

## The Production Function

**Short Run (SR):** At least one resource (usually capital) is fixed. Firms can hire more labor but cannot expand plant size.

**Long Run (LR):** All inputs are variable. Firms can adjust capital, labor, and technology, and can enter or exit the market.

### *Total, Marginal, and Average Product*

Term	Abbreviation	Formula	Description
<b>Total Product</b>	TP	—	Total quantity of output produced.
<b>Marginal Product</b>	MP	$\Delta TP \div \Delta \text{Labor}$	Change in output from one additional unit of the variable input.
<b>Average Product</b>	AP	$TP \div \text{Labor}$	Output per unit of the variable input.

### *Law of Diminishing Marginal Returns*

As successive units of a variable input are added to a fixed resource, **MP eventually declines** after a certain point.

Initially, workers specialize → output rises rapidly. Beyond a certain level, overcrowding and limited capital cause each additional worker to contribute less output. Eventually, MP can become zero or negative.

#### Relationship Between MP and AP

- When  $MP > AP \rightarrow AP$  rises.
- When  $MP < AP \rightarrow AP$  falls.
- MP intersects AP at AP's maximum point.

## Three Stages of Production

1. **Stage I: Increasing Returns to Labor**  
TP rises at an increasing rate; MP and AP increase due to specialization.
2. **Stage II: Diminishing Returns**  
TP rises at a decreasing rate; MP declines but remains positive. Firms operate in this range.
3. **Stage III: Negative Returns**  
TP decreases; MP becomes negative. Adding more workers reduces total output.

## Graphing Skills Checklist: Production Curves

1. Label axes: Labor on the horizontal axis, Output on the vertical.
2. Draw TP, MP, and AP curves.
3. Mark where MP peaks and begins to decline (onset of diminishing returns).
4. Indicate where MP crosses AP (maximum AP).
5. Shade the rational production region (Stage II).

## Short-Run Cost Structures

Cost Term	Abbreviation	Formula	Meaning
Fixed Cost	FC	—	Costs that do not change with output (rent, insurance).
Variable Cost	VC	—	Costs that vary with output (wages, materials).
Total Cost	TC	$FC + VC$	Overall cost of production.
Average Fixed Cost	AFC	$FC \div Q$	Declines continuously as output rises.
Average Variable Cost	AVC	$VC \div Q$	Falls, then rises (U-shaped).

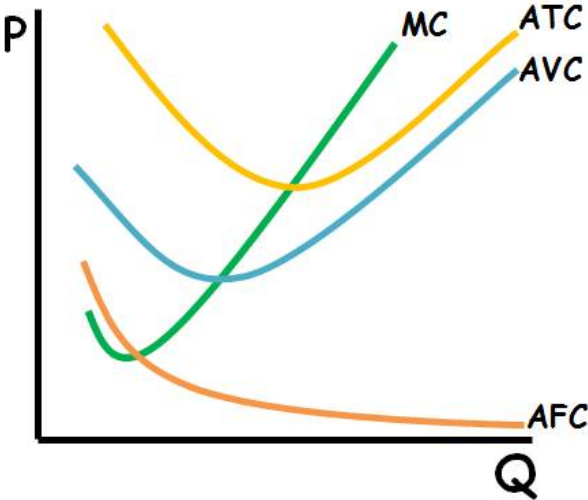
<b>Average Total Cost</b>	ATC	$TC \div Q = AFC + AVC$	Also U-shaped; combines both cost components.
<b>Marginal Cost</b>	MC	$\Delta TC \div \Delta Q$	Additional cost of producing one more unit.

Key Relationships

- MC intersects both AVC and ATC at their minimum points.
- When MP rises, MC falls (inputs are productive).
- When MP falls, MC rises (diminishing returns).
- As output increases, AFC continually declines, narrowing the gap between ATC and AVC.

Graphing Skills Checklist: Short-Run Costs

1. Vertical axis: Cost or Price; horizontal axis: Quantity (Q).
2. Draw **MC**, **AVC**, **ATC**, and **AFC** curves.
3. Label intersections: MC crosses AVC and ATC at their lowest points.
4. Show that AFC is continuously declining.
5. Indicate increasing- and diminishing-returns regions.



# Long-Run Costs and Economies of Scale

In the **long run**, all inputs are variable. Firms can change scale, adopt new technology, and adjust plant size. **LRATC** (Long-Run Average Total Cost) shows the lowest possible ATC at each level of output when the firm can vary all inputs.

