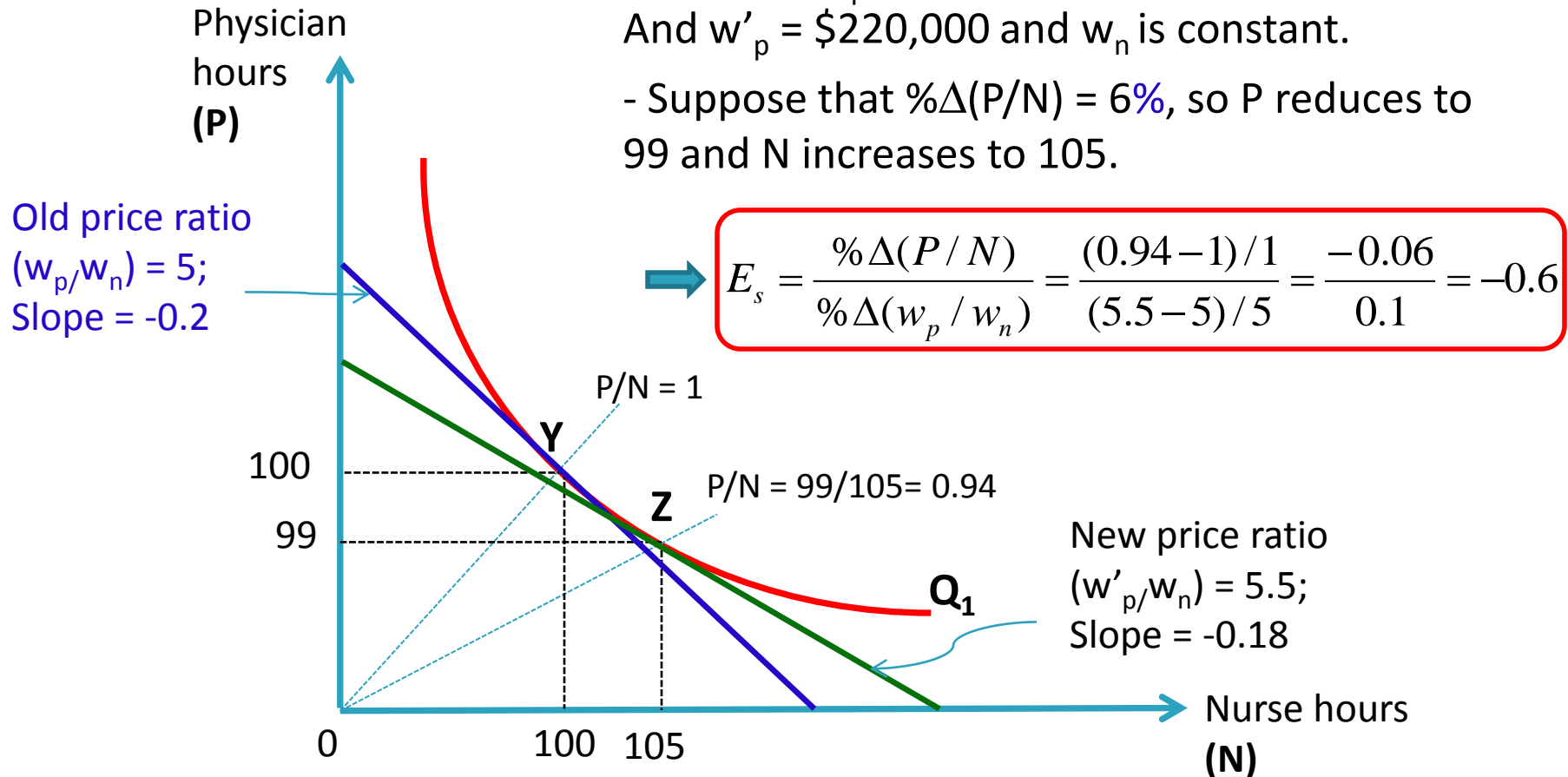
- If an input price changes, a cost-minimizing firm would respond by shifting away from the *costlier* input to the *cheaper* input.
- The new input combination is determined by the elasticity of substitution of inputs.
- The **elasticity of substitution** (E_s) measures the responsiveness of a cost-minimizing 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 W_p and W_n .

