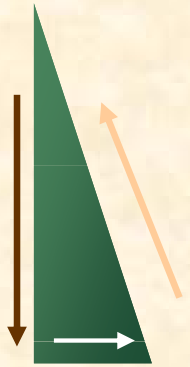
Measuring Cost: Which Costs Matter?

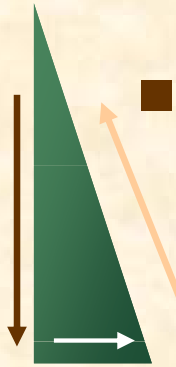
Explicit Costs vs. Implicit Costs

- **Explicit costs**: Costs that involve a direct monetary outlay (e.g. fuel, salaries of an aeroplane)
- **Implicit Costs:** Costs that do not involve outlays of cash (income it forgoes by not leasing this aeroplane)
- **Sacrificed costs**=sum of explicit and implicit costs associated with the decision



Opportunity costs

- **The value of the next best alternative that is forgone when another alternative is chosen.**
- The forward-looking nature of opportunity costs
- **Two options –** to run own business (costs 100 000 workers wages + 80 000 for supplies) or to be employed (income 75 000) => the opportunity cost of continuing in business over the next year is $255,000



- opportunity cost differs from the original expense incurred by the firm (*there are different opportunity costs for different decisions under different circumstances*)

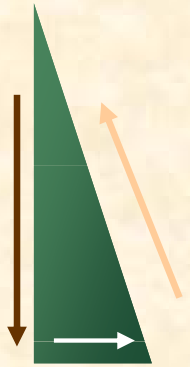
Measuring Cost: Which Costs Matter?

Economic Cost vs. Accounting Cost

- **Accounting Cost**: costs that would appear on accounting statements (explicit costs that have been incurred in the past)
- **Economic Cost:** The sum of the firm's explicit costs and implicit costs. Cost to a firm of utilizing economic resources in production, including opportunity cost (synonymous with opportunity costs)

Measuring Cost: Which Costs Matter?

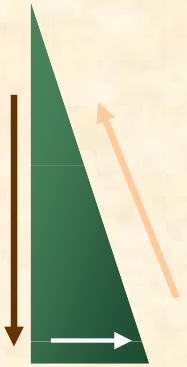
- **Opportunity cost:** Cost associated with opportunities that are foregone when a firm's resources are not put to their highest-value use.
- E.g.: A firm owns its own building and pays no rent for office space.
  - Does this mean the cost of office space is zero?



SUNK (UNAVOIDABLE) VERSUS NONSUNK (AVOIDABLE) COSTS

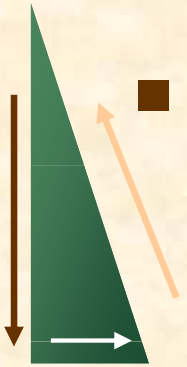
Economic Cost vs. Accounting Cost

- **sunk costs**: costs that have already been incurred and cannot be recovered
- **nonsunk costs:** Costs that are incurred only if a particular decision is made, so they are avoided if the decision is not made > avoidable costs)



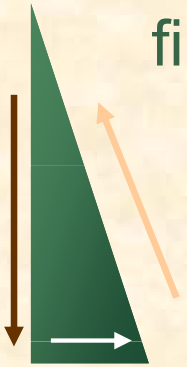
The cost minimization problem

- How to choose a combination of inputs to minimize the cost of producing a given quantity of output?
- a firm that seeks to minimize the cost of producing a given amount of output is called a **cost-minimizing firm**
- **Long run=** The period of time that is long enough for the firm to vary the quantities of all of its inputs as much as it desires (so all costs are nonsunk).
- **Short run=** The period of time in which at least one of the firm's input quantities cannot be changed.



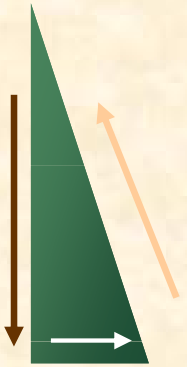
Short-run cost minimization

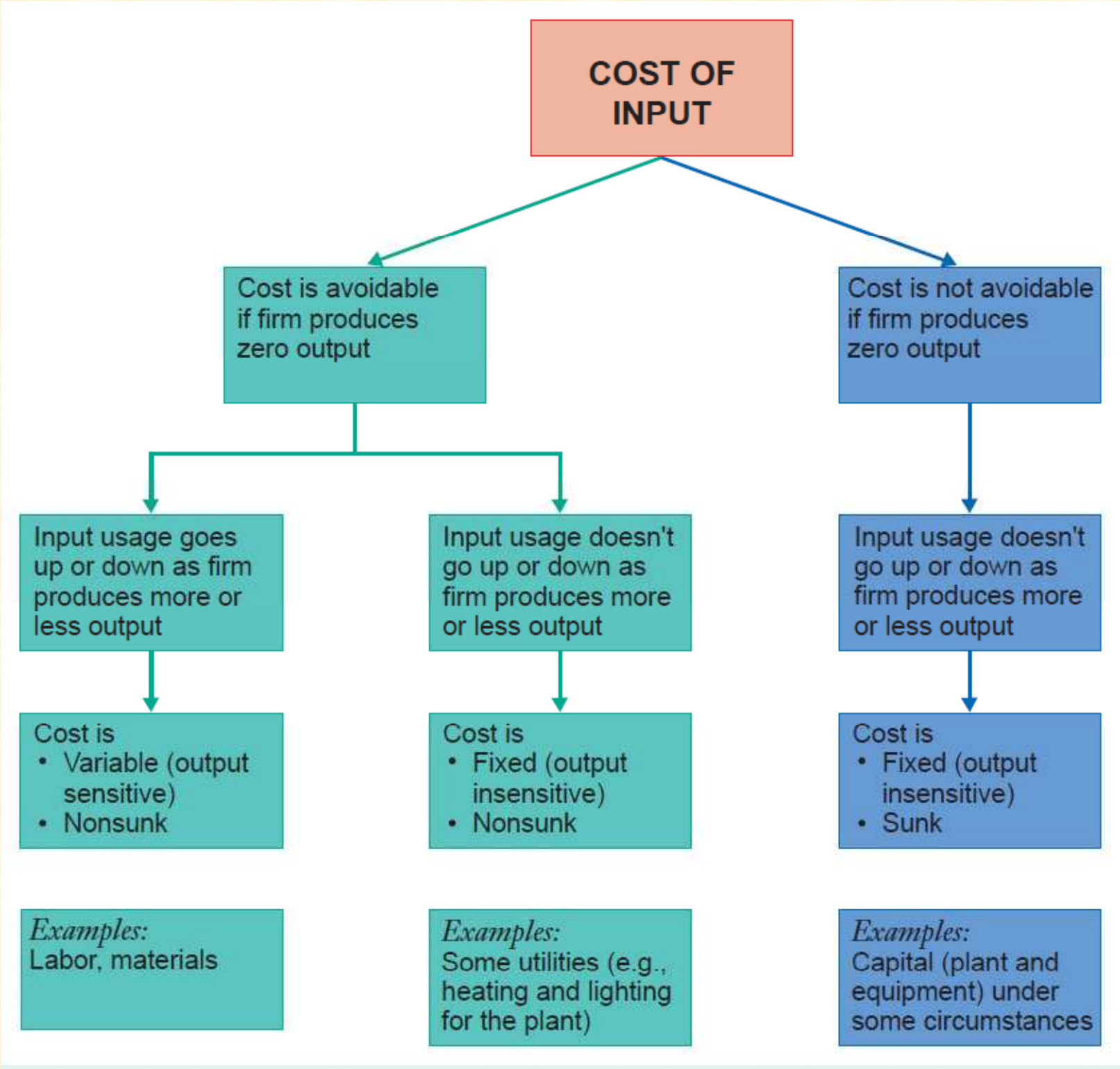
- A firm uses just two inputs (capital and labor)
- firm is unable to alter its quantity of capital, even if it produces zero output
- can alter its quantity of labor L (e.g., by hiring or firing workers).
- firm's total costs are wL + rK
- The firm's labor cost thus constitutes its total variable cost (the output-sensitive component of its costs) => **total variable cost**
- By contrast, the firm's capital cost will not go up or down as the firm produces more or less output => **total fixed cost**



Short-run cost minimization

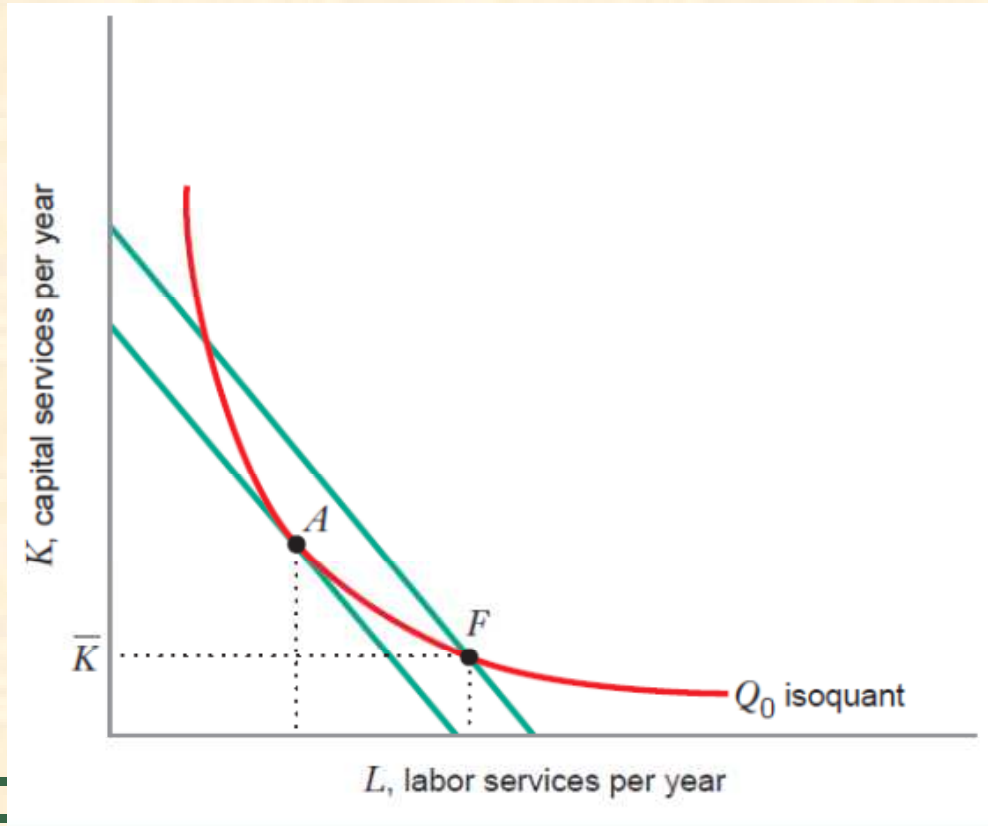
- **Should the firm produce no output, or should it produce some positive level of output?**
- the firm's total expenditure on labor is a nonsunk cost (since variable costs are completely avoidable)
- By contrast, the firm's fixed capital cost may be sunk or nonsunk (the fixed cost will be sunk if there are no alternative uses for and nonsunk if e.g. we find somebody who will rent our factory so we can cover our payments to bank)




COST OF INPUT
Cost is avoidable if firm produces zero output
Cost is not avoidable if firm produces zero output
Input usage goes up or down as firm produces more or less output
Input usage doesn't go up or down as firm produces more or less output
Input usage doesn't go up or down as firm produces more or less output
Cost is
• Variable (output sensitive)
• Nonsunk
Cost is
• Fixed (output insensitive)
• Nonsunk
Cost is
• Fixed (output insensitive)
• Sunk
Examples:
Labor, materials
Examples:
Some utilities (e.g., heating and lighting for the plant)
Examples:
Capital (plant and equipment) under some circumstances