## *Economies of Scale*

Occurs when **LRATC decreases** as output increases.

### **Causes:**

1. Labor and managerial specialization.
2. Efficient use of capital and technology.
3. Bulk purchasing and input discounts.
4. Spreading high fixed costs over more output.

## *Constant Returns to Scale*

When output doubles and costs double, **LRATC remains constant**. The firm is operating efficiently but without an additional cost advantage.

## *Diseconomies of Scale*

Beyond a certain size, **LRATC increases** as output expands.

### **Causes:**

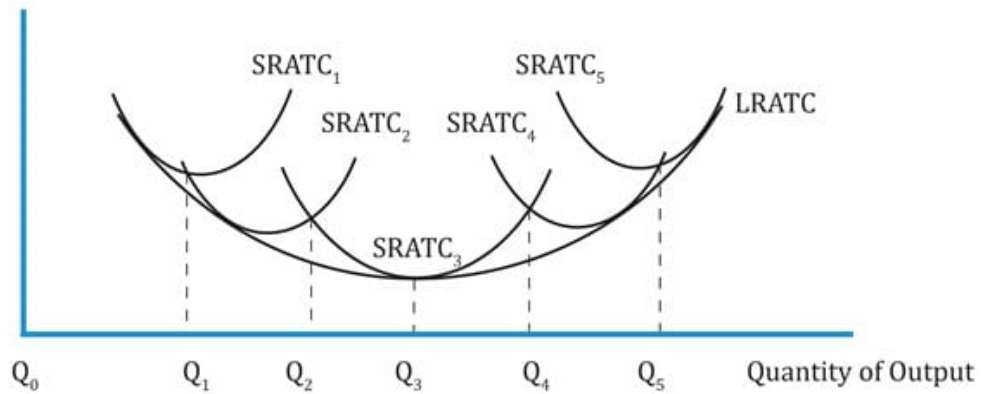
- Coordination and communication problems.
- Bureaucratic inefficiency.
- Resource bottlenecks or overextension.

## *Graphing Skills Checklist: LRATC Curve*

1. Label axes: Cost (vertical) and Quantity (horizontal).
2. Draw LRATC as a smooth U-shaped or L-shaped curve.
3. Identify downward (economies of scale), flat (constant returns), and upward (diseconomies) portions.
4. Label MES at the lowest point.

- Note that LRATC is tangent to a series of SRATC curves at optimal plant sizes.

Per Unit Cost



## Perfect Competition

### *Market Characteristics*

- Many buyers and sellers.
- Homogeneous products (identical goods).
- Easy entry and exit.
- Perfect information and resource mobility.
- Firms are **price takers** — the market determines price.

### *Revenue Relationships*

Term	Abbreviation	Formula	Under Perfect Competition
<b>Total Revenue</b>	TR	$P \times Q$	Total income from sales.
<b>Average Revenue</b>	AR	$TR \div Q$	Equal to price (P).
<b>Marginal Revenue</b>	MR	$\Delta TR \div \Delta Q$	Equal to price (P).

Thus, under perfect competition,  $P = MR = AR$ .

### ***Profit Maximization Rule***

A firm maximizes profit (or minimizes loss) where  $MR = MC$ .

- If  $MR > MC \rightarrow$  increase output.
- If  $MR < MC \rightarrow$  decrease output.
- At  $MR = MC \rightarrow$  optimal output ( $Q^*$ ).

### ***Short-Run Outcomes***

<b>Market Condition</b>	<b>Price–Cost Relationship</b>	<b>Outcome</b>
<b>Economic Profit</b>	$P > ATC$	Firm earns profit.
<b>Break-Even Point</b>	$P = ATC$	Firm earns normal profit.
<b>Economic Loss (Operate)</b>	$AVC < P < ATC$	Firm covers variable cost but not total cost; stays open short run.
<b>Shutdown Point</b>	$P = AVC$	Firm indifferent to operating or shutting down.
<b>Shutdown Decision</b>	$P < AVC$	Firm shuts down to avoid greater losses.

