

# Production, Costs, and Economies of Scale

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## Production, Costs, and Economies of Scale

A firm's decisions about how much to produce depend on two things: how much output it can squeeze from its inputs (its production function) and how much that production costs. These two sides are closely linked — the shape of cost curves follows directly from the behaviour of output.

### Short Run vs Long Run

In economics, the short run and long run are not fixed calendar periods. They are defined by whether inputs can be varied.

**Short run:** at least one factor of production is fixed — it cannot be changed regardless of how much the firm wants to produce. For most firms, capital (factories, machinery) is the fixed factor in the short run. Labour and raw materials are variable.

**Long run:** all factors of production are variable. The firm can change the size of its factory, buy new machines, or change the scale of its entire operation. There are no fixed factors.

### The Production Function

The **production function** describes the relationship between inputs and outputs. It shows the maximum output attainable from a given combination of inputs, at a given state of technology.

In the short run, the firm adds units of a variable input (labour) to a fixed input (capital). The result is captured by three measures:

Measure	Definition	Formula
Total Product (TP)	Total output produced by all units of the variable input	—
Average Product (AP)	Output per unit of variable input	$AP = TP \div L$
Marginal Product (MP)	Change in total output from adding one more unit of variable input	$MP = \Delta TP \div \Delta L$

## The Law of Diminishing Returns

As successive units of a variable input are added to a fixed input, the marginal product will eventually begin to fall. This is the **law of diminishing marginal returns** (or diminishing returns).

It applies only in the short run, because in the long run all inputs can be varied.

### Example

A firm has 5 machines (fixed). It hires workers one at a time:

Workers	TP	MP	AP
0	0	—	—
1	14	14	14.0
2	26	12	13.0
3	36	10	12.0
4	44	8	11.0
5	50	6	10.0
6	54	4	9.0
7	56	2	8.0
8	56	0	7.0
9	54	-2	6.0

Marginal product falls from the second worker onwards because each additional worker has less capital to work with. Beyond 8 workers, MP is negative and TP falls — the workers get in each other's way.

## Three Stages of Production

- **Stage 1** — MP is above AP; both MP and AP are rising. Fixed factor is underutilised.
- **Stage 2** — MP falls below AP; AP is declining; MP is still positive; TP is still rising. This is the rational stage for production.
- **Stage 3** — MP is negative; TP is falling. The firm is using too many variable inputs.

A profit-maximising firm produces in Stage 2, where TP is rising but at a decreasing rate, up to the point where  $MP = 0$ .

## Cost Functions

### Fixed and Variable Costs

Cost	Definition	Behaviour
Total Fixed Cost (TFC)	Costs that do not change with output	Constant at every level of output, including zero
Total Variable Cost (TVC)	Costs that vary directly with output	Zero when output is zero; rises as output rises
Total Cost (TC)	$TFC + TVC$	Always above TFC; $TC = TFC$ when $Q = 0$

Examples of fixed costs: rent on factory, insurance premiums, loan repayments, management salaries.

Examples of variable costs: raw materials, hourly labour, electricity for machines, packaging.

### Unit Costs

Cost	Definition	Formula
Average Fixed Cost (AFC)	Fixed cost per unit	$AFC = TFC \div Q$
Average Variable Cost (AVC)	Variable cost per unit	$AVC = TVC \div Q$
Average Total Cost (ATC)	Total cost per unit	$ATC = TC \div Q = AFC + AVC$
Marginal Cost (MC)	Cost of producing one additional unit	$MC = \Delta TC \div \Delta Q$

**AFC always falls as output rises** — the fixed cost is spread over more and more units.

**AVC, ATC, and MC are all U-shaped** in the short run. They fall initially as rising marginal product means each additional unit costs less, then rise as diminishing returns set in.

The relationship between MC and average costs:

- When MC is below ATC, it pulls ATC downward.
- When MC is above ATC, it pulls ATC upward.
- MC crosses ATC and AVC at their minimum points.

**Exam Tip**

A common exam question gives a table of TC values and asks you to calculate MC or ATC.  $MC = \text{change in TC when output rises by 1}$ ;  $ATC = TC \div Q$ . Marginal cost crosses average total cost at its lowest point — use this to check your numbers.

**Example**

From a production schedule:

Q	TC	ATC	MC
0	100	—	—
1	190	190	90
2	270	135	80
3	330	110	60
4	380	95	50
5	450	90	70
6	540	90	90
7	630	90	90
8	800	100	170

ATC reaches its minimum of **90 at  $Q = 5, 6, \text{ and } 7$ . MC crosses ATC at 90 ( $Q = 6$ )**, consistent with the rule that  $MC = ATC$  at the ATC minimum.

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alt="Short-run cost curves: AFC falls continuously; AVC and ATC are U-shaped; MC is U-shaped and intersects AVC and ATC at their minimum points"

caption="Short-run cost curves: MC cuts AVC and ATC at their lowest points"

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## Long-Run Production: Returns to Scale

In the long run, all inputs are variable. When a firm increases all its inputs by the same proportion, its output may respond in three ways:

Returns to Scale	What happens	Effect on LRAC
Increasing returns to scale	Output rises by a larger proportion than inputs	LRAC falls (economies of scale)

Constant returns to scale	Output rises by the same proportion as inputs	LRAC is constant
Decreasing returns to scale	Output rises by a smaller proportion than inputs	LRAC rises (diseconomies of scale)

## Economies of Scale

**Economies of scale** occur when a firm's long-run average cost (LRAC) falls as it expands its scale of production.

### Internal Economies of Scale

These arise from the growth of the individual firm:

Type	Explanation
Technical	Larger machines are often more efficient per unit; indivisibilities mean a large firm can use specialised equipment fully
Marketing	Buying in bulk reduces input costs; advertising costs spread over larger output
Financial	Larger firms can borrow at lower interest rates because they are seen as lower-risk
Managerial	Can hire specialist managers rather than one person doing everything
Risk-bearing	Diversifying across products and markets reduces the impact of any one failure

### External Economies of Scale

These arise from the growth of the entire industry, benefiting individual firms within it. For example, when the aluminium industry expands in a region, specialist suppliers set up nearby, reducing costs for all producers.

## Diseconomies of Scale

**Diseconomies of scale** occur when LRAC rises as the firm grows beyond an optimal size. The main causes are management problems:

- **Communication breakdown** — information becomes distorted as it passes through more layers of management.
- **Coordination problems** — aligning the actions of many specialised departments becomes difficult.
- **Worker alienation** — in very large organisations, workers feel anonymous and less motivated.
- **Slower decision-making** — consensus in large management teams takes longer to reach.
- **Over-specialisation boredom** — highly repetitive roles reduce motivation and job satisfaction.

The **minimum efficient scale (MES)** is the lowest output level at which the firm has fully exploited all economies of scale — where LRAC first reaches its minimum.

### Remember

Economies of scale reduce average cost as output rises. Diseconomies of scale increase average cost as the firm grows too large. The primary cause of diseconomies is management and coordination failure, not diminishing returns (which is a short-run phenomenon).