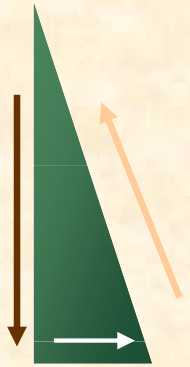
Short-run cost minimization

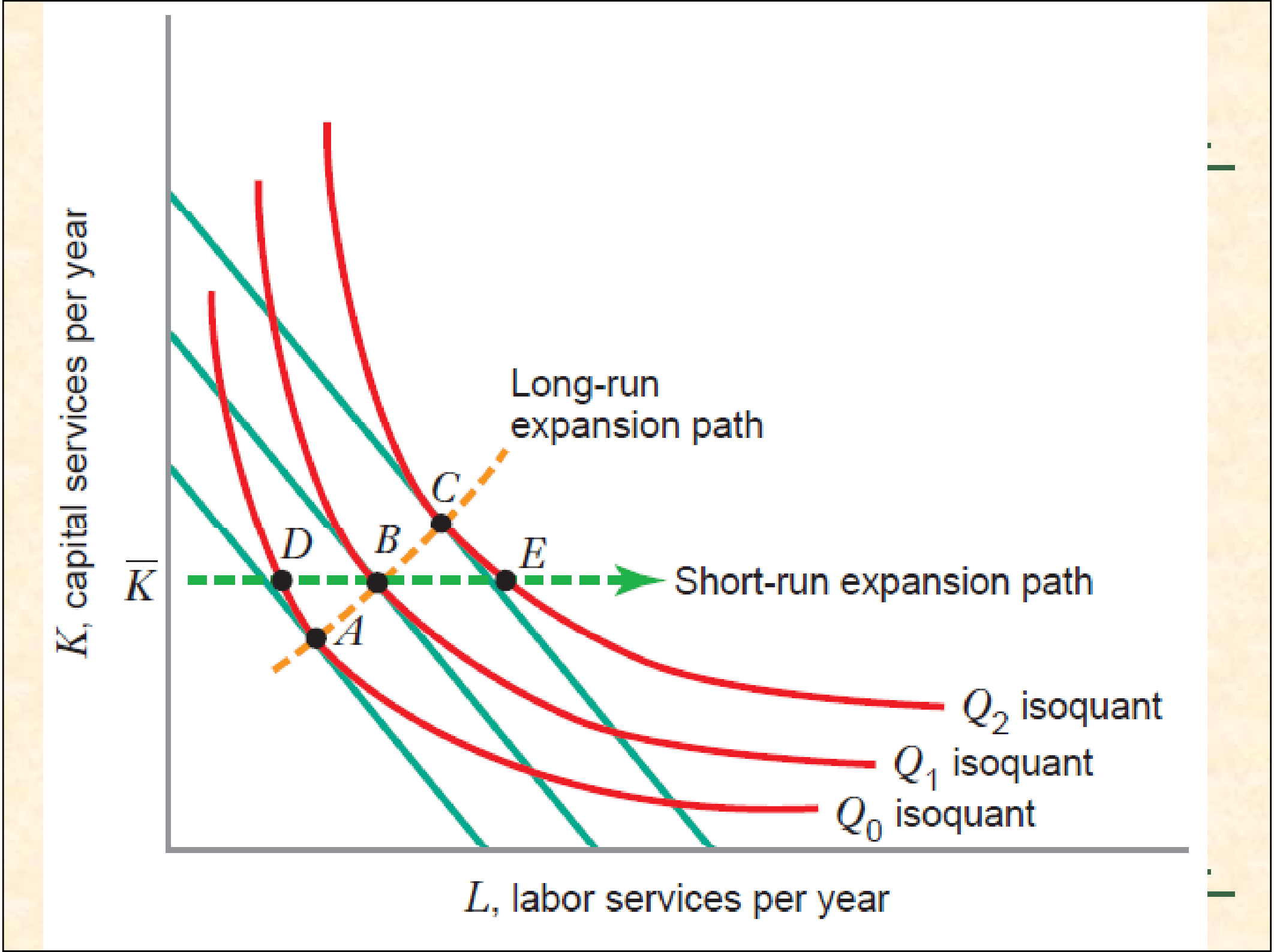
- the firm's problem when it seeks to produce a quantity of output Q_0 but is unable to change the quantity of capital from its fixed level
- The firm's only technically efficient combination of inputs occurs at point F



Short-run cost minimization

- firm cannot substitute between capital and labor => the determination of the optimal amount of labor does not involve a tangency condition
- in the short run, the firm will typically operate with higher total costs than it would if it could adjust all of its inputs freely

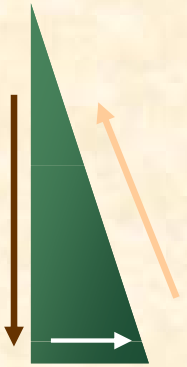



K, capital services per year
L, labor services per year
Long-run
expansion path
Short-run expansion path
$\overline{K}$
A
B
C
D
E
Q_2 isoquant
Q_1 isoquant
Q_0 isoquant

Measuring Cost: Which Costs Matter?

Fixed and Variable Costs

- Total output is a function of variable inputs and fixed inputs.
- Therefore, the total cost of production equals the fixed cost plus the variable cost

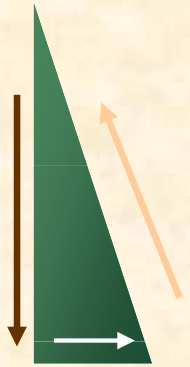


$$TC = FC + VC$$

Cost in the Short Run

- Marginal Cost (*MC*) is the cost of expanding output by one unit. Since fixed cost has no impact on marginal cost, it can be written as:

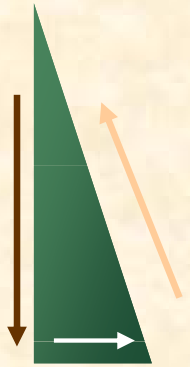
$$MC = \frac{\Delta VC}{\Delta Q} = \frac{\Delta TC}{\Delta Q}$$



Cost in the Short Run

- Average Total Cost (ATC) is the cost per unit of output, or average fixed cost (AFC) plus average variable cost (AVC). This can be written:

$$ATC = \frac{TC}{Q} = \frac{TFC}{Q} + \frac{TVC}{Q}$$



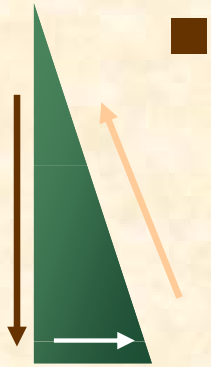
Cost in the Short Run

- Assume the wage rate (w) is fixed relative to the number of workers hired. Then:

$$MC = \frac{\Delta VC}{\Delta Q}$$

$$VC = wL$$

- Continuing:



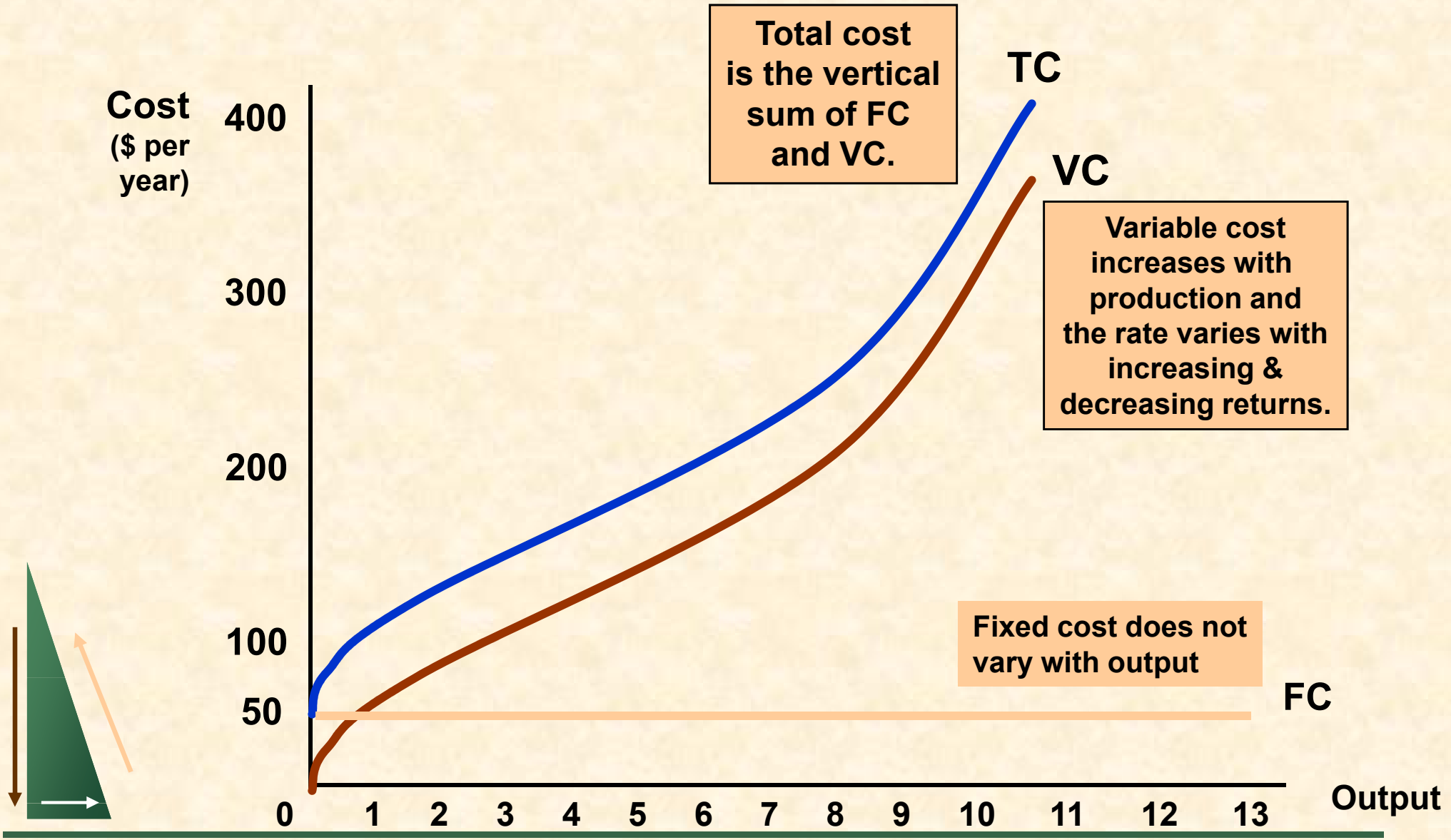
$$\Delta VC = w\Delta L$$

$$MC = \frac{w\Delta L}{\Delta Q} = \frac{w}{MP_L}$$

A Firm's Short-Run Costs ($)

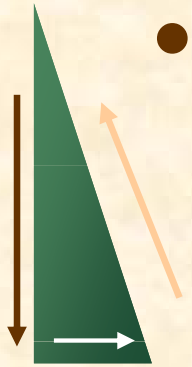
Rate of Output	Fixed Cost (FC)	Variable Cost (VC)	Total Cost (TC)	Marginal Cost (MC)	Average Fixed Cost (AFC)	Average Variable Cost (AVC)	Average Total Cost (ATC)
0	50	0	50	---	---	---	---
1	50	50	100				
2	50	78	128				
3	50	98	148				
4	50	112	162				
5	50	130	180				
6	50	150	200				
7	50	175	225				
8	50	204	254				
9	50	242	292				
10	50	300	350				
11	50	385	435				

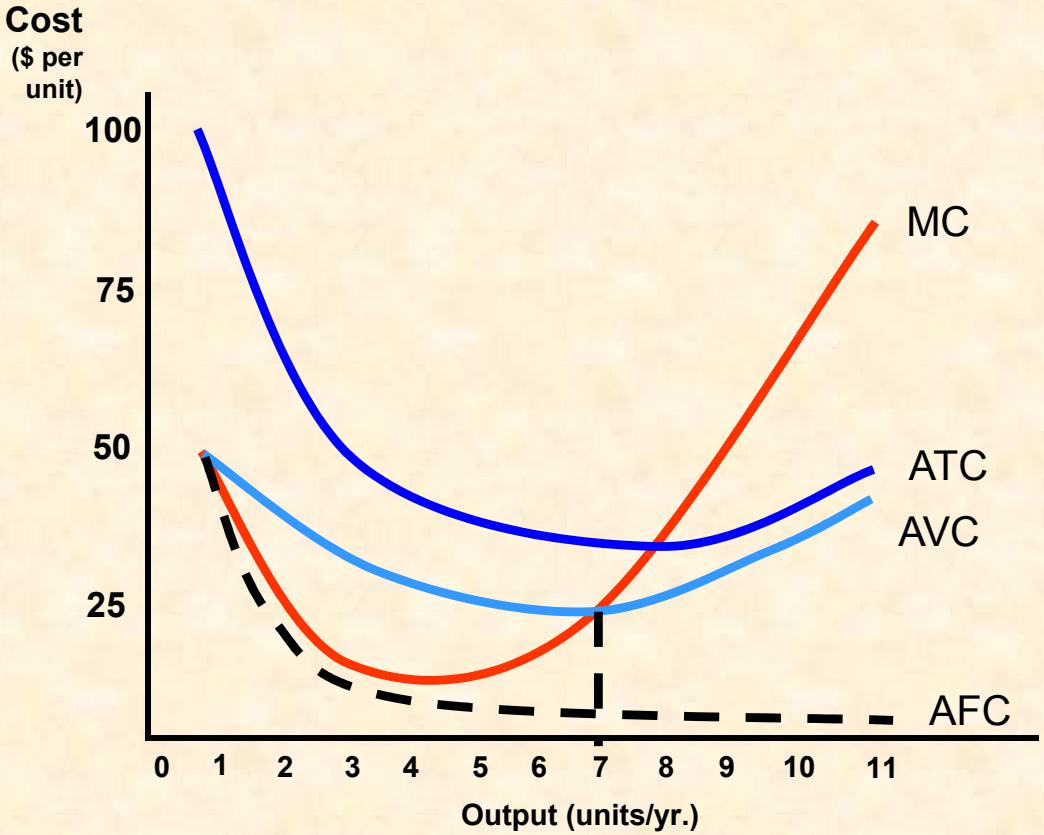
Cost Curves for a Firm



Cost Curves for a Firm

- Unit Costs
  - AFC falls continuously
  - When MC < AVC or MC < ATC, AVC & ATC decrease
  - When MC > AVC or MC > ATC, AVC & ATC increase



