

PRODUCTION

Analysis of Production:

Base our analysis on the *production function* the relationship between inputs used and maximum output attainable

- Inputs = factors of production. We collapse these into two: labor (L) and capital (K)

Form of this function:

$Q = f(K, L)$ - long-run production function

⇒ Output depends on the combination of inputs used and *both* L and K can vary

Definitions:

SHORT RUN (S/R): time period where the stock of physical capital is fixed (there is *no* time reference)

- To expand Q in S/R, must use more labor with the existing capital stock (plant or productive capacity)

⇒ *Fixed input* - one with constant quantity.

Results in fixed costs in S/R

⇒ *Variable input* - its use varies with Q.

Generates variable costs in S/R.

LONG-RUN (L/R): both labor *and* capital are variable in the long-run

- To ↑Q, can either (1) use more L; (2) use more K; or (3) use more L and K
- Technology is constant in the L/R

Elasticity of supply is greater in the long-run

Short-Run Production Function:

$Q = g(L)$, given K and technology

SHORT-RUN PRODUCTION

-Start with the short-run production function and derive productivity measures

$Q = g(L)$ given K and technology

Q	L
0	0
50	1
175	2
200	3

As $L \uparrow$ given K , $Q \uparrow$

Q: Since labor input has costs, *how much* L should be employed and how much Q should the

firm produce?

To answer this, need to look at **labor productivity** - output per unit of labor input

MARGINAL PRODUCT OF LABOR

(Marginal = Extra and Product = Output)

- Extra output when labor input rises (given K)
- The rate of change in Q as L varies (given K)
- Slope of the production function

$MP_L = \Delta Q / \Delta L$ given K and technology

Q	L	MP_L
0	0	-
50	1	50
175	2	<u>125</u>
200	3	25

MP_L rises, reaches a maximum, then declines

\Rightarrow Two people working *together* are more productive than each working separately (i.e., $MP_L \uparrow$). This results from:

SPECIALIZATION - workers only do *some* of the tasks, not the entire job

DIVISION OF LABOR - break the total job into separate tasks

Q: How do these result in rising MP_L ?

A: Less time switching between jobs and, as each worker does fewer jobs, gets to know these extremely well

- Benefits *and costs* are associated with this

Costs: (1) workers don't identify with final product; (2) alienation (boring/repetitive)

Eventually, the gains (economies) from specialization and division of labor are no longer possible, so $MP_L \downarrow$

Why? Fixed capital \Rightarrow eventually overutilize fixed capital (over crowding)

AGRICULTURAL EXAMPLE

Capital = fixed amount of land

At first: 1 acre/worker, then get 1/2 acre per worker (with $L=2$), 1/3 acre/worker when $L=3, \dots$, 1/10 acre/worker with $L=10$

\Rightarrow *Overutilization of the fixed factor (K) eventually offsets gains from specialization and the division of labor*

THIS IS RELATED TO OUTSOURCING

- Perform only those parts of the process you are efficient at and *outsource the rest* to firms that specialize in those things

Q: If $MP_L \downarrow$, does this mean that $Q \downarrow$?

A: Not necessarily. It is almost always true that as $MP_L \downarrow$ Q does *not* fall

- As $L \uparrow$, $Q \uparrow$ but at a decreasing rate

Maximum MP_L = point of diminishing returns

So, $\downarrow MP_L \Rightarrow$ diminishing returns

- This *might* mean Q is also falling, but generally $Q \uparrow$
- Guaranteed outcome in the short-run due to the definition - having a fixed factor

AVERAGE PRODUCT OF LABOR (AP_L)

output per worker

$AP_L = Q/L$ given K and technology

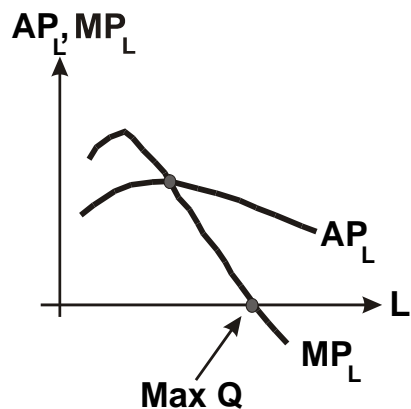
Q	L	MP_L	AP_L
0	0	-	-
50	1	50	50.0
175	2	125	87.5
200	3	25	66.7

