LECTURE 5: Cost Theory 비용이론

- Meaning and Measurements of Cost:
  - Which Costs Matter?
- Cost Minimization
- Costs in the Short Run and in the Long Run: Long-Run versus Short-Run Cost Curves
- Production with Two Outputs—Economies of Scope
- Dynamic Changes in Costs—The Learning Curve
- Estimating and Predicting Cost

Cost of production: The long run total cost function

- Given production technology, that is, input-output relation, and markets for these inputs
- How to combine factor inputs determines the firm's cost of production
- The **long run total cost function** relates minimized total cost to output, Q, and to the factor prices (w and r).
  - $TC(Q,w,r) = wL^*(Q,w,r) + rK^*(Q,w,r)$
  - Where: L^* and K^* are the long run input demand functions

Meaning of costs & Measuring Cost

- Meaning of costs, and how to measure them
  - For example, if a firm has to rent equipment or buildings, is the rent they pay a cost?
  - What if a firm owns its own equipment or building?
  - How are costs calculated here?

Measuring Cost: Which Costs Matter?

- Accountants tend to take a retrospective view of firms costs, where as economists tend to take a forward-looking view
- Accounting Cost 회계적 비용
  - Actual expenses plus depreciation charges for capital equipment
- Economic Cost 경제(학)적 비용
  - Cost to a firm of utilizing economic resources in production, including opportunity cost

Measuring Cost: Which Costs Matter?

- Economic costs distinguish between costs the firm can control and those it cannot
  - Concept of opportunity cost plays an important role
- Opportunity cost 기회비용
  - Cost associated with opportunities that are foregone when a firm's resources are not put to their highest-value use.

Opportunity Cost

- An Example
  - A firm owns its own building and pays no rent for office space
  - Does this mean the cost of office space is zero?
  - The building could have been rented instead
  - Foregone rent is the opportunity cost of using the building for production and should be included in economic costs of doing business

Opportunity Cost

- A person starting their own business must take into account the opportunity cost of their time
  - Could have worked elsewhere making a competitive salary
- Accountants and economists often treat depreciation differently as well

Measuring Cost: Which Costs Matter?

- Although opportunity costs are hidden and should be taken into account, sunk costs should not
- Sunk Cost
  - Expenditure that has been made and cannot be recovered
  - Should not influence a firm's future economic decisions.

Sunk Cost 매몰비용

- Firm buys a piece of equipment that cannot be converted to another use
- Expenditure on the equipment is a sunk cost
  - Has no alternative use so cost cannot be recovered – opportunity cost is zero
  - Decision to buy the equipment might have been good or bad, but now does not matter

Short Run costs

- Some costs vary with output, while some remain the same no matter amount of output
- Total cost can be divided into TC & VC
- **total cost (TC** or **C)** 총비용
  - Total economic cost of production, consisting of fixed and variable costs.
- **fixed cost (FC)** 고정비용
  - Cost that does not vary with the level of output and that can be eliminated only by shutting down.
- **variable cost (VC)** 변동비용
  - Cost that varies as output varies

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 (the cost of the fixed inputs) plus the variable cost (the cost of the variable inputs), or…

$$TC = FC + VC$$

Fixed and Variable Costs

- Which costs are variable and which are fixed depends on the time horizon
- Short time horizon – most costs are fixed
- Long time horizon – many costs become variable
- In determining how changes in production will affect costs, must consider if affects fixed or variable costs

Fixed Cost Versus Sunk Cost

- Fixed cost and sunk cost are often confused
  - Sunk costs are costs that have been incurred and *cannot be recovered*.
  - An example is the cost of R&D to a pharmaceutical company to develop and test a new drug and then, if the drug has been proven to be safe and effective, the cost of marketing it.
  - Whether the drug is a success or a failure, these costs cannot be recovered and thus are sunk.
  - **Amortizing Sunk Costs매몰비용의 이연상각**
    - **amortization** 이연상각 Policy of treating a one-time expenditure as an annual cost spread out over some number of years.

Measuring Cost: Which Costs Matter?

- Personal Computers
  - Most costs are variable
  - Largest component: labor
- Software
  - Most costs are sunk
  - Initial cost of developing the software

Marginal and Average Cost

- In completing a discussion of costs, must also distinguish between
  - Average Cost **(ATC or AC)** 총평균비용
  - Marginal Cost **(MC)** 한계비용
- After definition of costs is complete, one can consider the analysis between short-run and long-run costs

Measuring Costs

- Marginal Cost (MC):
  - The cost of expanding output by one unit.
  - Fixed cost have no impact on marginal cost, so it can be written as:

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

Measuring Costs

- Average Total Cost (ATC)
  - Cost per unit of output, consisting of
    - **average fixed cost (AFC)** 평균고정비용
    - Fixed cost divided by the level of output.
    - **average variable cost (AVC)** 평균변동비용
    - Variable cost divided by the level of output.

Measuring Costs

- ATC, AFC, AVC

$$ATC = \frac{TC}{q} = AFC + AVC$$

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

Measuring Costs

- All the types of costs relevant to production have now been discussed
- Can now discuss how they differ in the long and short run
- Costs that are fixed in the short run may not be fixed in the long run
- Typically in the long run, most if not all costs are variable

Determinants of Short-run Costs

- The rate at which these costs increase depends on the nature of the production process
  - The extent to which production involves diminishing returns to variable factors
- Diminishing returns to labor
  - When marginal product of labor is decreasing

Determinants of Short-run Costs

- If marginal product of labor decreases significantly as more labor is hired
  - Costs of production increase rapidly
  - Greater and greater expenditures must be made to produce more output
- If marginal product of labor decreases only slightly as increase labor
  - Costs will not rise very fast when output is increased

Determinants of Short-run Costs – An Example

- Assume the wage rate (w) is fixed relative to the number of workers hired.
- Variable costs is the per unit cost of extra labor times the amount of extra labor: wL

$$MC = \frac{\Delta VC}{\Delta q} = \frac{w\Delta L}{\Delta q}$$

Determinants of Short-run Costs – An Example

- Remembering that

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

- And rearranging

$$\Delta L \text{ for a } 1 \text{ unit } \Delta Q = \frac{\Delta L}{\Delta Q} = \frac{1}{\Delta MP_L}$$

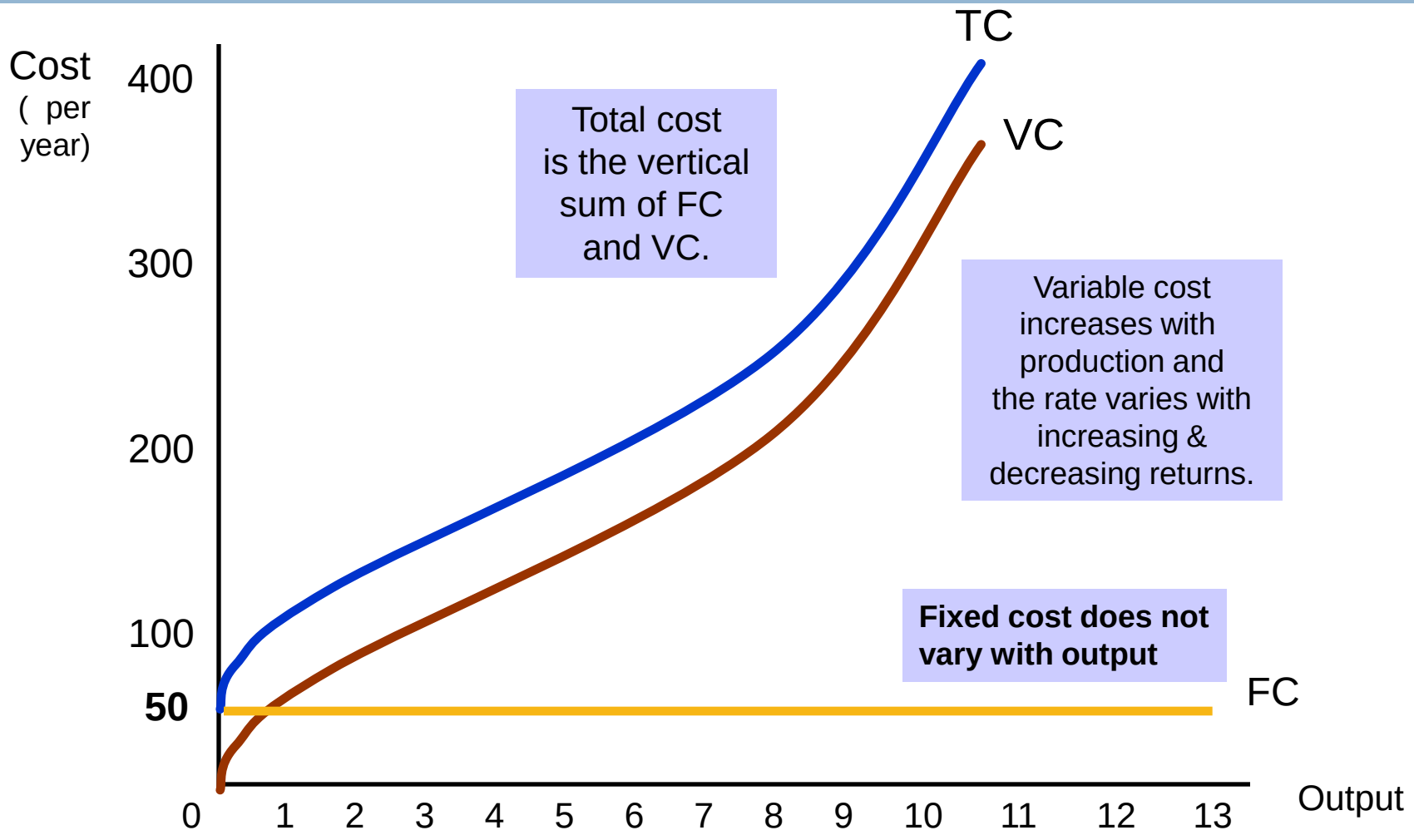
Determinants of Short-run Costs – An Example

- We can conclude:

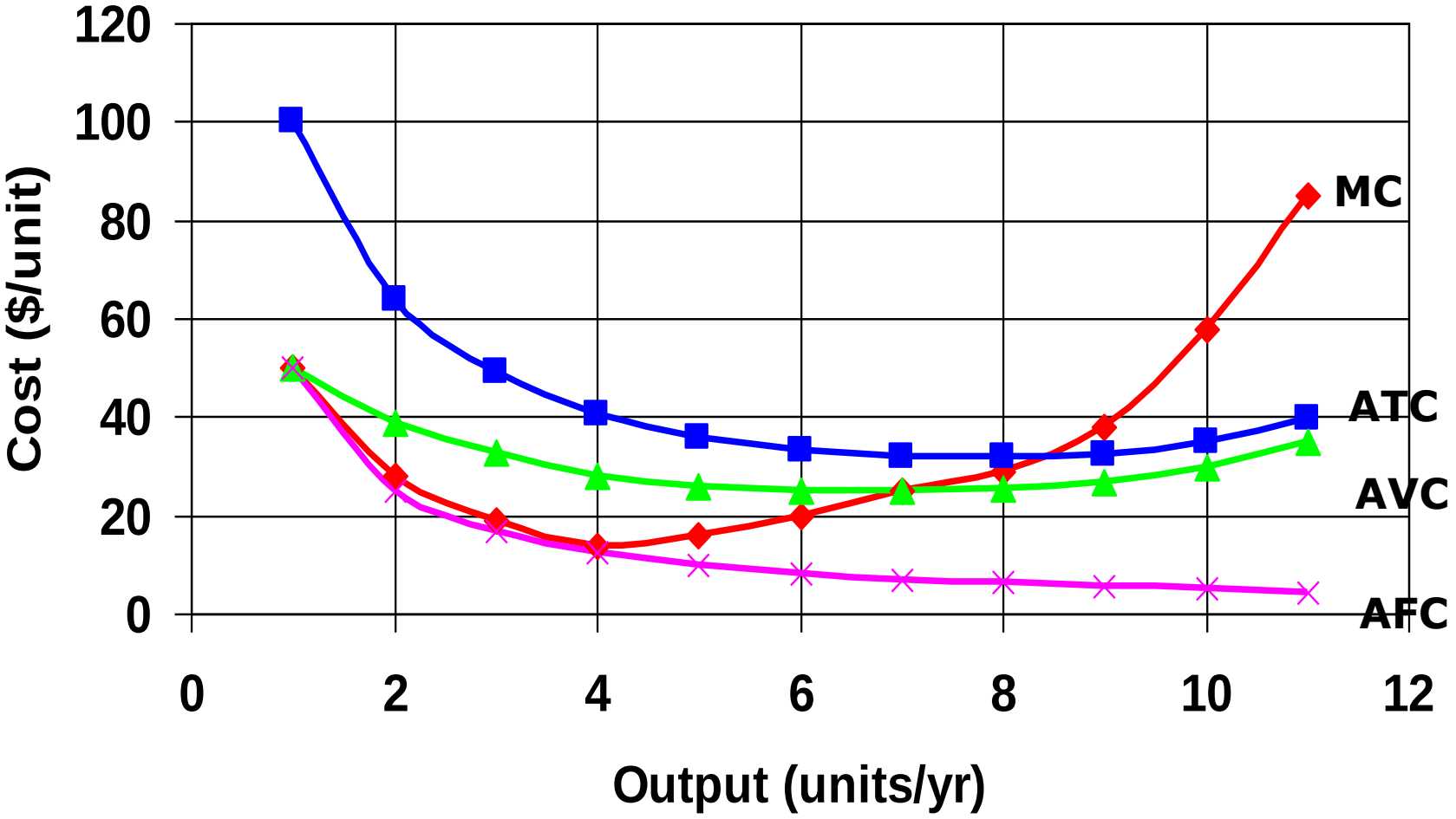
$$MC = \frac{w}{MP_L}$$

- …and a low marginal product (MP) leads to a high marginal cost (MC) and vise versa.

Cost Curves for a Firm



Cost Curves

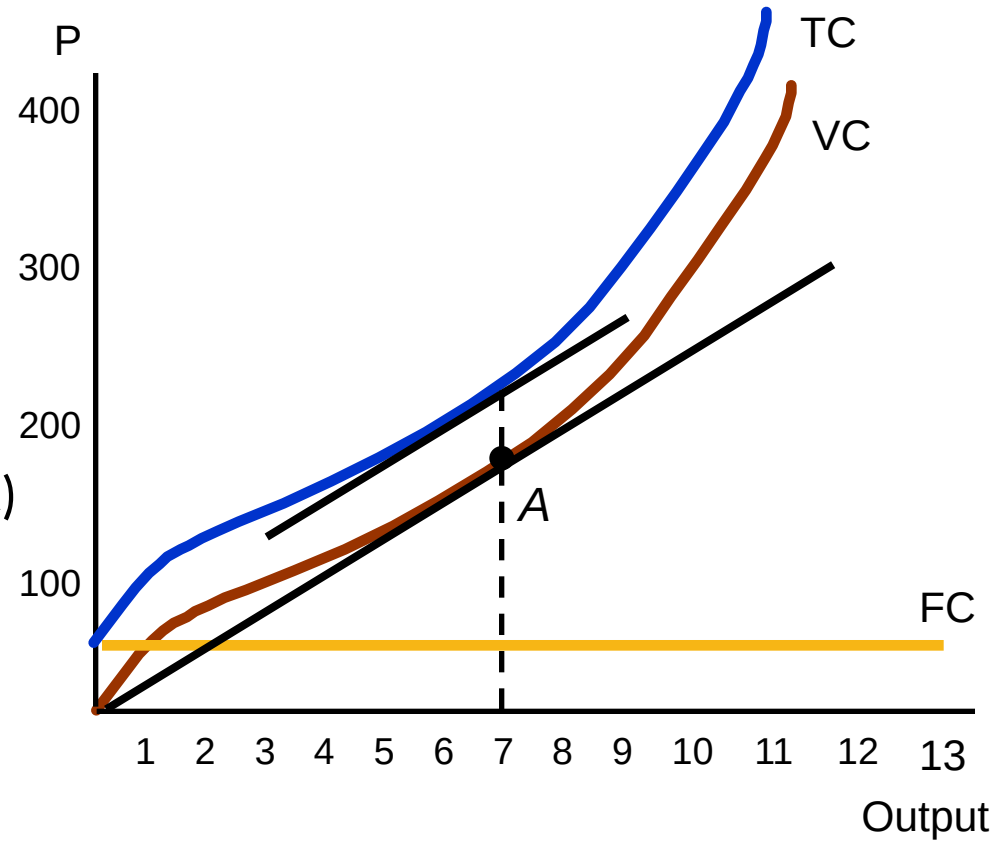

120
100
80
60
40
20
0
Cost ($/unit)
0
2
4
6
8
10
12
Output (units/yr)
MC
ATC
AVC
AFC

Cost Curves

- When MC is below AVC, AVC is falling
- When MC is above AVC, AVC is rising
- When MC is below ATC, ATC is falling
- When MC is above ATC, ATC is rising
- Therefore, MC crosses AVC and ATC at the minimums
  - The Average – Marginal relationship

Cost Curves for a Firm

- The line drawn from the origin to the variable cost curve:
  - Its slope equals AVC
  - The slope of a point on VC or TC equals MC
  - Therefore, MC = AVC at 7 units of output (point A)



Cost in the Long Run

- In the long run a firm can change all of its inputs
- The Cost-Minimizing Input Choice 비용최소화 (하는) 생산
  - In making cost minimizing choices, must look at the cost of using capital and labor in production decisions

Cost in the Long Run

- **The Price of Capital** 자본의 가격
- Capital is either rented/leased or purchased
  - We will consider capital rented as if it were purchased
  - *The price of capital is its user cost, given by r = Depreciation rate + Interest rate.*
  - **The Rental Rate of Capital** 자본의 임대료
  - **rental rate**
    - Cost per year of renting one unit of capital.

User Cost of Capital 자본의 사용자비용

- The user cost of capital must be considered
  - The annual cost of owning and using the airplane instead of selling or never buying it
  - Sum of the economic depreciation and the interest (the financial return) that could have been earned had the money been invested elsewhere

Cost in the Long Run

- Example: Assume Delta is considering purchasing an airplane for 150 million
  - Plane lasts for 30 years
  - 5 per year – economic depreciation for the plane
- User Cost of Capital = Economic Depreciation + (Interest Rate)*(Value of Capital)

  = 5 mil + (.10)(150 mil – depreciation)
  - Year 1 = 5 million + (.10)(150 million) = 20 million
  - Year 10 = 5 million +(.10)(100 million) = 15 million

Cost in the Long Run

- User cost can also be described as;
  - Rate per dollar of capital, r
  - r = Depreciation Rate + Interest Rate
- In our example, depreciation rate was 3.33% and interest was 10% so
  - r = 3.33% + 10% = 13.33%

Cost Minimizing Input Choice

- How do we put all this together to select inputs to produce a given output at minimum cost?
- Assumptions
  - Two Inputs: Labor (L) & capital (K)
  - Price of labor: wage rate (w)
  - The price of capital
    - r = depreciation rate + interest rate
    - Or rental rate if not purchasing
    - These are equal in a competitive capital market

