LN03: Production Economics

EEE 452: Engineering Economics

Md. Naqib Imtiaz Hussain

Lecture Overview

- What is production economics
- Core concepts
  - Production functions
  - Law of diminishing returns
  - Marginalizing concepts
- Application to tech industry
  - Software, Engineering firm , IoT device production
  - Cloud service production

What is production economics

- Production plants and group of industries take the following decisions
  - What to produce
  - How to produce and
  - How much to produce
- The field of knowledge that relates to these three decision points to maximize surplus and benefit is called production economics

Core concepts

- Production functions
- Law of diminishing returns
- Marginalizing concepts
- Cost concepts

What is production function?

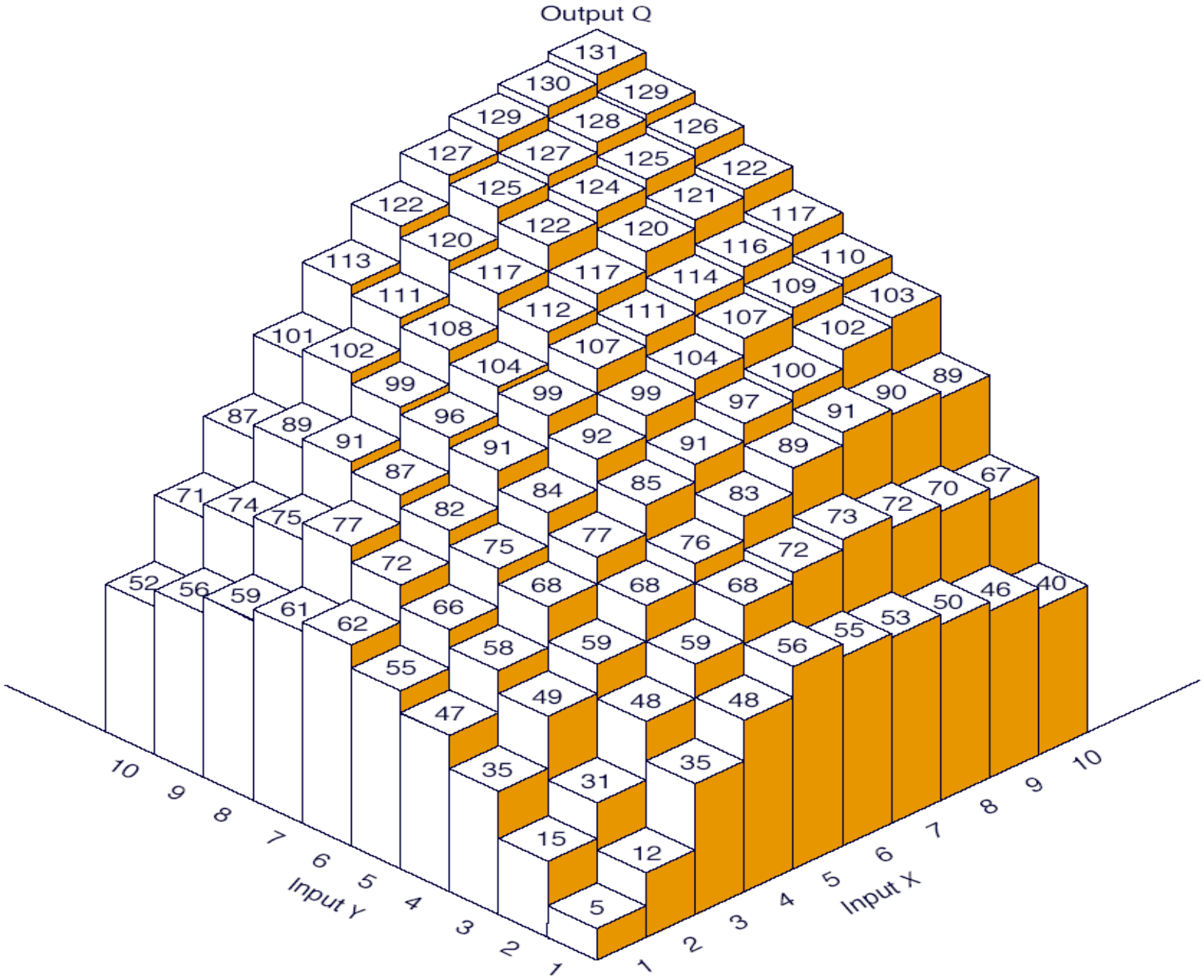
- It relates to different input factors to production outputs.
- describes the rate at which resources are transformed into products
- To allocate input factors in production to improve efficiency.
- Expect the resulting distribution of income to those factors
- Abstracting away from the technological problems of achieving technical efficiency

Key questions to think

- What is efficient production?
- How is the most profitable amount of input determined?
- How will production respond to a change in the price of an output?
- What enterprise combinations will maximize profits?
  - Should a tech startup pay for a new build system server or rent a cloud server?
  - How will network outage affect production if rented on cloud?

More about production functions

- Properties of Production Functions
- Production functions are determined by technology, equipment and input prices.
- Discrete production functions are lumpy.
- Continuous production functions employ inputs in small increments.

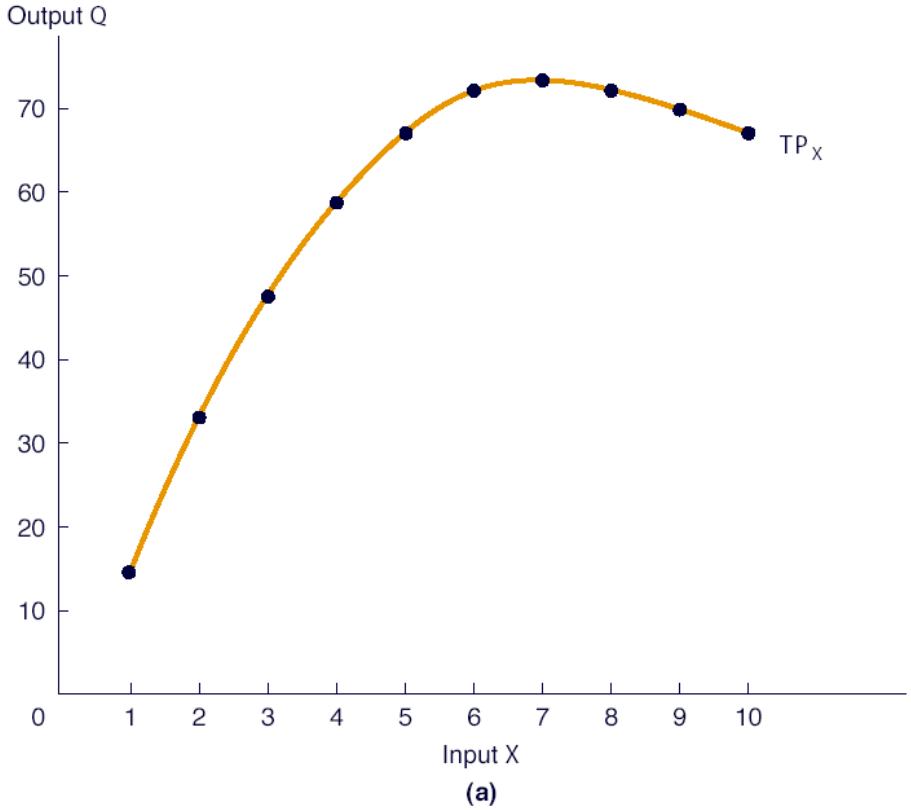

Output Q
131
130 129
129 128 126
127 127 125 122
125 124 121 117
122 122 120 116 110
120 117 117 114 109 103
113 111 112 111 107 102
108 107 104 100
101 102 99 99 99 97 91 90 89
104 99 96 91 92 91 89
87 89 91 87 84 85 83 73 72 70 67
71 74 75 77 82 75 77 76 72
72 68 68 68
52 56 59 61 62 66 58 59 59 56 55 53 50 46 40
55 49 48 48
47 35 31 35
15 12
5
Input Y
10 9 8 7 6 5 4 3 2 1
Input X
1 2 3 4 5 6 7 8 9 10

Returns to Scale and Returns to a Factor

- Returns to scale measure output effect of increasing all inputs.
- Returns to a factor measure output effect of increasing one input.