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

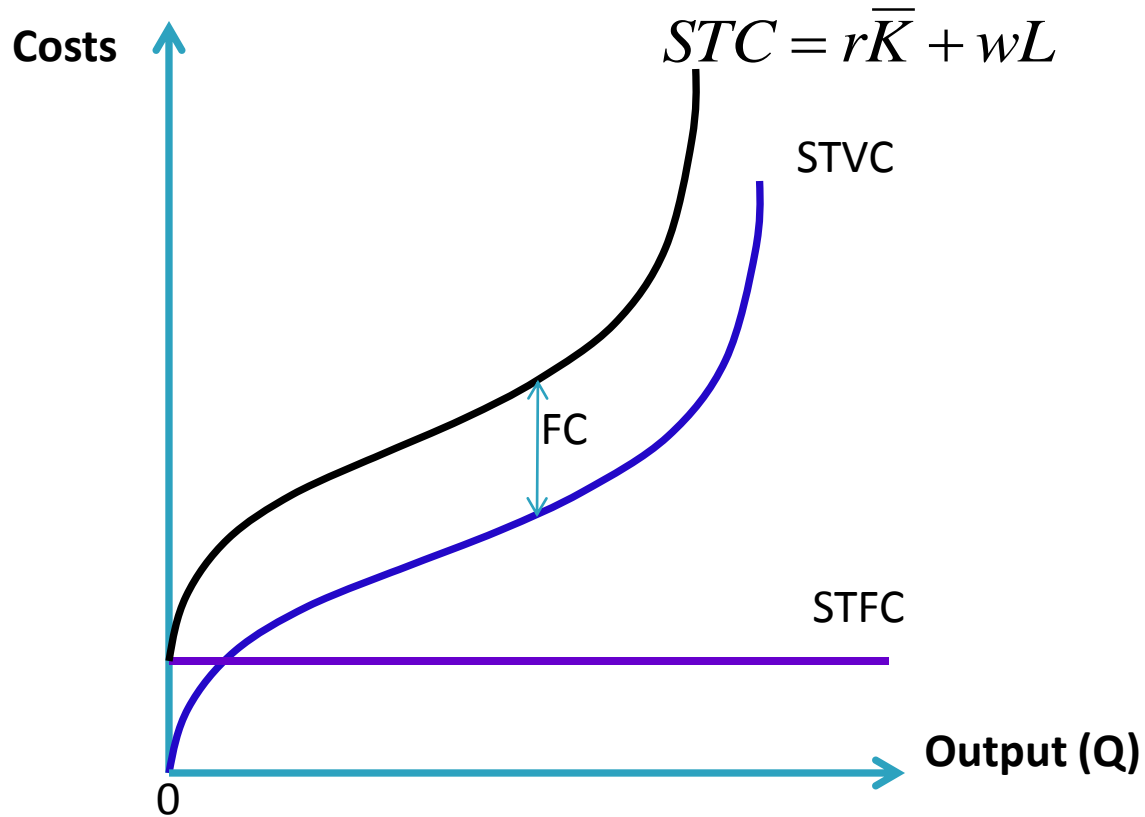
Substitution between Physicians and Nurses