Cost in the Long Run

- The Isocost Line 등비용선
  - A line showing all combinations of L & K that can be purchased for the same cost
  - Total cost of production is sum of firm's labor cost, wL and its capital cost rK

$$C = wL + rK$$

  - For each different level of cost, the equation shows another isocost line

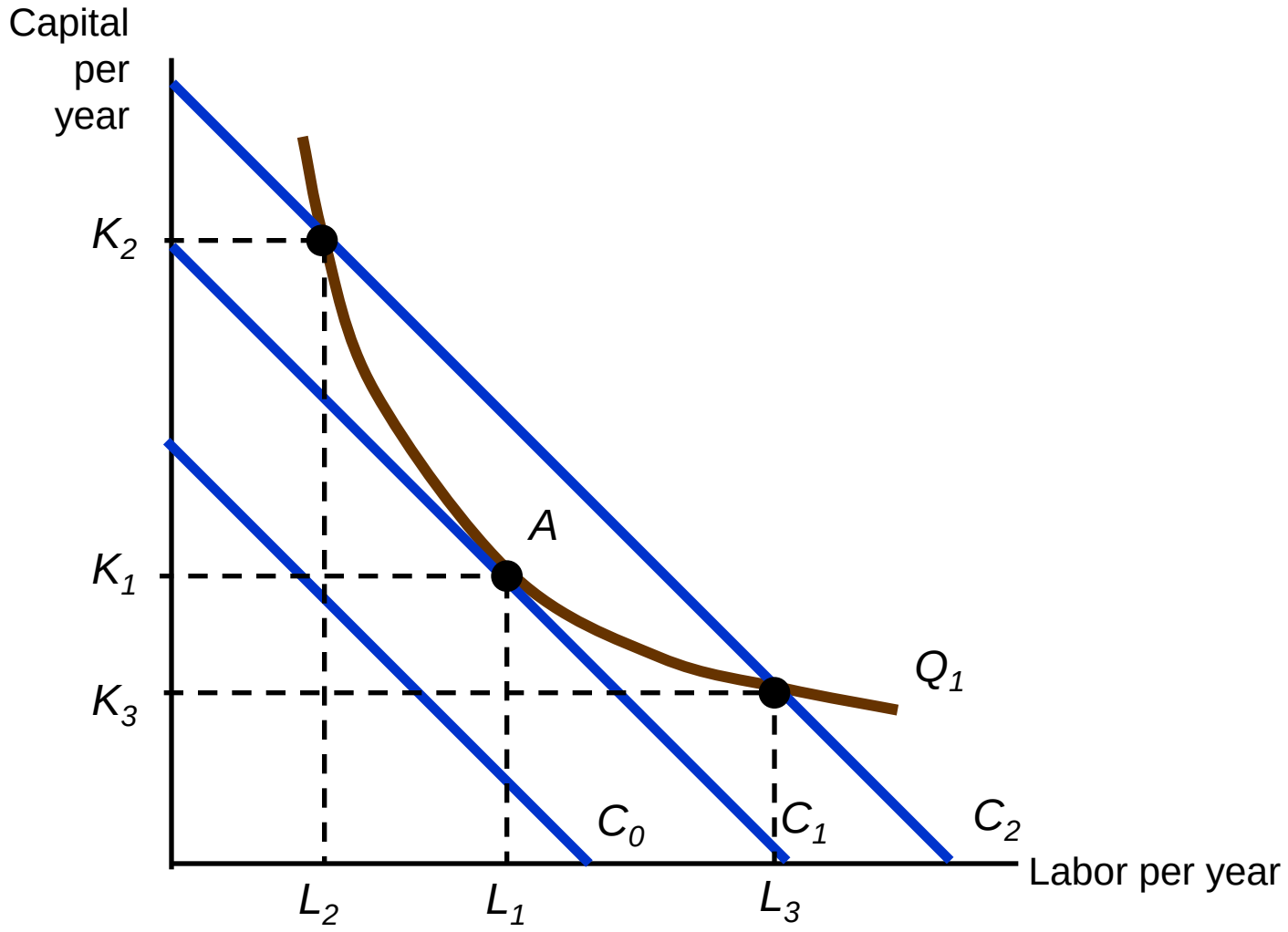
Cost in the Long Run

- Rewriting C as an equation for a straight line:
  - $K = C/r - (w/r)L$
  - Slope of the isocost:
    - $-w/r$ – is the ratio of the wage rate to rental cost of capital.
    - This shows the rate at which capital can be substituted for labor with no change in cost.

Choosing Inputs

- We will address how to minimize cost for a given level of output by combining isocosts with isoquants
- We choose the output we wish to produce and then determine how to do that at minimum cost
  - Isoquant is the quantity we wish to produce
  - Isocost is the combination of K and L that gives a set cost

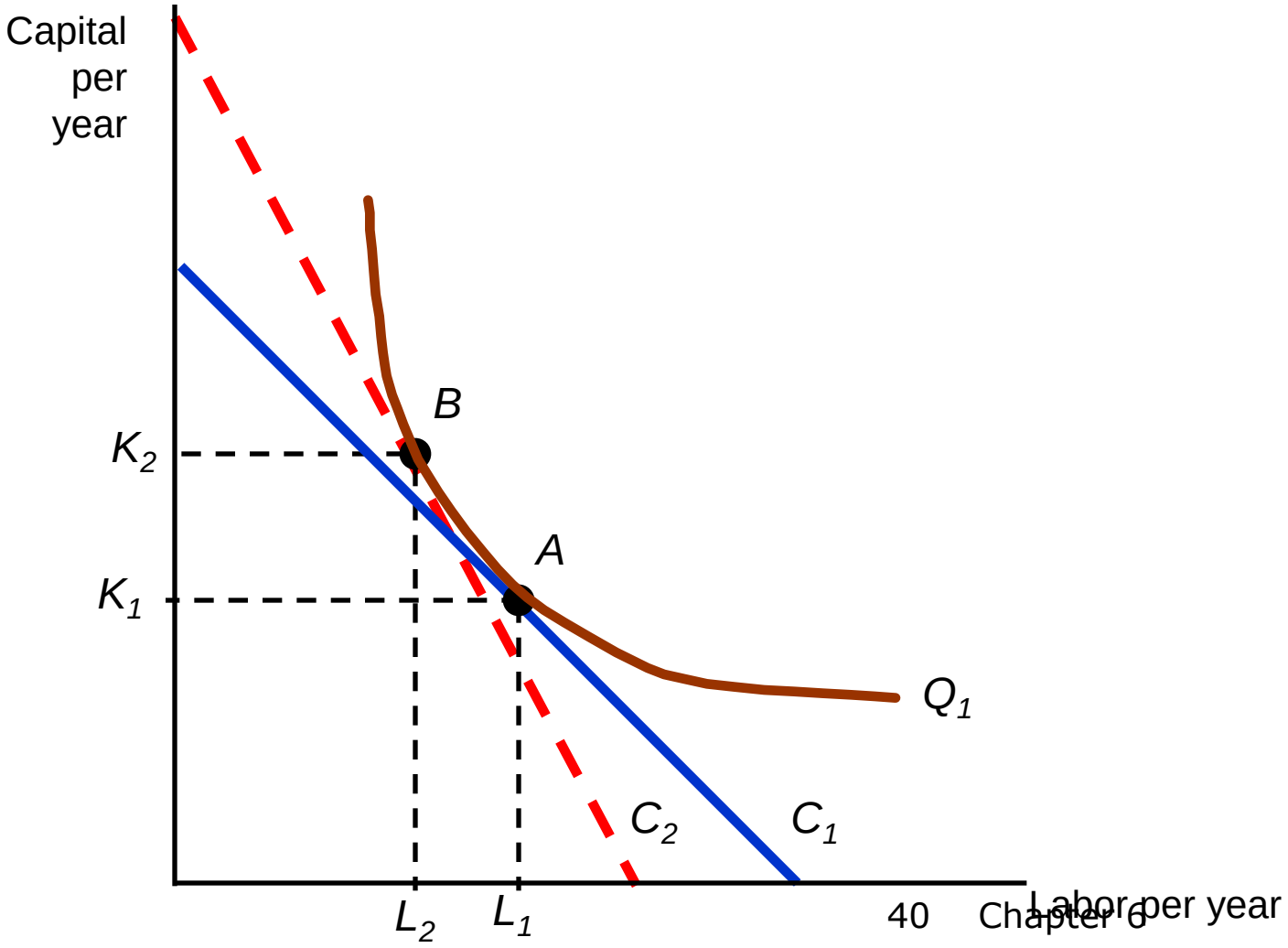
Producing a Given Output at Minimum Cost



Input Substitution When an Input Price Change

- If the price of labor changes, then the slope of the isocost line change, w/r
- It now takes a new quantity of labor and capital to produce the output
- If price of labor increases relative to price of capital, and capital is substituted for labor

Input Substitution When an Input Price Change



Cost in the Long Run

- How does the isocost line relate to the firm's production process?

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

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

$$MP_L/MP_K = w/r \text{ when firm minimizes cost}$$

Cost in the Long Run

- The minimum cost combination can then be written as:

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

  - Minimum cost for a given output will occur when each dollar of input added to the production process will add an equivalent amount of output.

Cost in the Long Run

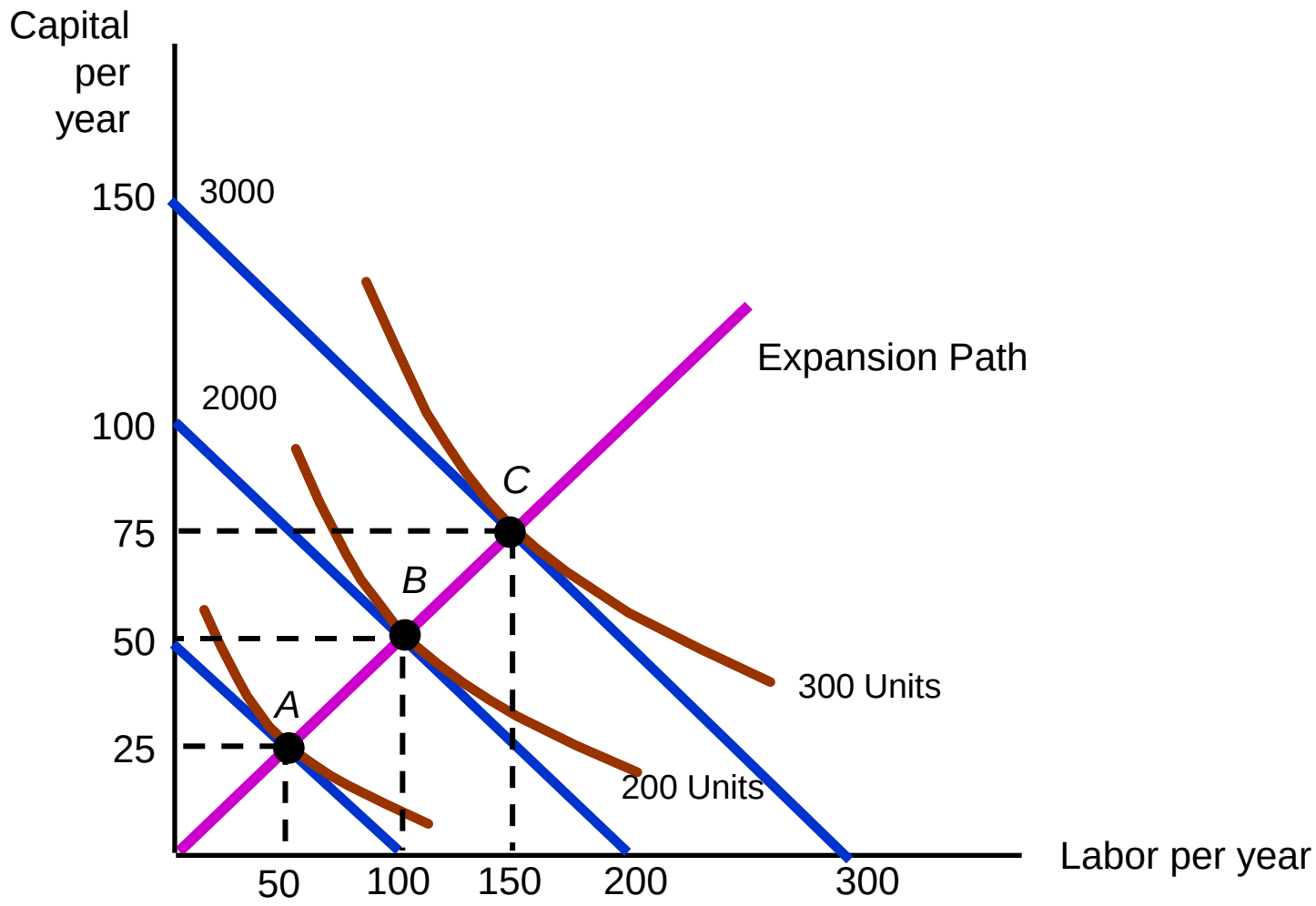
- If w = 10, r = 2, and $MP_L = MP_K$, which input would the producer use more of?
  - Labor because it is cheaper
  - Increasing labor lowers MP_L
  - Decreasing capital raises MP_K
  - Substitute labor for capital until

