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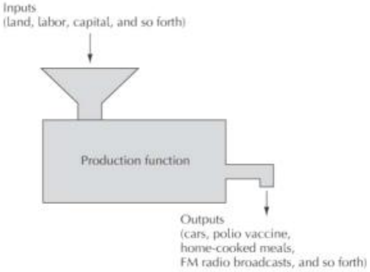
Modelling the producer: Production, Costs, and supply decisions

Figure 9-2: The Production Function



Short-Run Production

- In the short run, the firm’s production function is

$$q = f(\underbrace{L}_{\text{TREATED AS A VARIABLE INPUT}}, \overbrace{\bar{K}}^{\text{TREATED AS A FIXED INPUT}})$$

  - where q is output, L is workers, and K is the fixed number of units of capital.

LONG RUN PRODUCTION FUNCTION : $q = f(L, K)$

TP, AP, MP

- Total Product of Labor (TP_L or TP or Q (Output))

= TOTAL AMOUNT OF OUTPUT PRODUCED

EX: → # PIECES / TIME PERIOD

- Average Product of Labor (AP_L or AP)

$$AP_L = \frac{TP_L}{L} \quad \text{OR} = \frac{Q}{L}$$

EX: $Q = 1000\ /\ \text{DAY}$

$L = 5\ /\ \text{DAY}$

$$\Rightarrow AP_L = \frac{Q}{L} = \frac{1000\ /\cancel{\text{DAY}}}{5\ /\cancel{\text{DAY}}}$$

$AP_L = 200$ /

ON AVG, EACH WORKER PRODUCES 200 PER DAY

EX: FACTORY 1 VS FACTORY 2

$Q_1 = 1000$ $Q_2 = 1500$

$L_1 = 5$ $L_2 = 5$

$AP_L = 200$ $AP_L = \frac{1500}{5} = 300$

TP, AP, MP

AP_L MEASURES HOW PRODUCTIVE LABORS ARE.

- Marginal Product of Labor (MP_L or MP)

= EXTRA OUTPUT FROM AN EXTRA UNIT OF LABOR

$$MP_L = \frac{\Delta Q}{\Delta L} = \frac{Q_2 - Q_1}{L_2 - L_1}$$

EX: $L_1 = 5 \rightarrow Q_1 = 1000$

$L_2 = 6 \rightarrow Q_2 = 1200$

$$MP_L = \frac{Q_2 - Q_1}{L_2 - L_1} = \frac{1200 - 1000}{6 - 5} = \frac{200}{1}$$

Table 6.1 Total Product, Marginal Product, and Average Product of Labor with Fixed Capital

$Q = F(L, \bar{K})$

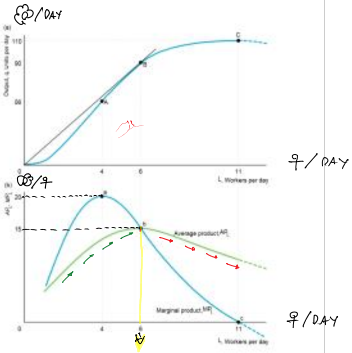
Capital, $\bar{K}$	Labor, L	Output, Total Product of Labor, Q	Marginal Product of Labor, $MP_L = \Delta Q/\Delta L$	Average Product of Labor, $AP_L = Q/L$
8	0	0		
8	1	5	5	5
8	2	18	13	9
8	3	36	18	12
8	4	56	20	14
8	5	75	19	15
8	6	90	15	15
8	7	98	8	14
8	8	104	6	13
8	9	108	4	12
8	10	110	2	11
8	11	110	0	10
8	12	108	−2	9
8	13	104	−4	8

MP_L > AP_L

MP_L > AP_L $AP_L \uparrow$

MP_L = AP_L $AP_L \uparrow$

Figure 6.1 Production Relationships with Variable Labor



Observations on TP, AP, and MP

FACT #1
(ON TP)

IF $L=0$, $Q=0$.

AS L RISES, Q ALSO RISES. WHEN $L=11$, Q STOPS TO INCREASE. IF $L>11$, Q STARTS TO FALL.

FACT #2
(ON AP)

WHEN $L<6$, AP_L IS RISING. ☺ (☺/♀ ↑)

WHEN $L=6$, AP_L REACHES ITS MAX ($AP_L = 15$)

WHEN $L>6$, AP_L IS FALLING. ☹ (☺/♀ ↓)

FACT# 3
(ON MP)

WHEN $L<4$, MP_L IS RISING

WHEN $L=4$, MP_L HITS ITS PEAK ($MP_L = 20$)

WHEN $L>4$, MP_L IS FALLING.