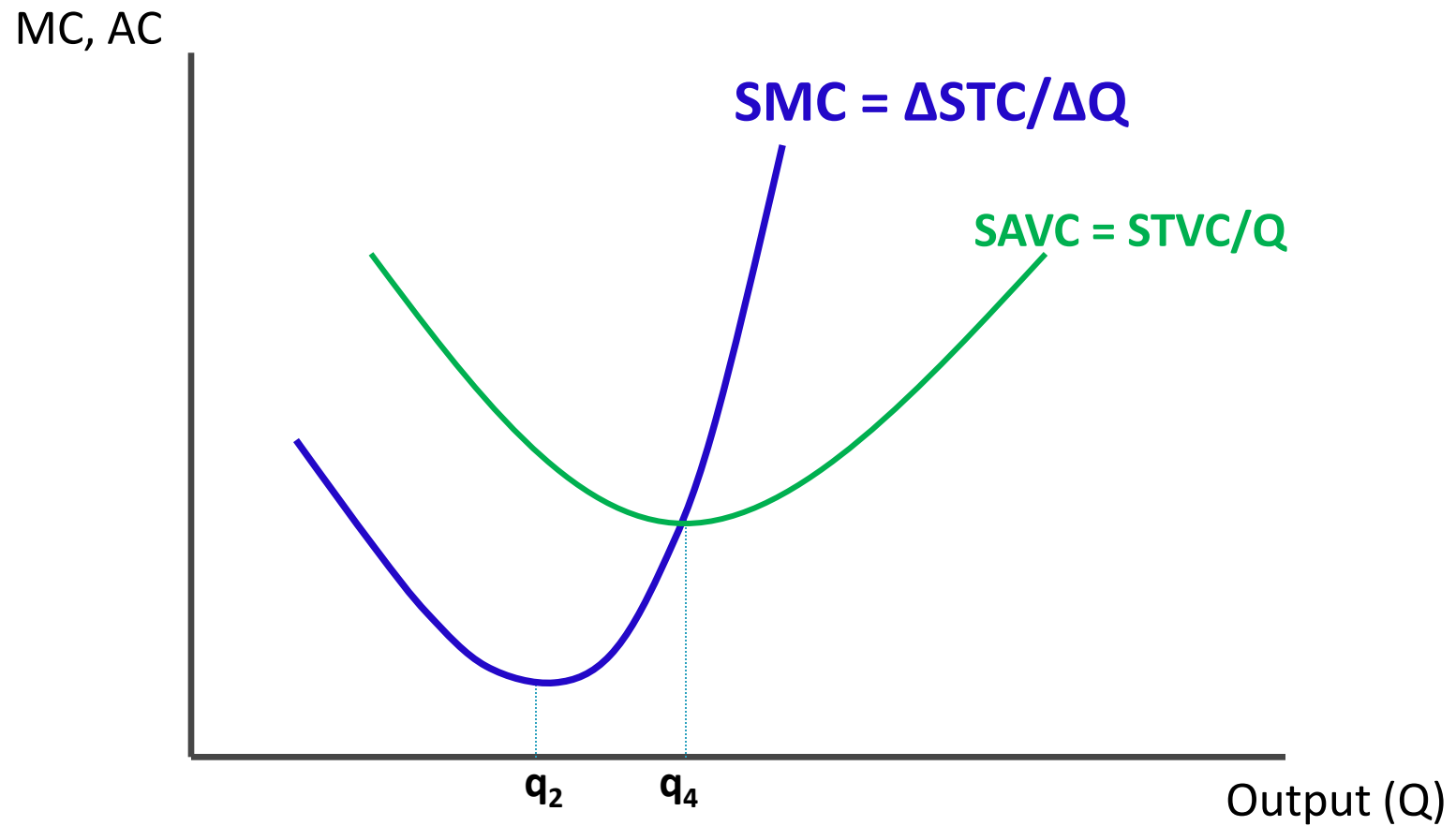
Input Substitution: Application

- $E_s = -0.6$ 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 ∞ .
 - $E_s = 0 \rightarrow$ No substitutability
 - Larger $E_s \rightarrow$ 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!)

Short-Run Cost Curve



Marginal Cost and Average Cost



Long-Run Cost Curve

- Hospital's cost minimization problem:

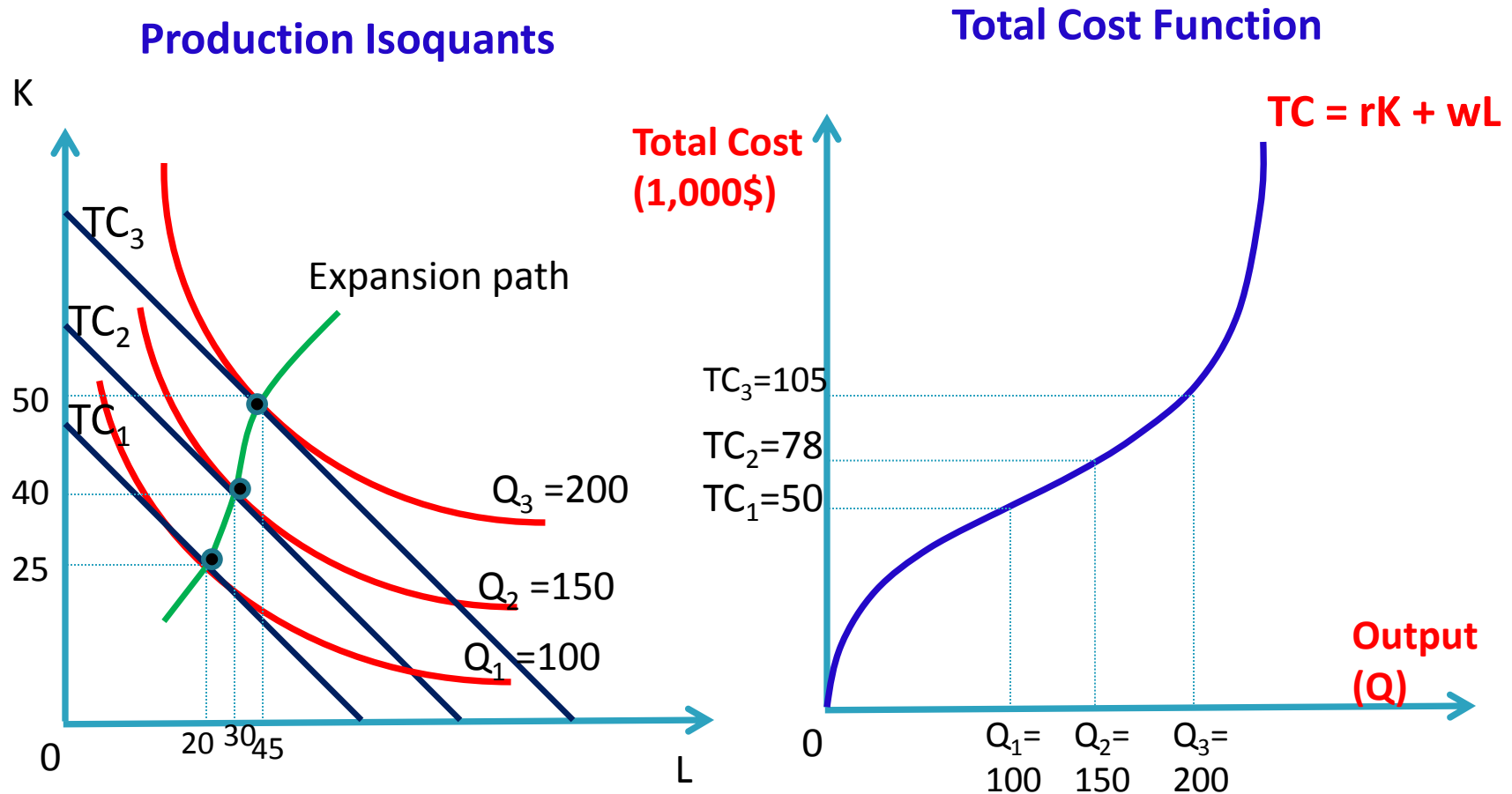
$$\text{Min } TC = rK + wL$$

$$\text{Subject to } Q^* = Q(K, L)$$

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

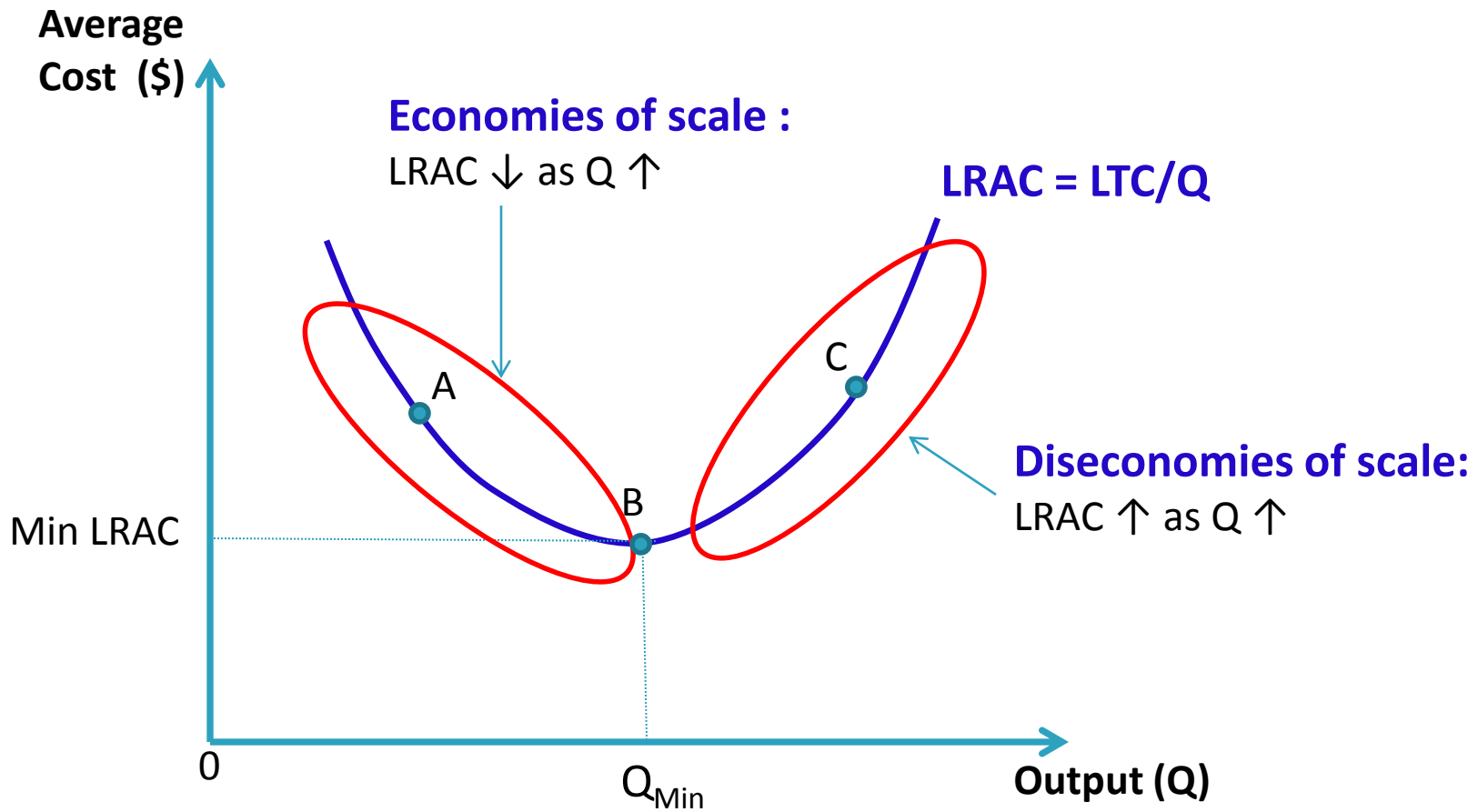
- The set of all possible points of tangency between the isocost curves and the isoquants is called the **expansion path**.
 - This curve tells the relationship between a **given output level** and its **minimum cost**.

Long-Run 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

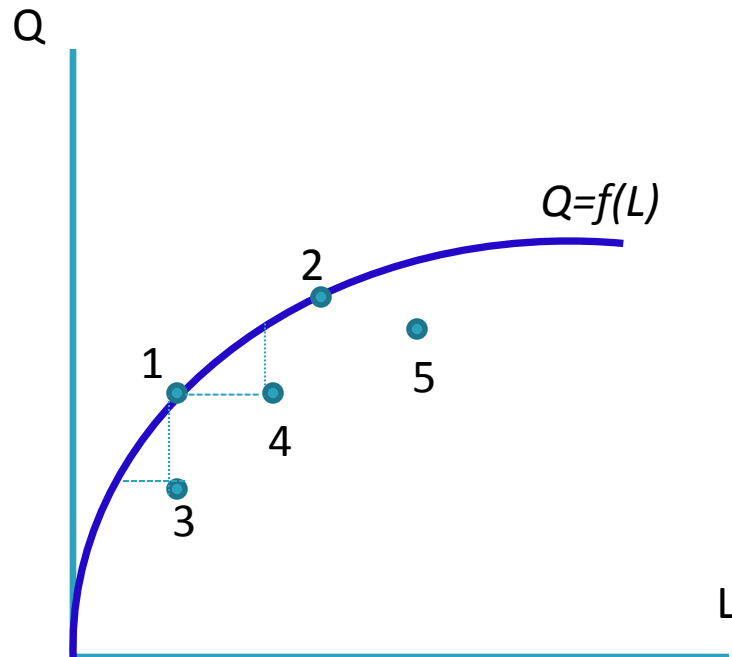
- Both concepts can provide implications to **public policy** and to **managerial policy**.
- **Economies of scale:**
 - Profit-maximizing firm
 - Prefers to produce where AC is still decreasing
 - Society's perspective
 - Prefers lowest average costs (**not necessary where it max π**)
- **Economies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