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

Cost in the Long Run

- Cost minimization with Varying Output Levels
  - For each level of output, there is an isocost curve showing minimum cost for that output level
  - A firm's expansion path shows the minimum cost combinations of labor and capital at each level of output.
  - Slope equals $\Delta K/\Delta L$

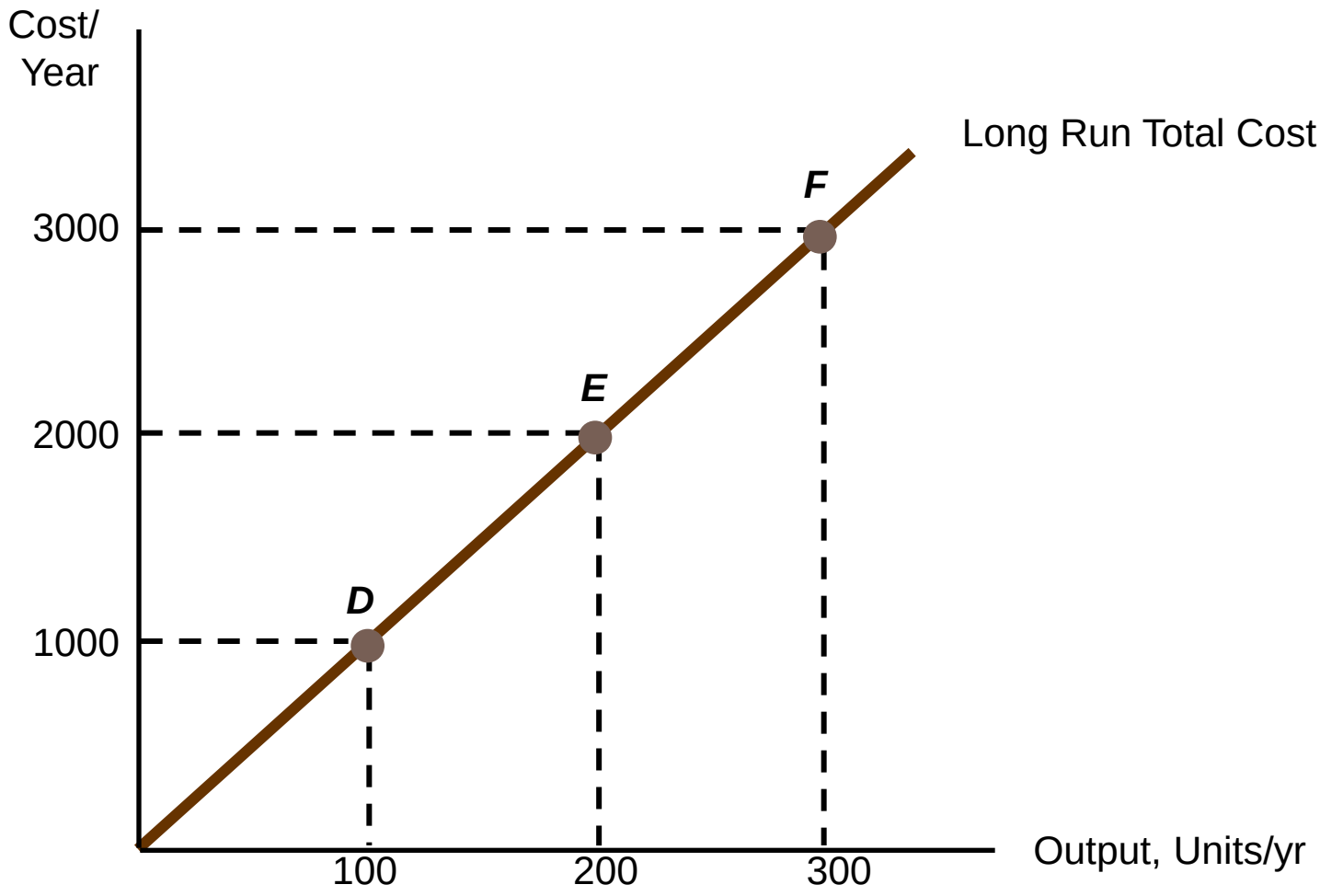
A Firm's Expansion Path 확장경로



Expansion Path & Long-run Costs

- Firms expansion path has same information as long-run total cost curve
- To move from expansion path to LR cost curve
  - Find tangency with isoquant and isocost
  - Determine min cost of producing the output level selected
  - Graph output-cost combination

A Firm's Long-Run Total Cost Curve



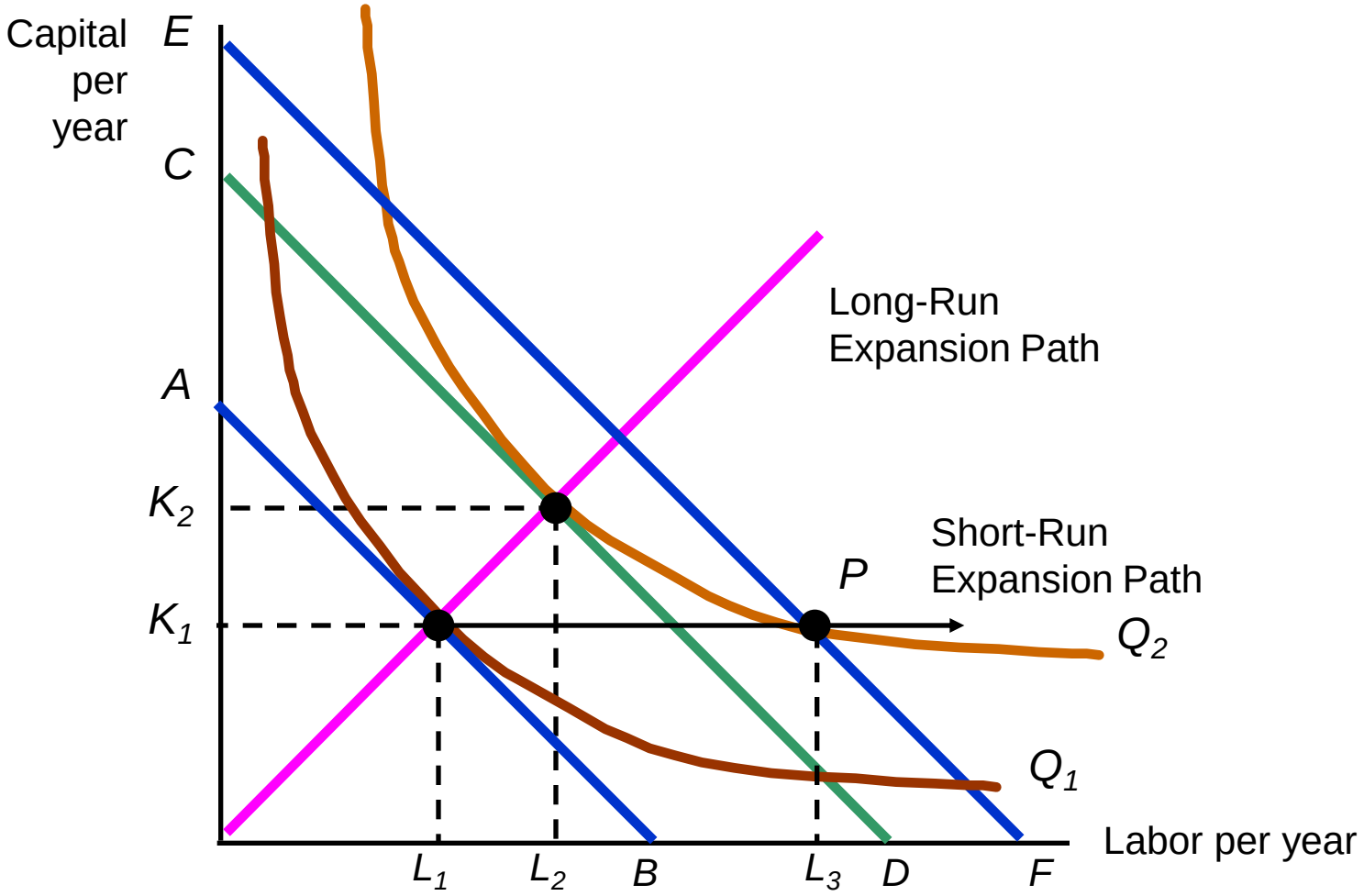
LECTURE 6: Cost-2

- Long-Run versus Short-Run Cost Curves
- Production with Two Outputs—Economies of Scope
- Dynamic Changes in Costs—The Learning Curve
- Estimating and Predicting Cost

Long-Run Versus Short-Run Cost Curves

- In the short run some costs are fixed
- In the long run firm can change anything including plant size
  - Can produce at a lower average cost in long run than in short run
  - Capital and labor are both flexible
- We can show this by holding capital fixed in the short run and flexible in long run

The Inflexibility of Short-Run Production



Long-Run Versus Short-Run Cost Curves

- Long-Run Average Cost (LAC) 장기평균비용
  - Most important determinant of the shape of the LR AC and MC curves is relationship between scale of the firm's operation and inputs required to min cost

1. Constant Returns to Scale
   - If input is doubled, output will double
   - AC cost is constant at all levels of output.