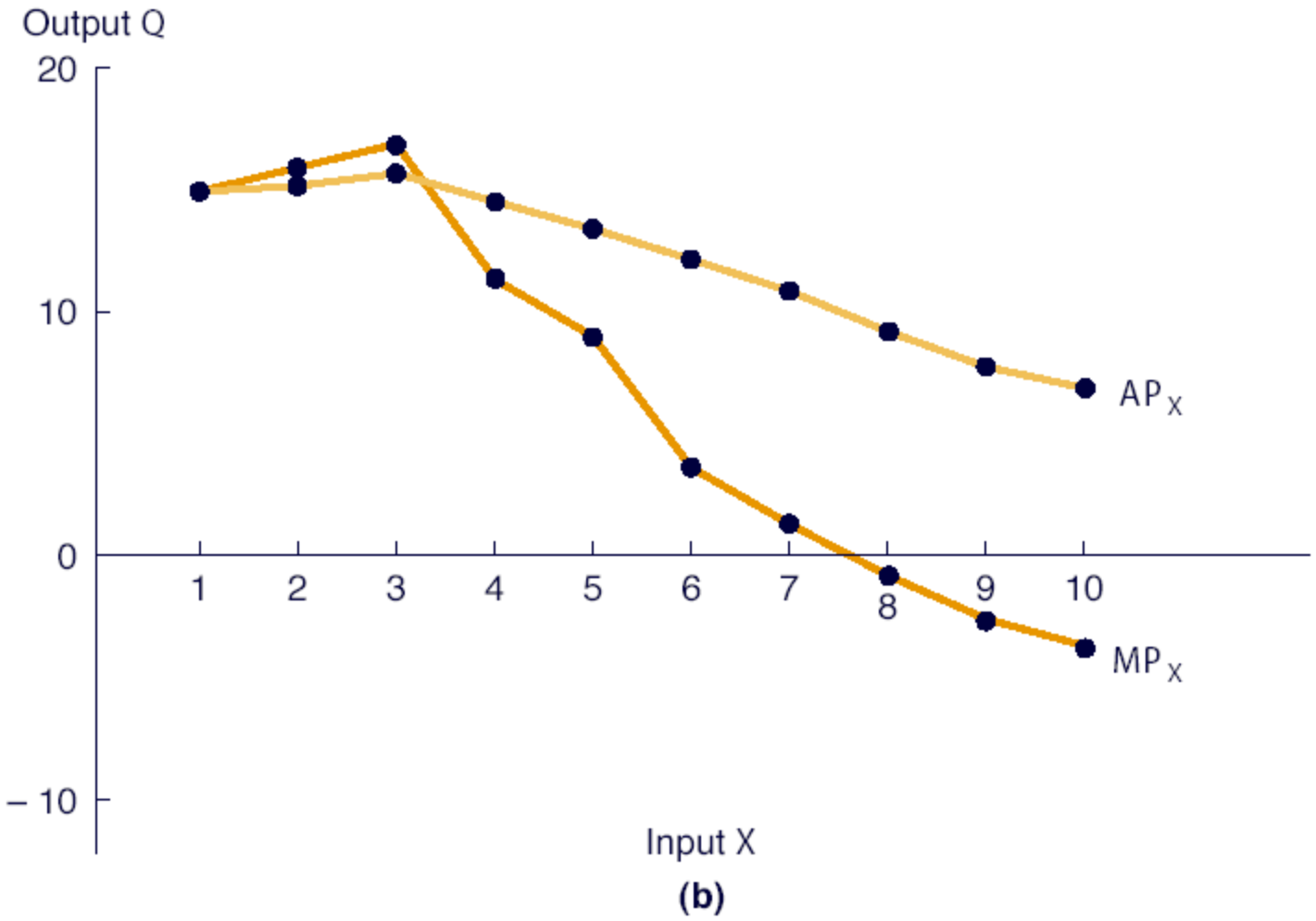
Total, Marginal, and Average Product

- Total Product
  - Total product is total output.



