LM 1 - Topics in Demand and Supply Analysis

CFA Level 1 - Economics

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Learning Outcomes

The candidate should be able to:

1. calculate and interpret price, income, and cross-price elasticities of demand and describe factors that affect each measure;
2. compare substitution and income effects;
3. contrast normal goods with inferior goods;
4. describe the phenomenon of diminishing marginal returns;
5. determine and interpret breakeven and shutdown points of production;
6. describe how economies of scale and diseconomies of scale affect costs.

Overview

Overview

Demand Function

- A **demand function** is a mathematical expression that attempts to capture the variables that influence the demand for a good or service.
- These variables include for example own price, income level, other goods' price:

$$Q_x^d = f(P_x, I, P_y)$$

- Often economists use simple linear functions as approximations.
- Example of Gazoline demand function:

$$Q_x^d = 84.5 - 6.39P_x + 0.25I - 2P_y$$

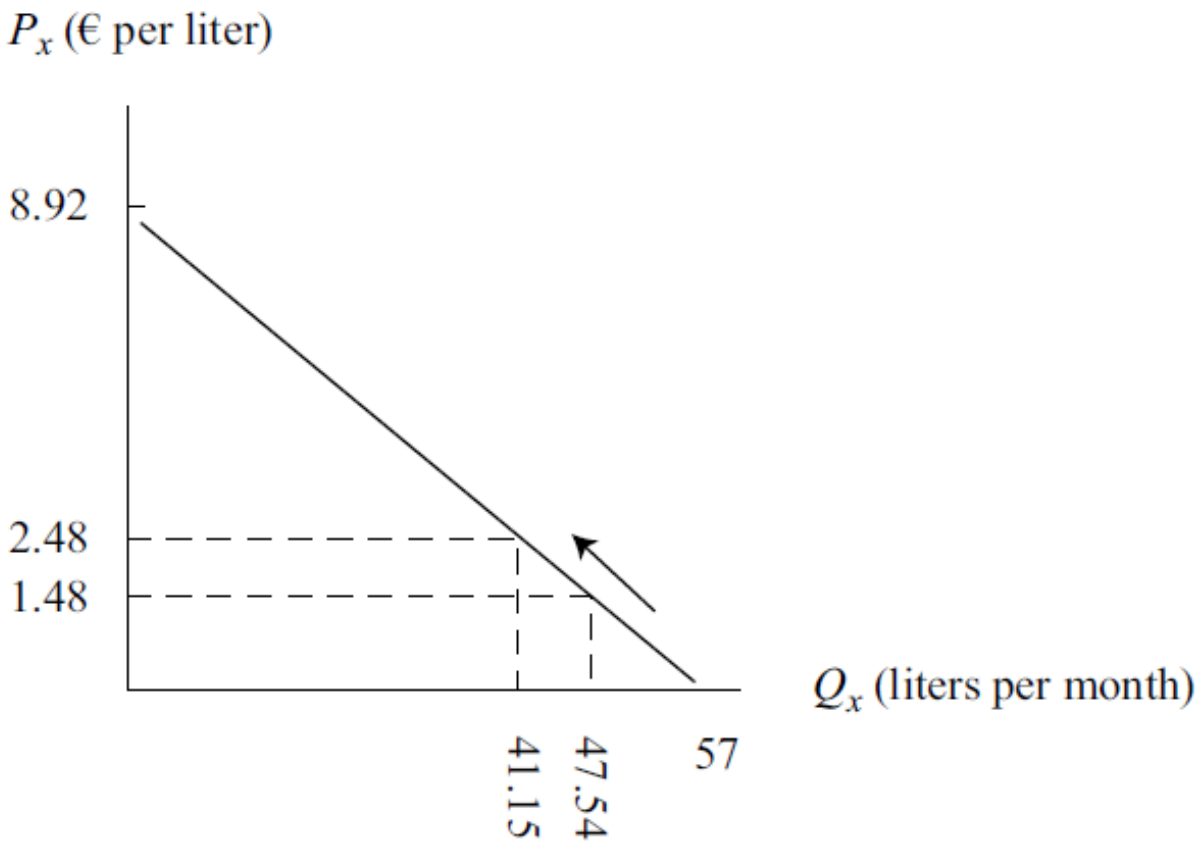
- We can focus on one of the variables by keeping the others constant. In our example, setting $I = 50$ and $P_y = 20$ yields

$$Q_x^d = 57 - 6.39P_x$$

- Solving for P_x as a function of Q_x^d yields the **inverse demand function**:

$$P_x = 8.92 - 0.156Q_x^d$$

Demand Curve



- The demand curve is a graphical depiction of the (inverse) demand function.
- Law of Demand: demand curves are negatively sloped.

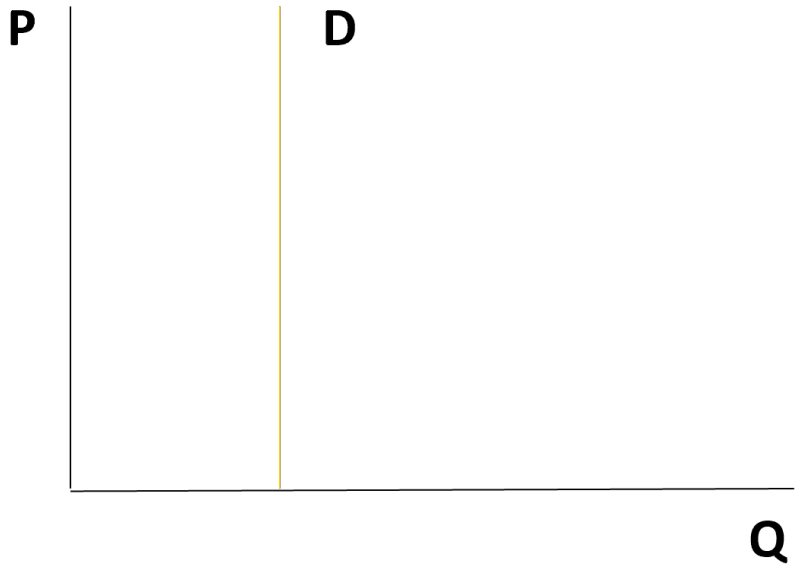
Own-Price Elasticity of Demand

- **Own-Price Elasticity of Demand** is a measure of how the quantity demanded changes (in %) in response to a (1%) change in its price:

$$\text{Own-Price Elasticity} = \frac{\%\text{ change in quantity demanded}}{\%\text{ change in price}}$$

- The demand is said to be **elastic** when it reacts more than one-to-one to a change in price, i.e. $|\text{Own-Price Elasticity}| > 1$.
- The demand is said to be **inelastic** if it reacts less than one-to-one to a change in price, i.e. $|\text{Own-Price Elasticity}| < 1$.
- The demand is said to be **unit elastic** if it reacts one-to-one to a change in price, i.e. $|\text{Own-Price Elasticity}| = 1$.

Extremes of Price Elasticity



(a) Perfectly inelastic demand (elasticity = 0)

(b) Perfectly elastic demand (elasticity = ∞)

Factors Affecting Price Elasticity of Demand

- Availability and closeness of substitutes.
  - Few or no substitutes $\rightarrow$ Demand is relatively inelastic.
  - One or more substitutes $\rightarrow$ Demand is relatively elastic.
- Portion of income spent on a good.
  - The larger the portion of income that is spent on a good, the more elastic the demand for that good will be.
- Time allowed to respond to change in price.
  - Price elasticity tends to be greater, the longer the time elapsed since the price change.
- Discretionary or non-discretionary
  - The more a good is seen as a necessity, the less elastic its demand is likely to be.

Income Elasticity of Demand

- **Income Elasticity of Demand** is a measure of how the quantity demanded changes (in %) in response to a (1%) change in consumer income:

$$\text{Income Elasticity} = \frac{\%\text{ change in quantity demanded}}{\%\text{ change in income}}$$

- Income elasticity can be positive, negative or zero.
- Normal goods: An increase in income will lead to an increase in demand, i.e. Income Elasticity > 0.
- Inferior goods: An increase in income will lead to a decrease in demand, i.e. Income Elasticity < 0.
- Changes in income shift the demand curve.