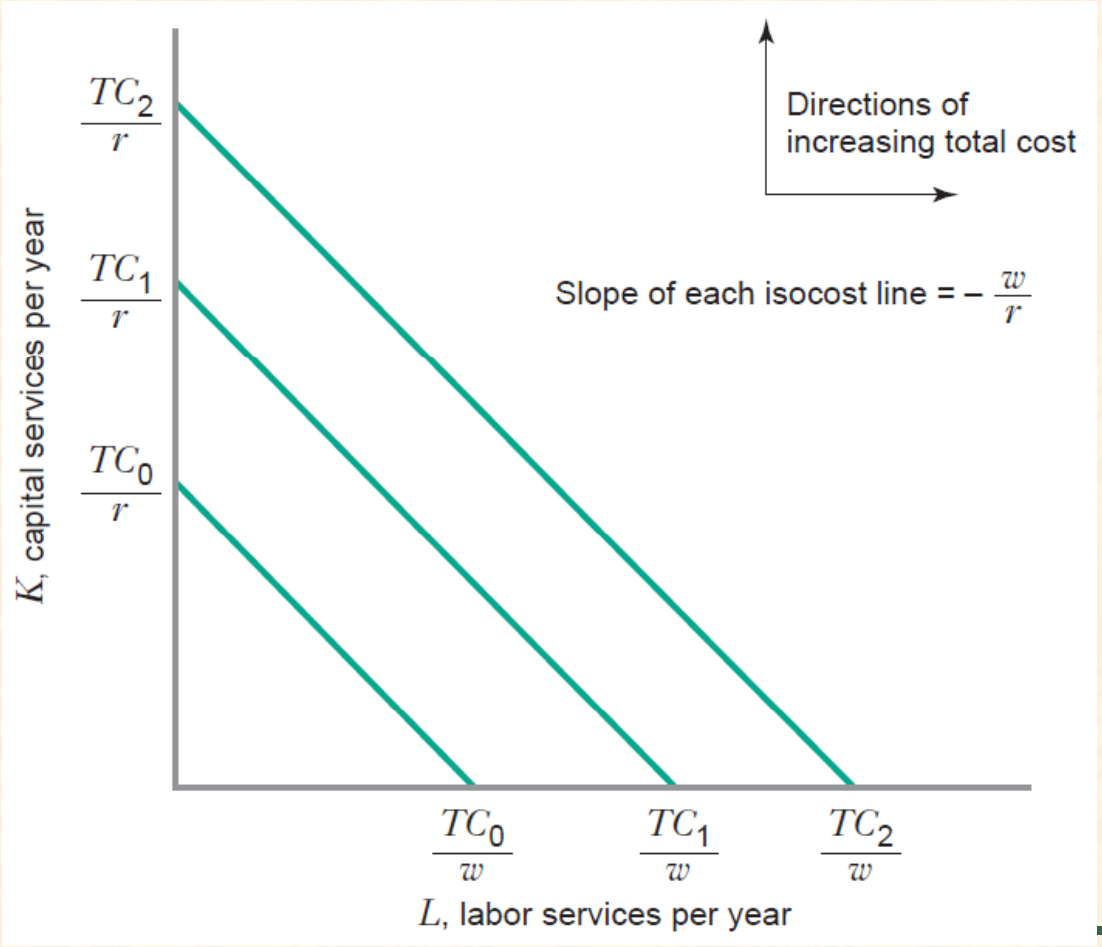


Long-run cost minimization

- Each input has a price
- The price of a unit of labor services—also called the wage rate - is w. This price per unit of capital services is r.
- Both prices could be explicit or implicit cost
- The firm has decided to produce Q_0 units of output (now this amount is exogenous => the question for managers is how to produce that amount in the cost-minimizing way)
- the manager must choose a quantity of capital K and a quantity of labor L that minimize the total cost TC= wL + rK of producing Q_0 units of output (TC is sum of all the economic costs when uses labour and capital services to produce output)

Isocost lines

- = The set of combinations of labor and capital that yield the same total cost for the firm (analogous to a BL)



$$MRTS_{L,K} = MP_L/MP_K$$

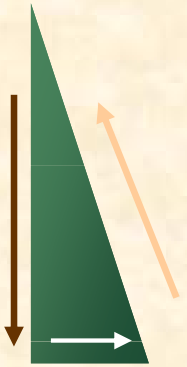
$$\frac{MP_L}{MP_K} = \frac{w}{r}$$

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

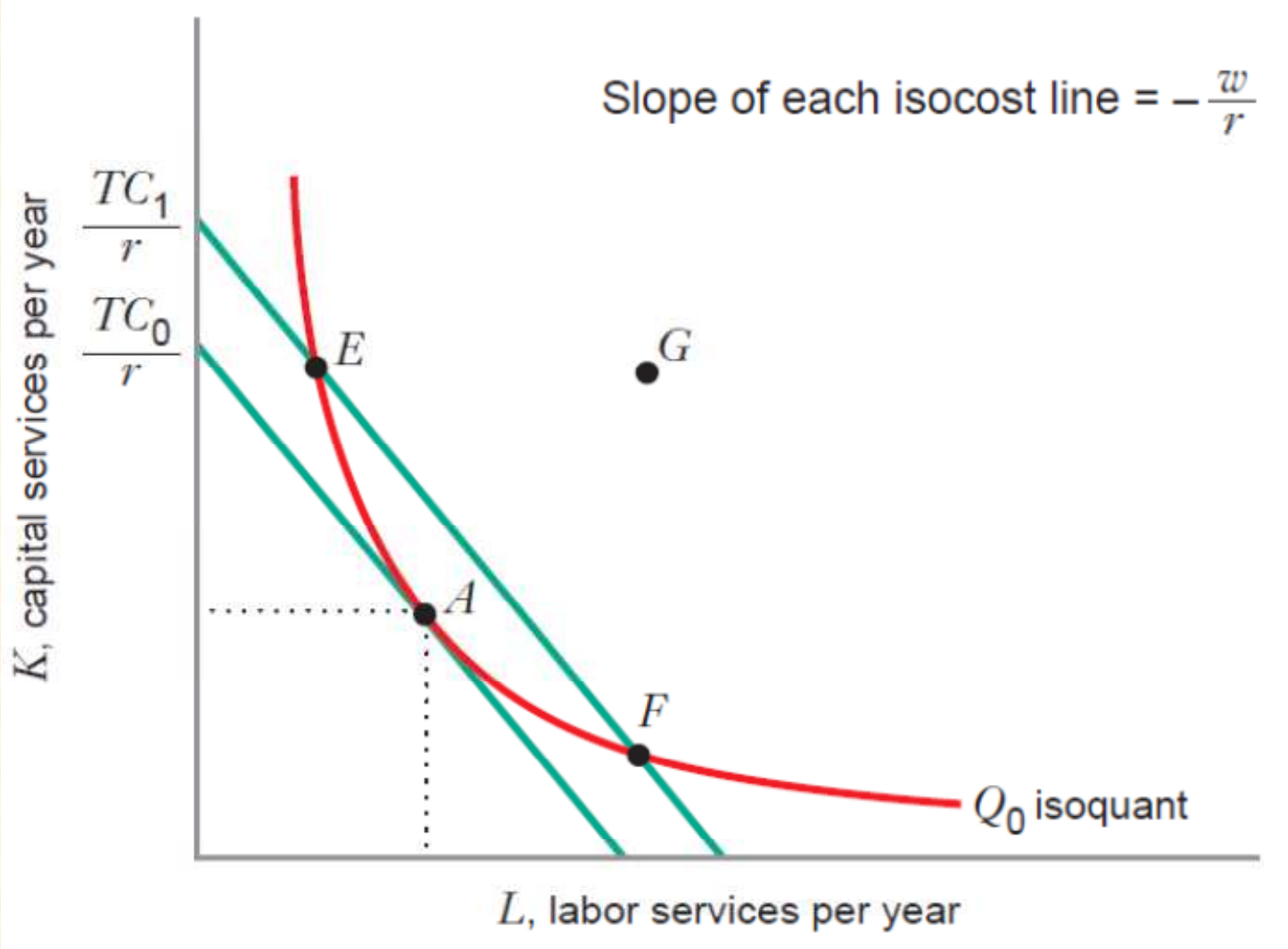
Long-run cost minimization

- Consider, for example, a case in which w=10 per labor-hour, r=20 per machine-hour, and TC=$1 million per year.

- Graphical illustration of isocost?
- What happen when TC will be $2 million and $3 million



Isocost lines



- Point **G** is off the Q_0 isoquant altogether. Although this input combination could produce Q_0 units of output, in using it the firm would be wasting inputs (i.e., point G is technically inefficient)

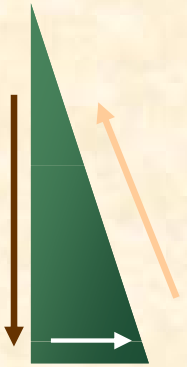
Points **E** and **F** are technically efficient, but they are not cost-minimizing because they are on an isocost line that corresponds to a higher level of cost than the isocost line passing through the cost-minimizing point **A**. By moving from point E to A or from F to A, the firm can produce the same amount of output, but at a lower total cost

Long-run cost minimization

- Suppose that the firm's production function is of the form

$$Q = 50\sqrt{LK}.$$

- MPL and MPK?
- w = 5 and r = 20
- What is the cost-minimizing input combination if the firm wants to produce 1,000 units per year?



Corner point solution

- The cost-minimizing input combination for producing Q_0 units of output occurs at point A, where the firm uses no capital.
- the marginal product per dollar spent on labor exceeds the marginal product per dollar spent on capital services:

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

- every additional dollar spent on labor yields more output than every additional dollar spent on capital. In this situation, the firm should substitute labor for capital until it uses no capital at all,

Corner point solution

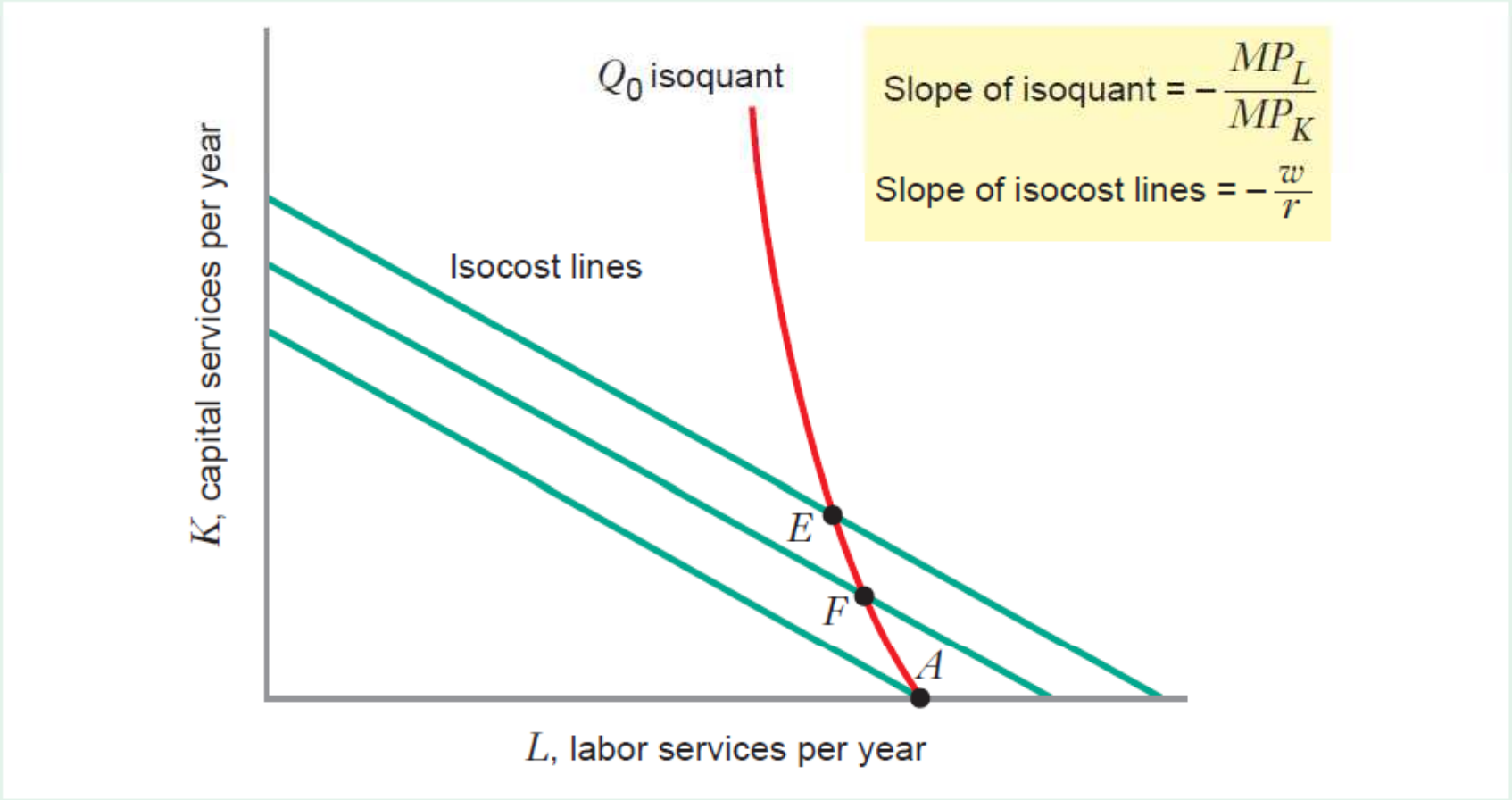


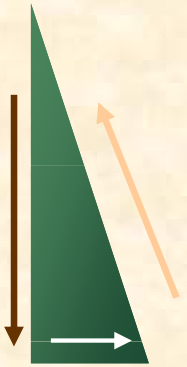
FIGURE 7.3 **Corner Point Solution to the Cost-Minimization Problem**
The cost-minimizing input combination occurs at point *A*, where the firm uses no capital. Points such as *E* and *F* cannot be cost minimizing, because the firm can lower costs and keep output the same by substituting labor for capital.