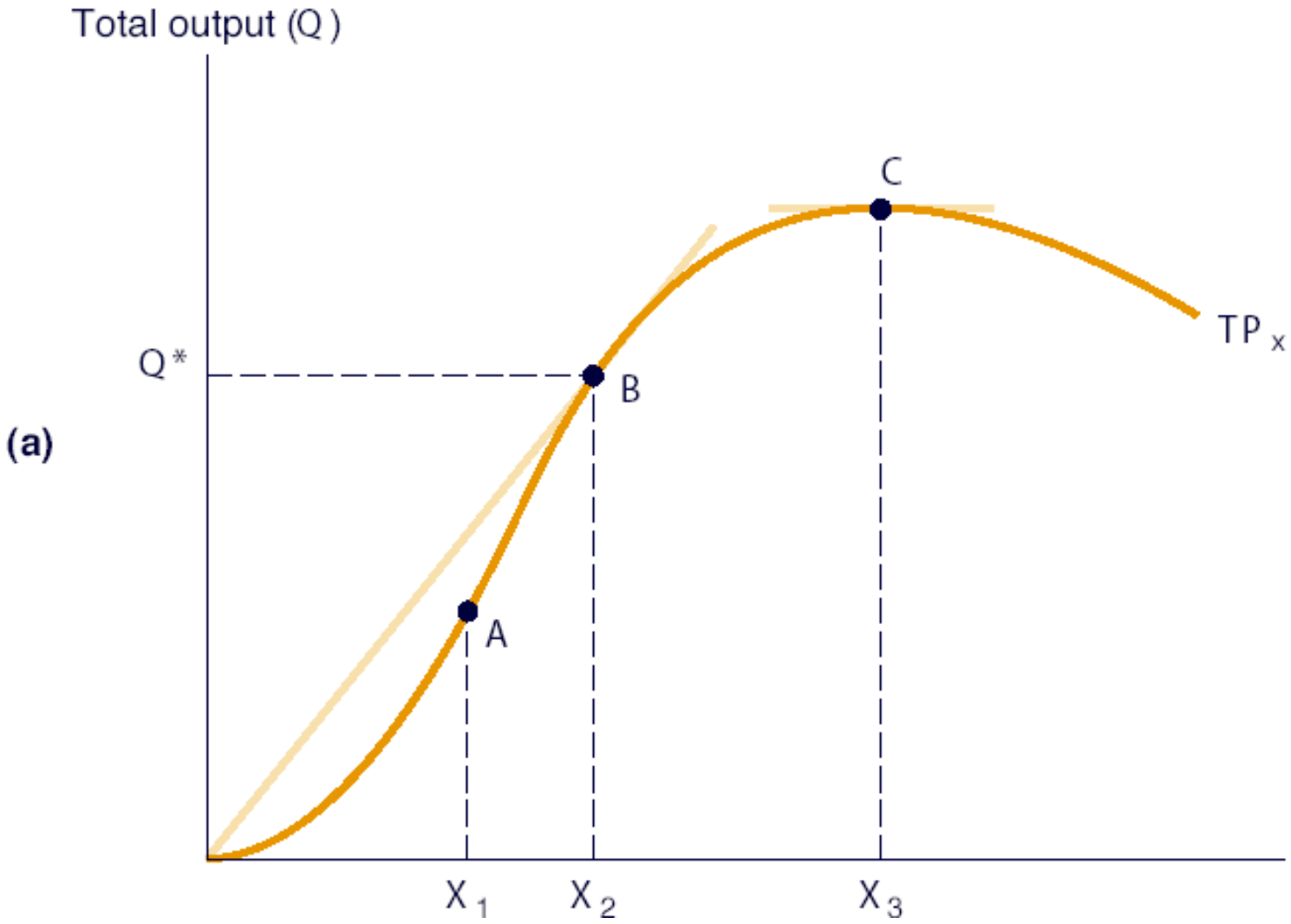
Marginal Product

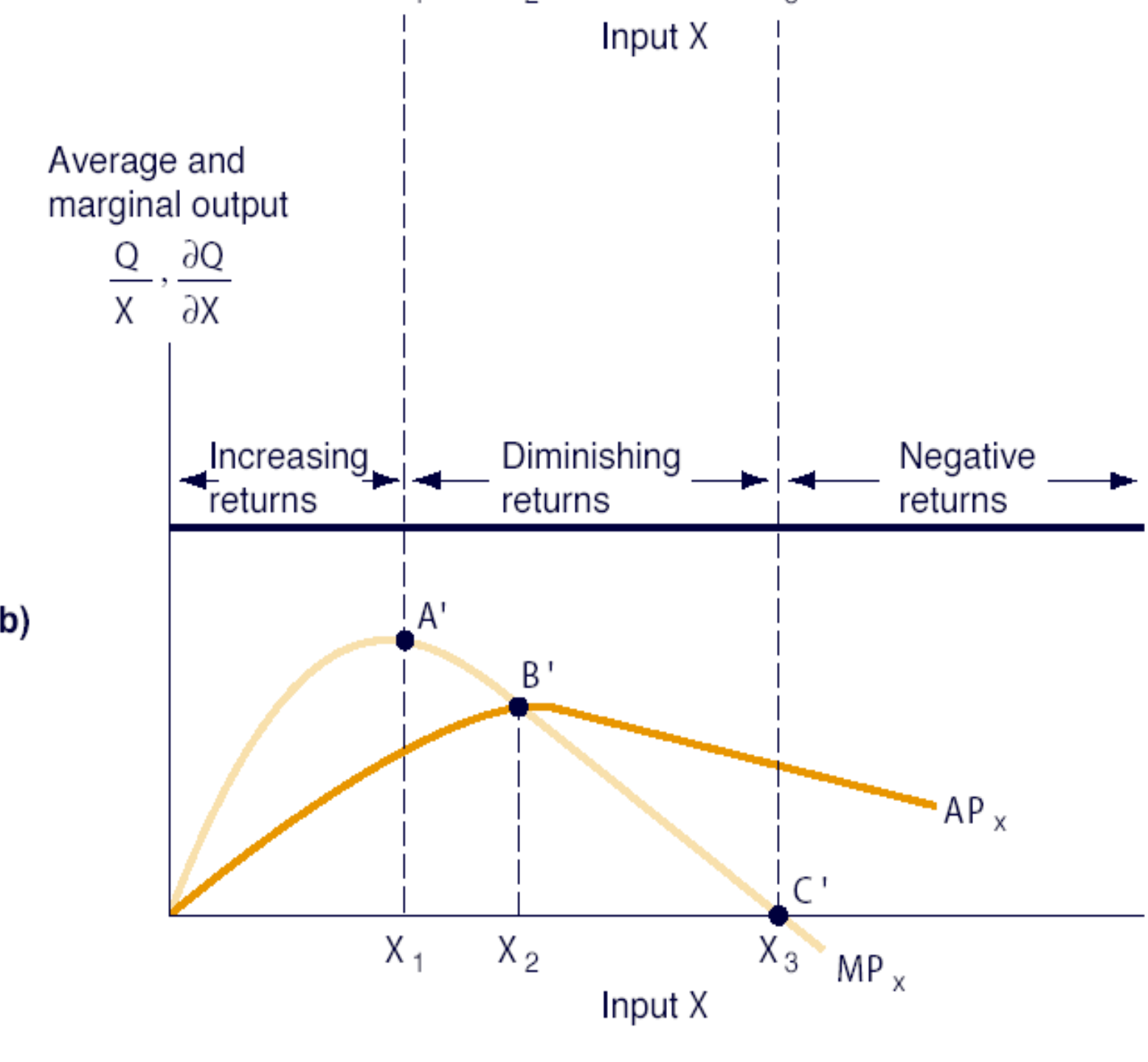
- Marginal product is the change in output caused by increasing input use.
  - If $MP_X = \partial Q / \partial X > 0$, total product is rising.
  - If $MP_X = \partial Q / \partial X < 0$, total product is falling (rare).
- Average product
  - $AP_X = Q / X$.


Output Q
20
10
0
– 10
1
2
3
4
5
6
7
8
9
10
AP_X
MP_X
Input X
(b)

Law of Diminishing Returns to a Factor

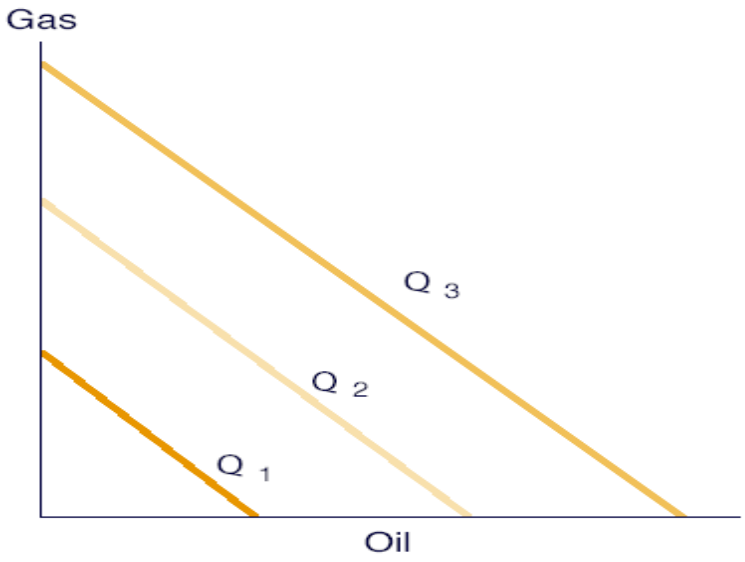
- Diminishing Returns to a Factor Concept
  - MP_X tends to diminish as X use grows.
  - If MP_X grew with use of X, there would be no limit to input usage.
  - $MP_X < 0$ implies irrational input use (rare).
- Illustration of Diminishing Returns to a Factor