FACT #4
(RELATIONSHIP BET. AP_L AND MP_L)

AT $L=6$, $AP_L = MP_L$ $(=15)$ ≈ TWO MOUNTAINS SHARE THE SAME HEIGHT.

WHEN $L<6$, $MP_L > AP_L$ AND AP_L IS RISING ☺

WHEN $L>6$ $MP_L < AP_L$ AND AP_L IS FALLING. ☹

Observations on TP, AP, and MP

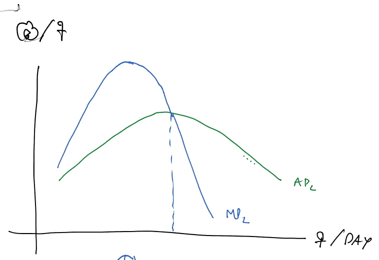
EX: $N = 30$ ♀, AVG HEIGHT = 160 cm. ≡ AP_L

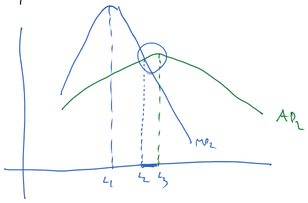
→ ADDING A DUTCH GUY W/ 200 cm :

$N = 30+1 = 31$, NEW AVG HEIGHT > 160

→ ADDING, INSTEAD, DORAEMON W/ 129 cm →

$N = 31$, NEW AVG HEIGHT < 160





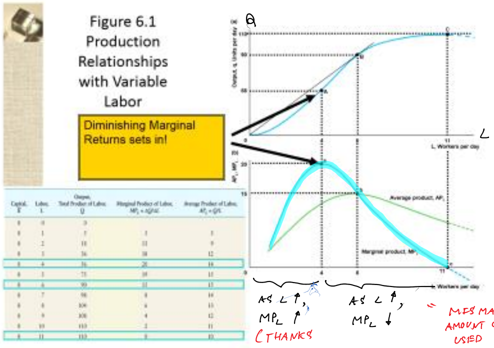


Figure 6.1
Production
Relationships
with Variable
Labor

Diminishing Marginal Returns sets in!

AS L ↑, MP_L ↑ (THANKS TO SPECIALIZATION & DIVISIONS OF LABOR)

AS L ↑, MP_L ↓ " MISMATCH BETWEEN AMOUNT OF LABOR USED AND AMOUNT OF CAPITAL THAT IS FIXED

EX: CROWDED KITCHEN (MORE CHEFS BUT LIMITED AMOUNT OF COOKING UTENSILS)

RECALL THAT

$MP_L = \frac{\Delta Q}{\Delta L}$ = SLOPE OF TP

Law of Diminishing Marginal Product of Labor (MP_L)

AS L RISES, GIVEN THE FIXED AMOUNT OF K, MARGINAL PRODUCT OF LABOR (MP_L) WILL EVENTUALLY DECLINE...

Costs of Production in the Short Run

TC, FC, and VC

TOTAL COST (TC) = TOTAL FIXED COST (TFC OR FC) + TOTAL VARIABLE COST (TVC OR VC)

(₿ / DAY)

$$\boxed{TC = FC + VC}$$

FC → DO NOT VARY W/ AMOUNT OF OUTPUT PRODUCED

VC → VARY W/ AMOUNT OF OUTPUT PRODUCED

$Q = F(L, K)$

AC, AFC, and AVC

AVERAGE COST (AC) OR AVERAGE TOTAL COST (ATC) = AVERAGE FIXED COST (AFC) + AVERAGE VARIABLE COST (AVC)

FROM $TC = FC + VC$ — ① (€/DAY)

$\frac{TC}{Q} = \frac{FC}{Q} + \frac{VC}{Q}$ — ②

$$\frac{\frac{\text{€}}{\cancel{DAY}}}{\frac{Q}{\cancel{DAY}}} = \frac{\text{€}}{Q}$$

$AC = AFC + AVC$

AC → UNIT COST OR COST PER UNIT OF OUTPUT

AFC → FIXED COST PER UNIT OF OUTPUT

AVC → VARIABLE COST PER UNIT OF OUTPUT

MC

Table 7.1 Variation of Short-Run Cost with Output

(€/DAY)

