# Chapter 6

## Production

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## Introduction

- Our study of consumer behavior was broken down into 3 steps
  - Describing consumer preferences
  - Consumers face budget constraints
  - Consumers choose to maximize utility
- Production decisions of a firm are similar to consumer decisions
  - Can also be broken down into three steps

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## Production Decisions of a Firm

1. (                 )
   - Describe how *inputs* can be transformed into *outputs*
     - Inputs: land, labor, capital & raw materials
     - Outputs: cars, desks, books, etc.
   - Firms can produce different amounts of outputs using different combinations of inputs

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## Production Decisions of a Firm

2. (                 )
   - Firms must consider *prices* of labor, capital and other inputs
   - As consumers must consider budget constraints, firms must be concerned about costs of production

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## Production Decisions of a Firm

3. (                )
   - Given input prices and production technology, the firm must choose *how much of each input* to use in producing output
   - Given prices of different inputs, the firm may choose different combinations of inputs to minimize costs

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## Q: Decision Making of Owner-Manager

- Suppose you are running a small business.
  - What is your objective?
  - What are you supposed to decide?
  - What is profit?
  - How can you make your profit max?

## The Technology of Production

- (                    ):
  - Indicates the highest output ($q$) that a firm can produce for every specified combination of inputs.
  - For simplicity, we will consider only labor (L) and capital (K)

## The Technology of Production

- The production function for two inputs:
  $$q = F(K, L)$$
  - Output ($q$) is a function of capital (K) and Labor (L)
  - If technology increases, more output can be produced for a given level of inputs

  - Q: Why is raw material not included?

## The Technology of Production

- (                ) versus Long-Run
  - It takes time for a firm to adjust production from one set of inputs to another
  - Firms must consider not only what inputs can be varied but over what period of time that can occur
  - We must distinguish between long run and short run

## The Technology of Production

- (                )
  - Period of time in which quantities of one or more production factors cannot be changed.
  - These inputs are called fixed inputs.
- Long-run
  - Amount of time needed to make all production inputs variable.
- Short-run and long-run are not time specific

## Production:  One Variable Input

- We assume (        ) is fixed and labor is variable
  - Output can only be increased by increasing labor
  - How does output change as the amount of labor is changed?

## Production:  One Variable Input

| Amount of Labor (L) | Amount of Capital (K) | Total Output (q) |
|---|---|---|
| 0 | 10 | 0 |
| 1 | 10 | 10 |
| 2 | 10 | 30 |
| 3 | 10 | 60 |
| 4 | 10 | 80 |
| 5 | 10 | 95 |
| 6 | 10 | 108 |
| 7 | 10 | 112 |
| 8 | 10 | 112 |
| 9 | 10 | 108 |
| 10 | 10 | 100 |

## Production: One Variable Input

- Average product of Labor - Output per unit of labor
- Measures the productivity of a firm's labor in terms of how much, on average, each worker can produce

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

## Production: One Variable Input

- (                    ) – additional output produced when labor increases by one unit
- Change in output divided by the change in labor

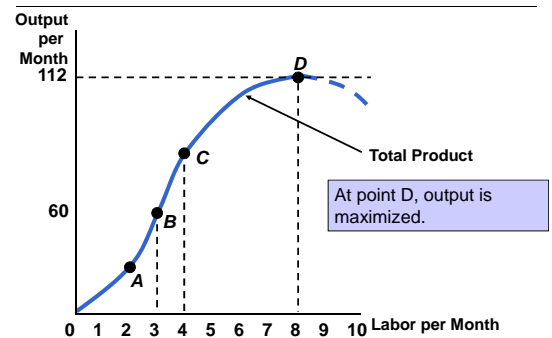$$MP_L = \frac{\Delta Output}{\Delta Labor\ Input} = \frac{\Delta q}{\Delta L}$$

## Production: One Variable Input

| Amount of Labor (L) | Amount of Capital (K) | Total Output (q) | Average Product (q/L) | Marginal Product (Δq/ΔL) |
|---|---|---|---|---|
| 0 | 10 | 0 | — | — |
| 1 | 10 | 10 | 10 | 10 |
| 2 | 10 | 30 | 15 | 20 |
| 3 | 10 | 60 | 20 | 30 |
| 4 | 10 | 80 | 20 | 20 |
| 5 | 10 | 95 | 19 | 15 |
| 6 | 10 | 108 | 18 | 13 |
| 7 | 10 | 112 | 16 | 4 |
| 8 | 10 | 112 | 14 | 0 |
| 9 | 10 | 108 | 12 | −4 |
| 10 | 10 | 100 | 10 | −8 |

## Production: One Variable Input



At point D, output is maximized.