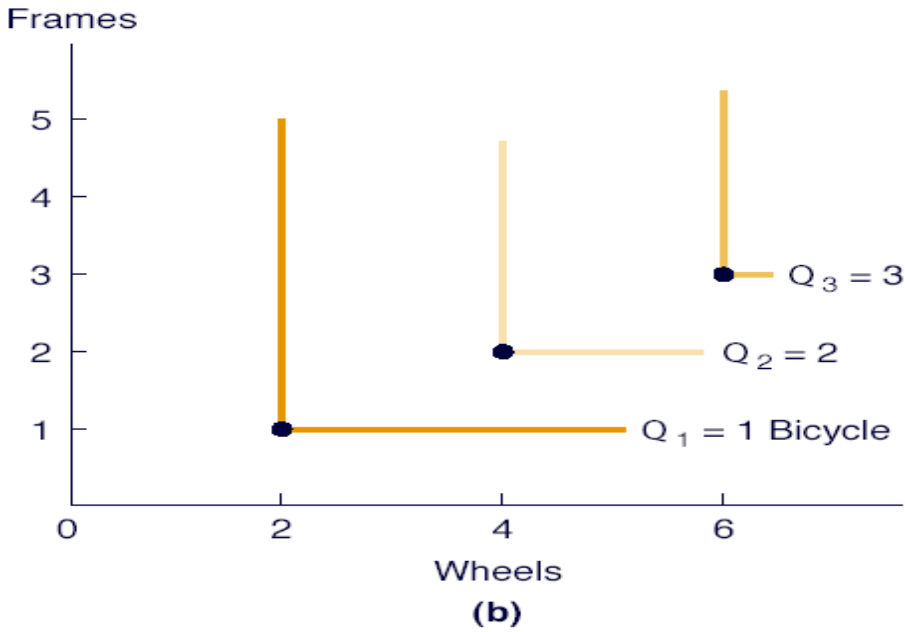

Total output (Q)
C
TP x
Q*
B
(a)
A
X 1
X 2
X 3

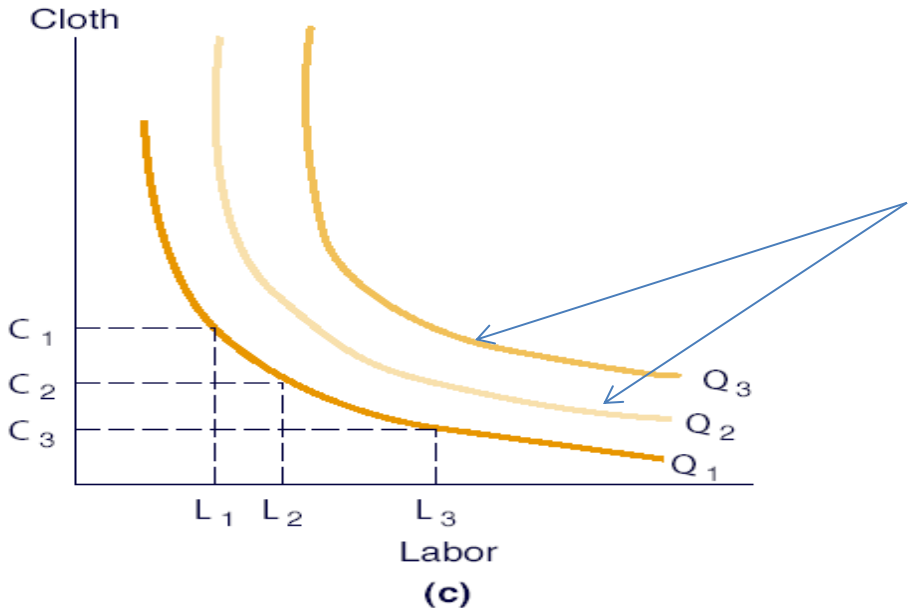

Input X
Average and marginal output
$\frac{Q}{X}, \frac{\partial Q}{\partial X}$
Increasing returns
Diminishing returns
Negative returns
b)
A'
B'
C'
AP_x
MP_x
X_1
X_2
X_3
Input X

Input combination choice

- Production Isoquants
  - Technical efficiency is least-cost production.
- Input Factor Substitution
  - Isoquant shape shows input substitutability.
  - C-shaped isoquants are common and imply imperfect substitutability.







Isoquant lines

(a) Perfect substitute

- If the two inputs are perfect substitutes, the resulting isoquant map generated is represented in fig. A; with a given level of production Q3, input X can be replaced by input Y at an unchanging rate. The perfect substitute inputs do not experience decreasing marginal rates of return when they are substituted for each other in the production function

(b) Perfect complements

- If the two inputs are perfect complements, the isoquant map takes the form of fig. B; with a level of production Q3, input X and input Y can only be combined efficiently in the certain ratio occurring at the kink in the isoquant. The firm will combine the two inputs in the required ratio to maximize profit.

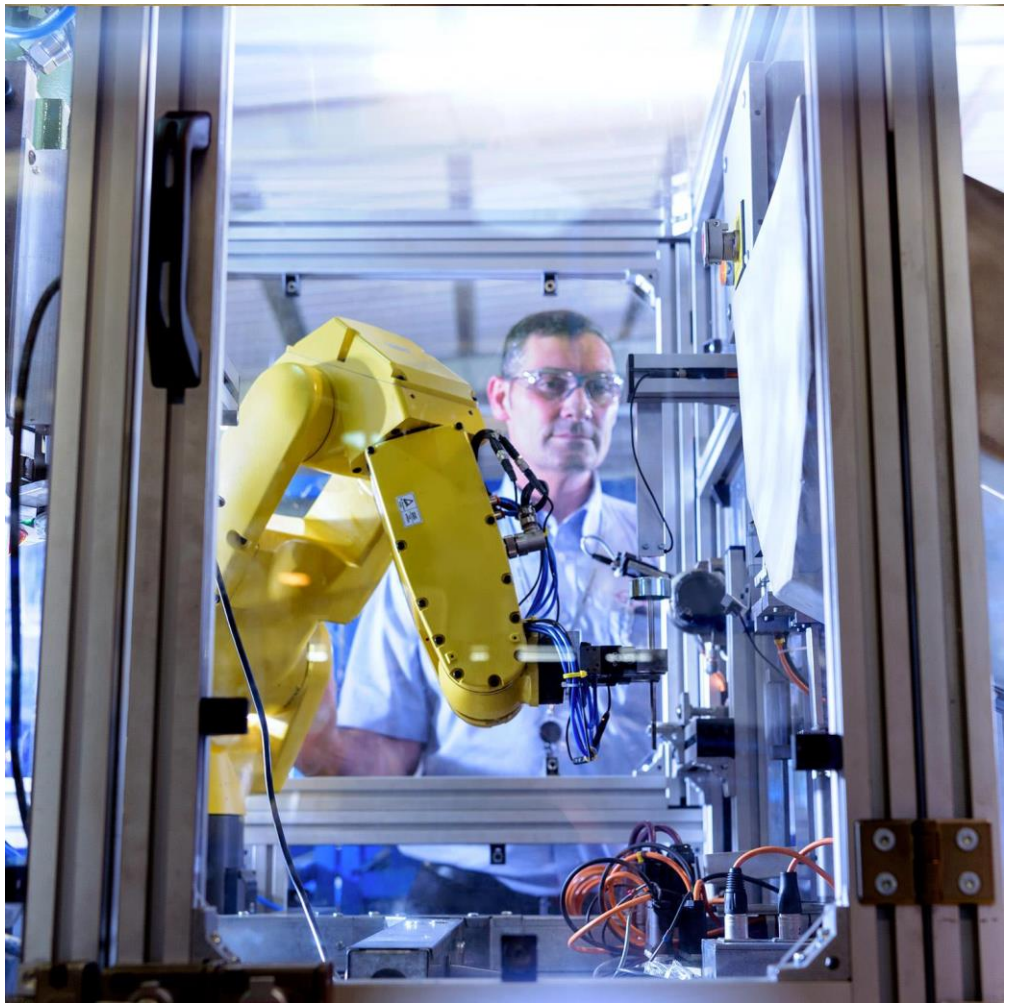
(c) Typical substitution

- Isoquants are typically combined with isocost lines in order to solve a cost-minimization problem for given level of output. In the typical case shown figure (c), with smoothly curved isoquants, a firm with fixed unit costs of the inputs will have isocost curves that are linear and downward sloped; any point of tangency between an isoquant and an isocost curve represents the cost-minimizing input combination for producing the output level associated with that isoquant. A line joining tangency points of isoquants and isocosts (with input prices held constant) is called the expansion path.