Efficiency

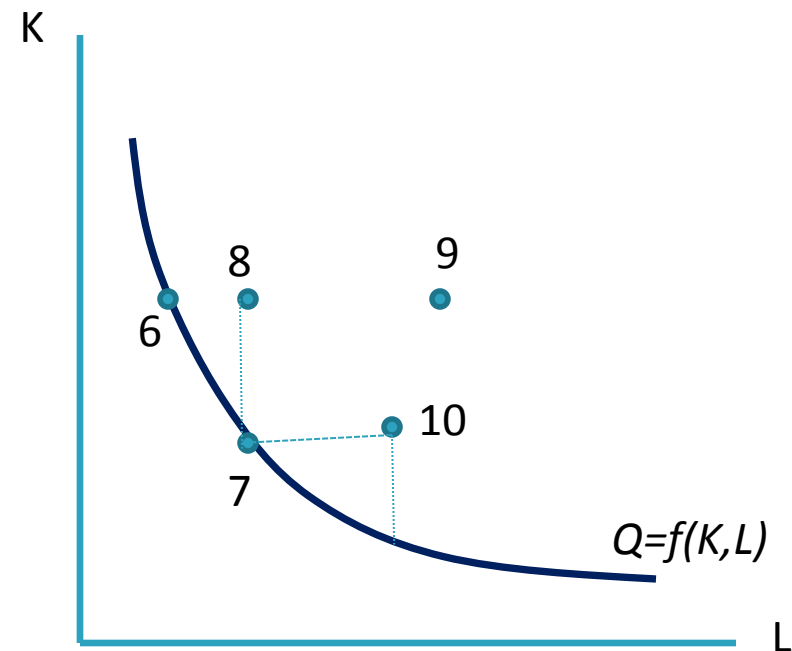
- **Technical efficiency**
 - Applies to production within a given firm
 - Technical efficiency is achieved when a maximum output is being produced from a given input combination.
- **Allocative efficiency**
 - Requires the efficient allocation of inputs between firms and between outputs.
 - Allocative 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



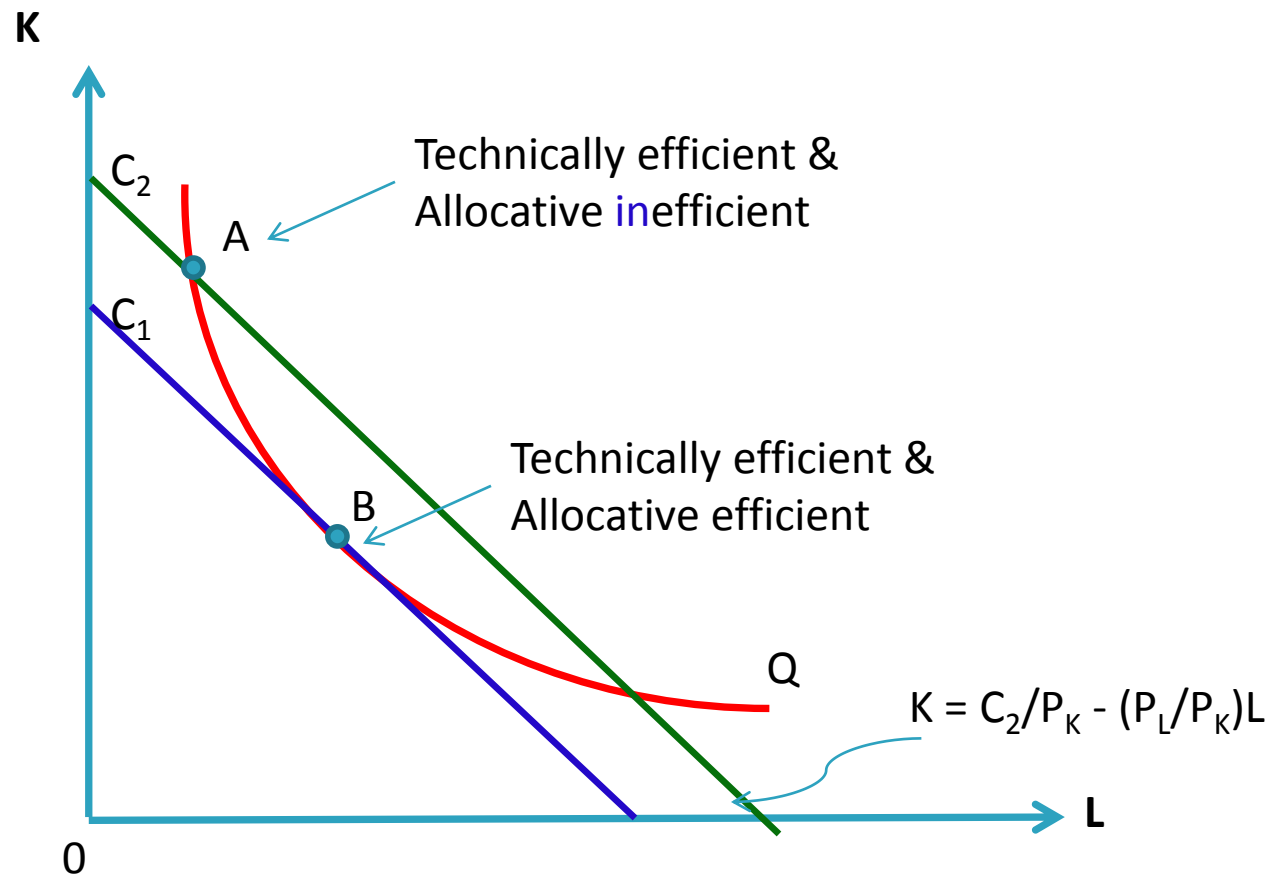
Technical inefficiency results when a firm uses more resources than necessary to produce a given level of output.