Output, q	Fixed Cost, FC	+ Variable Cost, VC	= Total Cost, TC	Marginal Cost, MC	Average Fixed Cost, $AFC = FC/q$	Average Variable Cost, $AVC = VC/q$	Average Cost, $AC = TC/Q$
0	48	0	48				
1	48	25	73	25	48	25	73
2	48	46	94	21	24	23	47
3	48	66	114	20	16	22	38
4	48	82	130	16	12	20.5	32.5
5	48	100	148	18	9.6	20	29.6
6	48	120	168	20	8	20	28
7	48	141	189	21	6.9	20.1	27
8	48	168	216	27	6	21	27
9	48	198	246	30	5.3	22	27.3
10	48	230	278	32	4.8	23	27.8
11	48	272	320	42	4.4	24.7	29.1
12	48	321	369	49	4.0	26.8	30.8

$q = f(L, \bar{K})$

$\frac{48}{73} = 0.65$ $\quad \frac{25}{73} \approx 0.35$

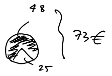
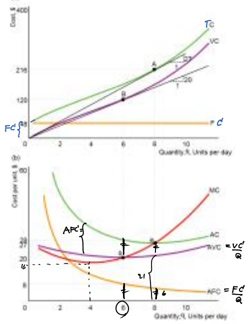
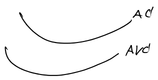


Figure 7.1 Short-Run Cost Curves

$\boxed{TC = FC + VC}$



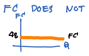
AC = AFC + AVC



Nature of Cost Curves

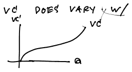
FACT #1

- FC DOES NOT VARY W/ AMOUNT OF OUTPUT PRODUCED (Q).



NOTE EVEN Q = 0, FC EXISTS

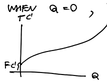
- VC DOES VARY W/ Q. THE HIGHER THE Q, THE HIGHER THE VC.



NOTE: WHEN Q = 0, VC = 0

- TC INCREASES WHEN Q INCREASES

WHEN Q = 0, $TC = FC + \overset{0}{\cancel{VC}} = FC$



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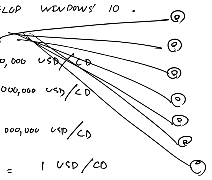
Nature of Cost Curves

FACT #2 (ON AFC OR $\frac{FC}{Q}$)

AS Q INCREASES, $\frac{FC}{Q}$ FALLS SHARPLY AT THE BEGINNING AND FALLS STEADILY LATER. (THIS IS SO CALLED "SPREADING EFFECT")

(Ex) BILL GATES SPENT 10 MILLION USD TO HIRE A RESEARCH TEAM TO DEVELOP WINDOWS 10.

$\boxed{FC = 10,000,000 \text{ USD}}$



IF Q = 1, $\frac{FC}{Q} = \frac{10,000,000}{1} = 10,000,000$ USD/CD

IF Q = 2, $\frac{FC}{Q} = \frac{10,000,000}{2} = 5,000,000$ USD/CD

⋮

IF Q = 10, $\frac{FC}{Q} = \frac{10,000,000}{10} = 1,000,000$ USD/CD

IF Q = 10,000,000, $\frac{FC}{Q} = \frac{10,000,000}{10,000,000} = 1$ USD/CD

IF = 1000,000,000, $\frac{FC}{Q} = \frac{1\cancel{0,000,000}}{100\cancel{0,000,000}} = 1$ CENT / CD !

FIXED COST IS SPREAD OVER "EACH UNIT OF CD"

OR

EACH CD HELPS TO SHARE THE FIXED COST AND AS Q ↑, $\frac{FC}{Q}$ ↓.

Nature of Cost Curves

FACT #3 (ON AVC OR $\frac{VC}{Q}$) : AVC IS U-SHAPED.

WHEN $Q < 6$, $\frac{VC}{Q}$ OR AVC IS FALLING. ☺

WHEN $Q = 6$, AVC BOTTOMS OUT.

WHEN $Q > 6$, AVC IS RISING. ☹

FACT #4 (ON AC OR $\frac{TC}{Q}$) : AC IS U-SHAPED.

