Production and short-run costs

Connect labor productivity to marginal cost, then separate marginal and average costs.

1 / Define the measures

In the short run, at least one input is fixed. Additional workers may initially improve specialization, then add less output as equipment and workspace become crowded. Falling marginal product can occur while total output still rises.

$$MP_L = \frac{\Delta Q}{\Delta L}, \qquad AVC = \frac{TVC}{Q}, \qquad ATC = \frac{TFC + TVC}{Q}$$

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

TFC is fixed cost; TVC is variable cost; TC is their sum. Average costs are undefined at zero output.

2 / Use a consistent numerical example

Labor is the only variable input. Each worker costs $20 per day, and fixed cost is $40 per day. MP is additional units per worker per day; MC, AVC, and ATC are dollars per unit.

L workers	Q units/day	MP	TVC $/day	TC $/day	Interval MC	AVC	ATC
0	0	-	0	40	-	-	-
1	10	10	20	60	2.00	2.00	6.00
2	30	20	40	80	1.00	1.33	2.67
3	45	15	60	100	1.33	1.33	2.22
4	55	10	80	120	2.00	1.45	2.18
5	60	5	100	140	4.00	1.67	2.33

With a constant wage, **MC = wage / MP**. MP rises from 10 to 20, then falls; interval MC first falls, then rises. At Q = 30, AVC = $1.33 and ATC = $2.67. At Q = 60, they are $1.67 and $2.33.

3 / Explain what moves an average

For either total or variable cost, the new average is a weighted average of the old average and the cost of additional units:

$$A_{\text{new}} = \frac{Q_{\text{old}} A_{\text{old}} + \Delta Q \cdot MC}{Q_{\text{old}} + \Delta Q}$$

MC below the old average pulls it down; MC above it pulls it up. **Rising MC does not immediately imply rising ATC.** For smooth U-shaped curves, MC crosses AVC and ATC at their minima; a discrete table need not show exact crossings.

Short run versus long run: In the long run all inputs can vary. Diseconomies of scale concern rising long-run average cost, not diminishing marginal returns with a fixed input.

Further reading: OpenStax, Principles of Microeconomics 3e, 7.2 - short-run production; 7.3 - short-run costs; 7.5 - long-run costs.