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

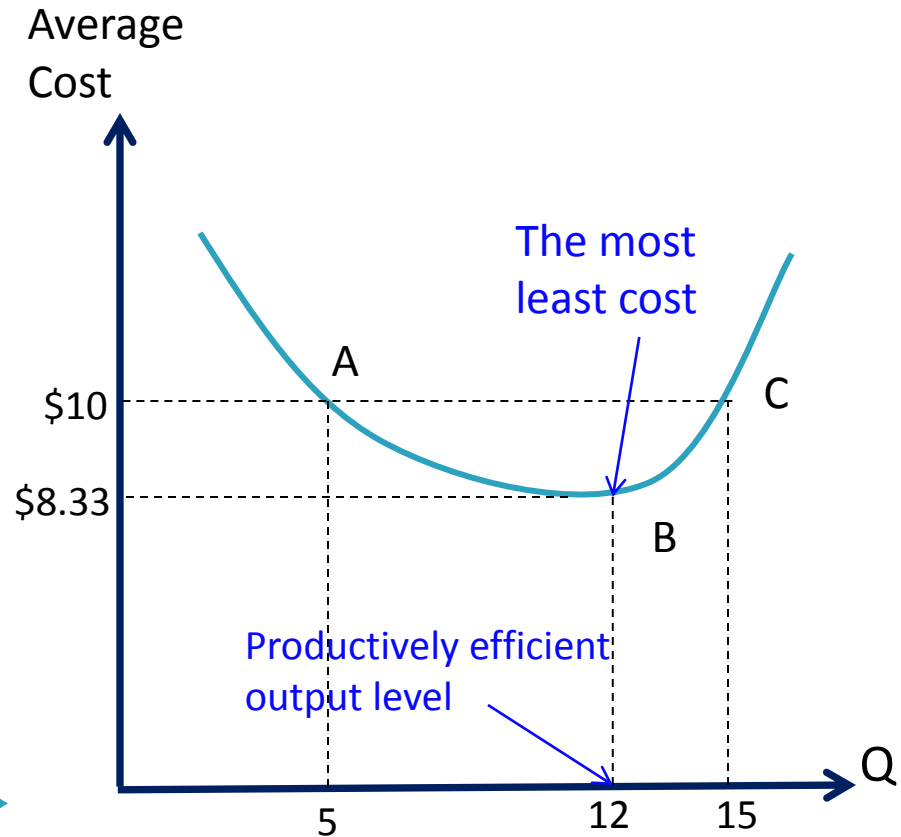
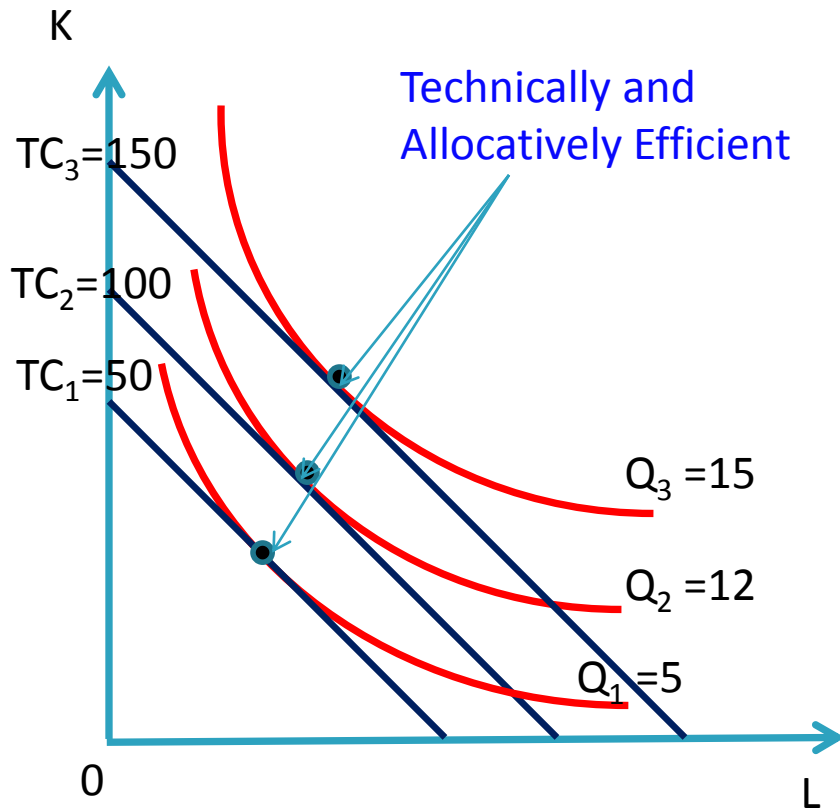