Marginal Rate of Technical Substitution

- $MRTS_{XY}=-MP_X/MP_Y$
- Rational Limits of Input Substitution
  - $MP_X<0$ or $MP_Y<0$ are never observed.

Story: Semiconductor

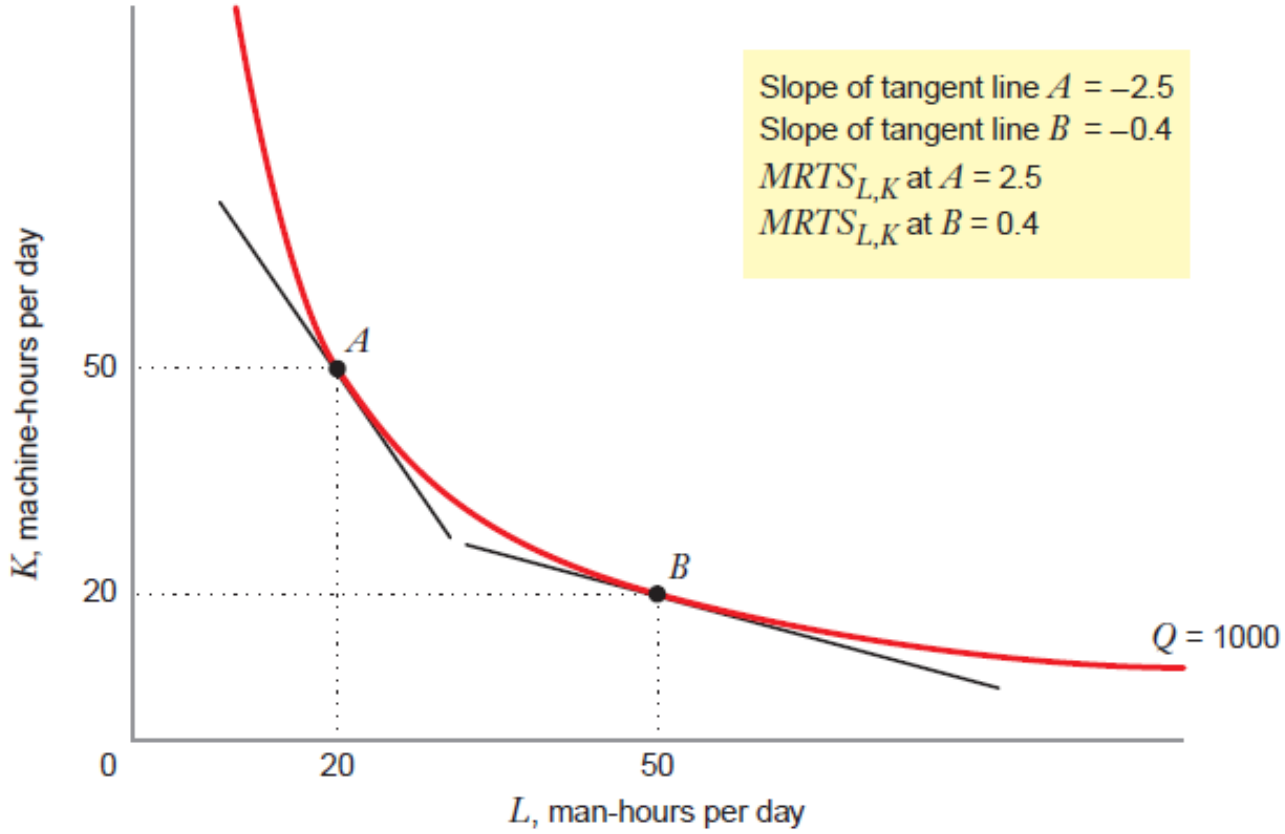


Story: Universal Robots launches Bangladesh operations

Only Labor and Capital as inputs

$$Q = f(L, K)$$

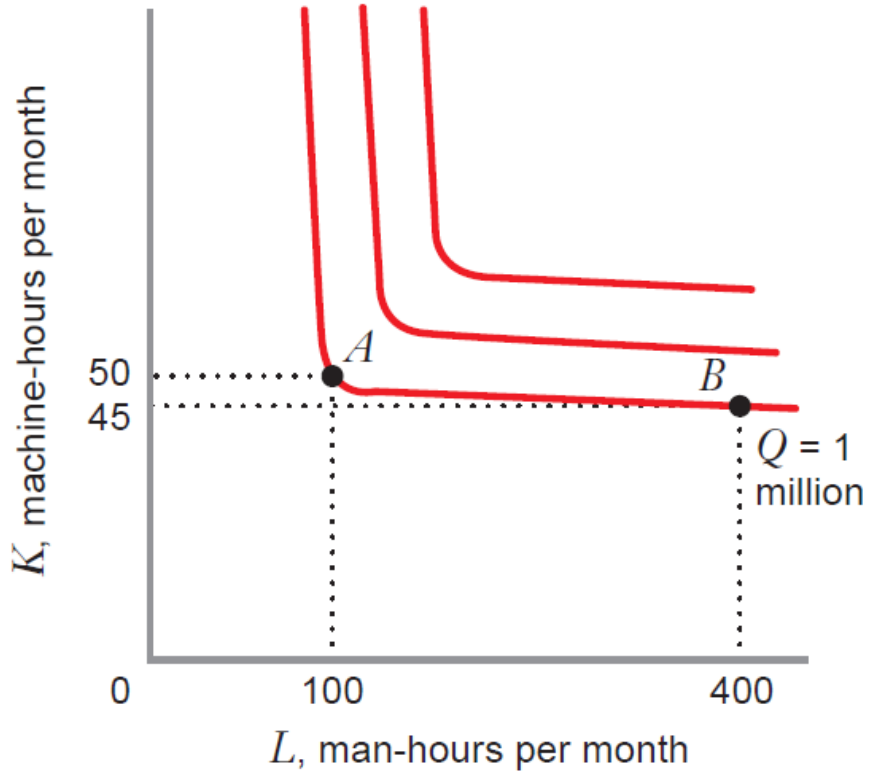
Marginal Rate of Technical Substitution



At point A, the MRTS(L,K_ is 2.5. Thus, the firm can hold output constant by replacing 2.5 machine hours of capital services with an additional man hour of labor. At point B, the MRTSL,K is 0.4. Here, the firm can hold output constant by replacing 0.4 machine-hours of capital with an additional man-hour of labor