Cross-Price Elasticity of Demand

- **Cross-Price Elasticity of Demand** is a measure of how the quantity demanded of one good changes (in %) in response to a (1%) change in the price of another good:

$$\text{Cross-Price Elasticity} = \frac{\%\text{ change in quantity demanded of good 1}}{\%\text{ change in price of good 2}}$$

- Substitute goods: An increase in the price of good 2 will lead to an increase in the demand of good 1, i.e. Cross-Price Elasticity > 0.
- Complement goods: An increase in the price of good 2 will lead to an decrease in the demand of good 1, i.e. Cross-Price Elasticity < 0.

Income Effect vs. Substitution Effect

- When the price of a good falls, that good becomes relatively less costly compared to other goods $\rightarrow$ **substitution effect** shifts consumption towards more of that good (always positive)
- When the price of a good falls, total expenditure decreases (higher purchasing power) $\rightarrow$ **income effect** can result in more or less consumption of the good.
- Three possible cases for the net effect of a decrease in price:
  1. Both substitution and income effects are positive $\rightarrow$ Consumption of the good will increase.
  2. Income effect is negative but not large enough to dominate substitution effect $\rightarrow$ Consumption of the good will increase.
  3. Income effect is negative and large enough to dominate substitution effect $\rightarrow$ Consumption of the good will decrease.

Special Types of Goods

- Veblen good: A good for which a higher price can make it more desirable (e.g. luxury goods). $\rightarrow$ The demand curve can be upward sloping over a certain price range.
- Giffen good: An inferior good for which the negative income effect outweighs the positive substitution effect $\rightarrow$ the demand curve is upward sloping. (e.g. potatoes during the Irish Great Famine)

Overview

Production and Costs

- Cost of production depends on the amount of inputs (factors of production) and input prices.
- Examples of inputs: employee hours, machine hours, raw materials, etc.
- To keep things simple, economists typically focus on two inputs: labor, L, and capital, K.
- In this simple case, total cost is given by

$$TC = wL + rK$$

- Input productivity measures output per unit of input.
- Cost minimization and profit maximization require maximizing productivity.

Total, Average and Marginal Product

- Total product: sum of the output from all inputs during a period of time, typically denoted Q.
- Average product: total product divided by the quantity of a given input, e.g. Q/L.
- Marginal product: the additional production output resulting from a one unit increase in input keeping other inputs constant.
- Marginal product of labor:

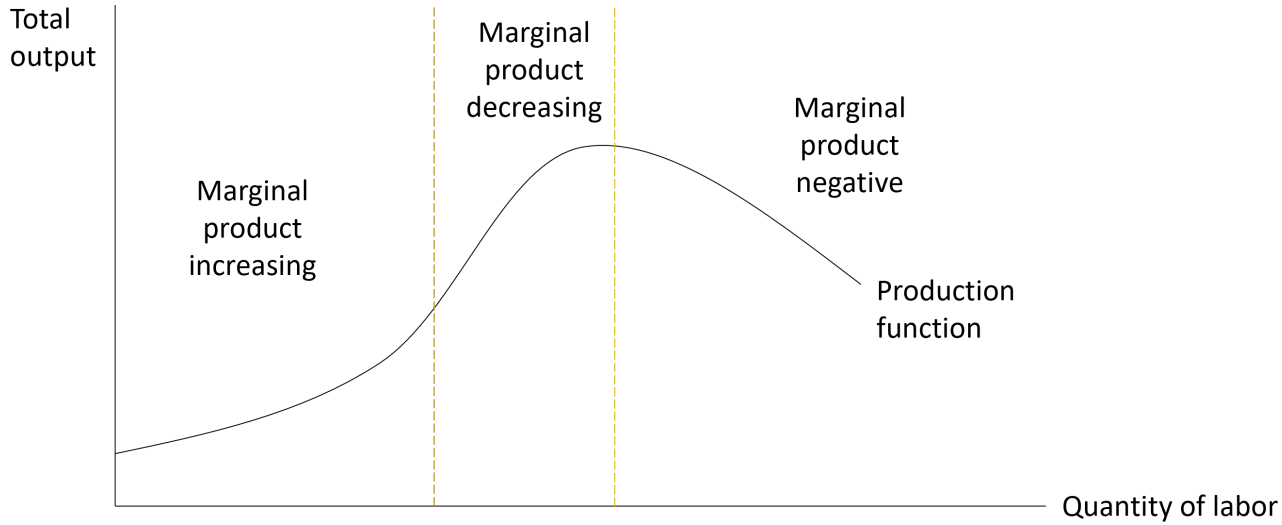
$$MPL = \frac{\Delta Q}{\Delta L}$$

- Diminishing marginal returns occur when the addition of an incremental unit of one production input, keeping other inputs constant, results in a progressively smaller increase in output.

Total, Average and Marginal Product: Example

	Output (Q)	Number of Worker Hours (L)	Average Product of Labor (AP_L)
Company A	100,000	100	1,000
Company B	180,000	200	900
Company C	200,000	250	800

Increasing vs. Diminishing Marginal Returns



- Increasing marginal returns occur when the addition of an incremental unit of one production input, keeping other inputs constant, results in a progressively larger increase in output.
- Diminishing marginal returns occur when the addition of an incremental unit of one production input, keeping other inputs constant, results in a progressively smaller increase in output.

Total, Average and Marginal Product: Example

Labor (L)	Total Product (Q_L)	Average Product (AP_L)	Marginal Product (MP_L)
0	0	—	—
1	100	100	100
2	210	105	110
3	300	100	90
4	360	90	60
5	400	80	40
6	420	70	20
7	350	50	–70

Economic Profit vs. Accounting Profit

- Economic Profit = Total Revenue - Economic Cost.
- Accounting Profit = Total Revenue - Accounting Cost.
- Economic Cost is forward looking and relies on the concept of opportunity cost.
- Opportunity cost is the benefit foregone by not implementing the next best alternative.
- Economic Cost includes shareholders' required return.

Profit Maximization

- Firm's management objective is to maximize shareholders' wealth.
- This is done by maximizing economic profit.
- Two very important concepts for profit maximization:
  - Marginal revenue;
  - Marginal cost.

Marginal Revenue

- Marginal revenue (MR) is the additional revenue the firm realizes from the decision to increase output by one unit per time period:

$$MR = \frac{\Delta TR}{\Delta Q} = \frac{\Delta(P \times Q)}{\Delta Q}$$

- It's easy to show that for a very small ΔQ we can write:

$$MR \approx \frac{P \times \Delta Q + \Delta P \times Q}{\Delta Q} = P + \frac{\Delta P}{\Delta Q} Q$$

- Relationship between MR and P depends on the slope of the demand curve facing the firm $\frac{\Delta P}{\Delta Q}$.
- This in turn depends on the structure of market competition between firms.

Marginal Revenue

- Under perfect competition, firm faces perfectly elastic (firm-specific) demand curve $\Rightarrow \frac{\Delta P}{\Delta Q} = 0$.
- In this case firm can sell as much as it wants at the market price $\Rightarrow MR = P$.
  - Setting price above market price implies no sales.
  - Firm has no incentive in selling below market price.
- Under imperfect competition, firm faces negatively sloped (market) demand curve $\Rightarrow \frac{\Delta P}{\Delta Q} < 0$.
- Firm must lower the price in order to sell an additional unit $\Rightarrow MR < P$.

Marginal Cost

- Marginal cost (MC) is the increase to total cost resulting from the firm's decision to increase output by one additional unit per time period:

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

- Economists usually distinguish between short-run marginal cost (SMC) and long-run marginal cost (LMC).
- Over the short run, labor (L) is assumed to be variable while capital (K) is assumed to be constant.
- Over the long run, all inputs are assumed to be variable.