Long-run cost minimization

- Suppose that we have the linear production function:

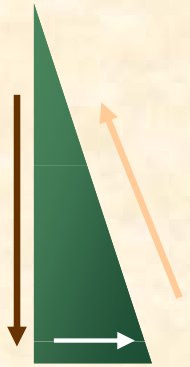
$Q = 10L + 2K$

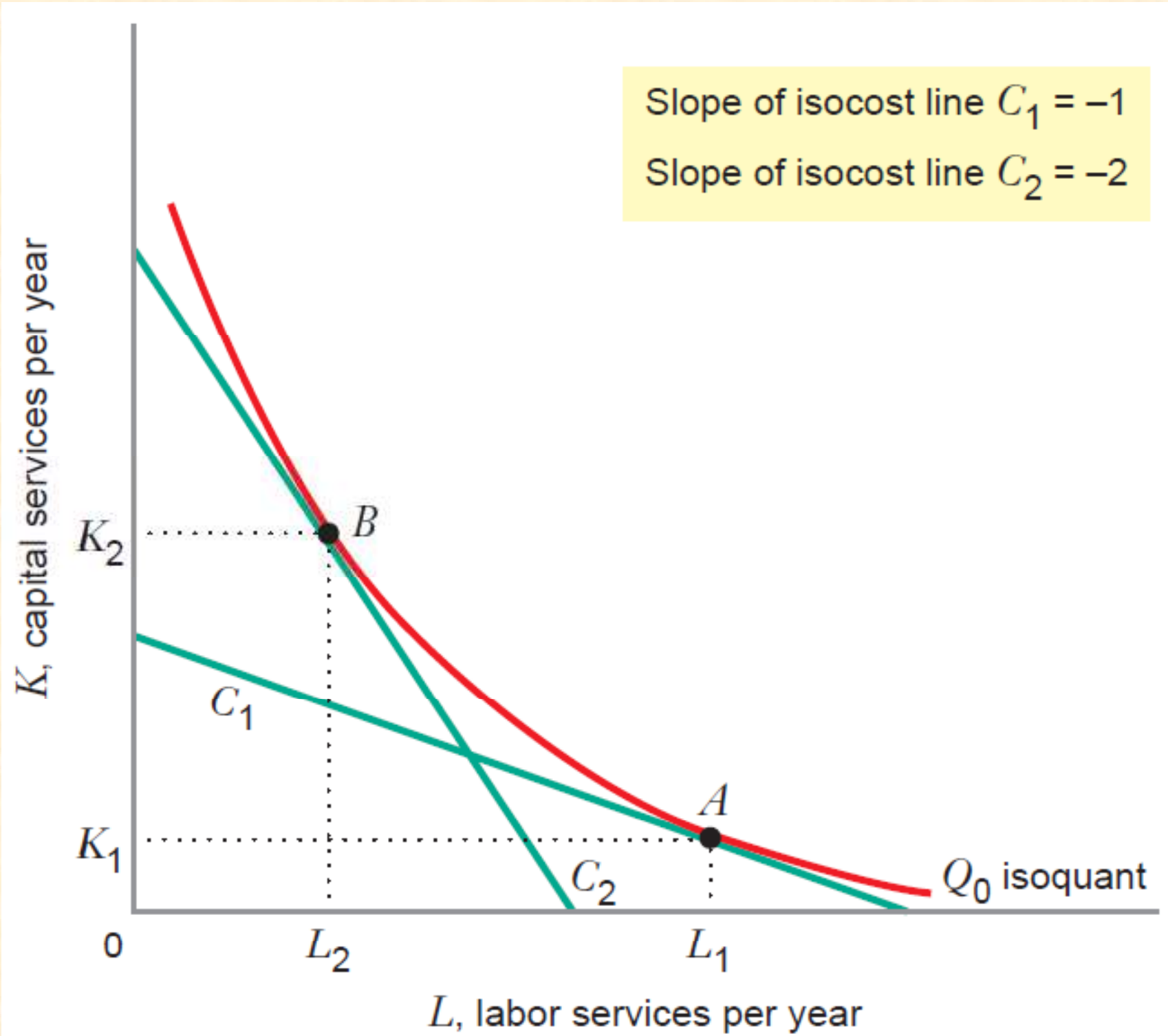
- MPL and MPK?
- w = 5 and r = 2
- What is the cost-minimizing input combination if the firm wants to produce 200 units?



Comparative statics analysis of changes in input prices

- = how changes in input prices and output affect the firm's cost-minimization problem
- Suppose price of labor w changes, with the price of capital r held constant at 1 and the quantity of output held constant at Q_0
- If w increases from 1 to 2 => it causes substitution capital for labor (the isocost lines is steeper)
- It causes changes the position of the tangency point between the isocost line and the isoquant

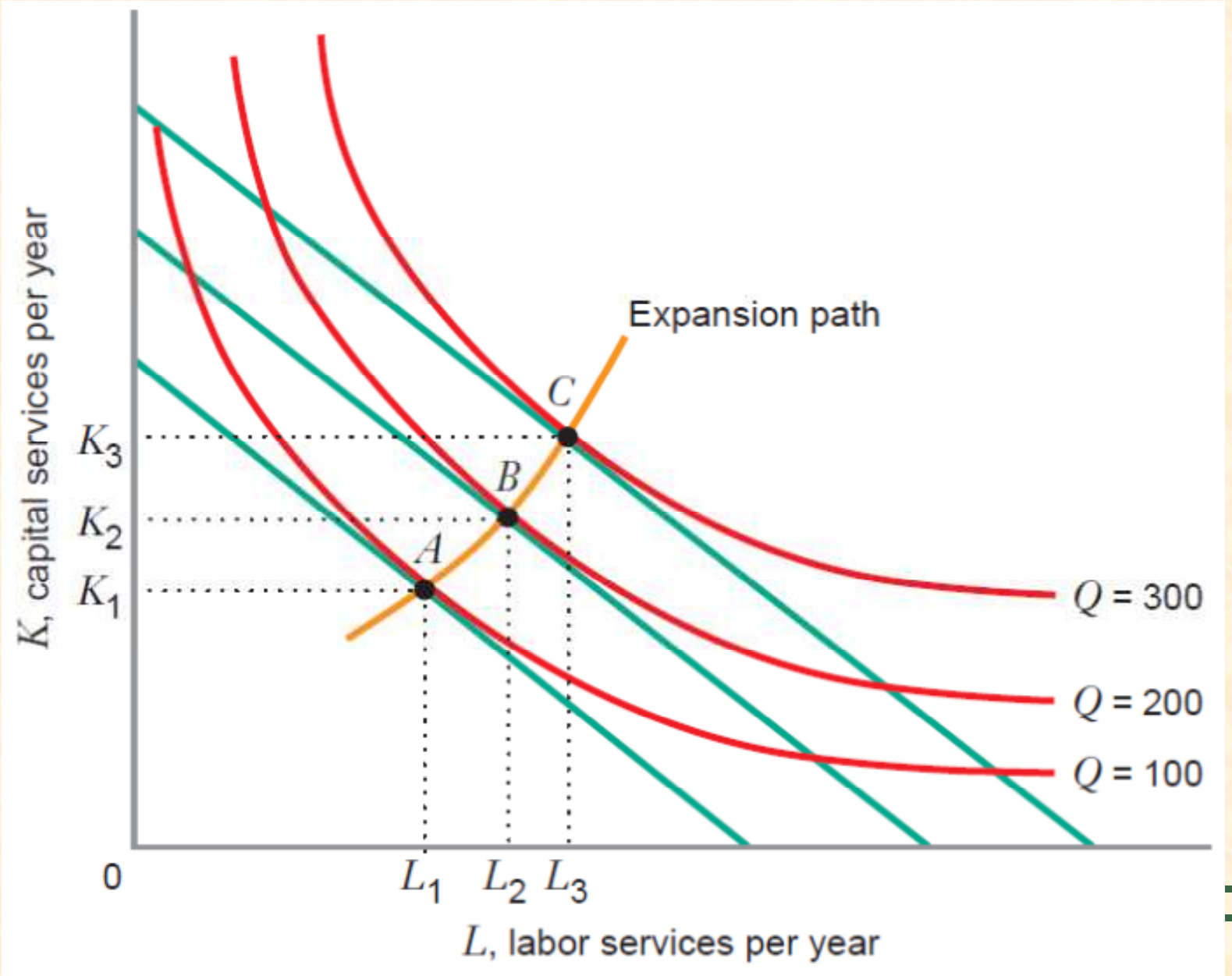



Slope of isocost line C_1 = –1
Slope of isocost line C_2 = –2
K, capital services per year
K_2
K_1
B
A
C_1
C_2
Q_0 isoquant
0
L_2
L_1
L, labor services per year

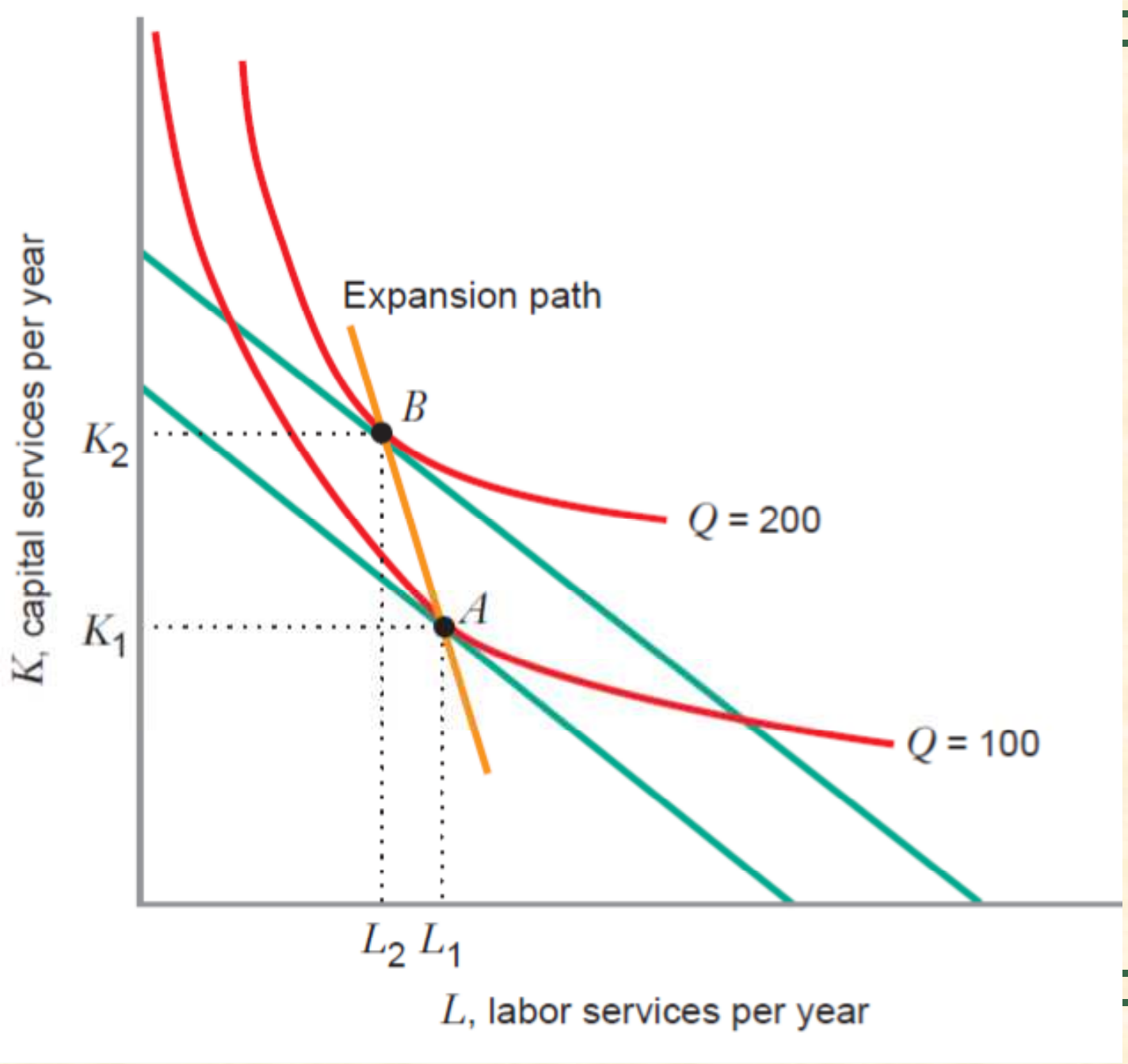
Comparative statics analysis of changes in output