AP_L rises, reaches a maximum, then falls
- this is related to diminishing returns

Average - Marginal Relationship

Example - test scores where average is average test grade and marginal refers to scores on makeup exams

- (1) If average X is rising (i.e., when count makeup exams, average grade rises), then marginal exceeds the average
- (2) If average X is falling, then marginal is less than the average
- (3) At max or min X, average X is constant, so marginal X equals average X



PRODUCTIVITY AND PRODUCTION

In the short-run, as $L \uparrow$ given K , $Q \uparrow$

- Eventually, as this continues, $Q \uparrow$ but at a decreasing rate - *diminishing returns*

Note: If K changes, both AP_L and MP_L change in the same direction, *shifting* both curves

Traditional view: both AP_L and MP_L depend on capital so if $K \uparrow$ (long-run) both rise
 \Rightarrow Reliance on mass production for productivity gains (in the past era)

TODAY'S WORLD: it is possible to raise productivity *without changing either capital or technology*

- In reality, productivity depends on both capital and worker effort level (E)
- Effort level is determined by *management practices* \Rightarrow there is a technology for management

The recent technological improvement in management: **Horizontal Management**

This replaced **VERTICAL MANAGEMENT**, which has many levels of managers (upper & middle levels) once necessary for communication within firms

- It arose after WWII in the US based on military hierarchy

Problems: (1) workers are separated from many of the layers of management;
(2) With technology, pure repetition in manufacturing is no longer as prevalent

In Place of This:

Flexible Production - where output is tailored to the demands of *specific* customers, not merely the large production runs of the past

Horizontal Management - fewer layers between the "top" and basic workers
⇒ This is a labor-saving technology

This has led to *white collar unemployment* and greater worker empowerment

- Workers help to determine production methods, ways to lower cost, raise productivity, and boost quality
- This offsets worker alienation from specialization/division of labor

Along with this: (1) Outsourcing;
(2) Permanently smaller workforces that must be retrained/upskilled through time

Niche for Small Businesses:

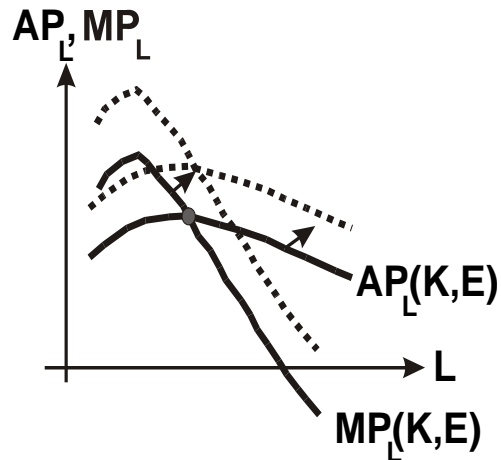
By finding ways to improve effort level, it is no longer necessary to raise K to raise productivity (less reliance on mass production methods)

⇒ Work smarter, not necessarily larger

⇒ *Flexible labor practices*

So: both AP_L and MP_L depend on capital (K) and the effort level of workers (E)

- Given capital, the greater is effort level, the higher will be both the AP_L and MP_L



Q: Why is it important to get higher productivity?

A: Higher productivity allows the firm to lower its costs, making it more competitive and profitable

Putting this all together: **LEAN PRODUCTION**

A production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination.

(from Wikipedia.com)

- Taiichi Ohno (a Toyota engineer) is credited with developing this method, also called the Toyota Production System (TPS)
- LP constantly attempts to reduce or eliminate wasteful uses of resources, including worker time, and adapting production to ever more efficient ways of producing the outputs, constantly raising productivity and reducing “waste”
- Workers become multi-skilled by doing several tasks overall and continually adapting them to be done better and more efficiently (worker empowerment)
- This is consistent with both horizontal management and flexible production
- The adaptive nature of this process also enables firms using it to respond more quickly to changes in product demand
- The definition of “waste” must distinguish between

activity that adds value, waste in general, and activities that fail to add value.