Marginal Cost

- When the change in output is very small, SMC can be written as:

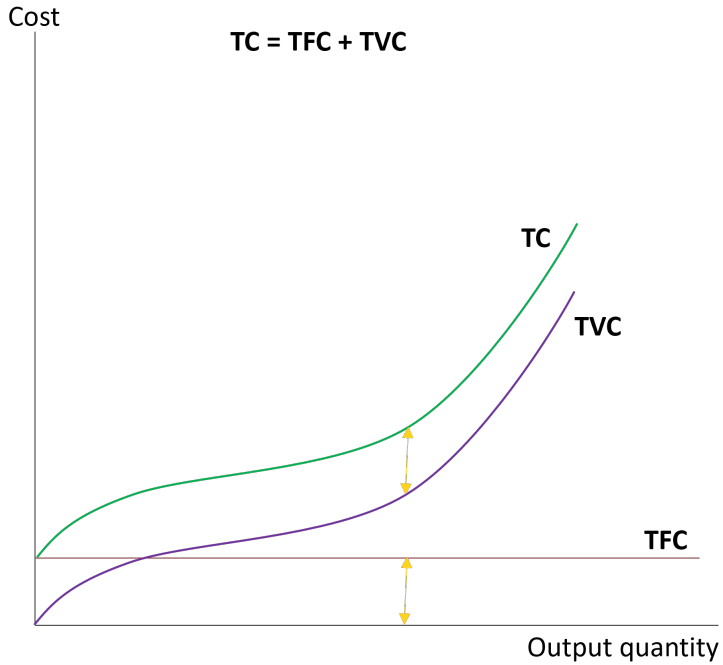
$$SMC \approx \frac{w}{MPL}$$

- SMC is decreasing in labor productivity and increasing in the wage rate.
- Increasing marginal returns to labor imply a decreasing SMC.
- Diminishing marginal returns to labor imply an increasing SMC.

Profit Maximization

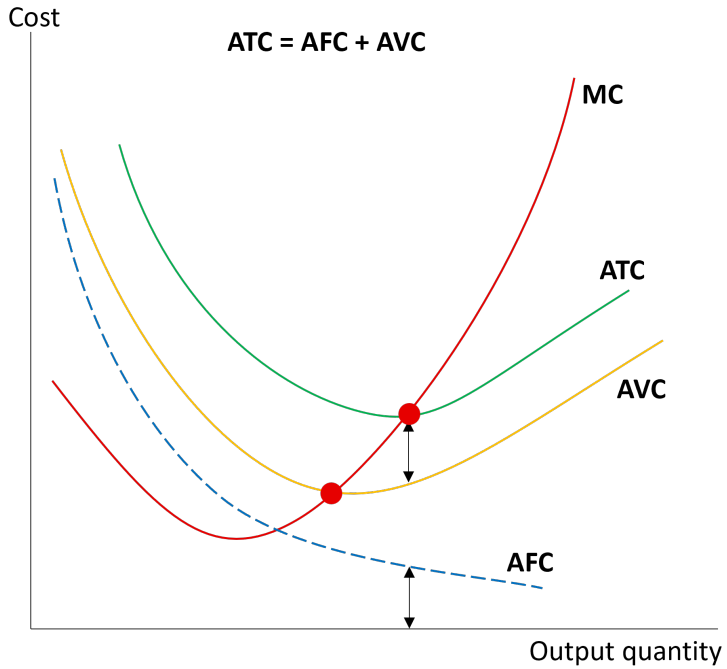
- What is the quantity of production that maximizes profit?
- An additional unit of output increases profit if $MR > MC \Rightarrow$ Firm should increase output.
- An additional unit of output reduces profit if $MR < MC \Rightarrow$ Firm should lower output.
- A profit maximizing firm should increase output until $MR = MC$ (first-order condition) and MC is not falling (second-order condition).

Total Costs



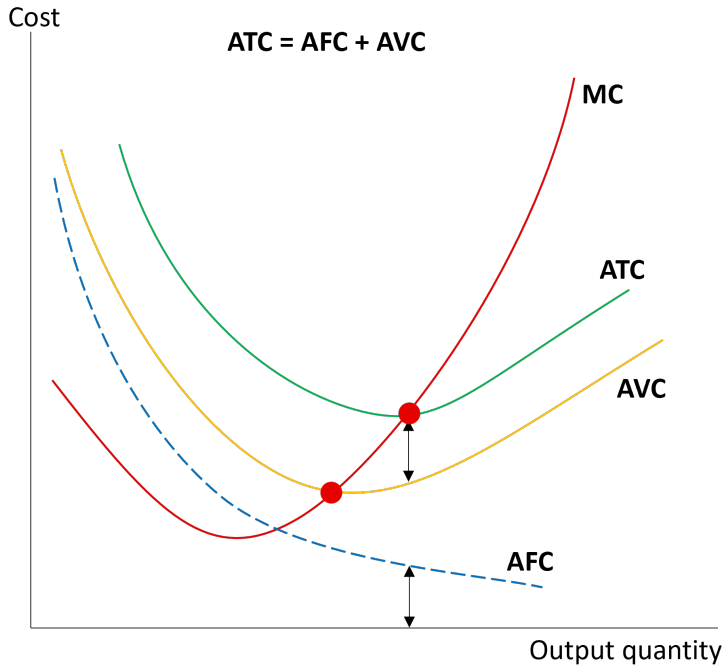
- Total fixed cost (TFC): costs that do not vary with the quantity of output and cannot be avoided over the period of analysis.
- Total variable cost (TVC): costs that vary with output over the period of analysis.
- Total cost (TC): the sum of fixed and variable costs.

Average Costs



- Average fixed cost (AFC) $= \frac{\text{TFC}}{\text{Q}}$
- Average variable cost (AVC) $= \frac{\text{TVC}}{\text{Q}}$
- Average total cost (ATC) $= \frac{\text{TC}}{\text{Q}} = \text{AFC} + \text{AVC}$