- = changes in output quantity Q, with the prices of inputs (capital and labor) held constant.
- Expansion path= A line that connects the cost-minimizing input combinations as the quantity of output, Q, varies, holding input prices constant.
- as quantity of output increases, the quantity of each input also increases => both labor and capital are normal inputs => the expansion path is upward sloping
- When one of inputs is inferior (e.g. To increase output firm uses using more capital but less labor) => the expansion path is downward sloping

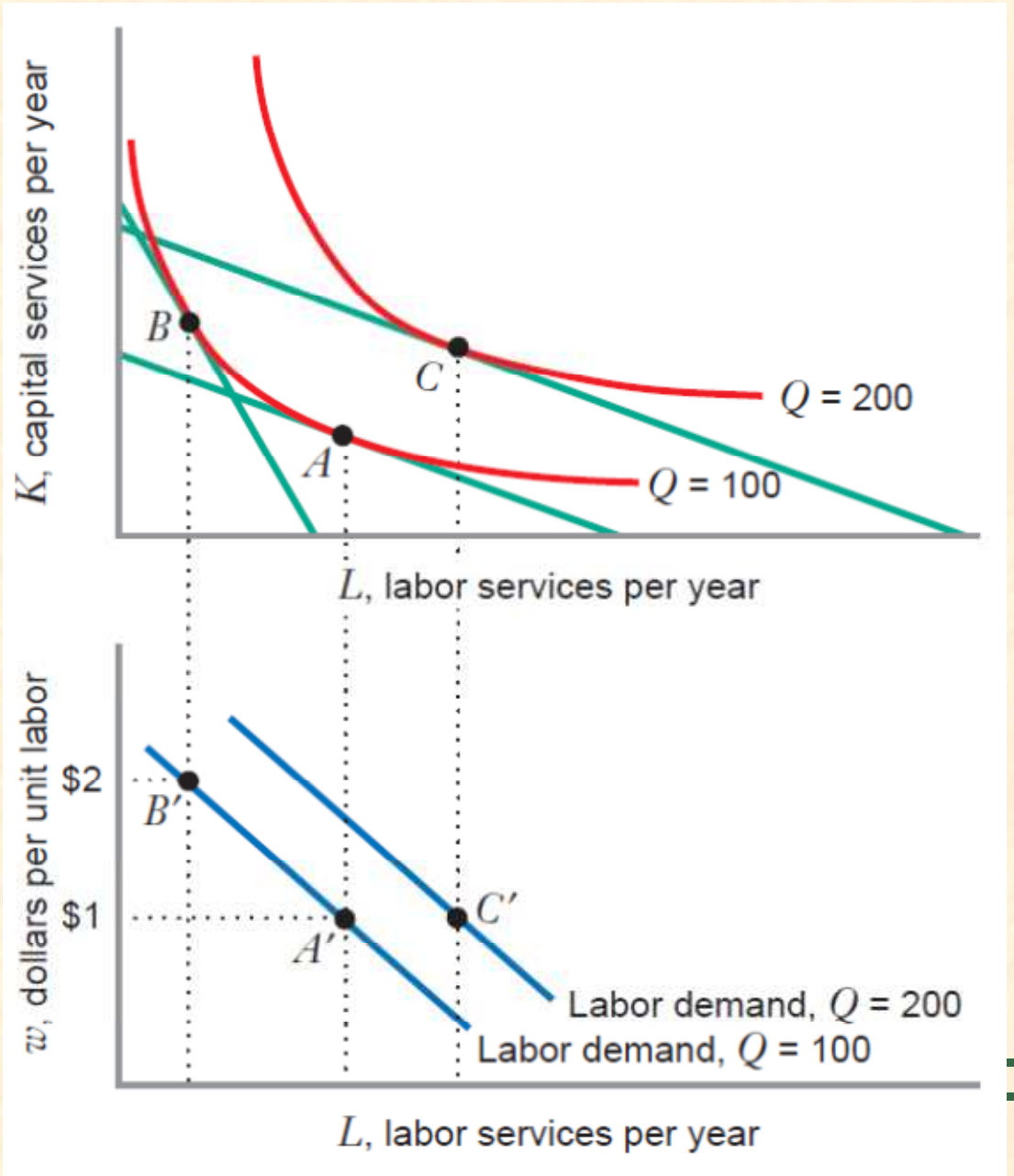
Normal inputs



One input is inferior (labour)



The input demand curves

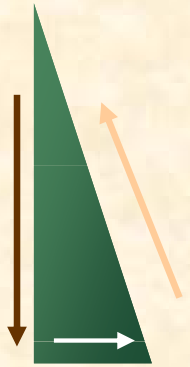


Deriving the input demand curves form a production function

- Suppose that a firm faces the production function:

$$Q = 50\sqrt{LK}.$$

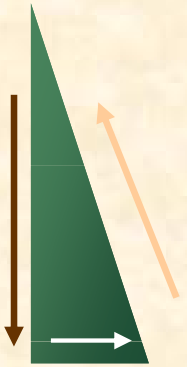
- What are the demand curves for labor and capital?



Cost in the Long Run

The Cost Minimizing Input Choice

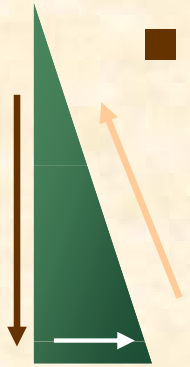
- Assumptions
  - Two Inputs: Labor (L) & capital (K)
  - Price of labor: wage rate (w)
  - The price of capital: r = depreciation rate + interest rate
- Question
  - If capital was rented, would it change the value of r ?



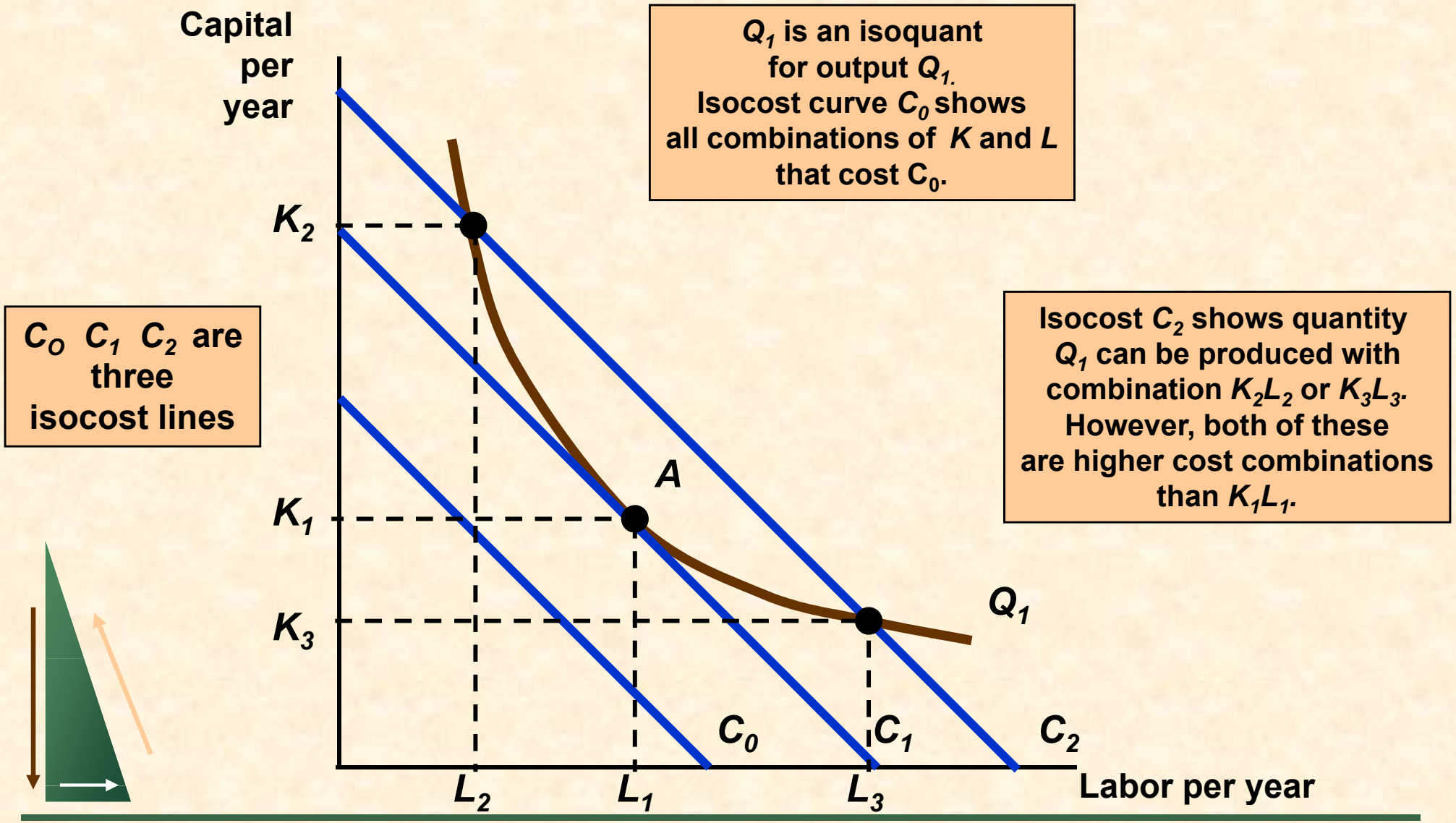
Cost in the Long Run

The Cost Minimizing Input Choice

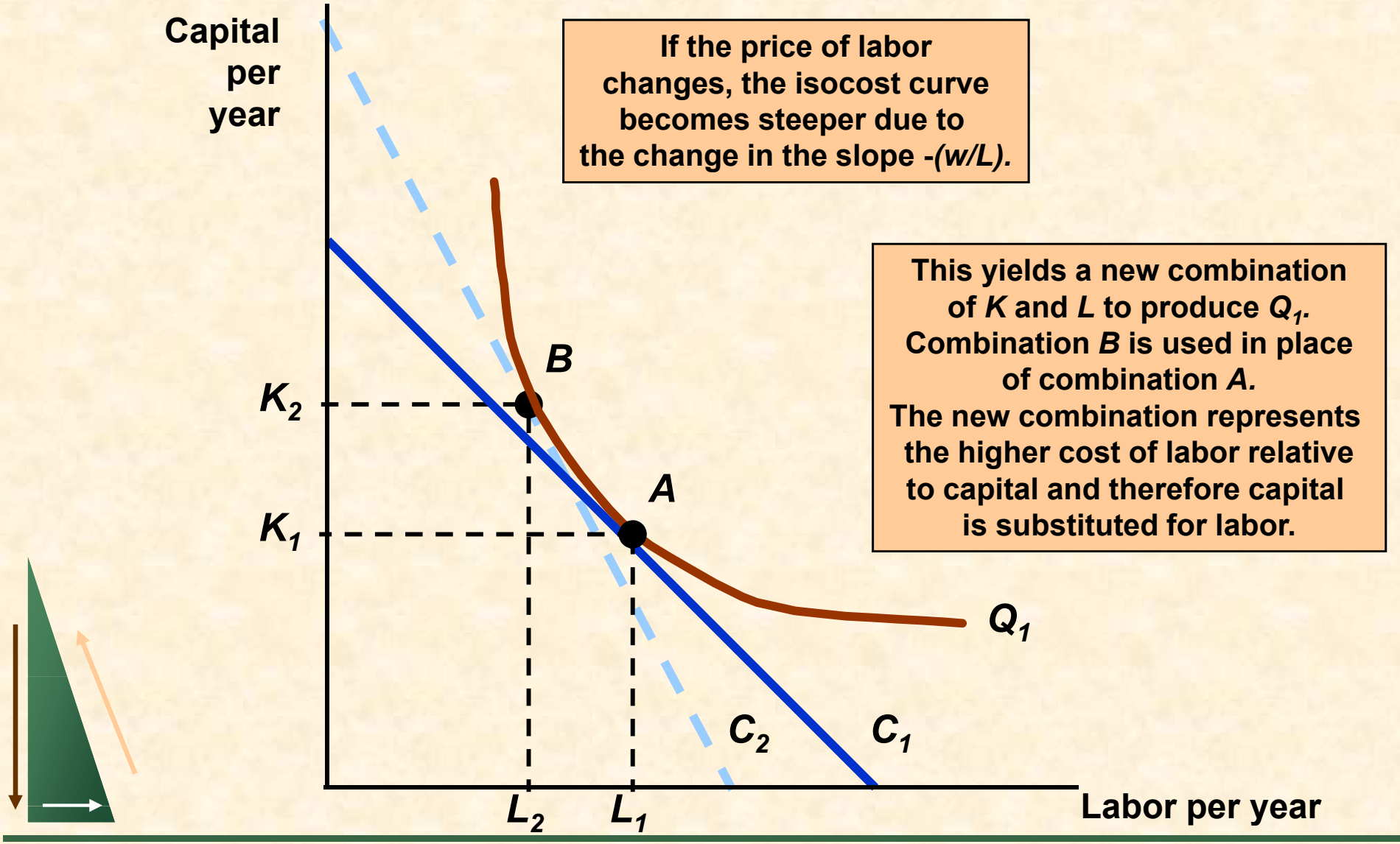
- The Isocost Line: shows all combinations of *L* & *K* that can be purchased for the same cost
  - $C = wL + rK$
- Rewriting *C* as linear: $K = C/r - (w/r)L$
- The slope of the isocost line: $\Delta K / \Delta L = -(w/r)$
- is the ratio of the wage rate to the rental cost of capital. This shows the rate at which capital can be substituted for labor with no change in cost.