Source: Besanko: Ch6

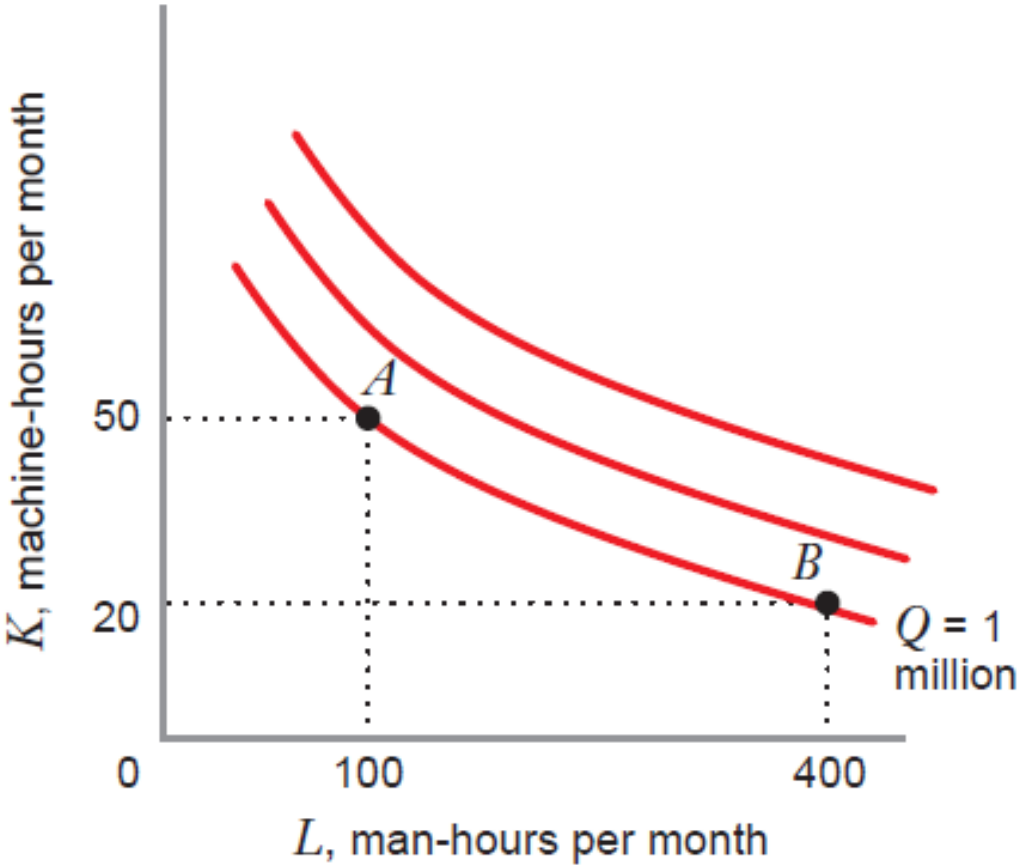
Very hard to substitute



start from point *A* and move along the isoquant *Q* 1. If the firm increases one input significantly (either *L* or *K*), it will only be able to reduce the other input by a small amount. The firm is in a position where there is virtually no substitutability between labor and capital.

Source: Besanko: Ch6

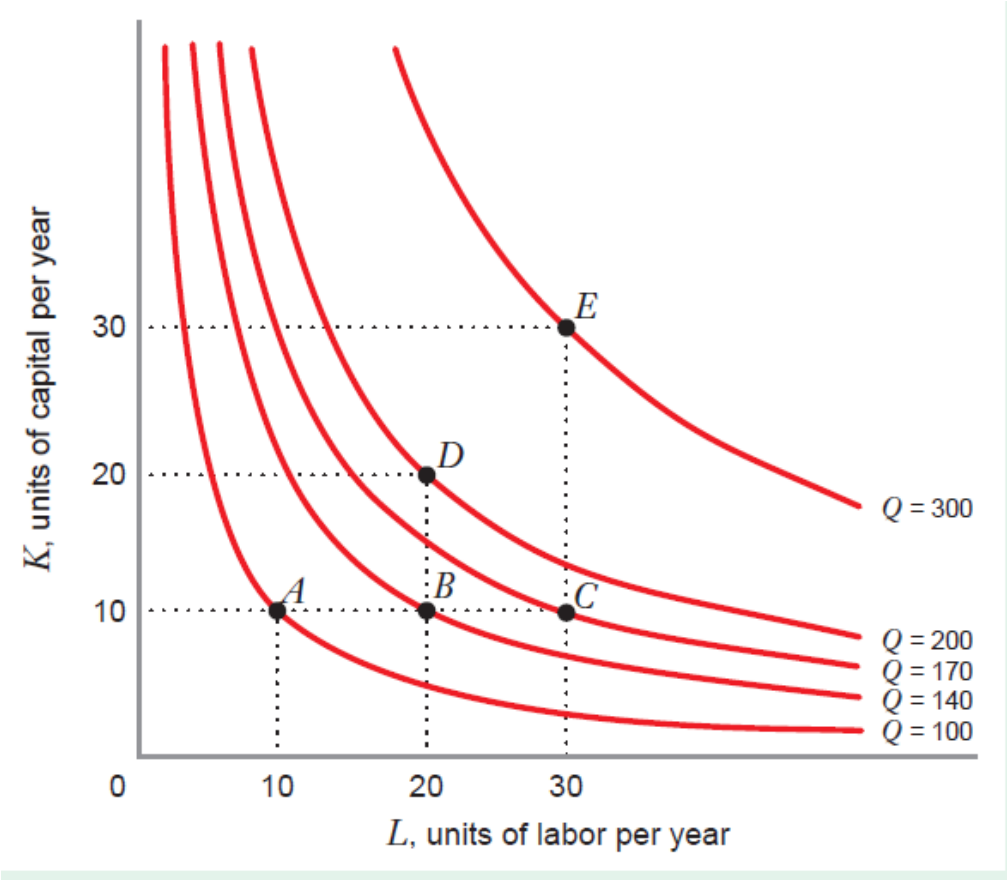
Abundant substitution



The firm has abundant substitution opportunities—that is, a significant increase in one input would allow the firm to reduce the other input by a significant amount, holding output constant.

Source: Besanko: Ch6

Diminishing Marginal Returns versus Returns to Scale



This production function exhibits constant returns to scale but diminishing marginal returns to labor.