Technical and Allocative Efficiencies

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

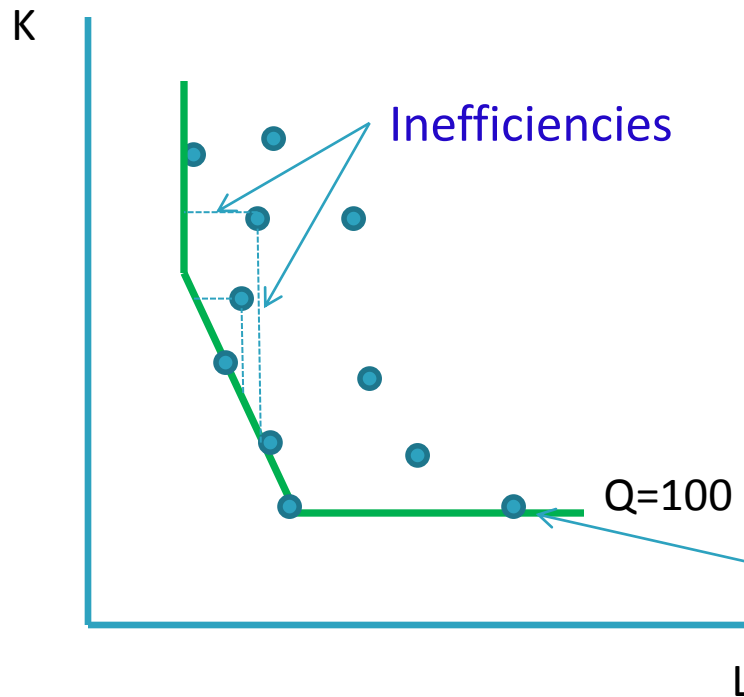
- Consider another example

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

- Which quantity level is productively efficient?

➔ $Q = 100$.

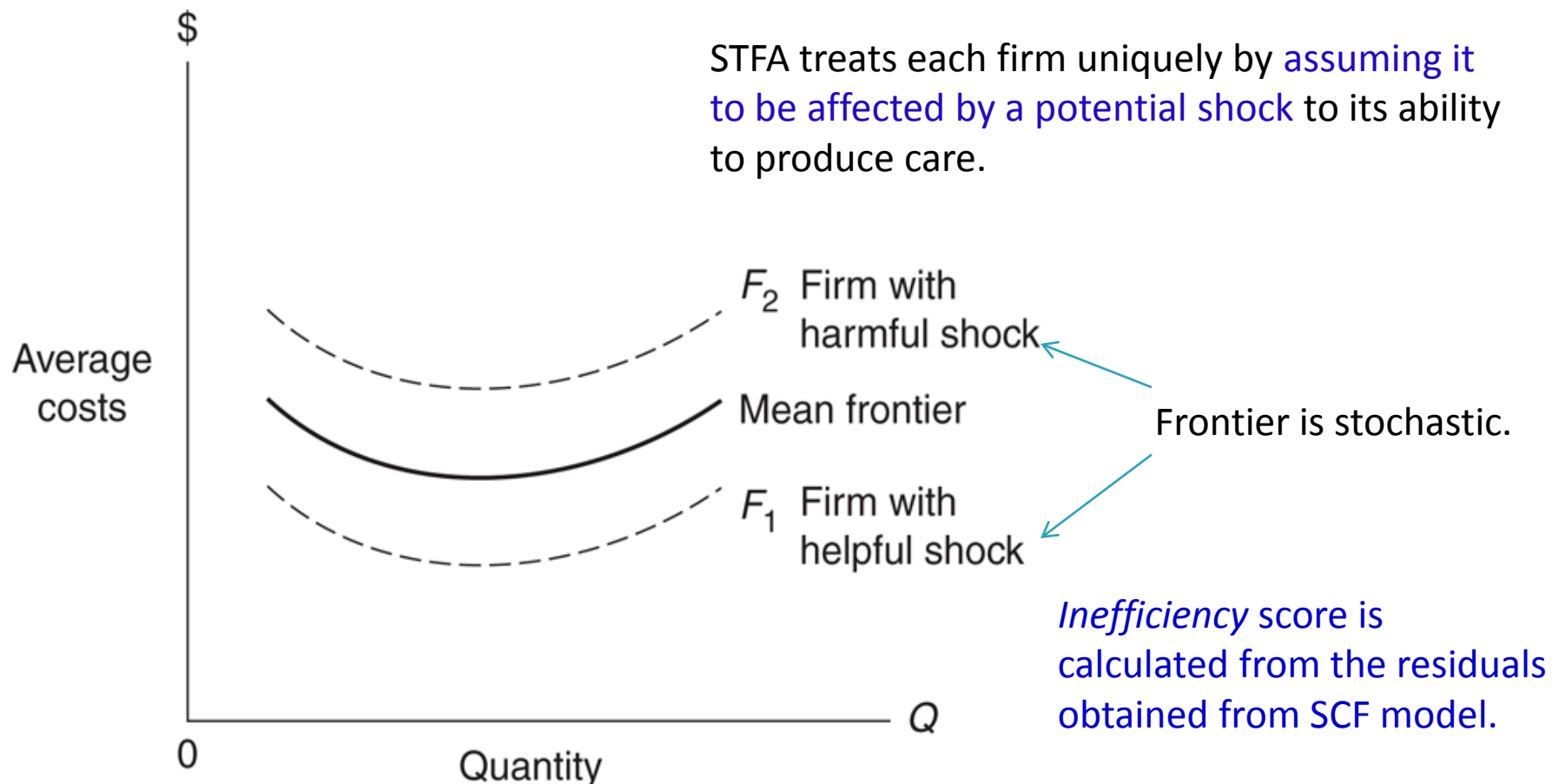
Frontier Analysis: Data Envelope Analysis