### ***Graphing Skills Checklist***

1. Draw two graphs: market and firm side-by-side.
2. Market graph: Supply (S) and Demand (D) intersect at equilibrium price ( $P_e$ ).
3. Firm graph: Draw **horizontal demand =  $MR = AR = P_e$** .
4. Plot **MC**, **AVC**, and **ATC** curves.
5. Mark  **$MR = MC \rightarrow Q^*$** .

6. Shade **profit** (if  $P > ATC$ ) or **loss** (if  $P < ATC$ ).
7. Mark **shutdown point** where  $P = \min AVC$ .

## Long-Run Adjustments and Equilibrium

### *Entry and Exit Dynamics*

- **Economic Profit:** attracts new firms → market supply increases → price falls → profits eliminated.
- **Economic Loss:** causes firms to exit → supply decreases → price rises → losses eliminated.
- This continues until firms earn **normal profit (zero economic profit)**.

### *Long-Run Equilibrium*

In the long run, a perfectly competitive firm satisfies:

$$P = MR = MC = \min ATC$$

At this point:

- Firms produce at the lowest possible cost.
- No incentive for entry or exit.
- Each firm earns zero economic profit (normal profit).

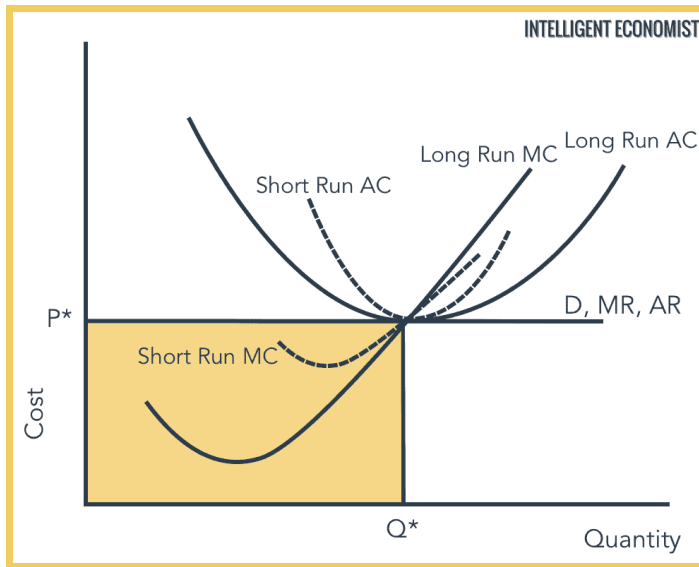
### *Efficiency Conditions*

- **Allocative Efficiency:**  $P = MC$  → society's resources are used where marginal benefit equals marginal cost.
- **Productive Efficiency:**  $P = \text{minimum ATC}$  → goods produced at the lowest cost.  
Perfect competition achieves both.

### *Graphing Skills Checklist: Long-Run Equilibrium*

1. Draw market and firm diagrams together.
2. Market: S and D intersect at  $P_e$  and  $Q_e$ .
3. Firm:  $P = MR = MC = \min ATC$ .
4. The firm's ATC curve is tangent to the price line.
5. No shaded profit or loss region — firm earns normal profit.

6. Label both efficiency conditions ( $P = MC$  and  $P = \min ATC$ ).



## Key Formulas and Quick Reference

Concept	Formula	Notes
<b>Total Revenue (TR)</b>	$P \times Q$	—
<b>Total Cost (TC)</b>	$FC + VC$	—
<b>Profit (<math>\pi</math>)</b>	$TR - TC$	Economic profit if $> 0$
<b>Average Fixed Cost (AFC)</b>	$FC \div Q$	Always decreases
<b>Average Variable Cost (AVC)</b>	$VC \div Q$	U-shaped
<b>Average Total Cost (ATC)</b>	$TC \div Q = AFC + AVC$	U-shaped

<b>Marginal Cost (MC)</b>	$\Delta TC \div \Delta Q$	Intersects AVC & ATC minima
<b>Marginal Product (MP)</b>	$\Delta TP \div \Delta \text{Labor}$	—
<b>Average Product (AP)</b>	$TP \div \text{Labor}$	—

### Common Graphing Mistakes

1. Forgetting to label all axes and curves clearly.
2. Misplacing intersections (MC must cut ATC/AVC at their minimums).
3. Confusing TR and TC areas with profit/loss rectangles.
4. Drawing MP and MC in the same graph — they belong to different spaces (production vs. cost).
5. Using curved demand for a perfectly competitive firm (should be perfectly elastic).