WHEN $Q < 8$, AC IS FALLING ☺

WHEN $Q = 8$ AC BOTTOMS OUT

WHEN $Q > 8$ AC IS HEADING UP ☹

FACT # 5 (ON MC)

WHEN $Q < 4$, MC IS FALLING

WHEN $Q = 4$, MC BOTTOMS OUT $(= 16)$

WHEN $Q > 4$, MC IS RISING. ☹

OBSERVE THAT MC CUTS AT THE BOTTOM OF AVC (WHEN $Q = 6$)

NEXT, MC CUTS AT THE BOTTOM OF AC (WHEN $Q = 8$)

Nature of Cost Curves

FACT #6 (MC & AVC)

$$\boxed{AVC = \frac{VC}{Q}}$$

$$MC = \frac{\Delta TC}{\Delta Q} = \frac{\Delta(FC + VC)}{\Delta Q}$$

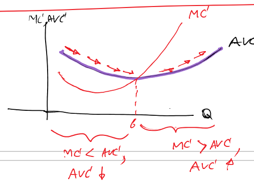
$$= \frac{\cancel{\Delta FC}}{\Delta Q} \xrightarrow{} 0 + \frac{\Delta VC}{\Delta Q}$$

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

WHEN MC < AVC, AVC ↓

WHEN MC > AVC, AVC ↑

} RELATIONSHIP BET. MC & AVC

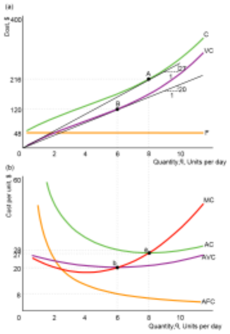


$$AP = \frac{Q}{L} \qquad MP = \frac{\Delta Q}{\Delta L}$$

WHEN MP > AP, AP ↑

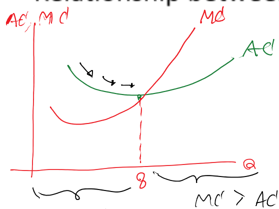
WHEN MP < AP, AP ↓

Relationship between AVC and MC



Relationship between AVC and MC

Relationship between AC and MC



$AC = \frac{TC}{Q}$

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

MC < AC, AC ↓

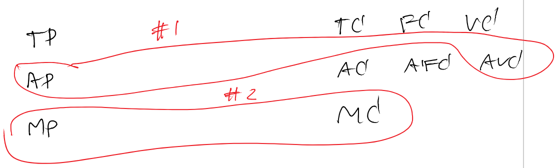
MC > AC, AC ↑

$\boxed{\text{FACT \# 7}}$

Relationship between AC and MC

Linkage between Production and Costs

Mind Map

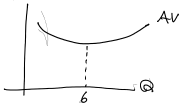


PRODUCTION & COST ARE CLOSELY LINKED!

TO UNDERSTAND THE NATURE OF COST CURVES, ESPECIALLY AVC AND AC, WE HAVE TO MAKE A CONNECTION BET. PRODUCTION & COSTS

Relationship between AVC and AP_L

(WHY AVC IS U – SHAPED ?)



CONSIDER $AVC = \frac{VC}{Q}$.

PRODUCTION FUNCTION: $Q = F(L, \bar{K})$

PRICE OF USING L (P_L) = wage (w)

$$AVC = \frac{VC}{Q} = \frac{w \cdot L}{Q} = w \cdot \frac{1}{\frac{Q}{L}} = w \cdot \frac{1}{AP_L}$$

$$\boxed{AVC = \frac{w}{AP_L}}$$

GIVEN w, WHEN $AP_L \uparrow$, AVC OR $\frac{VC}{Q}$ WILL FALL ☺

WHEN $AP_L \downarrow$, AVC OR $\frac{VC}{Q}$ WILL RISE ☹.

WHEN $MP_L > AP_L \rightarrow AP \uparrow \rightarrow AVC \downarrow$

WHEN $MP_L < AP_L \rightarrow AP \downarrow \rightarrow AVC \uparrow$

~~\$~~ + ~~\$~~

EX:

$L_1 = 10$ 🧍

$Q_1 = 1000$ 🍪

$w = 300$ BAHT/🧍/DAY

$AP_L = \frac{Q_1}{L_1} = \frac{1000}{10} = 100$ 🍪/🧍

$AVC = \frac{VC}{Q} = \frac{w \cdot L}{Q} = \frac{300 \cdot 10}{1000} = 3$ BAHT/🍪