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)



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: $C = f(OP, IP) = OP^a \times IP^b$
 - Regional hospitals: constant returns to scale (i.e. $a+b = 1$)
 - Community & Provincial hospitals: decreasing cost (i.e. $a+b < 1$)

Case Study:

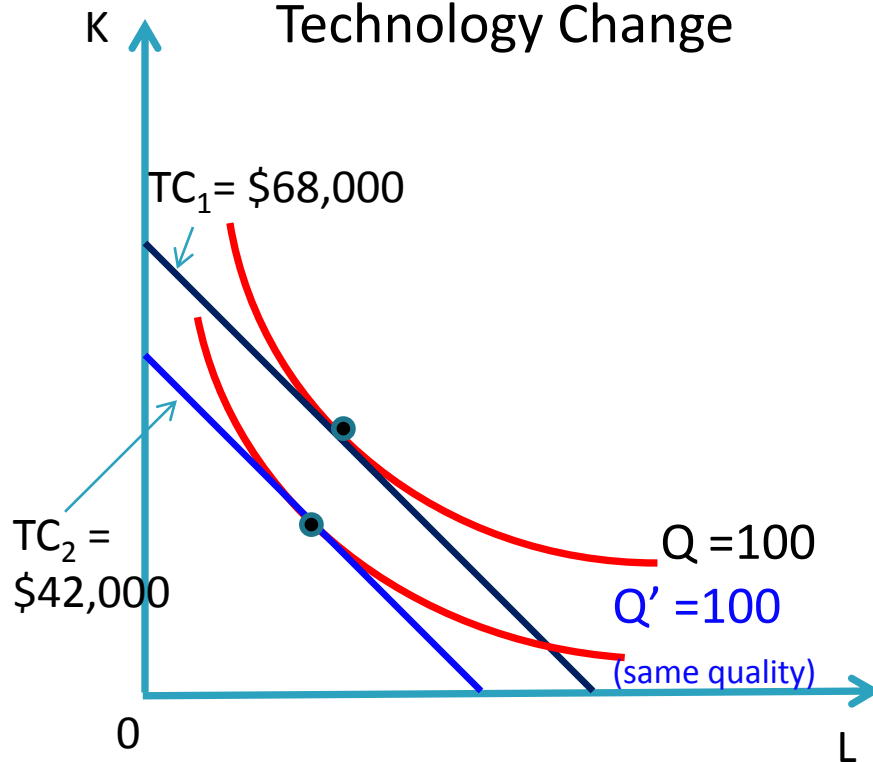
Efficiency of Public Hospitals in Thailand

(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.

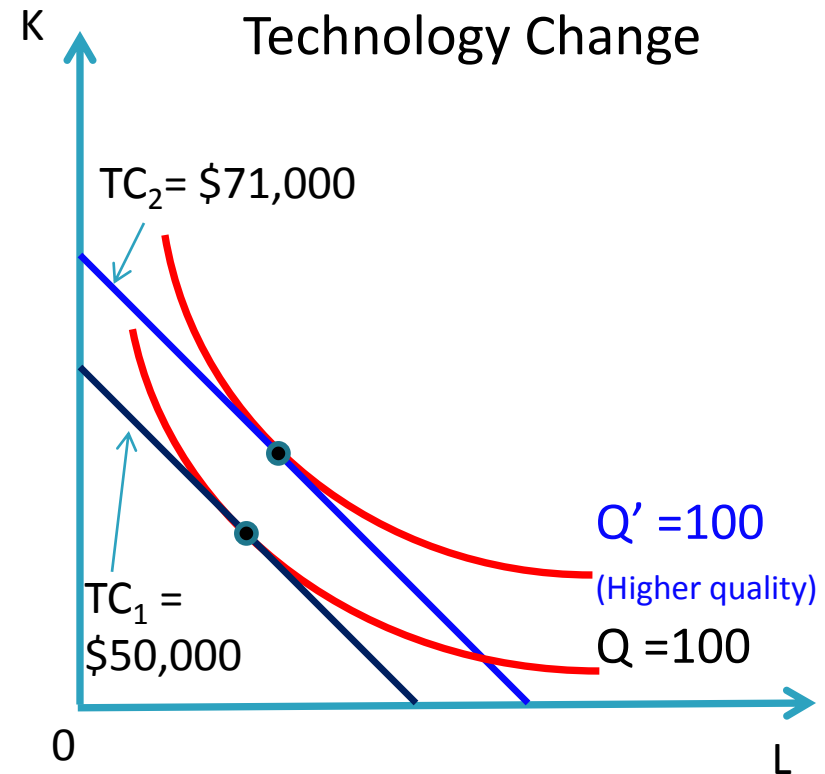
Technological Changes and Costs

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

- Example: 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.