Producing a Given Output at Minimum Cost



Input Substitution with an Input Price Change



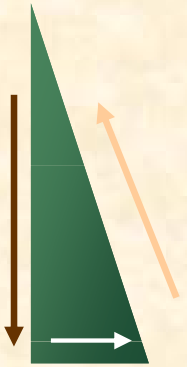
Cost in the Long Run

- Isoquants and Isocosts and the Production Function

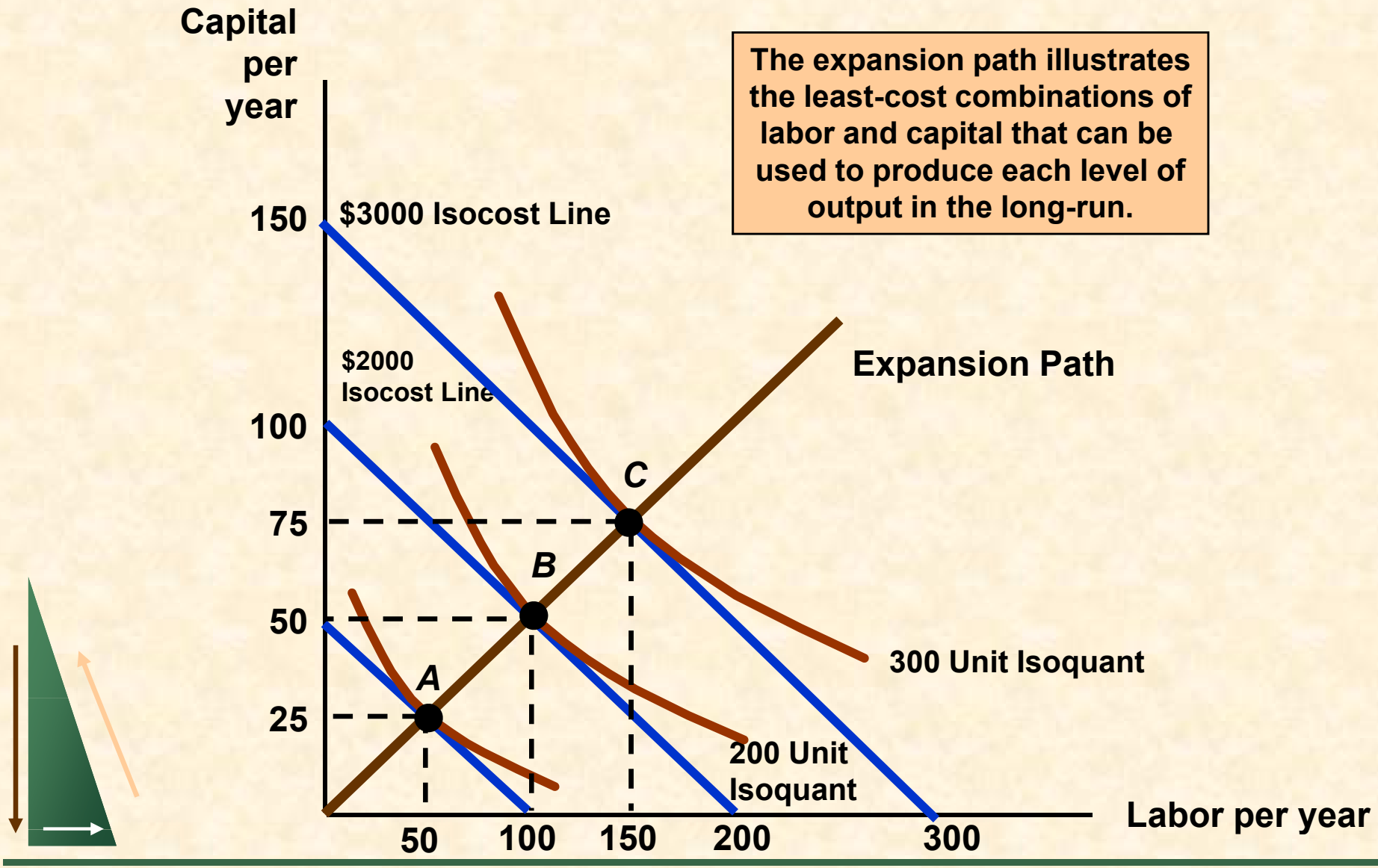
$$\text{MRTS} = -\Delta K/\Delta L = \text{MP}_L/\text{MP}_K$$

$$\text{Slope of isocost line} = \Delta K/\Delta L = -w/r$$

$$MP_L/MP_K = w/r$$

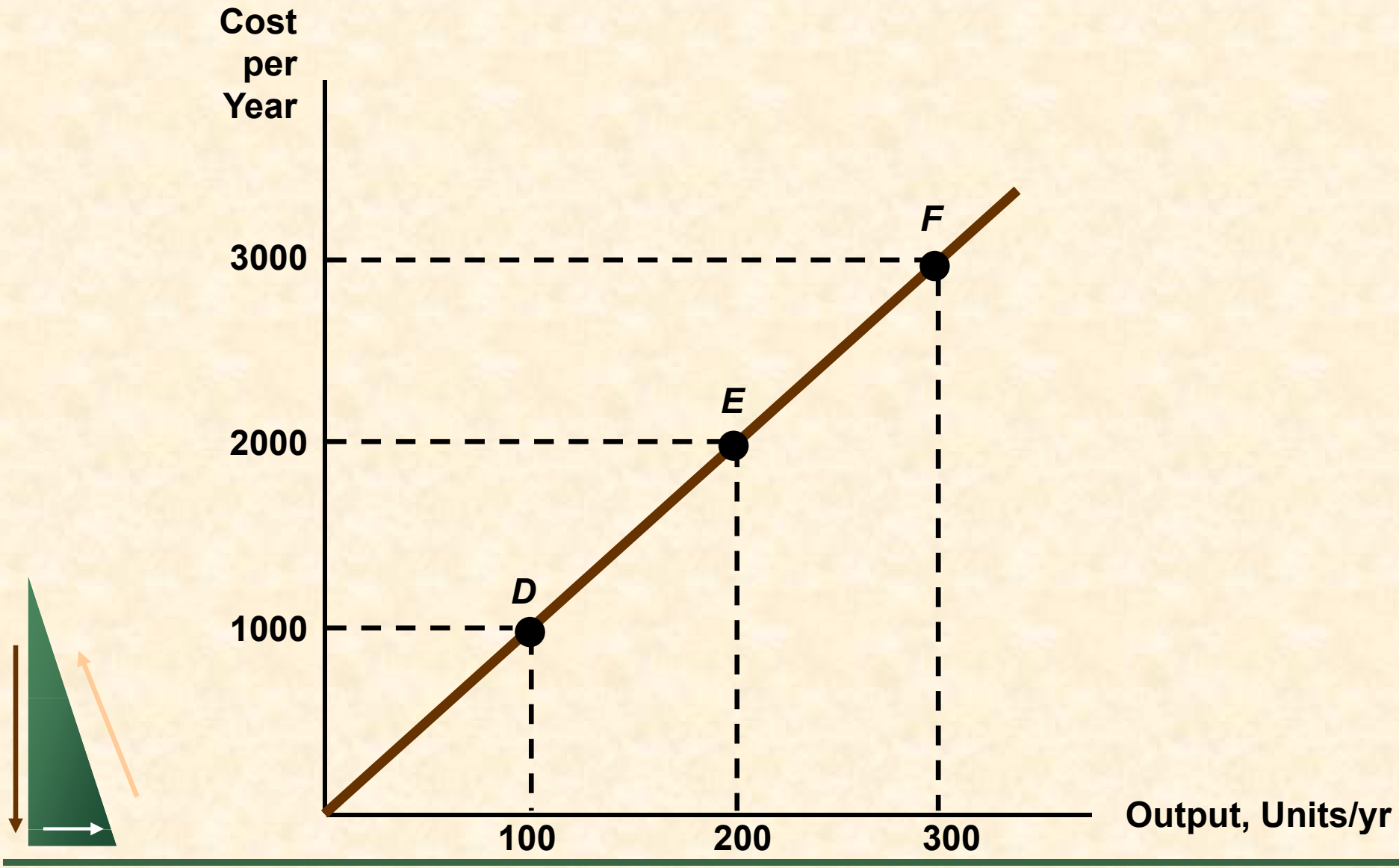


A Firm's Expansion Path

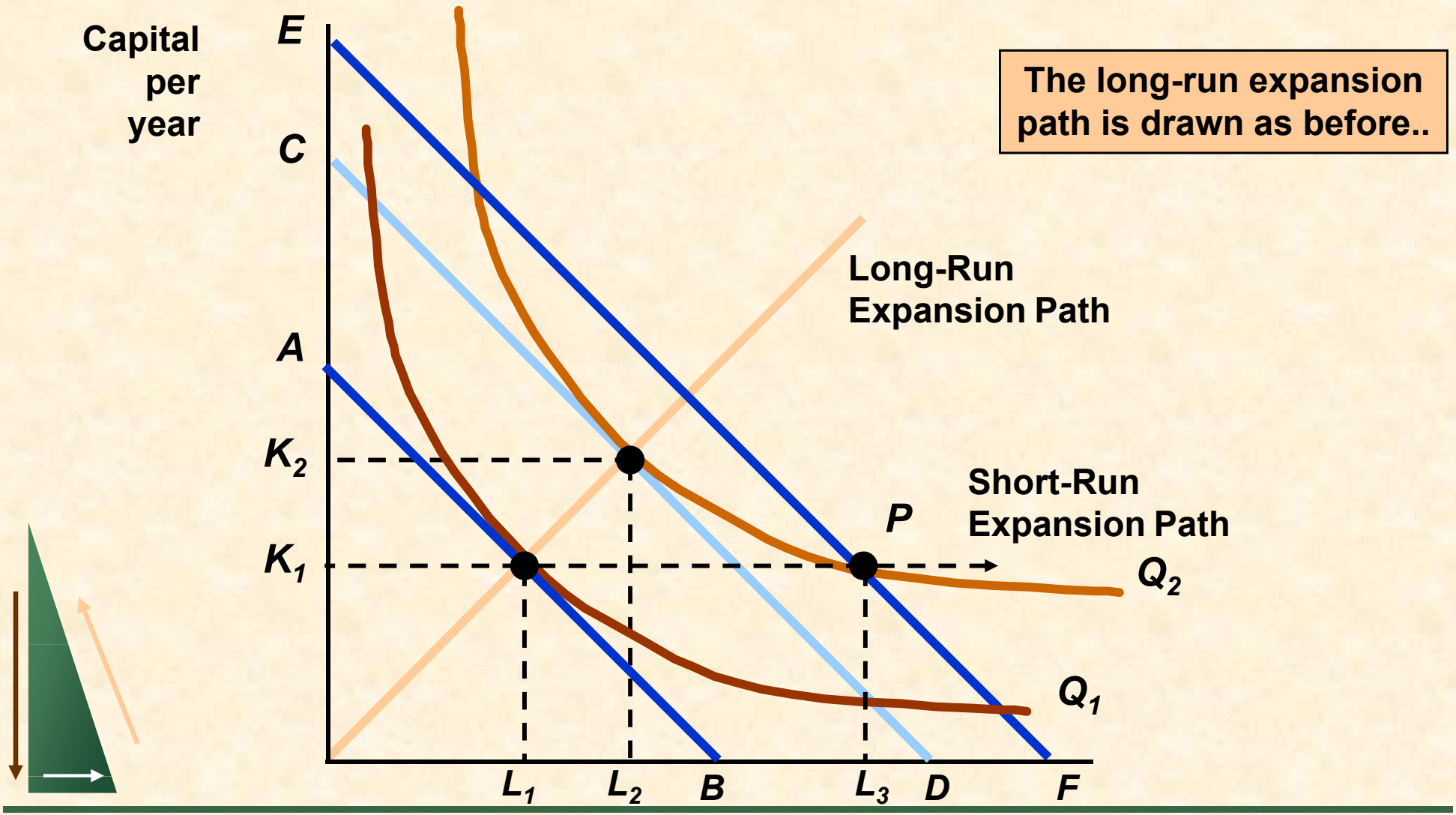


The expansion path illustrates the least-cost combinations of labor and capital that can be used to produce each level of output in the long-run.

A Firm's Long-Run Total Cost Curve

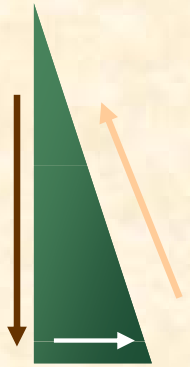


LR Versus SR Cost Curves: The Inflexibility of SR Production



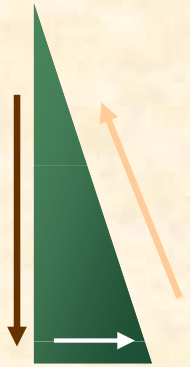
LR Versus SR Cost Curves

- Long-Run Average Cost (LRAC)
  - **Constant Returns to Scale**: If input is doubled, output will double; average cost is constant at all levels of output.
  - **Increasing Returns to Scale**: If input is doubled, output will more than double; average cost decreases at all levels of output.
  - **Decreasing Returns to Scale**: If input is doubled, the increase in output is less than doubled; average cost increases with output.