SUPPOSE FC = 1000 BAHT/DAY

$AFC = \frac{FC}{Q} = \frac{1000}{1000} = 1$ BAHT/🍪

SO

$L_2 = 11$ 🧍

$Q_2 = 1200$ 🍪

$AP_L = \frac{Q_2}{L_2} = \frac{1200}{11} = 109.09$ 🍪/🧍

25%

75%

AC = AFC + AVC

= 1 + 3

= 4 BAHT/🍪

25% PAY TO FIXED INPUT

Q = 1000

75% → PAY VARIABLE INPUT

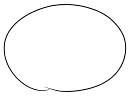
$$AVC = \frac{w \cdot L}{Q} = \frac{300 \cdot 11}{1200} = \frac{3300}{1200} = 2.75 \text{ BAHT/🍪}$$

$AFC = \frac{FC}{Q} = \frac{1000}{1200} = 0.833$

SO, AC = AFC + AVC

= 0.833 + 2.75

= 3.583 BAHT/🍪



$\frac{0.8333}{3.583}$ (= 23.25) Vs $\frac{2.75}{3.583}$ (= 76.8

Relationship between MP_L and MC

$MP_L = \frac{\Delta Q}{\Delta L}$ (EXTRA COOKIE FROM EXTRA WORKER)

$MC = \frac{\Delta TC}{\Delta Q}$ (EXTRA COST FROM EXTRA COOKIE)

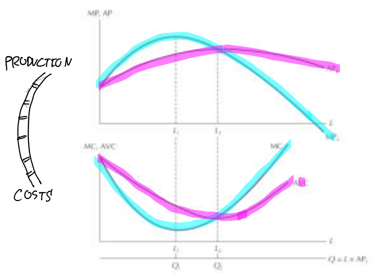
$$MC = \cancel{\frac{\Delta FC}{\Delta Q}}^{0} + \frac{\Delta VC}{\Delta Q} = \frac{\Delta VC}{\Delta Q} = \frac{\Delta (w \cdot L)}{\Delta Q} = w \cdot \frac{\Delta L}{\Delta Q} = w \cdot \frac{1}{\frac{\Delta Q}{\Delta L}} = w \cdot \frac{1}{MP_L}$$

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

→ GIVEN w, WHEN $MP_L \uparrow$, $MC \downarrow$

WHEN $MP_L \downarrow$, $MC \uparrow$.

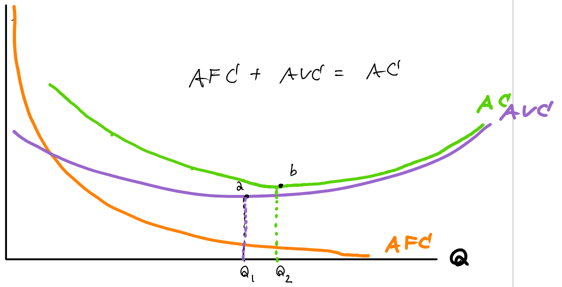
Summary: The Relationship Between AP, MP, AVC, and MC



AVC IS A MIRROR IMAGE OF AP_L

MC " ——— " MP_L

Why Short Run Average Cost Curve (SAC, SRAC) is U-Shaped?



AFC + AVC = AC

- FROM Q = 0 → Q = Q_1 : AFC (↓) + AVC ↓ = AC ↓

  SPREADING EFFECT

  MP > AP → AP ↑

  ( )

- FROM Q = Q_1 → Q = Q_2 : AFC (↓) + AVC (↑) = AC ↓

  ↓ AFC > ↑ AVC → AC ↓

  $MP_L < AP_L$ → AP ↓

  (LAW OF DIMINISHING MP_L OPERATES)

  CALLED " DIMINISHING RETURN EFFECT "

SO, NOW SPREADING EFFECT " DOMINATES " DIMINISHING RETURN EFFECT , SO AC STILL FALLS.

FROM Q_2 ONWARD, AFC ↓ + AVC ↑ = AC ↑

AS DMR. EFFECT OUTWEIGHS SPREADING EFFECT,

SO AC ↑

EFFECT

FALLS.

FROM Q_2 ONWARD, $\underset{\downarrow}{AFC} + \underset{\uparrow}{AVC} = \underset{\uparrow}{AC}$

AS DMR. EFFECT OUTWEIGHS SPREADING EFFECT,

SO AC ↑

References

Frank, R.H. Microeconomics and Behavior. 8th ed. McGraw-Hill, 2010.

Perloff, Jeffery M. Microeconomics, (6th ed.) Boston: Addison - Wesley, 2012.