Relationship between Production and Costs

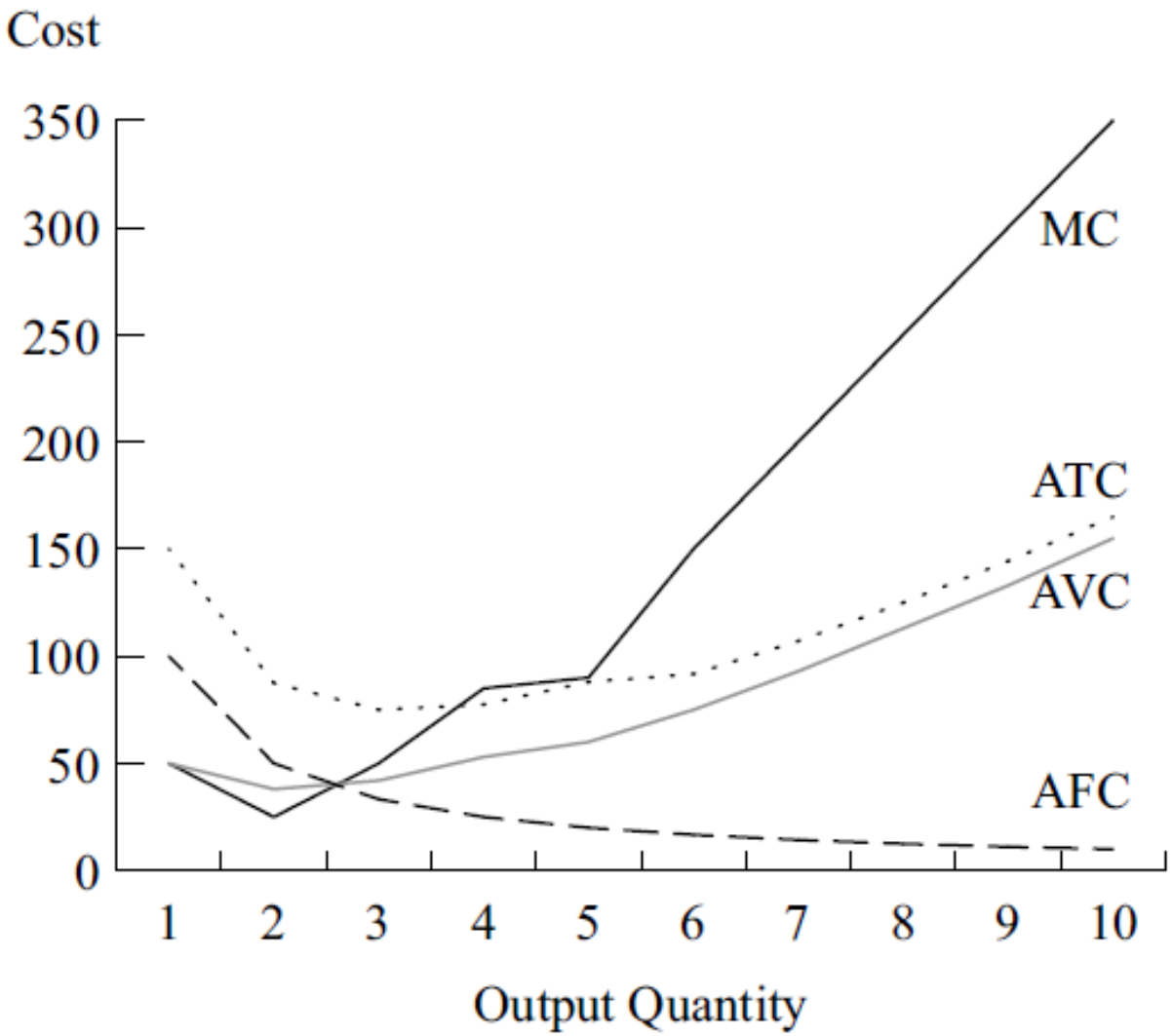


- As output increases, AFC decreases as TFC are spread over a larger quantity.
- MC intersects both ATC and AVC in their minimum points.
- When MC is below AVC, AVC is decreasing. When MC is above AVC, AVC is increasing.

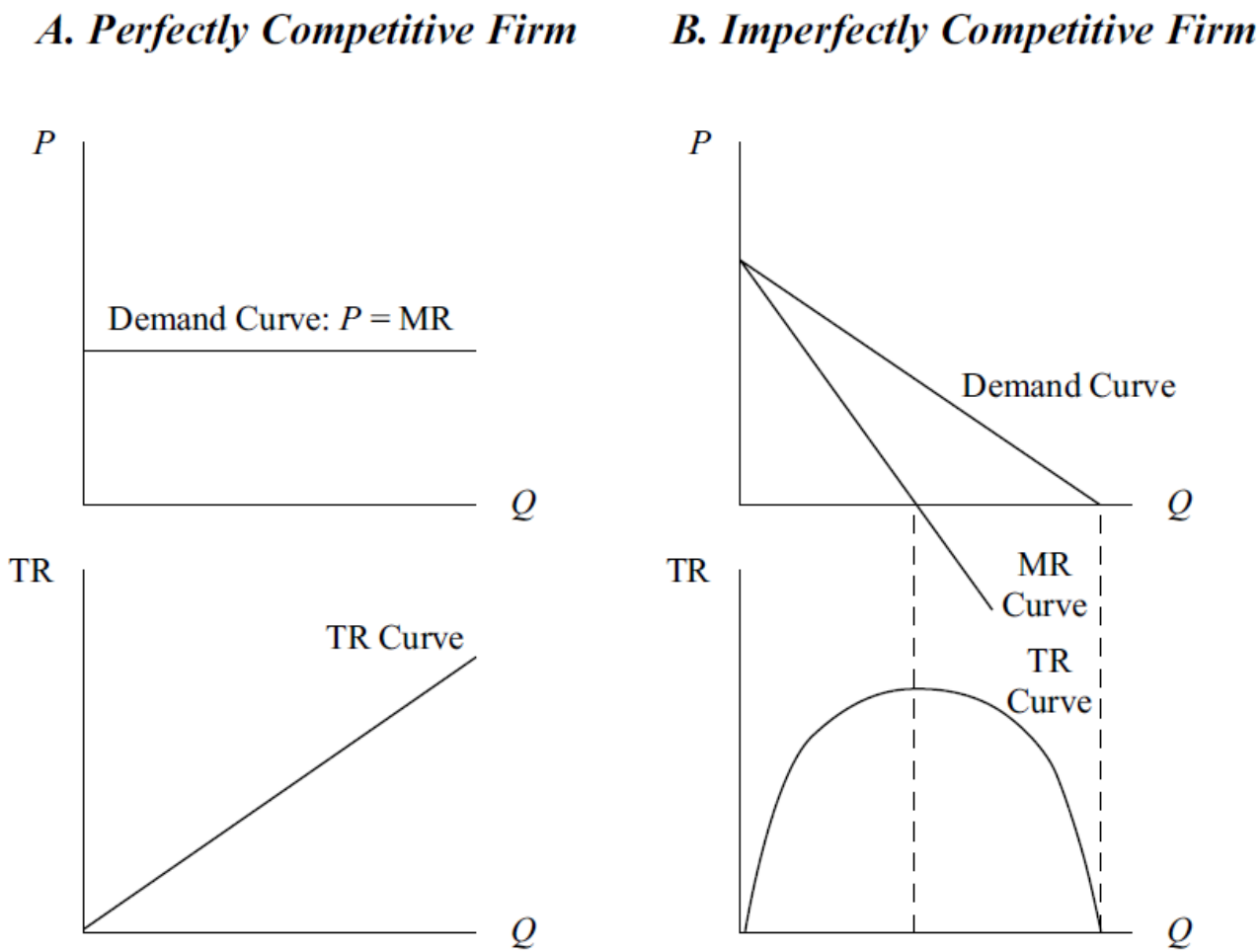
Relationship between Production and Costs: Example

Quantity (Q)	TFC[a]	AFC	TVC	AVC	TC	ATC	MC
0	100	—	0	—	100	—	—
1	100	100.0	50	50.0	150	150.0	50
2	100	50.0	75	37.5	175	87.5	25
3	100	33.3	125	41.7	225	75.0	50
4	100	25.0	210	52.5	310	77.5	85
5	100	20.0	300	60.0	400	80.0	90
6	100	16.7	450	75.0	550	91.7	150
7	100	14.3	650	92.9	750	107.1	200
8	100	12.5	900	112.5	1,000	125.0	250
9	100	11.1	1,200	133.3	1,300	144.4	300
10	100	10.0	1,550	155.0	1,650	165.0	350