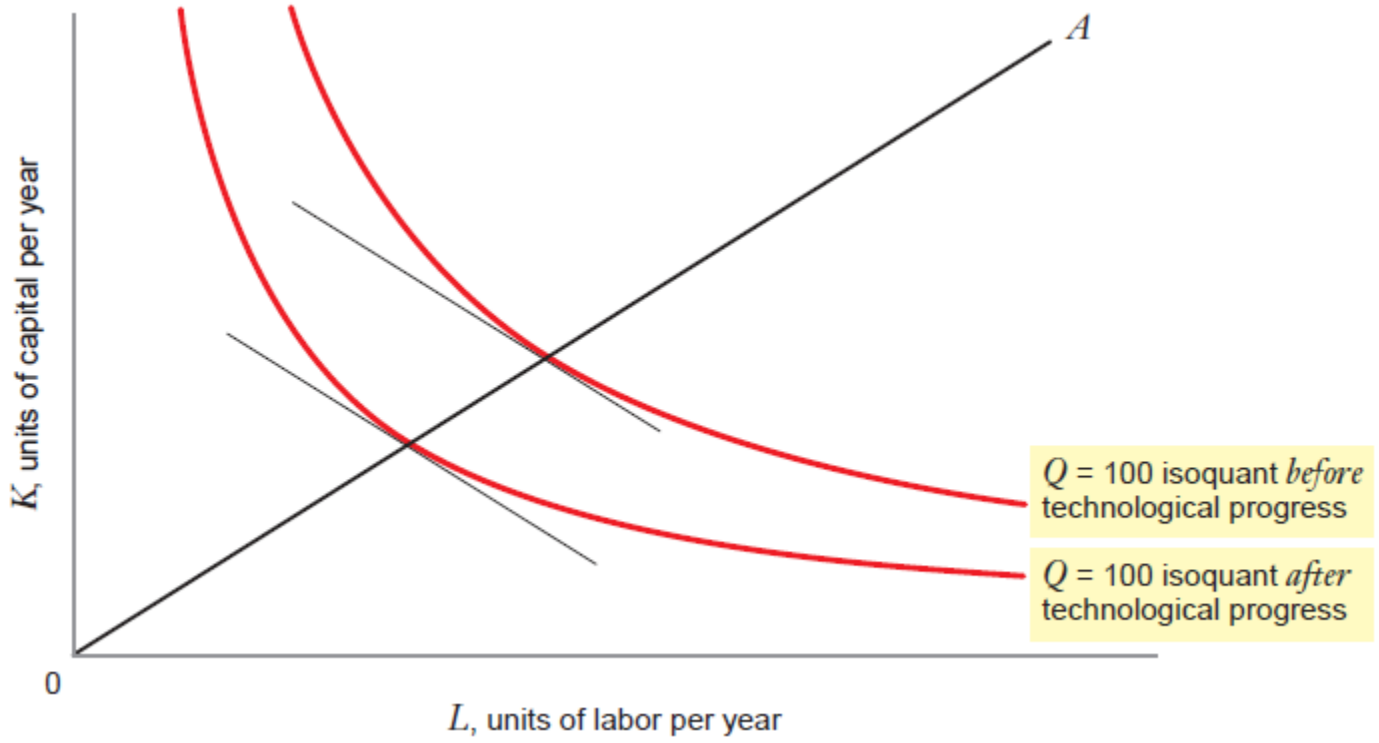
Source: Besanko: Ch6

Technological progress

- Production functions can shift over time due to technological progress.
- It refers to a situation in which a firm can achieve more output from a given combination of inputs, or equivalently, the same amount of output from lesser quantities of inputs.