## Product Curves

AP is slope of line from origin to point on TP curve

## Product Curves

MP is slope of line tangent to corresponding point on TP curve
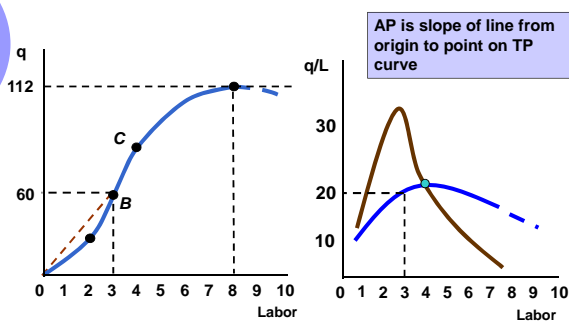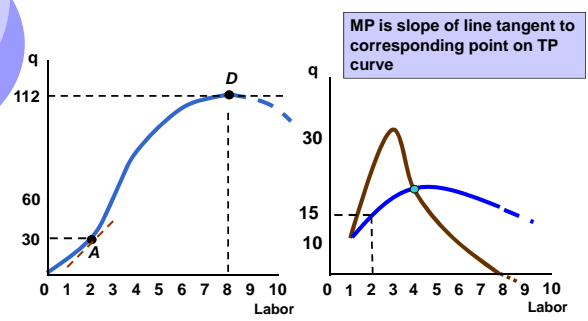
## Law of Diminishing (Marginal) Returns

- When the labor input is small and capital is fixed, output increases considerably since workers can begin to specialize and MP of labor increases
- When the labor input is large, some workers become less efficient and MP of labor decreases

## Production: Two Variable Inputs

| Capital Input | Labor Input 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 20 | 40 | 55 | 65 | (75) |
| 2 | 40 | 60 | (75) | 85 | 90 |
| 3 | 55 | (75) | 90 | 100 | 105 |
| 4 | 65 | 85 | 100 | 110 | 115 |
| 5 | (75) | 90 | 105 | 115 | 120 |

## Production: Two Variable Inputs

- The information can be represented graphically using isoquants
  - Curves showing all possible combinations of inputs that yield the same output

- Curve 1 shows all possible combinations of labor and capital that will produce 55 units of output

## Isoquant Map



Ex: 55 units of output can be produced with 3K & 1L (at A) OR 1K & 3L (at D)

$q_3 = 90$
$q_2 = 75$
$q_1 = 55$
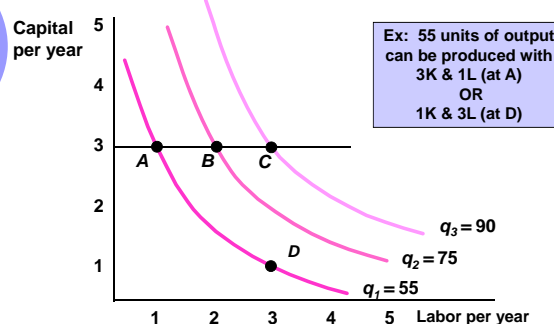
## Production: Two Variable Inputs

- Holding capital at 3 and increasing labor from 0 to 1 to 2 to 3.
  - Output increases at a decreasing rate (0, 55, 20, 15) illustrating diminishing marginal returns from labor.

## Production: Two Variable Inputs

- ( )
  - Slope of the isoquant shows how one input can be substituted for the other and keep the level of output the same.
  - marginal rate of technical substitution (MRTS)

## Production: Two Variable Inputs
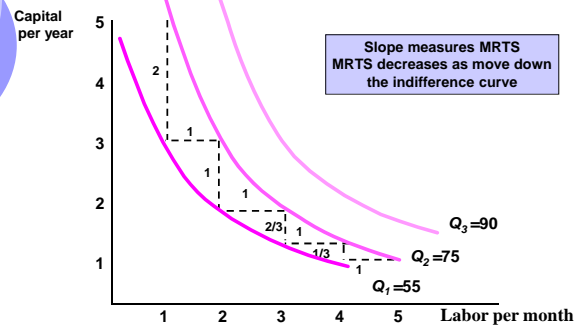
- The Marginal Rate of Technical Substitution equals:

$$MRTS = \frac{Change\ in\ Capital\ input}{Change\ in\ Labor\ input}$$

$$MRTS = -\frac{\Delta K}{\Delta L}\ (for\ a\ fixed\ level\ of\ q)$$

## Marginal Rate of Technical Substitution



Capital per year

Slope measures MRTS
MRTS decreases as move down
the indifference curve

$Q_3$=90

$Q_2$=75

$Q_1$=55

Labor per month

## MRTS and Marginal Products

- If we increase labor and decrease capital to keep output constant, we can see how much the increase in output is due to the increased labor
  - Amount of labor increased times the marginal productivity of labor

$$= (MP_L)(\Delta L)$$

## MRTS and Marginal Products

- Similarly, the decrease in output from the decrease in capital can be calculated
  - Decrease in output from reduction of capital times the marginal produce of capital

$$= (MP_K)(\Delta K)$$

## MRTS and Marginal Products

- If we are holding output constant, the net effect of increasing labor and decreasing capital must be zero
- Using changes in output from capital and labor we can see

$$(MP_L)(\Delta L) + (MP_K)(\Delta K) = 0$$

## MRTS and Marginal Products

- Rearranging equation, we can see the relationship between (          )