- Non-value adding work is wasteful work that is routinely done under existing work practices
- It is essential that firms practicing LP measure the various types of “waste” so that the results of changes based on LP can be monitored (and ultimately improved upon!) and kept consistent with overall goals

The Ten Rules of Lean Production: (from SearchCIO.com)

1. Eliminate waste
2. Minimize inventory
3. Maximize flow
4. Pull production from customer demand
5. Meet customer requirements
6. Do it right the first time
7. Empower workers
8. Design for rapid changeover
9. Partner with suppliers
10. Create a culture of continuous improvement

Reference:

<http://totalqualitymanagement.wordpress.com/2008/10/28/lean-production-system/>

LONG-RUN PRODUCTIVITY

The long-run production function is:

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

As both K and L can change in L/R

To $\uparrow Q$ in the long-run, can:

- $\uparrow L$
- $\uparrow K$ (larger facilities/new equipment)
- Increase both K and L

Over some range of production there are **Increasing Returns to Scale** - as both K and L change by the same proportion (ex: double), Q changes by a greater proportion (Scale refers to K and L together)
ex: If *both* K and L are doubled, Q may triple
 \Rightarrow Lower cost per unit in this range, called either **mass production economies** or **economies of scale**. Eventually these end.
(note: economies are *cost savings*)

PRACTICE QUESTIONS

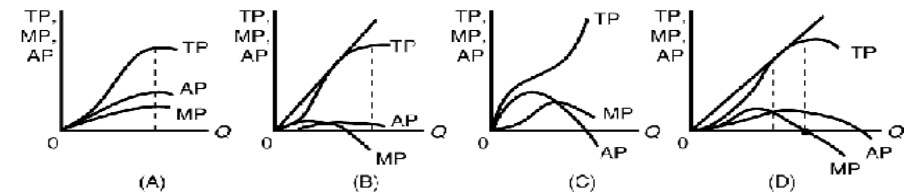
Which statement is true?

- A) Diminishing returns set in after marginal product intersects average product.
- B) Underlying the law of diminishing returns is the assumption that at least one input remains fixed.
- C) The law of diminishing marginal returns implies that there will never be increasing returns to scale.
- D) Given a total product curve for labor, $Q = 5L$, labor is only subject to diminishing marginal returns after $L = 5$.

When marginal product reaches its maximum, what can be said of total product?

- A) total product must be at its maximum.
- B) total product starts to decline even if marginal product is positive.
- C) total product is increasing if marginal product is still positive.
- D) total product levels off.

Use the following to answer using these graphs:



Which of the above properly depicts the relationships TP, AP, and MP?

- A) graph A
- B) graph B
- C) graph C
- D) graph D

When diminishing returns to labor begins,

- a. total costs start to rise.
- b. variable costs start to rise.
- c. average variable costs start to rise.
- d. marginal cost starts to rise.
- e. average total cost starts to rise.

The term *diminishing returns to labor* means that

- a. total output decreases as one more unit of labor is applied to production.
- b. increases in output decline as additional units of labor are used in production.
- c. the market value of labor decreases as more labor is supplied.
- d. the production of labor is becoming less profitable with decreasing real wages.

Because of the relationship of the marginal to the average, the marginal product intersects

- A) the total product at the latter's inflection point.
- B) the marginal cost curve at its minimum point.
- C) the average product at the latter's minimum point.
- D) the average product at the latter's maximum point.
- E) the average cost at the latter's minimum point.

In the short run, output:

- A) is absolutely fixed.
- B) can vary as the result of using a fixed amount of plant and equipment more or less intensively.
- C) may be altered by varying the size of plant and equipment which now exist in the industry.
- D) can vary as the result of changing the size of existing plants and by new firms entering or leaving the industry.

Which is most likely to be a *long-run* adjustment for a firm that manufactures cars on an assembly line basis?

- A) an increased amount of aluminum the firm buys.
- B) a change in the production managers of the assembly line.
- C) a change in the production to a redesigned, new model car.
- D) an increase in the number of shifts of workers from two to three.

KNOW HOW TO CALCULATE MARGINAL AND AVERAGE PRODUCT FROM A TABLE OF VALUES FOR Q AND L