Long-Run Average Cost

- **long-run average cost curve (LAC)** 장기평균비용 곡선
  Curve relating average cost of production to output when all inputs, including capital, are variable.

- **short-run average cost curve (SAC)** 단기평균비용 곡선
  Curve relating average cost of production to output when level of capital is fixed.

- **long-run marginal cost curve (LMC)** 장기한계비용 곡선
  Curve showing the change in long-run total cost as output is increased incrementally by 1 unit.

Long-Run Versus Short-Run Cost Curves

2. Increasing Returns to Scale
   - If input is doubled, output will more than double
   - AC decreases at all levels of output.
3. Decreasing Returns to Scale
   - If input is doubled, output will less than double
   - AC increases at all levels of output

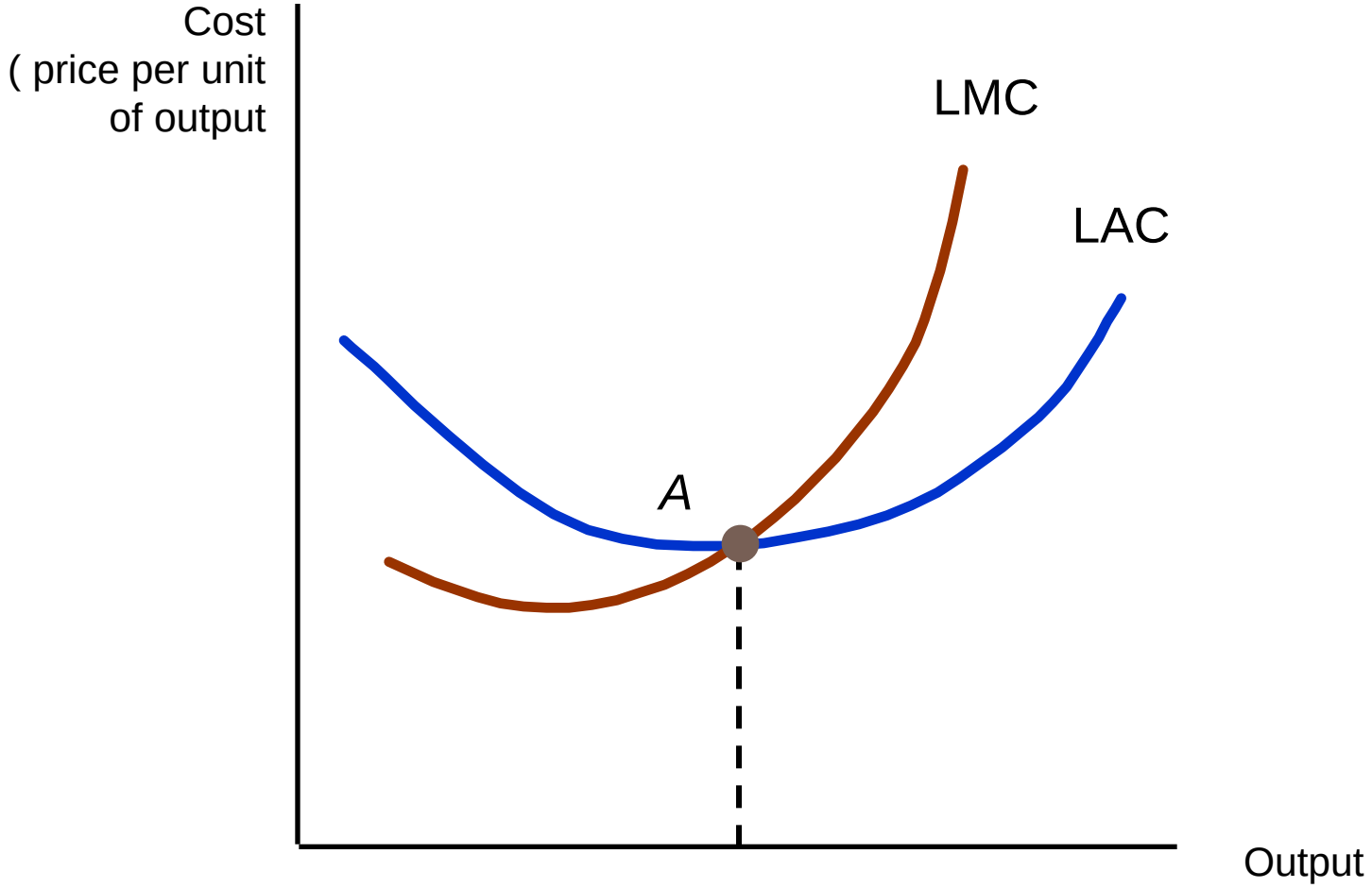
Long-Run Versus Short-Run Cost Curves

- In the long-run:
  - Firms experience increasing and decreasing returns to scale and therefore long-run average cost is "U" shaped.
  - Source of U-shape is due to returns to scale instead of decreasing returns to scale like the short run curve
  - Long-run marginal cost curve measures the change in long-run total costs as output is increased by 1 unit

Long-Run Versus Short-Run Cost Curves

- Long-run marginal cost leads long-run average cost:
  - If LMC < LAC, LAC will fall
  - If LMC > LAC, LAC will rise
  - Therefore, LMC = LAC at the minimum of LAC
- In special case where LAC if constant, LAC and LMC are equal

Long-Run Average and Marginal Cost



Long Run Costs

- As output increases, firm's AC of producing is likely to decline to a point
  1. On a larger scale, workers can better specialize
  2. Scale can provide flexibility – managers can organize production more effectively
  3. Firm may be able to get inputs at lower cost if can get quantity discounts. Lower prices might lead to different input mix

Long Run Costs

- At some point, AC will begin to increase
  1. Factory space and machinery may make it more difficult for workers to do their job efficiently
  2. Managing a larger firm may become more complex and inefficient as the number of tasks increase
  3. Bulk discounts can no longer be utilized. Limited availability of inputs may cause price to rise

Long Run Costs

- When input proportions change, the firm's expansion path is no longer a straight line
  - Concept of return to scale no longer applies
- Economies of scale reflects input proportions that change as the firm change its level of production

Economies and Diseconomies of Scale

- Economies of Scale 규모의 경제
  - Increase in output is greater than the increase in inputs.
- Diseconomies of Scale 규모의 불경제
  - Increase in output is less than the increase in inputs.
- U-shaped LAC shows economies of scale for relatively low output levels and diseconomies of scale for higher levels

Cost Functions & Measurement of Scale Economies

- Scale Economy Index (SCI)
  - EC = 1, SCI = 0: no economies or diseconomies of scale
  - EC > 1, SCI is negative: diseconomies of scale
  - EC < 1, SCI is positive: economies of scale

Long Run Costs

- Increasing Returns to Scale
  - Output more than doubles when the quantities of all inputs are doubled
- Economies of Scale 규모의 경제(성)
  - Doubling of output requires less than a doubling of cost
- **diseconomies of scale** 규모의 불경제(성)
  - Situation in which a doubling of output requires more than a doubling of cost.

Long Run Costs

- Economies of scale are measured in terms of cost-output elasticity, E_C ,(비용-생산 탄력성)
- EC is the percentage change in the cost of production resulting from a 1-percent increase in output

$$E_C = \frac{\Delta C / C}{\Delta Q / Q} = \frac{MC}{AC}$$

Long Run Costs

- EC is equal to 1, MC = AC
  - Costs increase proportionately with output
  - Neither economies nor diseconomies of scale
- EC < 1 when MC < AC
  - Economies of scale
  - Both MC and AC are declining
- EC > 1 when MC > AC
  - Diseconomies of scale
  - Both MC and AC are rising