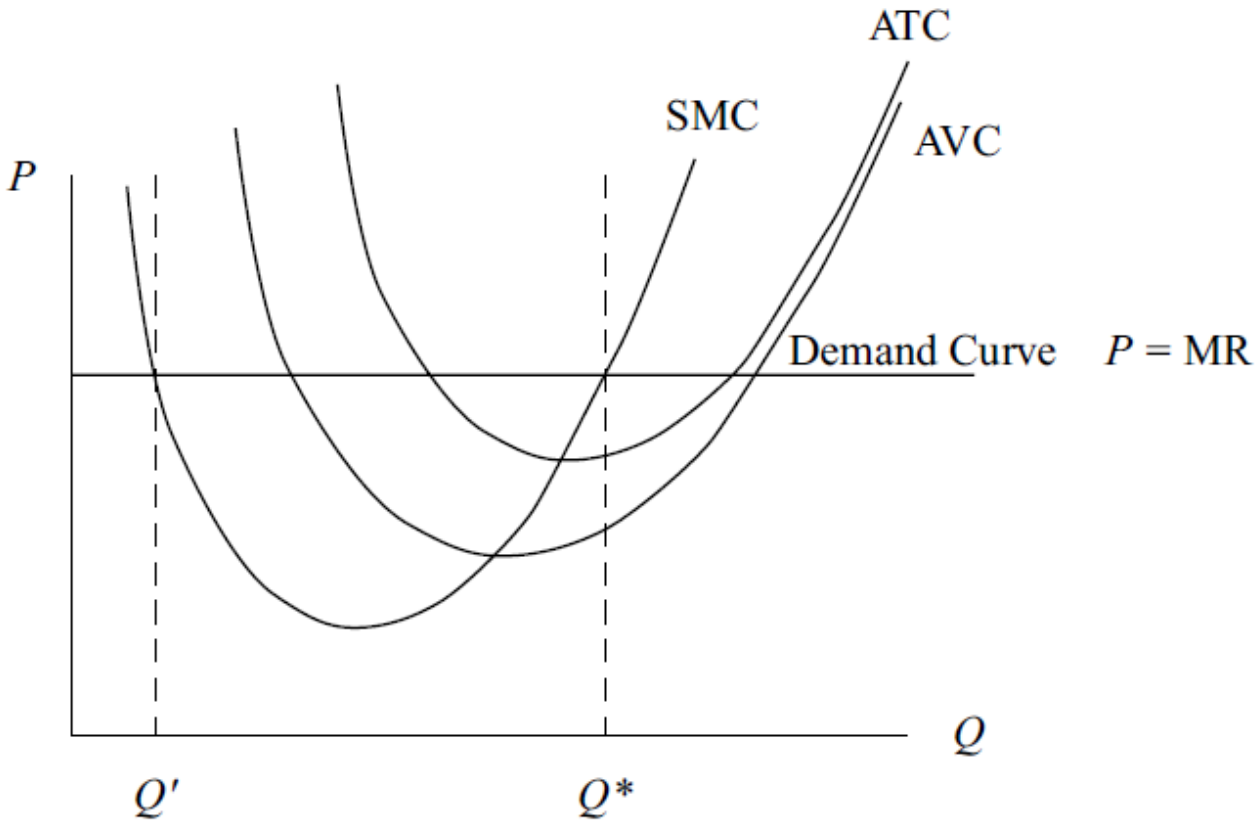
Relationship between Production and Costs: Example



Perfect vs. Imperfect Competition

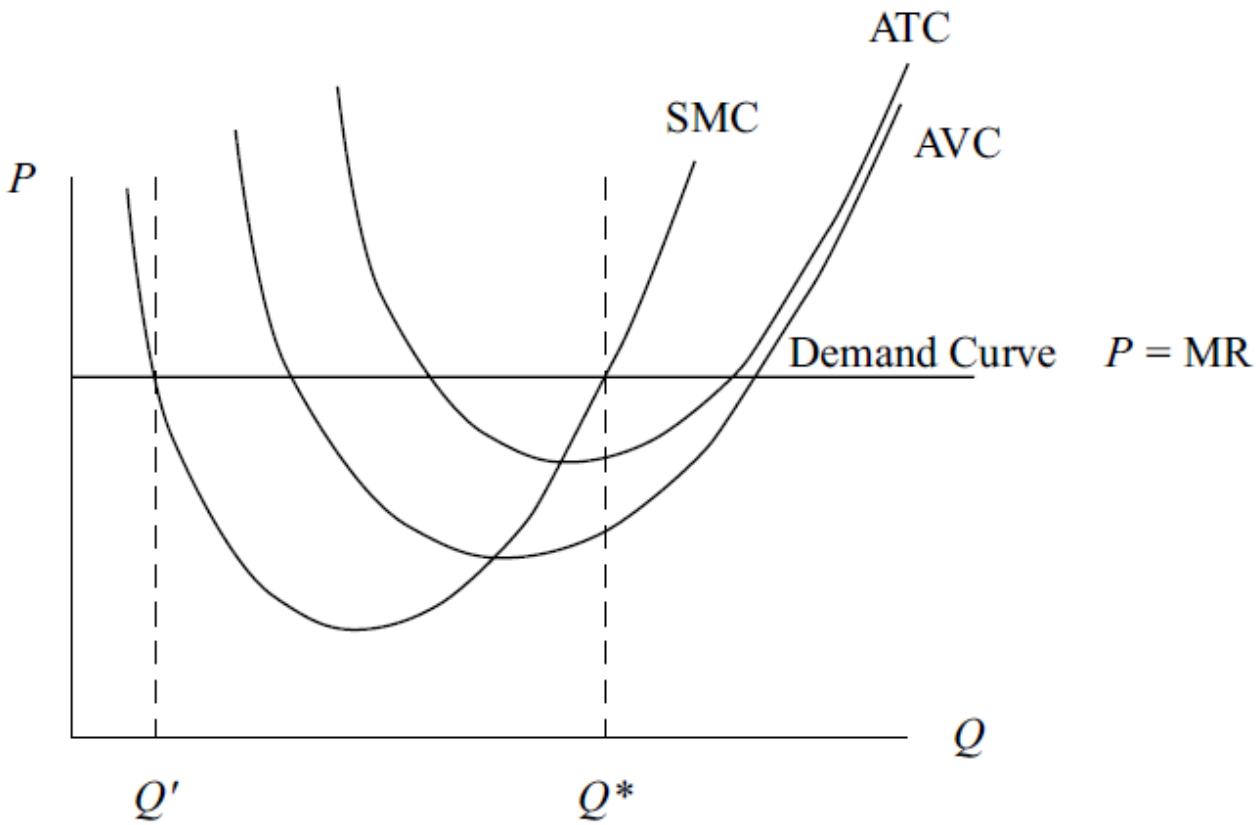


Profit Maximization under Perfect Competition



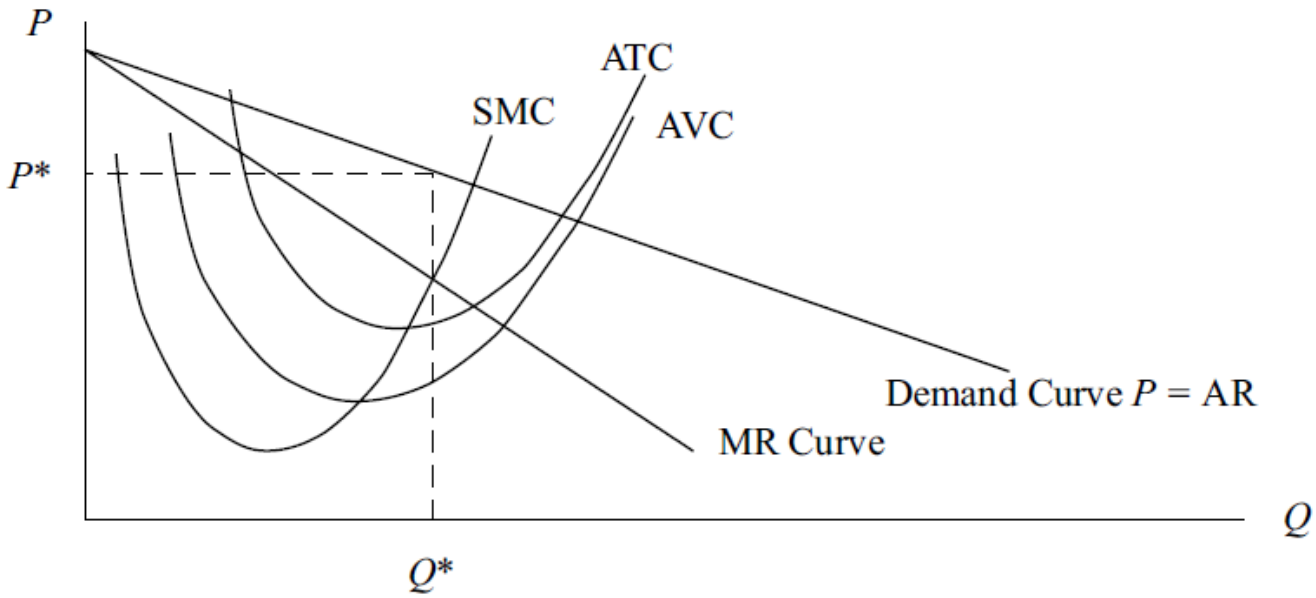
- Firm maximizes profits by producing Q^* where $SMC = MR = P$ and SMC is increasing.
- Shifts in the demand curve result in changes in Q^*.