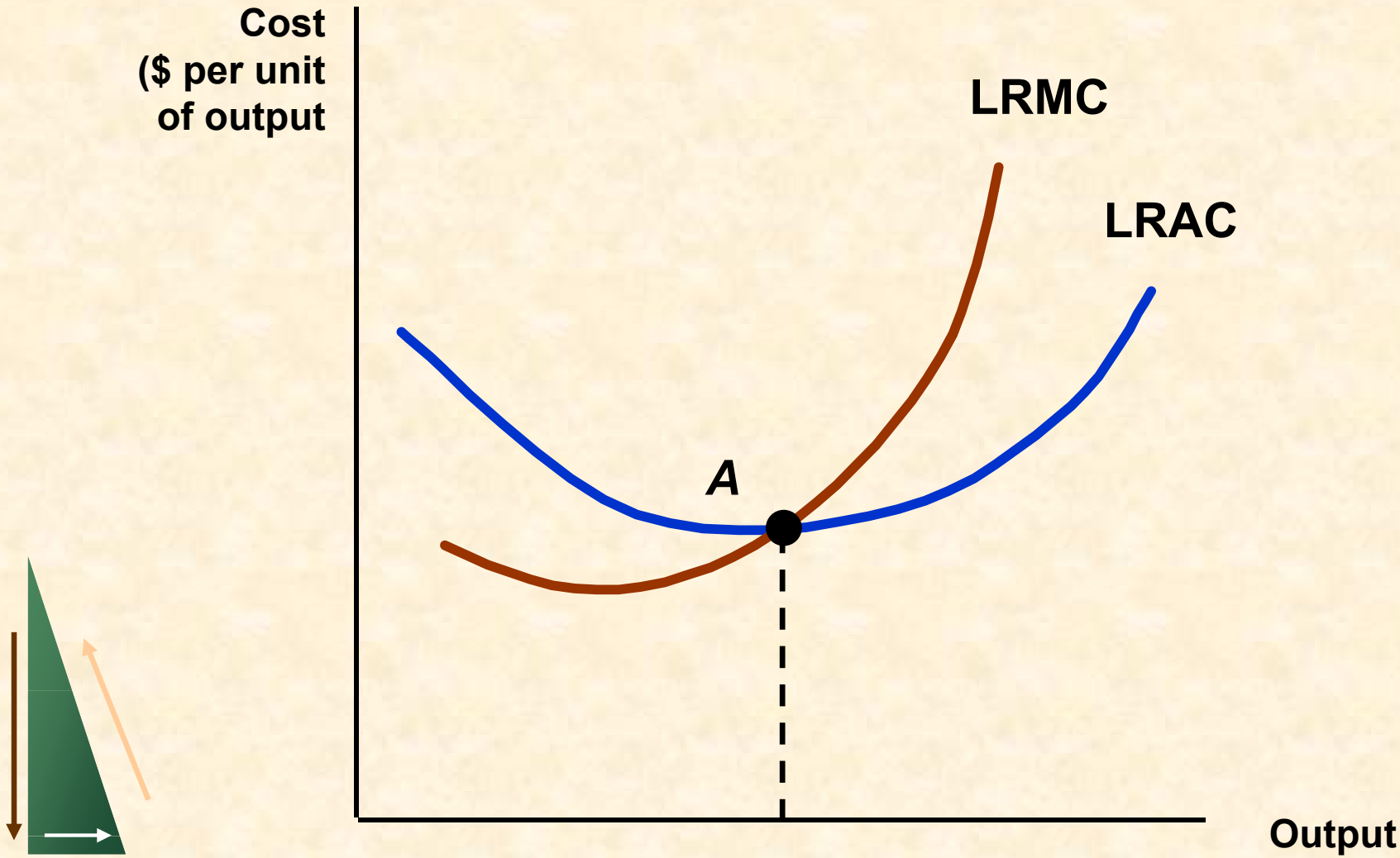


LR Versus SR Cost Curves

- Long-Run Average Cost (LRAC)
  - In the long-run: firms experience increasing and decreasing returns to scale and therefore long-run average cost is “U” shaped.
  - Long-run marginal cost leads long-run average cost:
    - If LRMC < LRAC, LRAC will fall
    - If LRMC > LRAC, LRAC will rise
    - Therefore, LRMC = LRAC at the minimum of LRAC

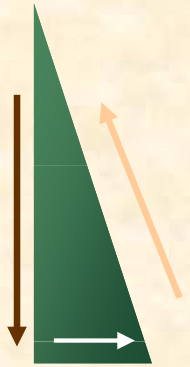


Long-Run Average and Marginal Cost

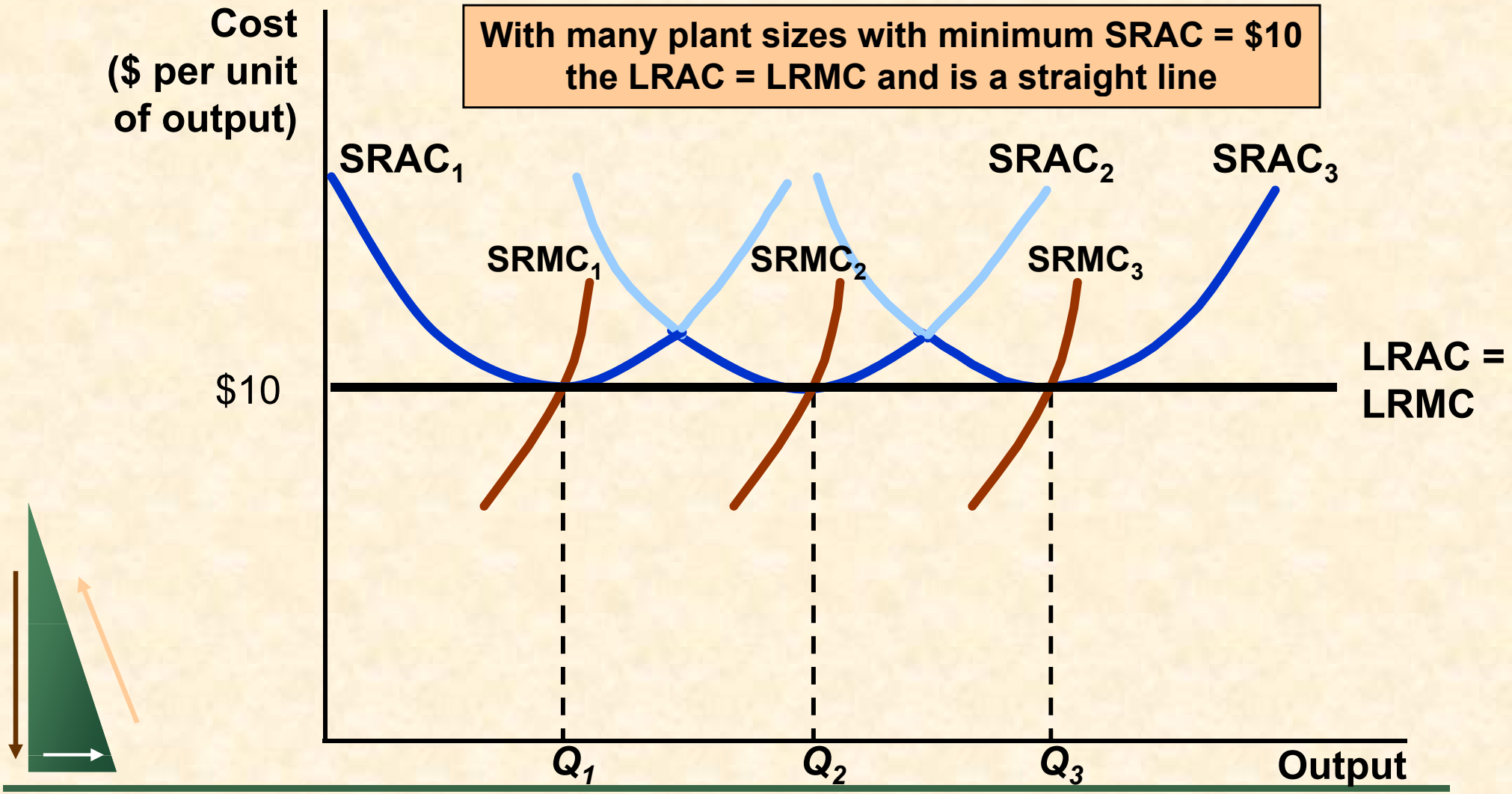


LR Versus SR Cost Curves

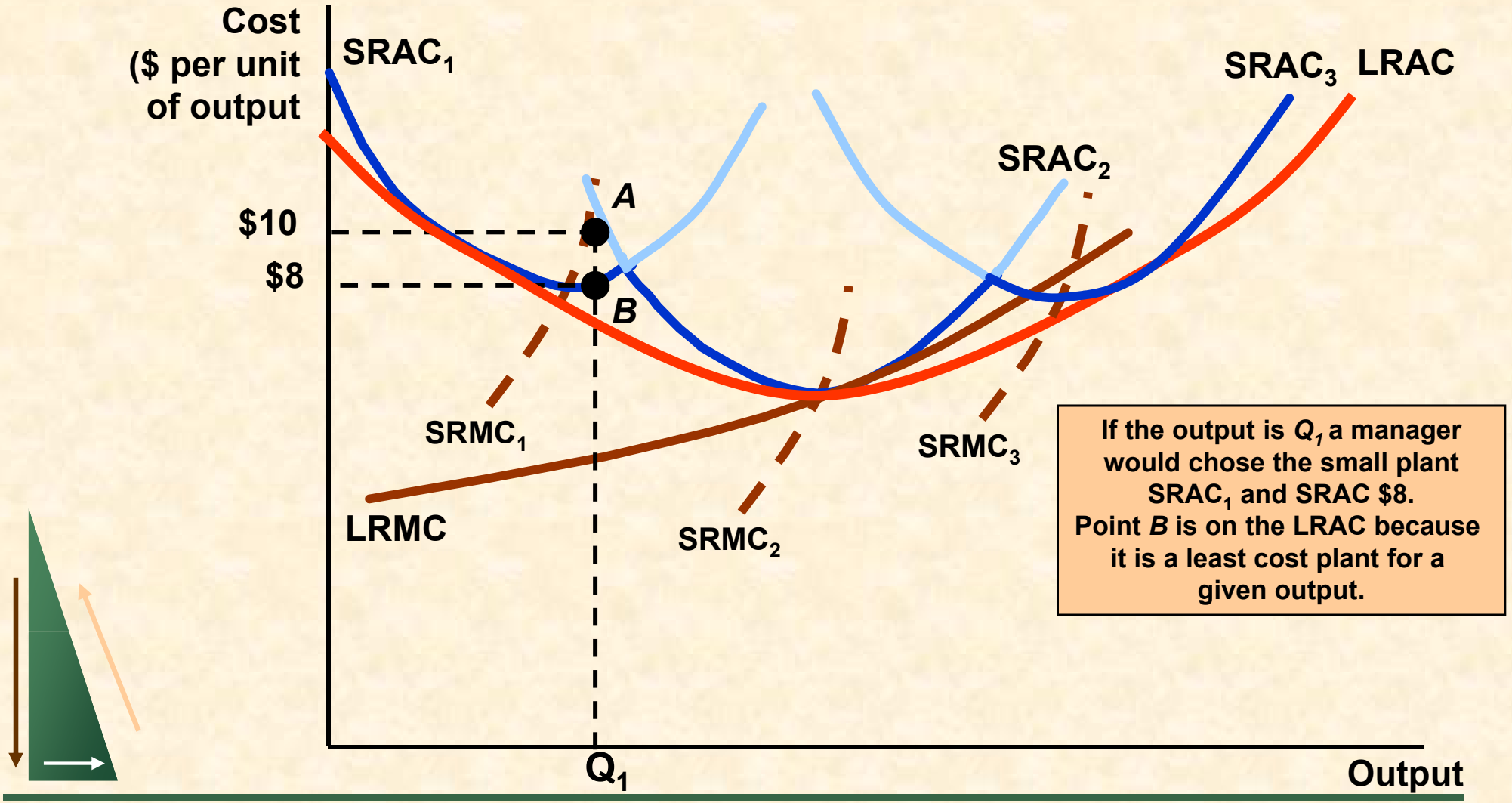
- Economies & Diseconomies of Scale
  - Economies of Scale: Increase in output is greater than the increase in inputs.
  - Diseconomies of Scale: Increase in output is less than the increase in inputs.
- Measuring Economies of Scale
  - E_c = % change in cost from a 1% increase in Q