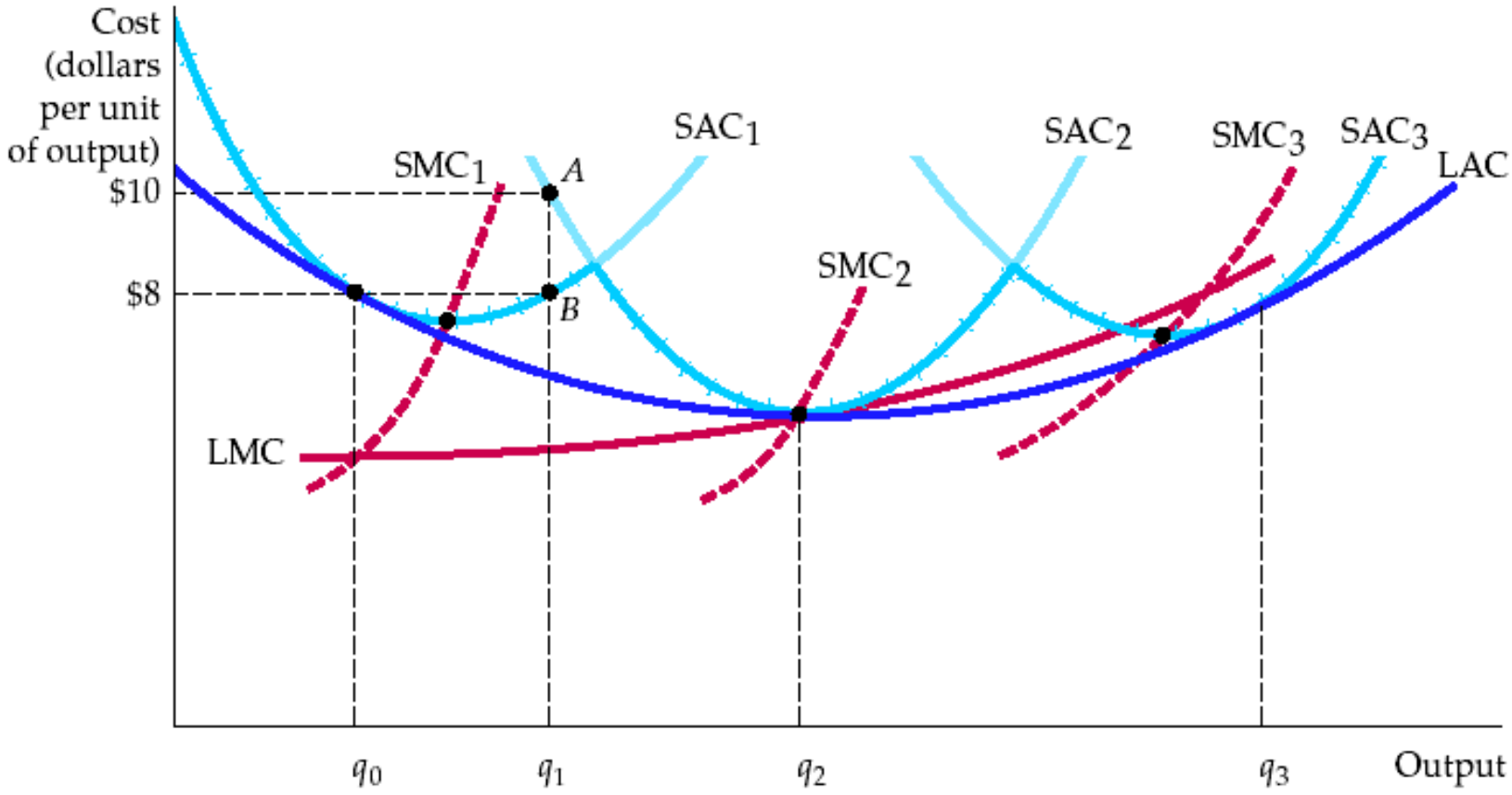
Long-Run Versus Short-Run Cost Curves

- We will use short and long-run cost to determine the optimal plant size
- We can show the short run average costs for 3 different plant sizes
- This decision is important because once built, the firm may not be able to change plant size for a while

Long-Run Cost with Constant Returns to Scale

- The optimal plant size will depend on the anticipated output
  - If expect to produce q_0, then should build smallest plant: AC = 8
  - If produce more, like q_1, AC rises
  - If expect to produce q_2, middle plant is least cost
  - If expect to produce q_3, largest plant is best

Long-Run Cost with Economies and Diseconomies of Scale



Long-Run Cost with Constant Returns to Scale

- What is the firms' long-run cost curve?
  - Firms can change scale to change output in the long-run.
  - The long-run cost curve is the dark blue portion of the SAC curve which represents the minimum cost for any level of output.
  - Firm will always choose plant that minimizes the average cost of production

Long-Run Cost with Constant Returns to Scale

- The long-run average cost curve envelopes the short-run average cost curves
- The LAC curve exhibits economies of scale initially but exhibits diseconomies at higher output levels

Production with Two Outputs – Economies of Scope

- Many firms produce more than one product and those product are closely linked
- Examples:
  - Chicken farm--poultry and eggs
  - Automobile company--cars and trucks
  - University--Teaching and research

Production with Two Outputs – Economies of Scope

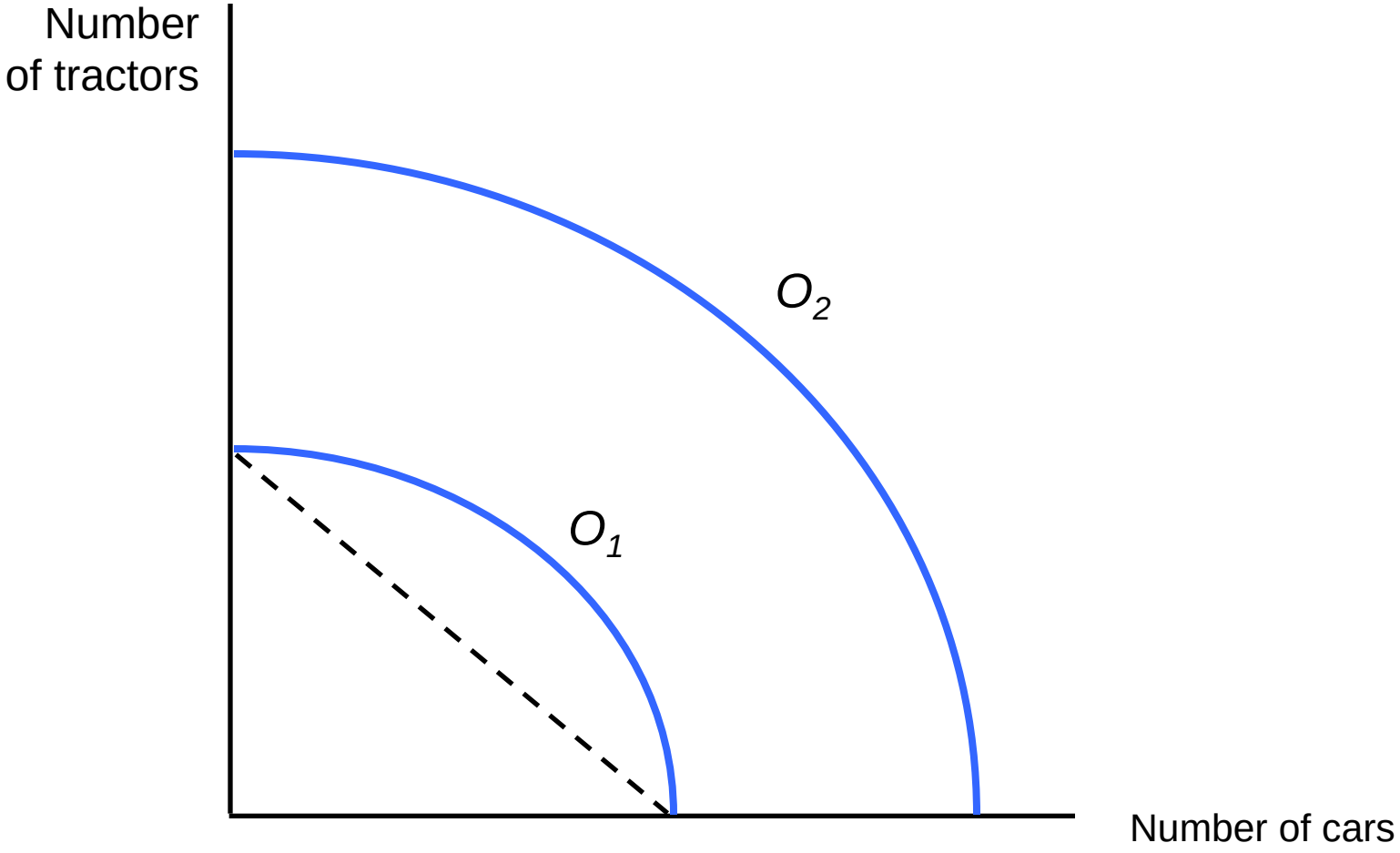
- Advantages

1. Both use capital and labor.
2. The firms share management resources.
3. Both use the same labor skills and type of machinery.

Production with Two Outputs – Economies of Scope 범위(의) 경제(성)

- Firms must choose how much of each to produce.
- The alternative quantities can be illustrated using product transformation curves
  - Curves showing the various combinations of two different outputs (products) that can be produced with a given set of inputs

Product Transformation Curve



Product Transformation Curve

- Product transformation curves are negatively slope
  - To get more of one output, must give up some of the other output
- Constant returns exist in this example
  - Second curve lies twice as far from origin as the first curve
- Curve is concave
  - Joint production has its advantages

Production with Two Outputs – Economies of Scope

- There is no direct relationship between economies of scope and economies of scale.
  - May experience economies of scope and diseconomies of scale
  - May have economies of scale and not have economies of scope

Production with Two Outputs – Economies of Scope

- The degree of economies of scope (SC) can be measured by percentage of cost saved producing two or more products jointly:

$$SC = \frac{C(q_1) + C(q_2) - C(q_1, q_2)}{C(q_1, q_2)}$$

  - $C(q_1)$ is the cost of producing q_1
  - $C(q_2)$ is the cost of producing q_2
  - $C(q_1, q_2)$ is the joint cost of producing both products

Production with Two Outputs – Economies of Scope

- With economies of scope, the joint cost is less than the sum of the individual costs
- Interpretation:
  - If SC > 0 – Economies of scope
  - If SC < 0 – Diseconomies of scope
  - The greater the value of SC, the greater the economies of scope

Dynamic Changes in Costs – The Learning Curve

- Firms may lower their costs not only due to economies of scope, but also due to managers and workers become more experienced at their jobs
- As management and labor gain experience with production, the firm's marginal and average costs may fall