Profit Maximization under Perfect Competition



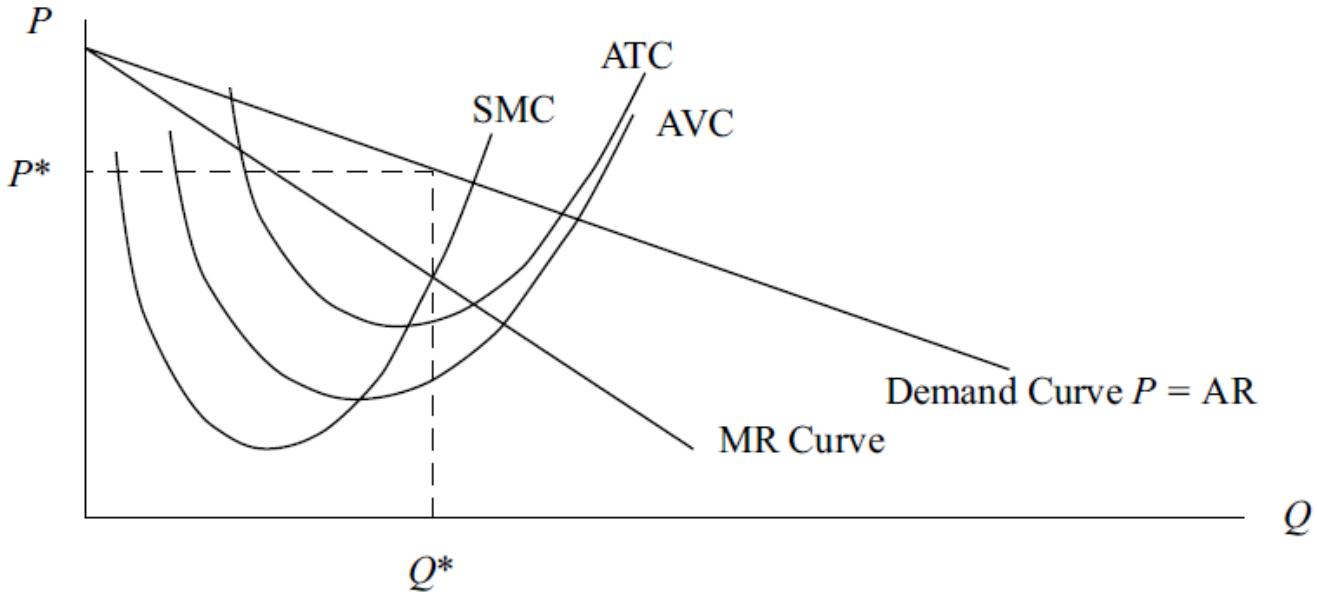
- In the short run, firm is earning a positive economic profit at Q^* since $ATC < P$.
- In the long run, entry of new competitors will shift demand curve down to the level where $P = ATC = MC \Rightarrow$ economic profit $= 0$.

Profit Maximization under Imperfect Competition



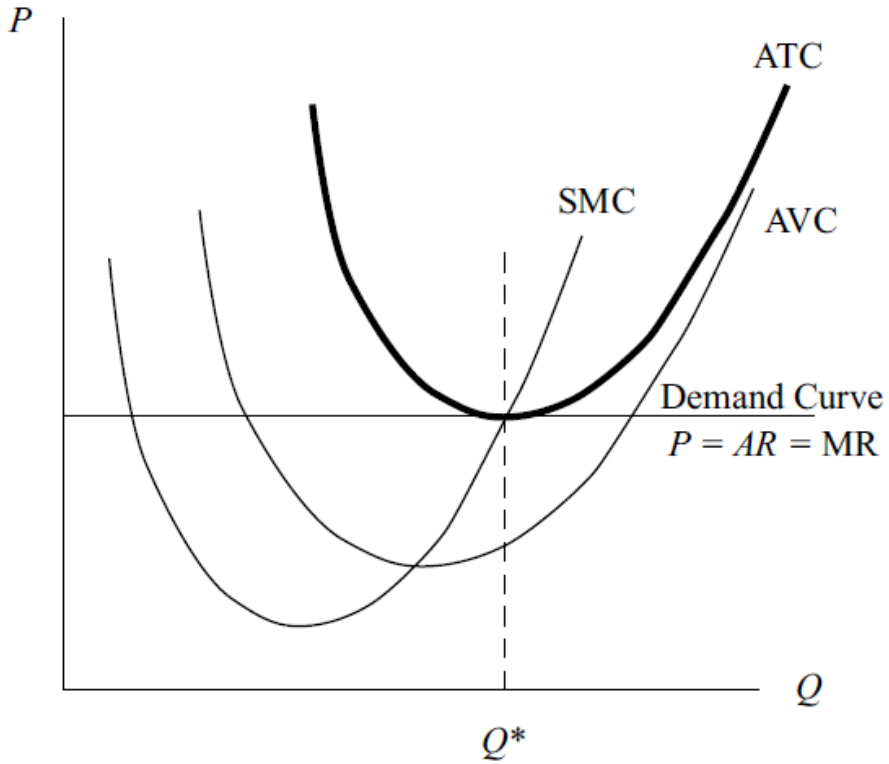
- Firm maximizes profits by producing Q^* where $SMC = MR$ and SMC is increasing.
- Once Q^* is determined, the optimal price P^* is determined on the demand curve.
- Shifts in the demand curve result in shifts in MR curve and changes in Q^*.

Profit Maximization under Imperfect Competition



- Monopolist firm is earning a positive economic profit at Q^* since $ATC < P^*$.
- Barriers to entry prevent new competitors from entering the market and keep economic profits positive in the long run.

Breakeven under Perfect Competition



- A firm is said to **breakeven** if $TR = TC \Rightarrow AR = ATC$.
- At the breakeven point, the firm covers its economic costs (accounting costs + implicit opportunity costs) and just earns a normal profit (zero economic profits).

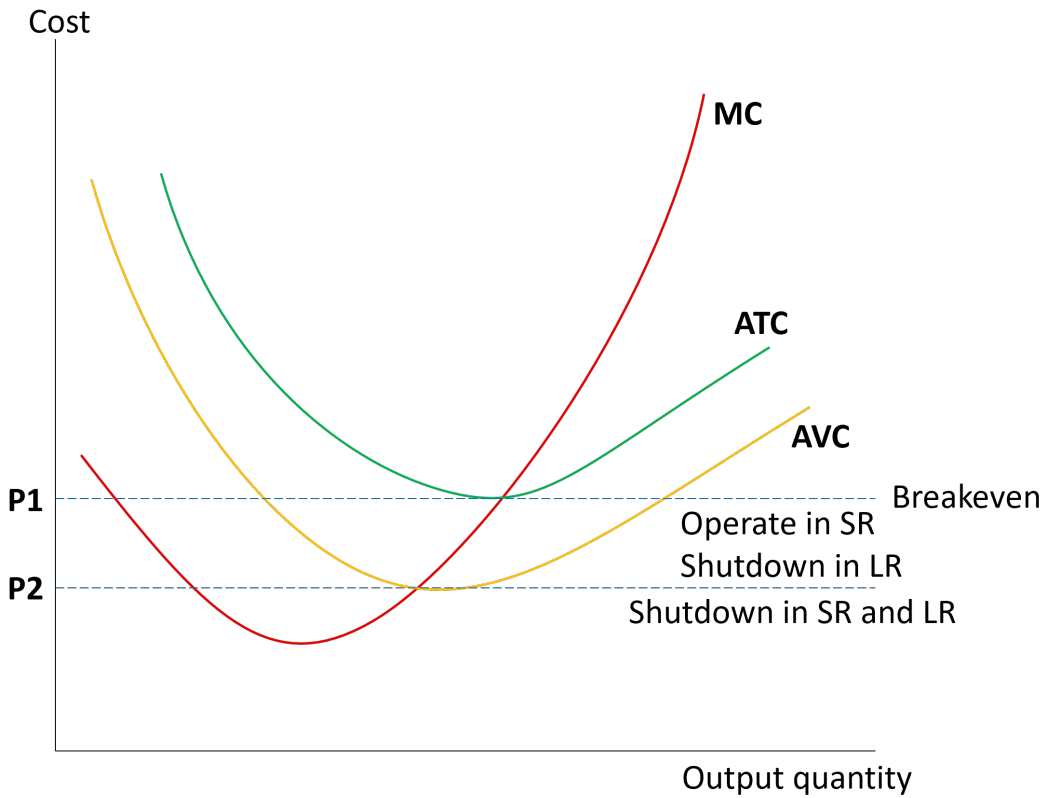
Shutdown and Breakeven Under Perfect Competition