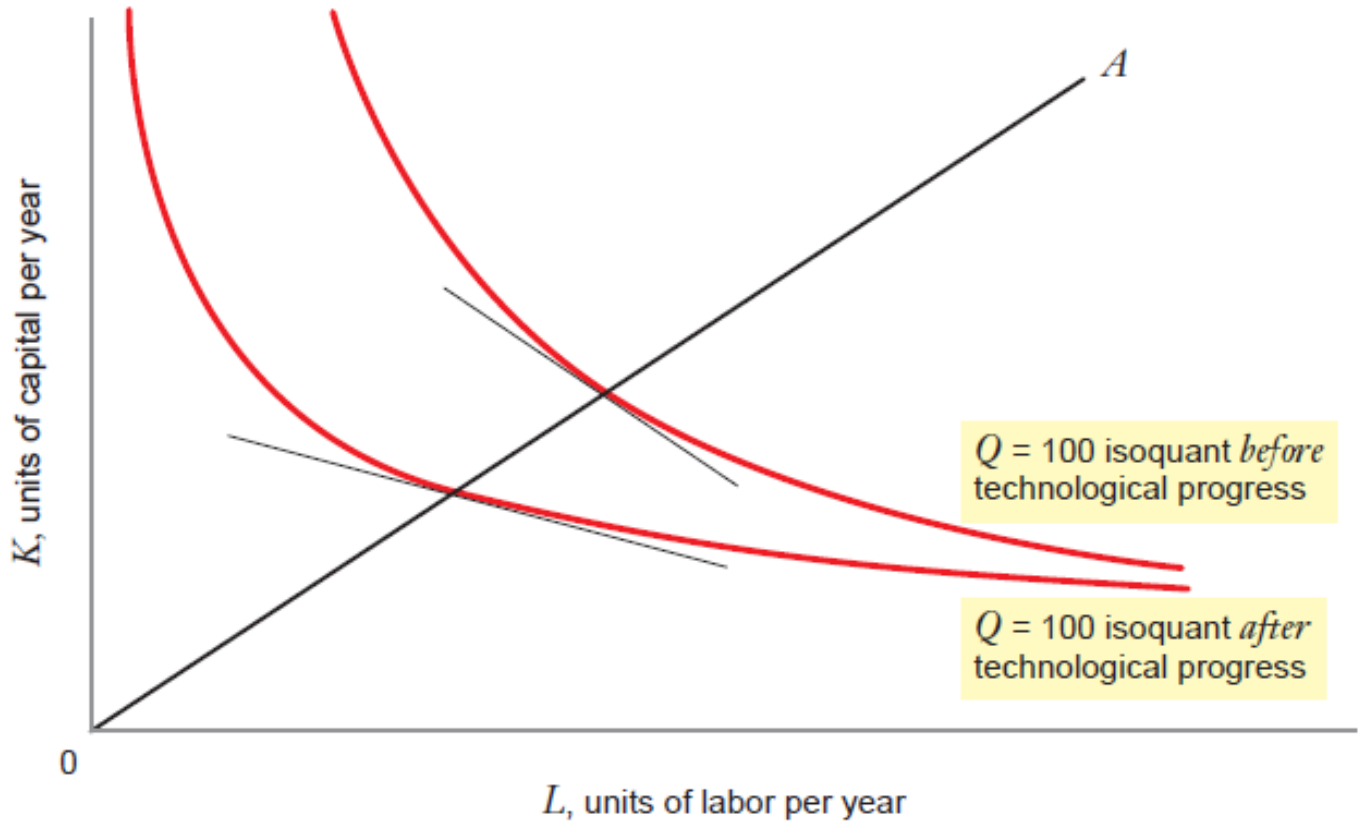
Source: Besanko: Ch6

Neutral Tech. Progress



Source: Besanko: Ch6

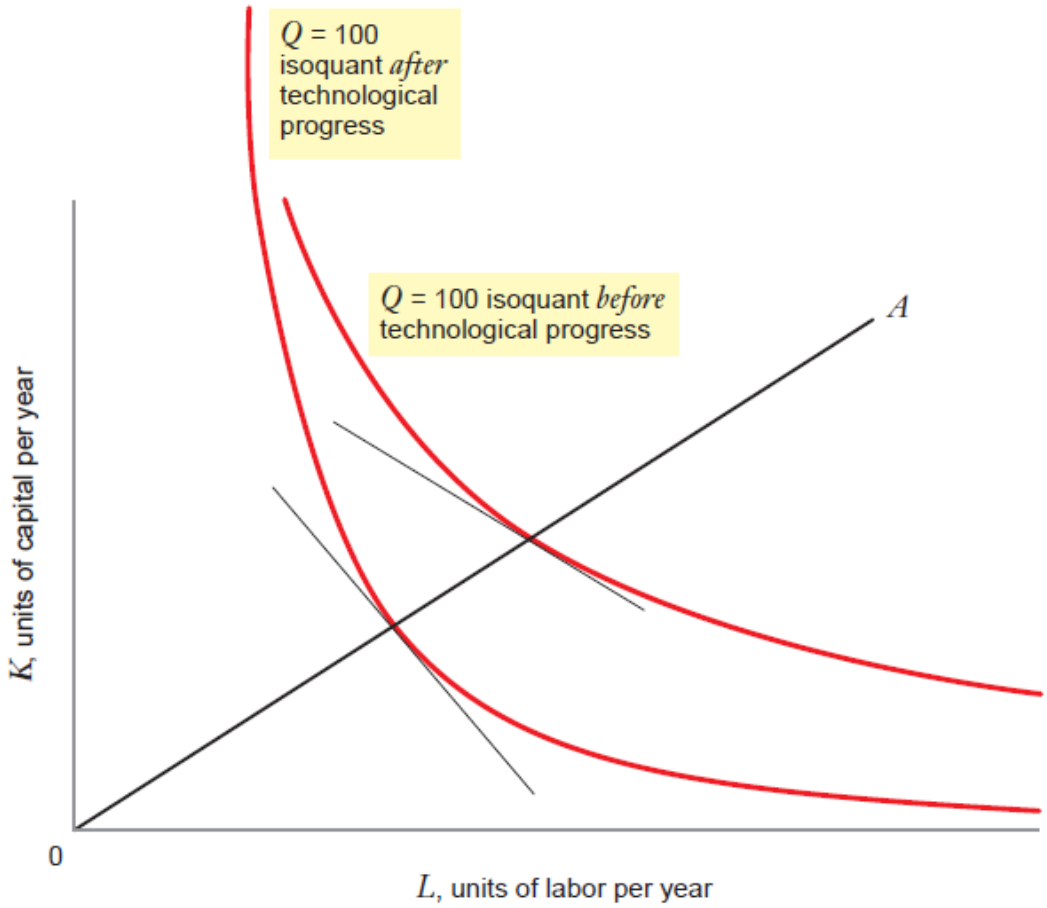
Labor-saving tech. progress



Under labor-saving technological progress, an isoquant corresponding to any particular level of output shifts inward, but the *MRTSL,K* along any ray from the origin, such as 0*A*, goes down.

Source: Besanko: Ch6

Capital-saving tech progress



Under capital-saving technological progress, an isoquant corresponding to any particular level of output shifts inward, but the *MRTSL,K* (the negative of the slope of a line tangent to the isoquant) along any ray from the origin, such as 0*A*, goes up

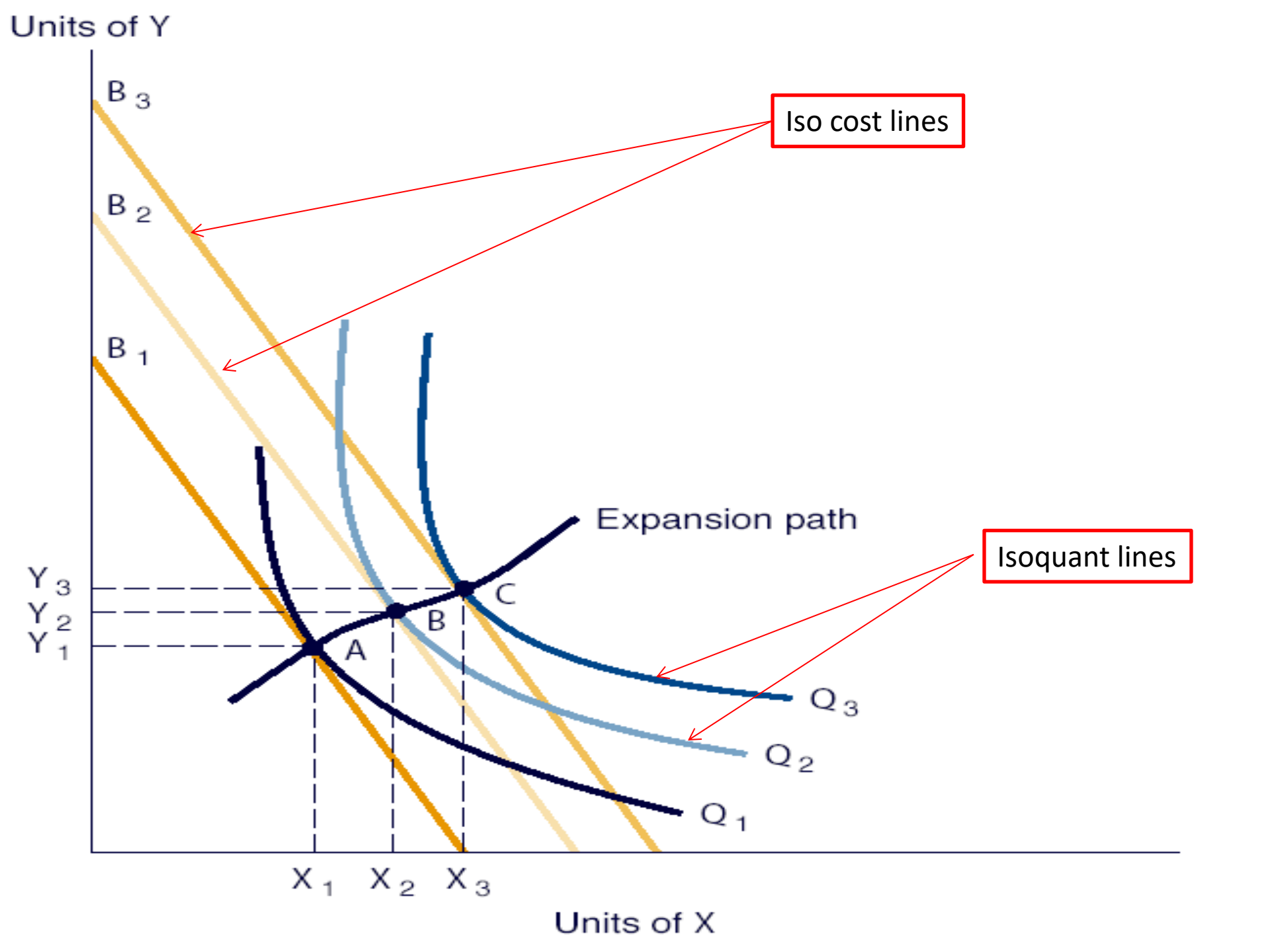
Source: Besanko: Ch6

Optimal Combination of Multiple Inputs

- Budget Lines
  - Least-cost production occurs when $MP_X/P_X = MP_Y/P_Y$ and $P_X/P_Y = MP_X/MP_Y$
- Expansion Path
  - Shows efficient input combinations as output grows.
- Illustration of Optimal Input Proportions
  - Input proportions are optimal when no additional output could be produce for the same cost.
  - Optimal input proportions is a necessary but *not* sufficient condition for profit maximization.

Optimal levels of multiple inputs

- Optimal Employment and Profit Maximization
  - Profits are maximized when $MRP_X = P_X$ for all inputs.
  - Profit maximization requires optimal input proportions *plus* an optimal level of output.


Units of Y
B 3
B 2
B 1
Iso cost lines
Expansion path
Isoquant lines
Y 3
Y 2
Y 1
A
B
C
Q 3
Q 2
Q 1
X 1
X 2
X 3
Units of X

Exercise

Production Function	MP_L	MP_K	$MRTS_{L,K}$	Diminishing Marginal Product of Labor?	Diminishing Marginal Product of Capital?	Diminishing Marginal Rate of Technical Substitution?
$Q = L + K$						
$Q = \sqrt{LK}$						
$Q = \sqrt{L} + \sqrt{K}$						
$Q = L^3K^3$						
$Q = L^2 + K^2$						

Summary

- Core concepts
  - Production functions
  - Law of diminishing returns
  - Marginalizing concepts