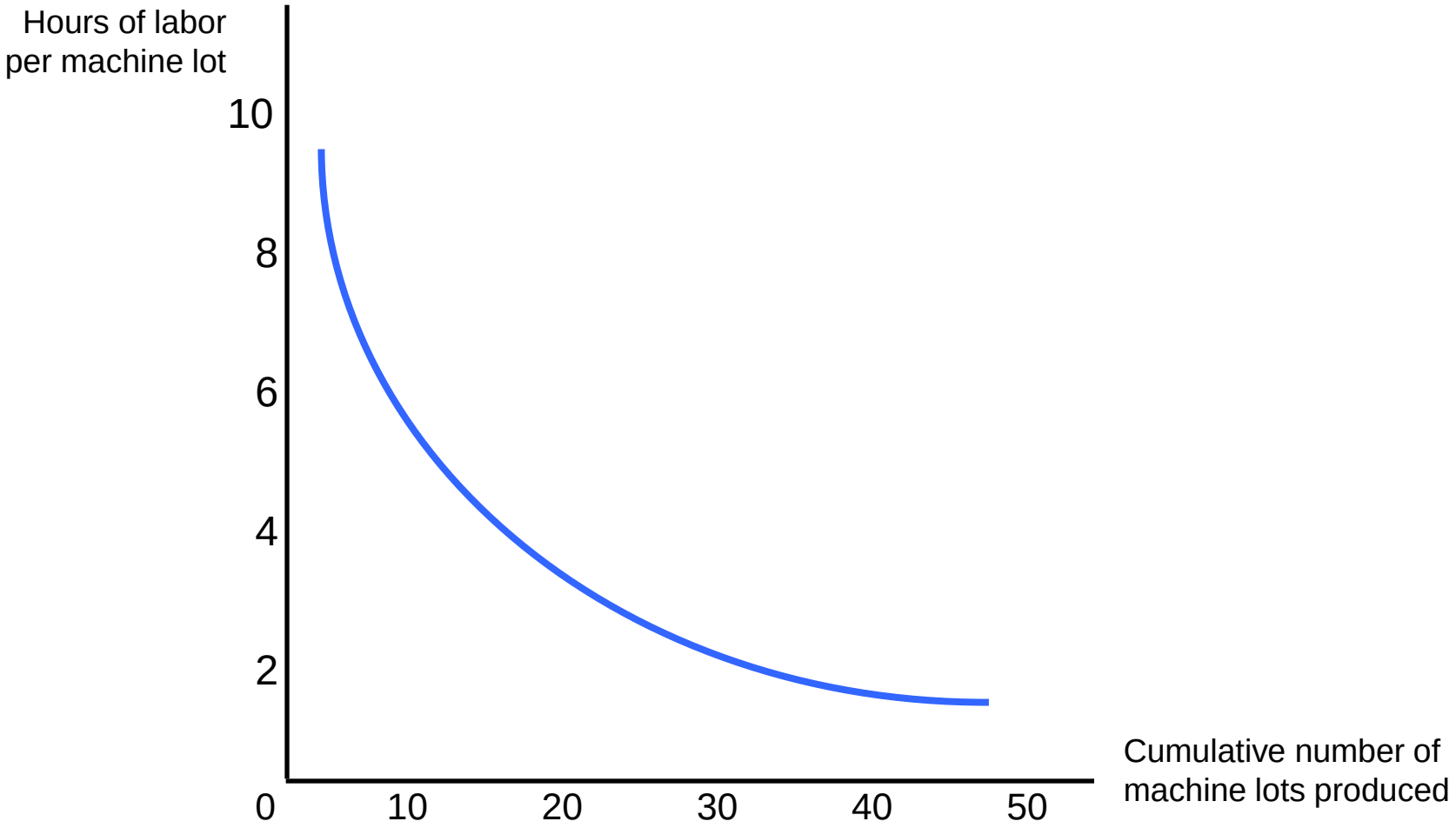
Dynamic Changes in Costs – The Learning Curve 학습(경험) 곡선

- Reasons
  1. Speed of work increases with experience
  2. Managers learn to schedule production processes more efficiently
  3. More flexibility is allowed with experience. May include more specialized tools and plant organization
  4. Suppliers become more efficient passing savings to company

Dynamic Changes in Costs – The Learning Curve

- The learning curve measures the impact of worker's experience on the costs of production.
- It describes the relationship between a firm's cumulative output and amount of inputs needed to produce a unit of output.

The Learning Curve



The Learning Curve

- The horizontal axis measures the cumulative number of hours of machine tools the firm has produced
- The vertical axis measures the number of hours of labor needed to produce each lot.

Dynamic Changes in Costs – The Learning Curve

- The learning curve in the figure is based on the relationship:

$$L = A + BN^{-\beta}$$

N = cumulative units of output produced

L = labor input per unit of output

A, B and β are constants

A & B are positive and β is between 0 and 1

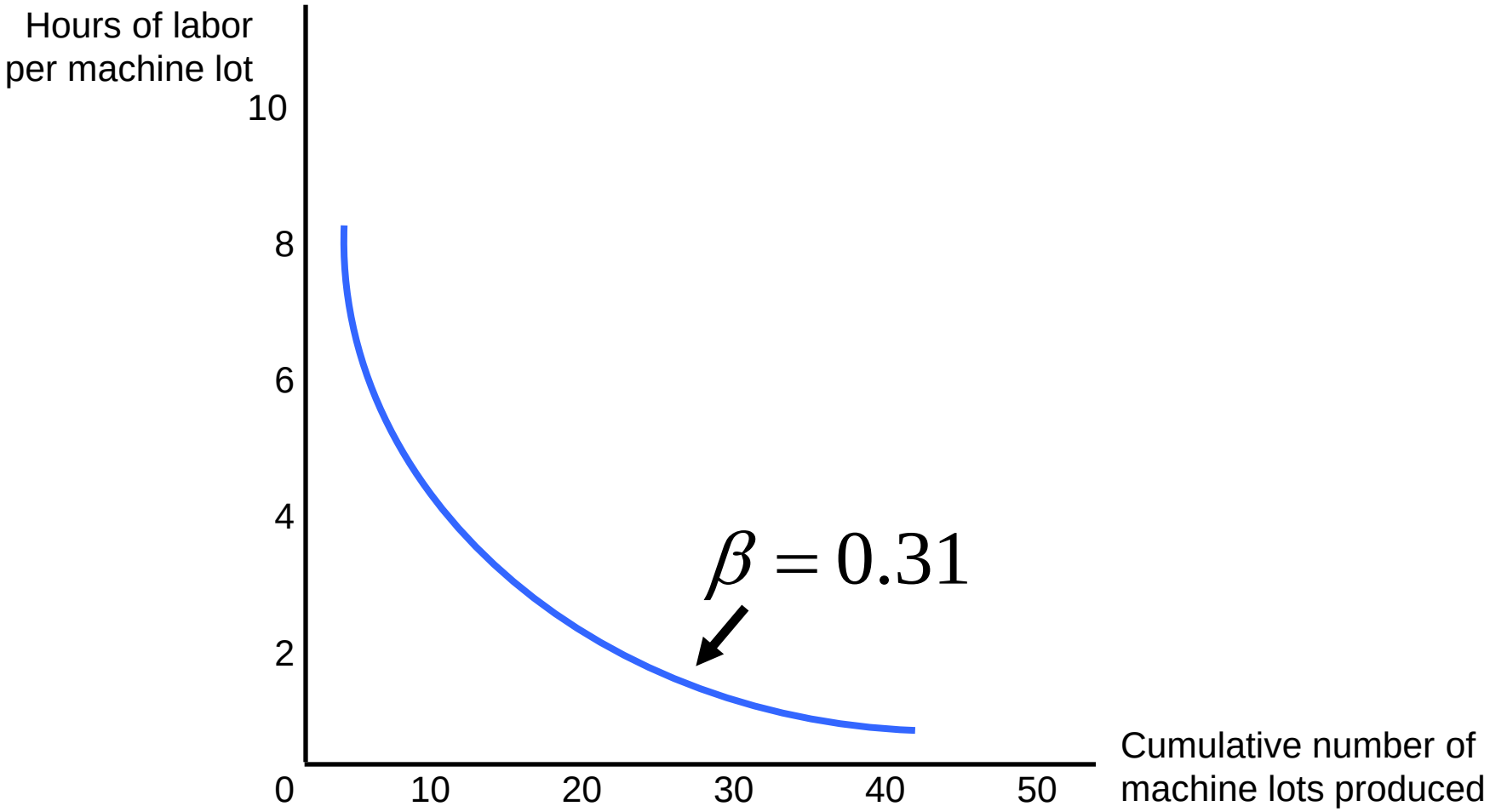
Dynamic Changes in Costs – The Learning Curve

- If $N = 1$
  - L equals A + B and this measures labor input to produce the first unit of output
- If $\beta = 0$
  - Labor input per unit of output remains constant as the cumulative level of output increases, so there is no learning

Dynamic Changes in Costs – The Learning Curve

- If $\beta > 0$ and N increases,
  - L approaches A, and A represents minimum labor input/unit of output after all learning has taken place.
- The larger β,
  - The more important the learning effect.

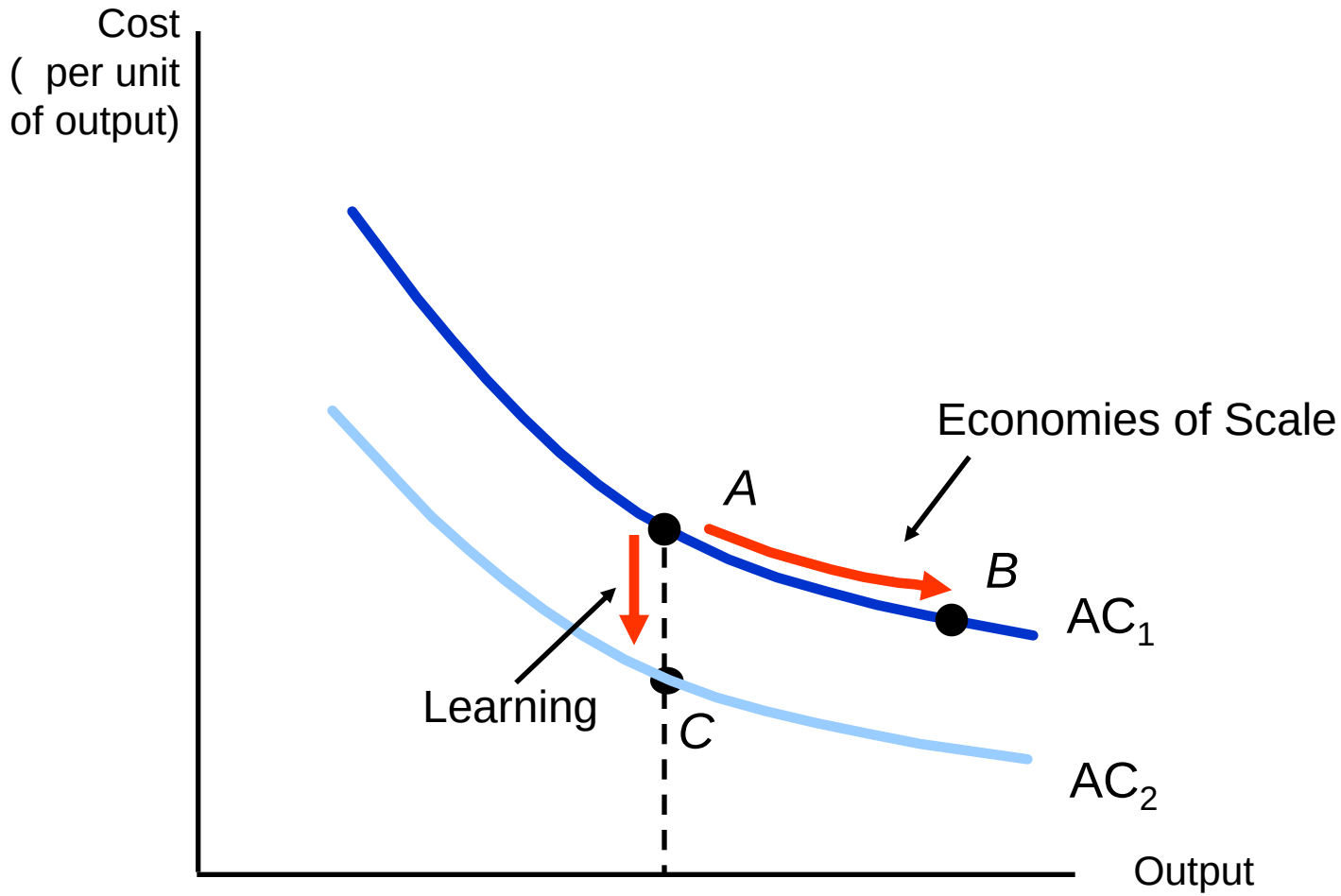
The Learning Curve



Dynamic Changes in Costs – The Learning Curve

- Observations
  1. New firms may experience a learning curve, not economies of scale.
     - Should increase production of many lots regardless of individual lot size
  2. Older firms have relatively small gains from learning.
     - Should produce its machines in very large lots to take advantage of lower costs associated with size