- We need to distinguish between breakeven analysis in the **short run (SR)** and in the **long run (LR)**.
  - Short run (SR): time period over which some factors of production (costs) remain fixed.
  - Long run (LR): time period over which all factors of production (costs) are considered variable i.e. can be adjusted.
- In the LR, a firm will not operate if it cannot earn at least zero economic profit.
- In the SR, a firm might find it advantageous to operate even if it cannot earn at least zero economic profits.
- The difference stems from the fact that fixed costs are considered "sunk costs" in the SR.

Short Run Example

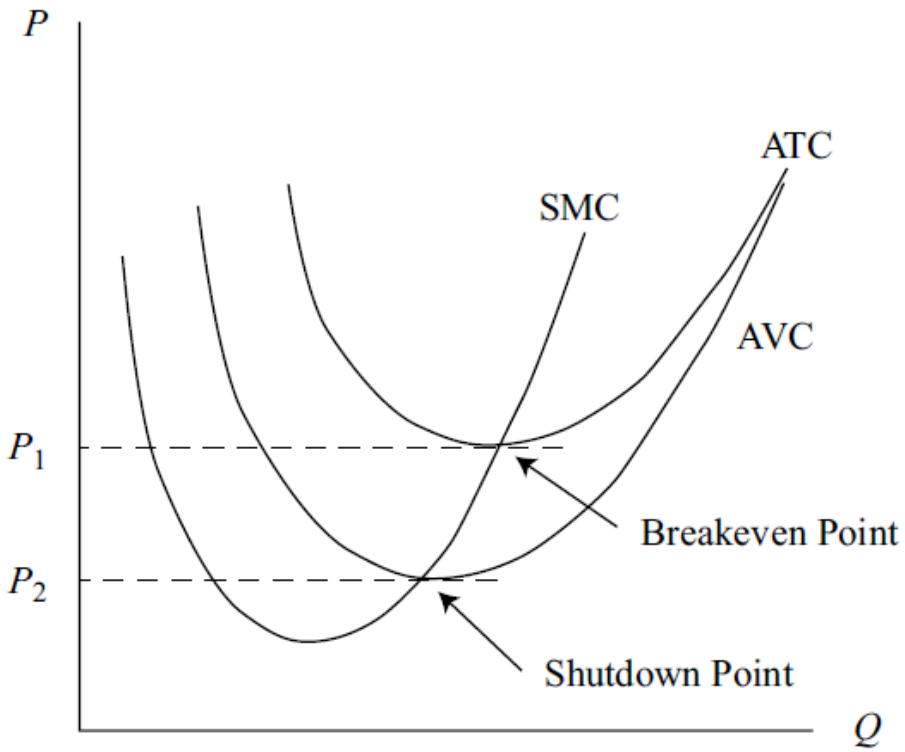
- Firm is producing 100 units sold at a price of 4\$.
- TR = 400\$.
- Assume at $Q = 100$, $AVC = 3.75$ and $AFC = 3.25$
- $ATC = AVC + AFC = 7$
- Firm is earning negative economic profits of 300\$ (economic loss).
- Should the firm shut down immediately?
- Assume fixed cost is unavoidable: $TFC = 325$.
- If firm shuts down without producing $\Rightarrow$ Economic profit = -325\$.
- If the firm continues to operate $\Rightarrow$ Economic profit = -300\$.
- The loss is lower because revenues from production cover TVC and part of TFC.
- The key point here is that TFC for the period is already incurred and the firm can cover part of it by operating.

Shutdown and Breakeven Under Perfect Competition



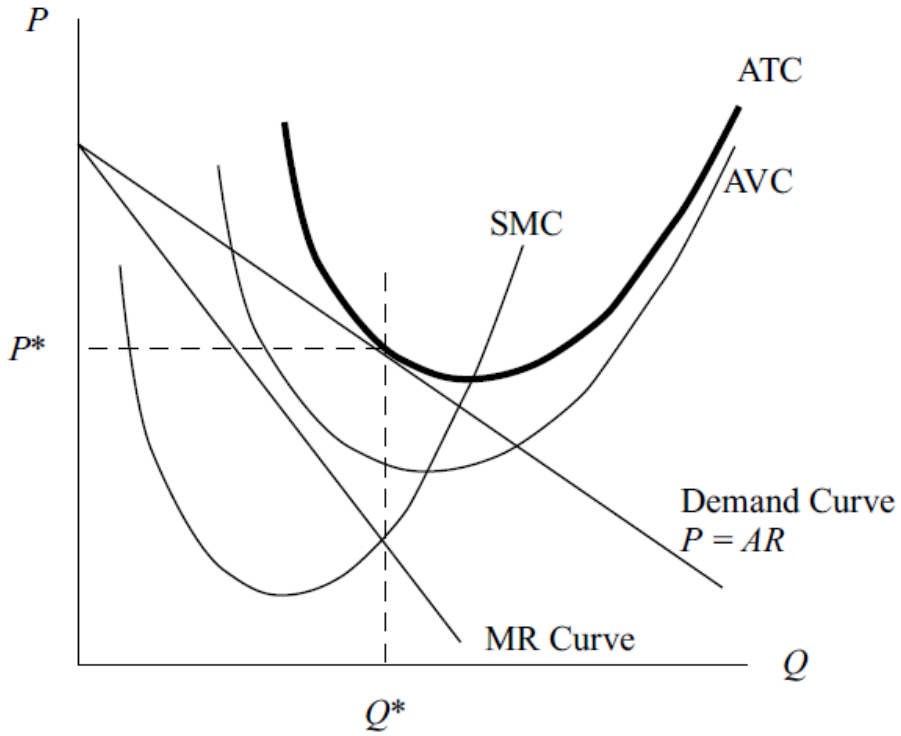
- If P $\geq$ ATC: the firm should operate in both SR and LR.
- If P $\geq$ AVC but P $<$ ATC: the firm should operate in SR but exit in LR.
- If P $<$ AVC: the firm should shutdown in SR and exit in LR.

Shutdown and Breakeven Under Perfect Competition



- Breakeven point = minimum ATC.
- Shutdown point = minimum AVC.