LR Cost with Constant Returns to Scale

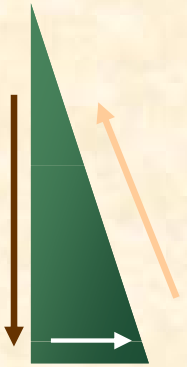


LR Cost with Economies and Diseconomies of Scale

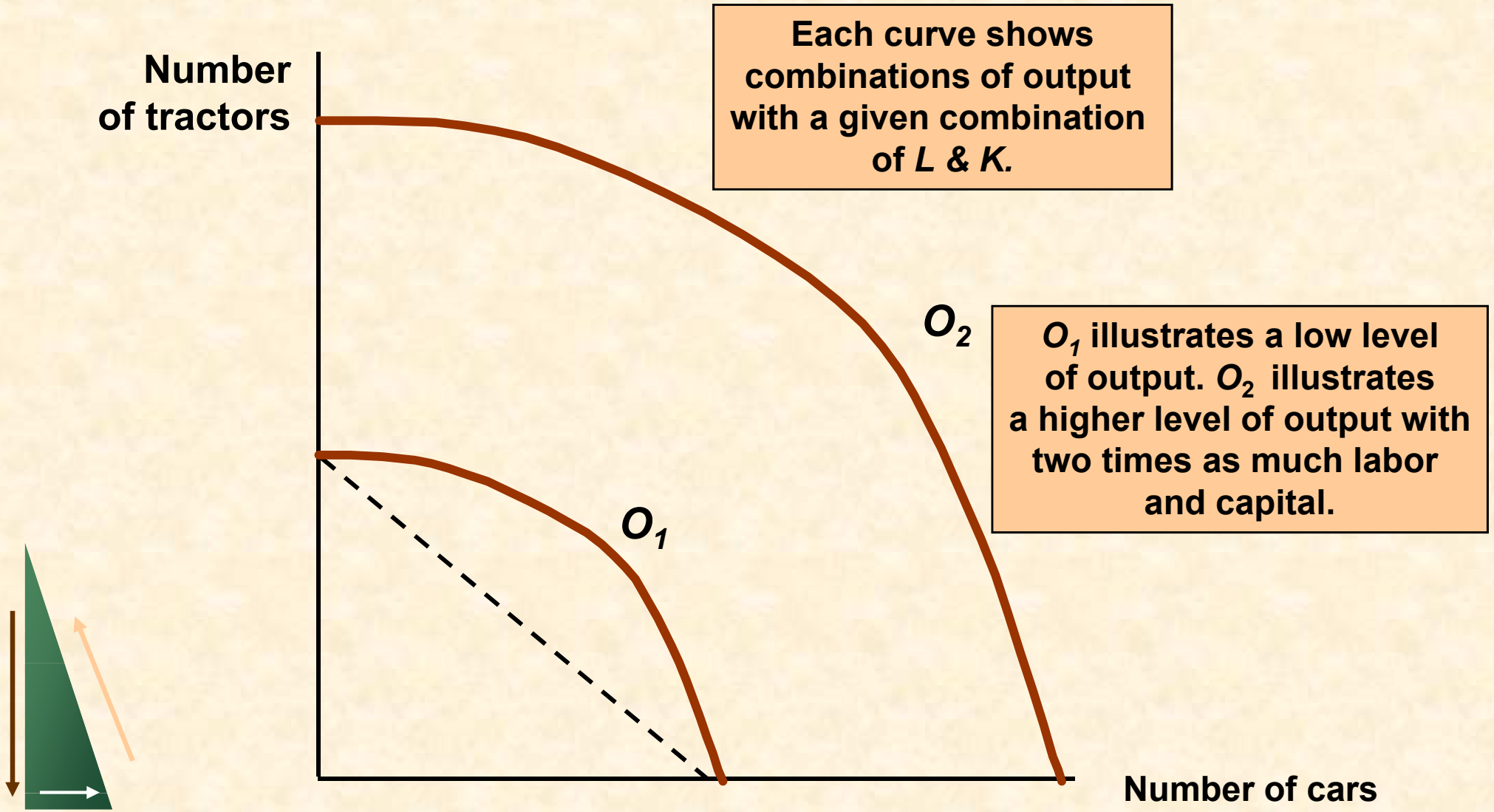


Production with Two Outputs: Economies of Scope

- Economies of scope exist when the joint output of a single firm is greater than the output that could be achieved by two different firms each producing a single output.
- What are the advantages of joint production?
  - Consider an automobile company producing cars and tractors: both use capital and labor; the firms share management resources; both use the same labor skills and type of machinery.



Product Transformation Curve

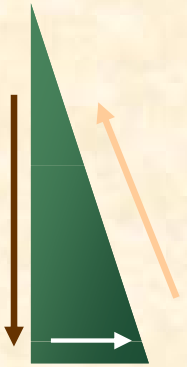


Production with Two Outputs: Economies of Scope

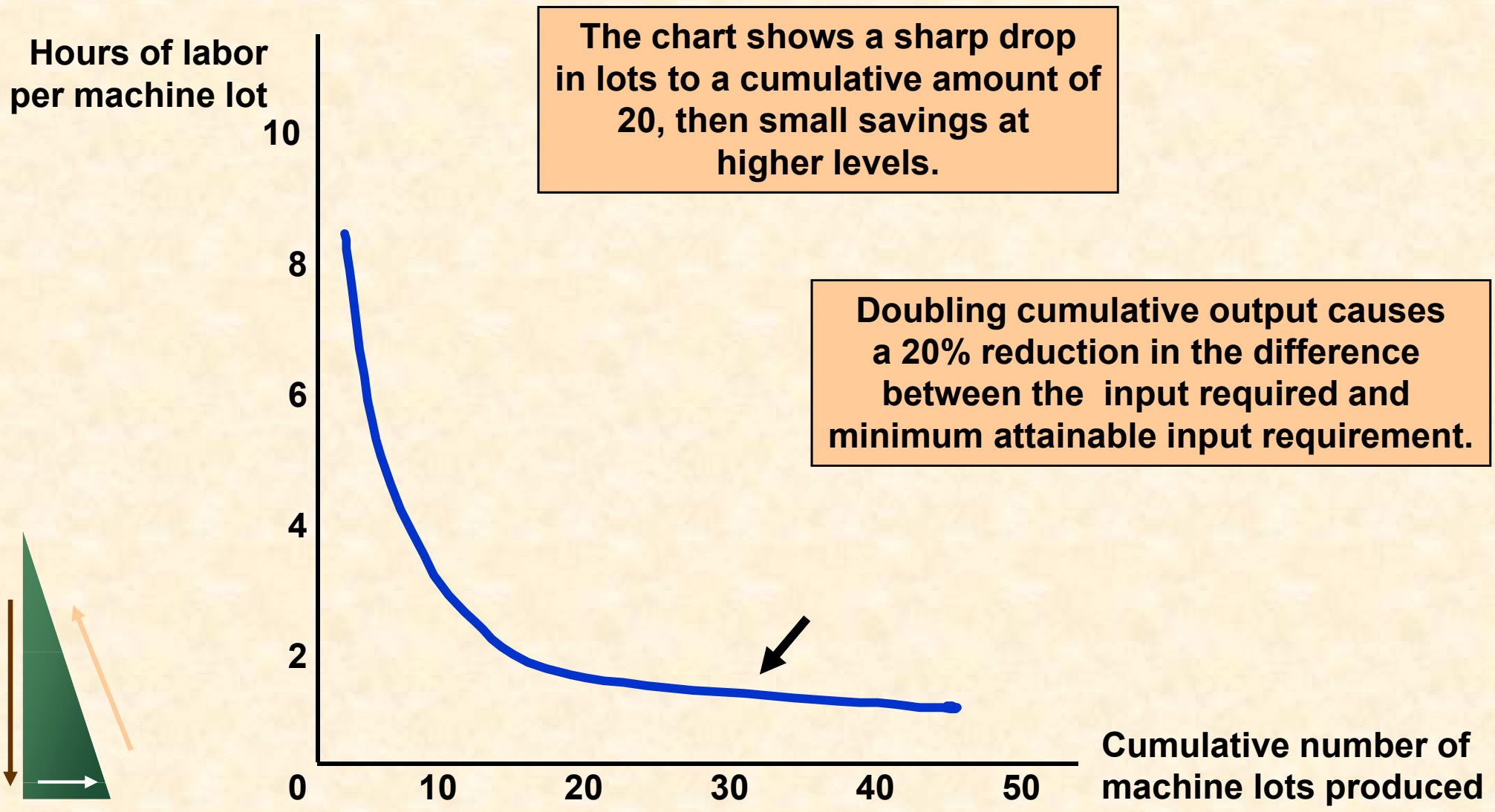
- There is no direct relationship between economies of scope and economies of scale.
- The *degree of economies of scope* measures the savings in cost and can be written:

$$SC = \frac{C(Q_1) + C(Q_2) - C(Q_1, Q_2)}{C(Q_1, Q_2)}$$

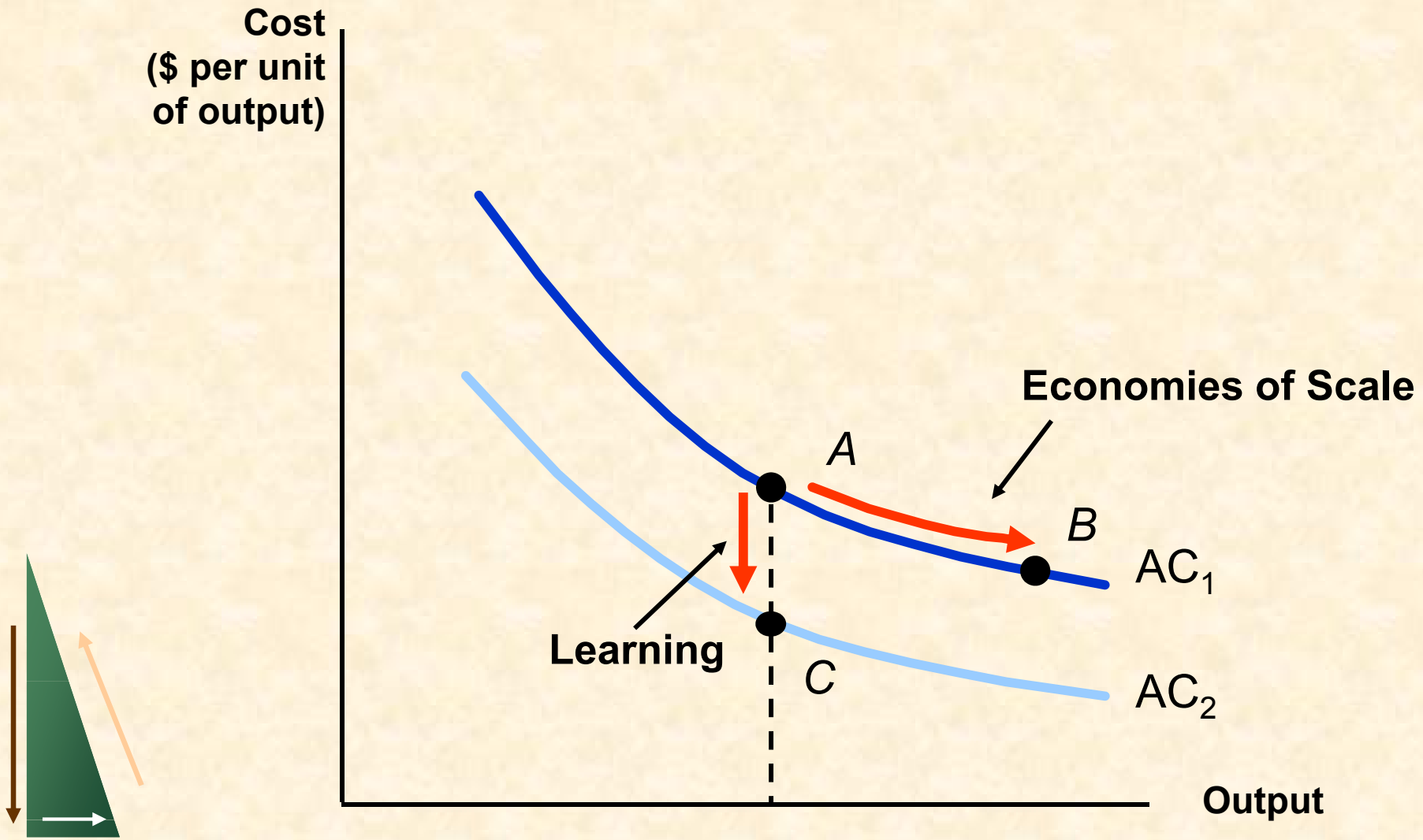
- $C(Q_1)$ is the cost of producing Q_1
- $C(Q_2)$ is the cost of producing Q_2
- $C(Q_1Q_2)$ is the joint cost of producing both products



The Learning Curve

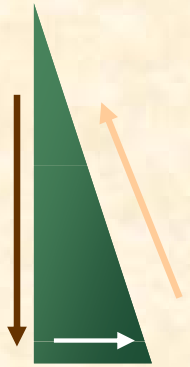


Economies of Scale Versus Learning



The Learning Curve in Practice

- Scenario: A new firm enters the chemical processing industry.
- Do they:
  1) Produce a low level of output and sell at a high price?
  2) Produce a high level of output and sell at a low price?
- How would the learning curve influence your decision?



The Learning Curve in Practice: Empirical Results

- Study of 37 chemical products
  - Average cost fell 5.5% per year
  - For each doubling of plant size, average production costs fall by 11%
  - For each doubling of cumulative output, the average cost of production falls by 27%
- Semiconductors: a study of 7 generations of DRAM semiconductors from 1974-1992 found learning rates averaged 20%.
- In the aircraft industry, learning rates are as high as 40%.