Economies of Scale Versus Learning



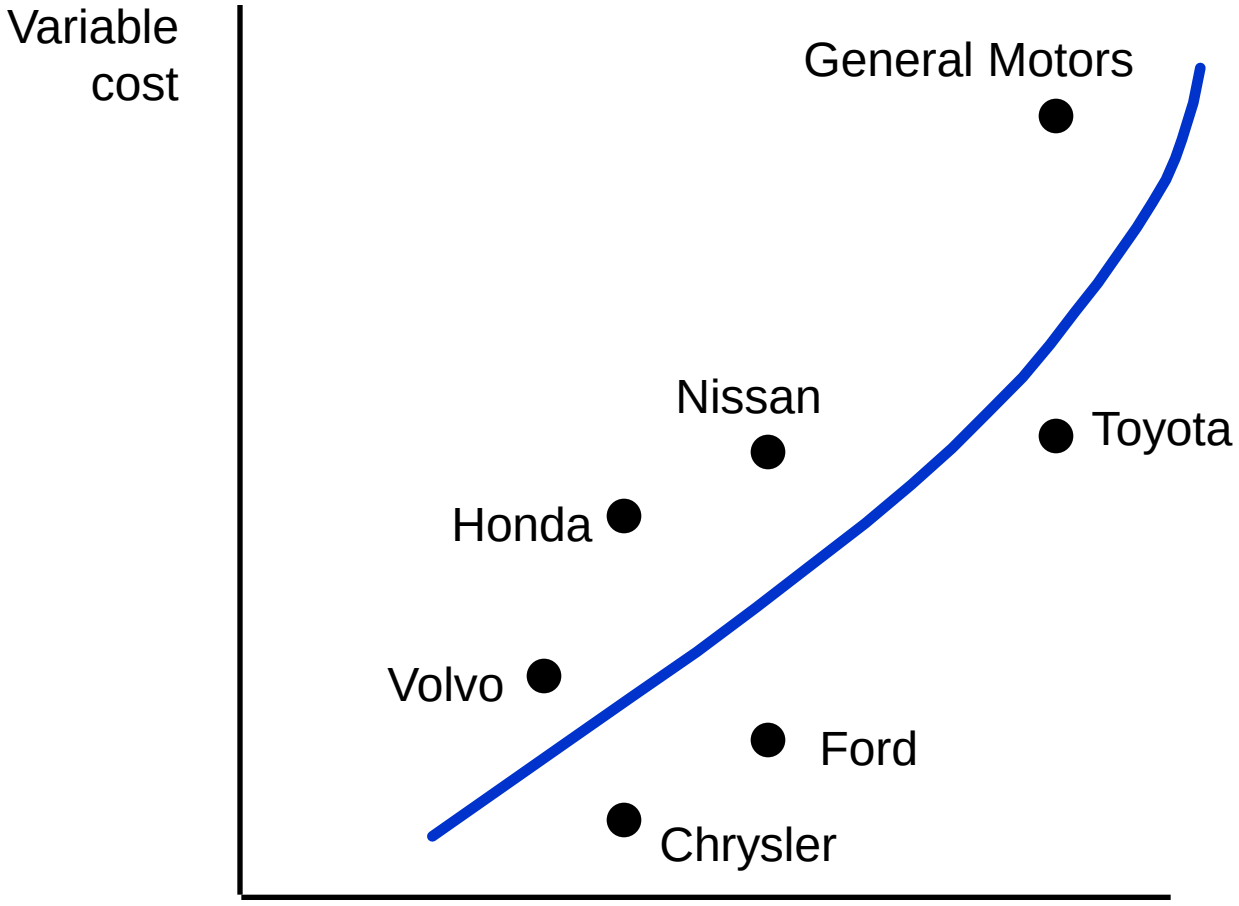
The Learning Curve in Practice

- Applying Learning Curves
  1. To determine if it is profitable to enter an industry.
  2. To determine when profits will occur based on plant size and cumulative output.

Estimating and Predicting Cost

- Estimates of future costs can be obtained from a cost function, which relates the cost of production to the level of output and other variables that the firm can control.
- Suppose we wanted to derive the total cost curve for automobile production.

Total Cost Curve for the Automobile Industry



Estimating and Predicting Cost

- A linear cost function might be:

$$VC = \beta Q$$

- The linear cost function is applicable only if marginal cost is constant.
  - Marginal cost is represented by β

Estimating and Predicting Cost

- If we wish to allow for a U-shaped average cost curve and a marginal cost that is not constant, we might use a quadratic cost function:

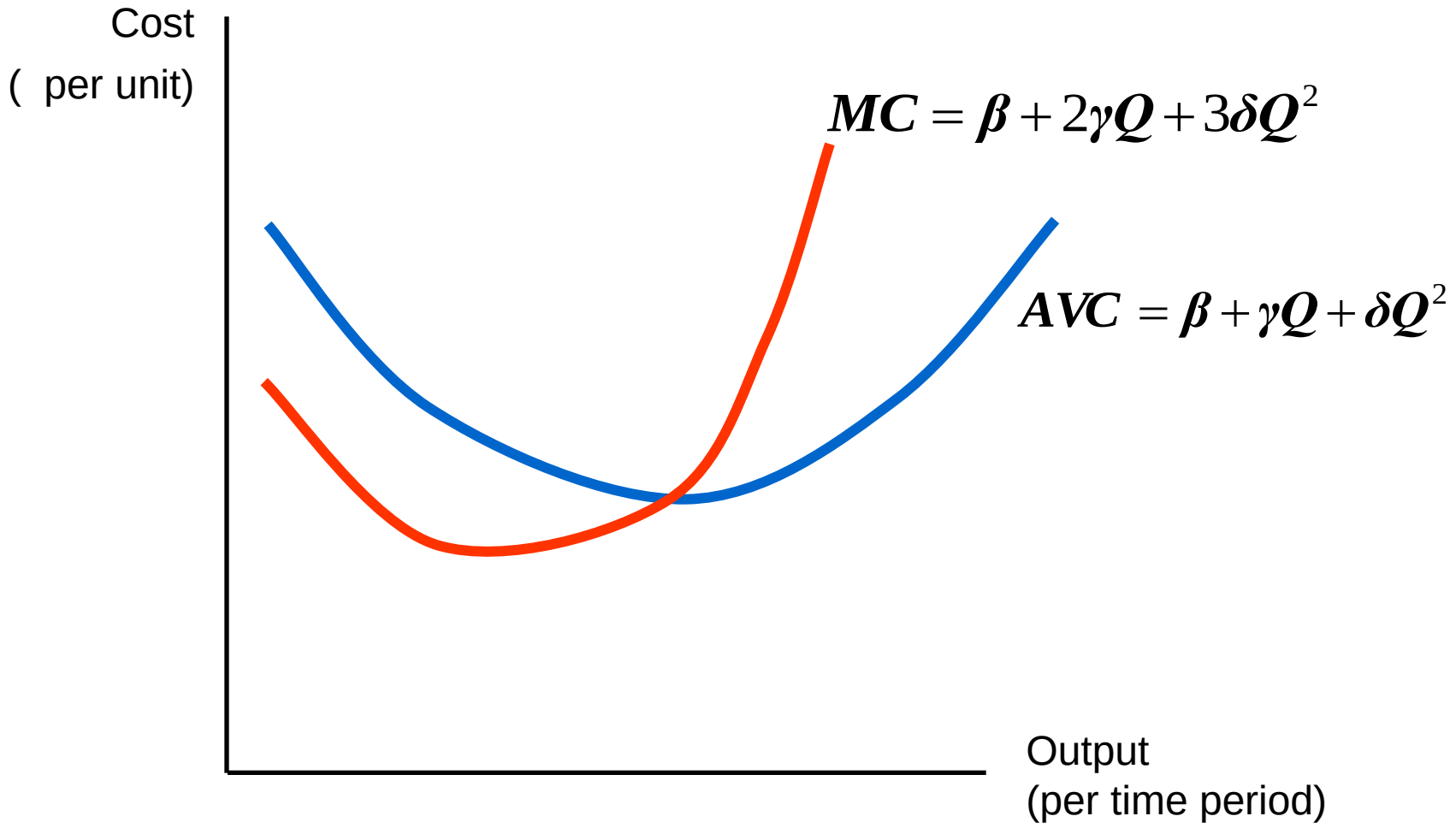
$$VC = \beta Q + \gamma Q^2$$

Estimating and Predicting Cost

- If the marginal cost curve is also not linear, we might use a cubic cost function:

$$VC = \beta Q + \gamma Q^2 + \delta Q^3$$

Cubic Cost Function



Estimating and Predicting Cost

- Difficulties in Measuring Cost
  1. Output data may represent an aggregate of different type of products.
  2. Cost data may not include opportunity cost.
  3. Allocating cost to a particular product may be difficult when there is more than one product line.