Shutdown and Breakeven Under Imperfect Competition



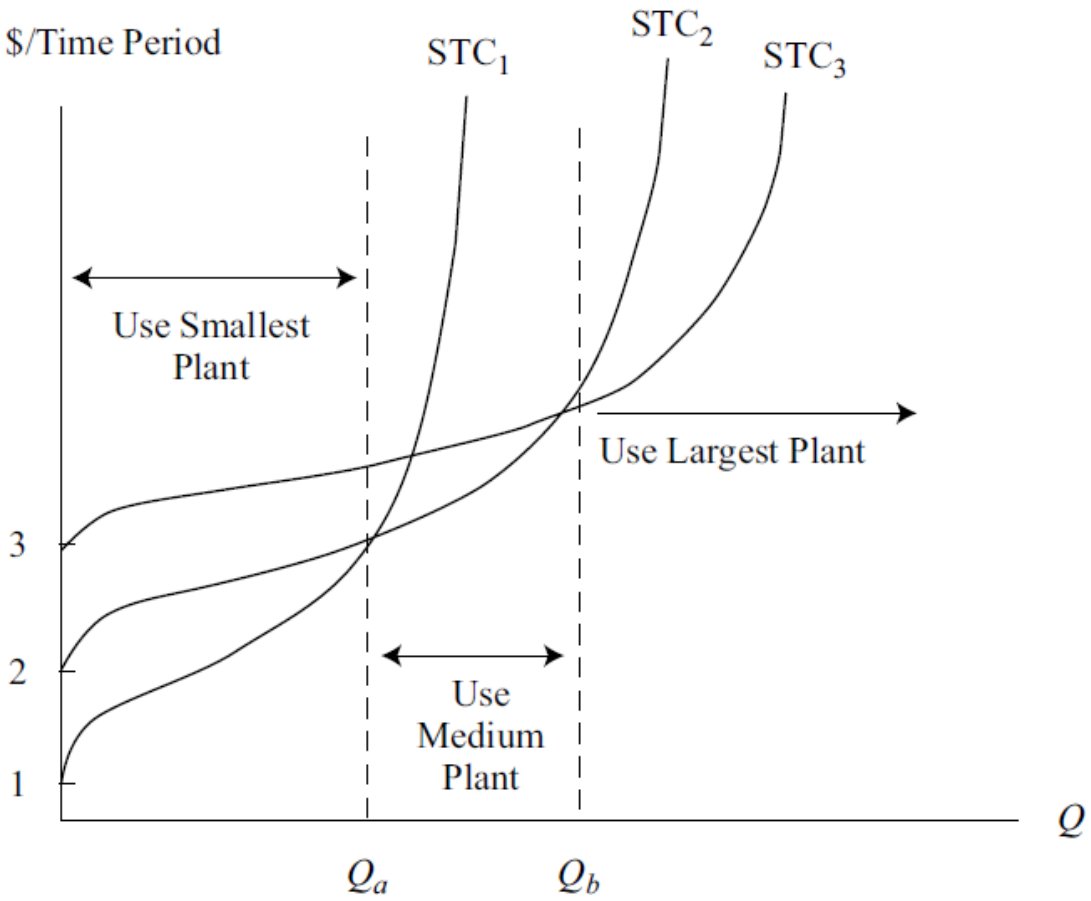
- If P $\geq$ ATC: the firm should operate in both SR and LR.
- If P $\geq$ AVC but P $<$ ATC: the firm should operate in SR but exit in LR.
- If P $<$ AVC: the firm should shutdown in SR and exit in LR.

Shutdown and Breakeven Under Imperfect Competition

- Analysis can also be done in terms of TR, TC and TVC.

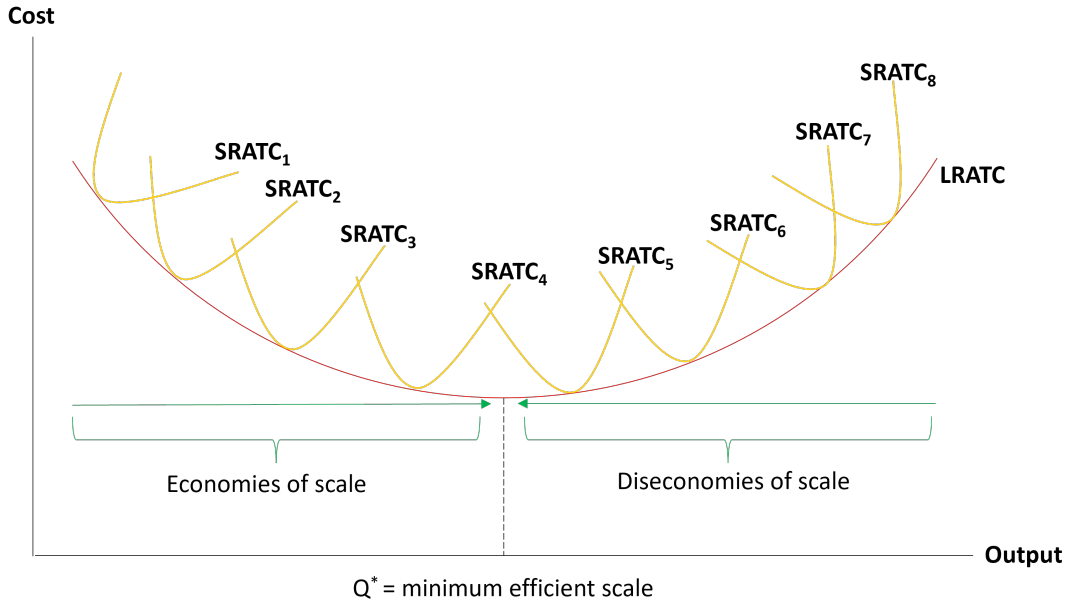
Situation	**SR decision**	**LR decision**
TR $\geq$ TC	Stay in market	Stay in market
TR $\geq$ TVC but TR $<$ TC	Stay in market	Exit market
TR $<$ TVC	Shut down production	Exit market

Short Run Total Cost and Plant Size



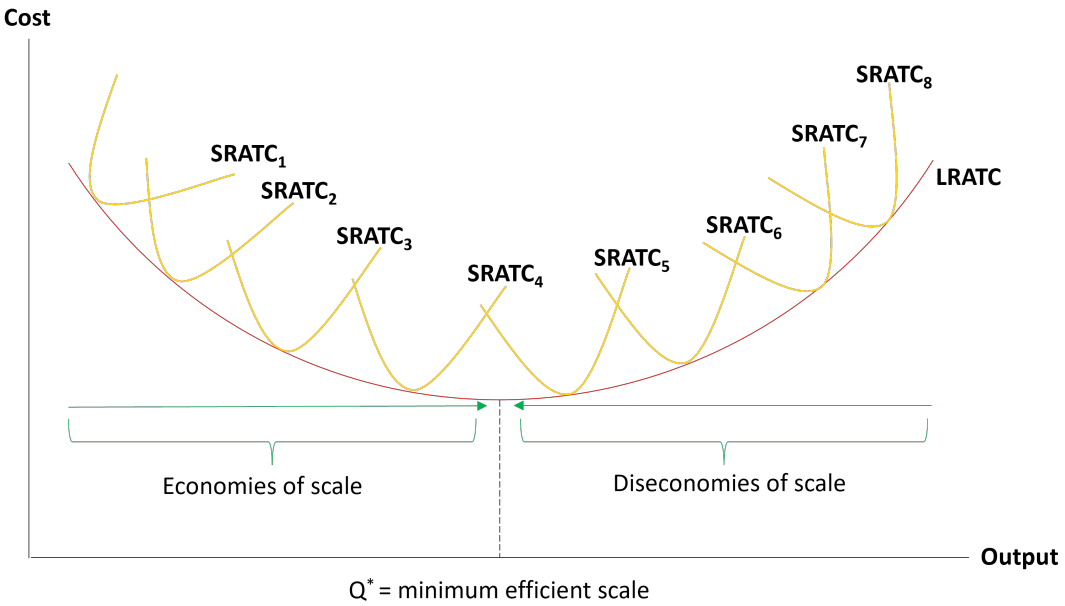
- Change in capital input changes the short run total cost (STC) curve.
- The choice of capital input (scale or plant size) depends on the level of output chosen by the firm.

Economies and Diseconomies of Scale



- Scale of operations (e.g. plant size) is fixed in SR but can be adjusted in LR.
- Each point along the ATC curve in the LR corresponds to the minimum ATC for a given scale in the SR.

Economies and Diseconomies of Scale



- **Economies of scale** result from factors such as labor specialization, mass production, and investment in more efficient technology.
- **Diseconomies of scale** may result as the increasing bureaucracy of larger firms and regulation leads to inefficiencies, issues coming with a larger workforce, greater barriers to innovation.