$$(MP_L)(\Delta L) + (MP_K)(\Delta K) = 0$$

$$(MP_L)(\Delta L) = -(MP_K)(\Delta K)$$

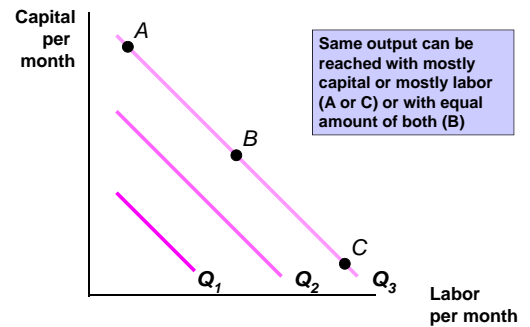$$\frac{(MP_L)}{(MP_K)} = -\frac{\Delta L}{\Delta K} = MRTS$$

## Isoquants: Special Cases

1. (                    )
   - ○ MRTS is constant at all points on isoquant
   - ○ Same output can be produced with a lot of capital or a lot of labor or a balanced mix

## Perfect Substitutes



Capital per month

*A*

*B*

*C*

Same output can be reached with mostly capital or mostly labor (A or C) or with equal amount of both (B)
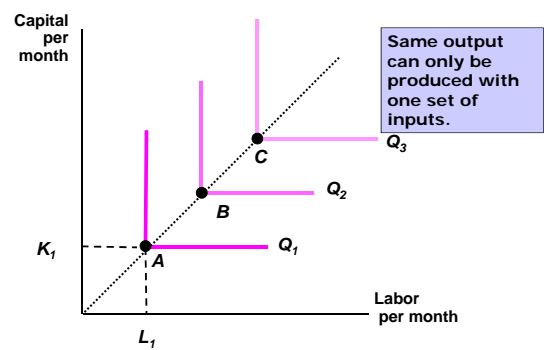
$Q_1$  $Q_2$  $Q_3$

Labor per month

## Isoquants: Special Cases

2. Perfect Complements
   - ○ Fixed proportions production function
   - ○ There is no substitution available between inputs
   - ○ The output can be made with only a specific proportion of capital and labor
   - ○ Cannot increase output unless increase both capital and labor in that specific proportion

## Fixed-Proportions Production Function



Capital per month

Same output can only be produced with one set of inputs.

*C*  $Q_3$

*B*  $Q_2$

$K_1$  *A*  $Q_1$

Labor per month

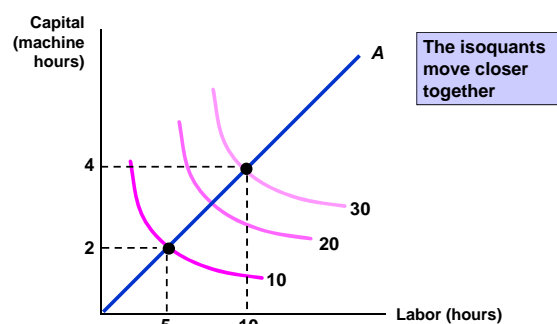$L_1$

## Returns to Scale

- ● Rate at which output increases as inputs are increased proportionately
   - ○ (                    )
   - ○ Constant returns to scale
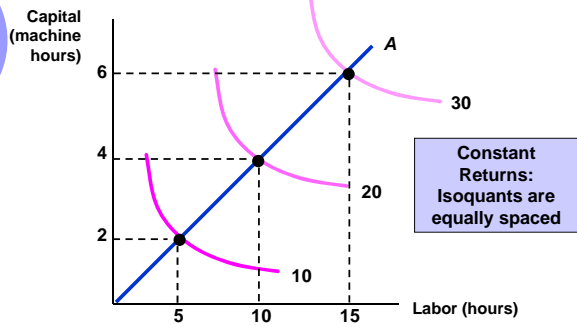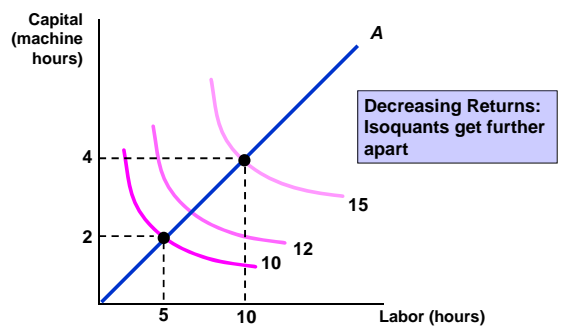   - ○ Decreasing returns to scale

## Increasing Returns to Scale



Capital (machine hours)

*A*

The isoquants move closer together

4

2

30

20

10

Labor (hours)

5    10

## Returns to Scale

Capital (machine hours)

A

6
4
2

30
20
10

Labor (hours)
5   10   15

**Constant Returns: Isoquants are equally spaced**

## Returns to Scale

Capital (machine hours)

A

4
2

15
12
10

Labor (hours)
5   10

**Decreasing Returns: Isoquants get further apart**