Producer Theory

Sections 7.1-7.2
and
Sections 8.1-8.6

Outline

- Sections 7.1-7.2: Production costs
- Sections 8.1-8.6: Short term profit maximization

7.1

MEASURING COST: WHICH COSTS MATTER?

- **total cost (TC** or **C)** Total economic cost of production, consisting of fixed and variable costs.

  Total cost = (Fixed cost) + (Variable cost)

  $TC(q) = FC + VC(q)$ (where q = output quantity)

- **fixed cost (FC)** Cost that does not vary with the level of output. These costs can be eliminated *only by shutting down*.

- **variable cost (VC)** Cost that varies as output rate varies.

How do we know which costs are fixed and which are variable? It depends on the timescale…

Over a **very short time horizon**—say, a few months—*most costs are fixed*. Over such a short period, a firm is usually obligated to pay for contracted shipments of materials.

Over a **very long time horizon**—say, ten years—*nearly all costs are variable*. Workers and managers can be laid off (or employment can be reduced by attrition), and much of the machinery can be sold off or not replaced as it becomes obsolete and is scrapped.

7.1

Marginal cost

Marginal Cost (MC)

- **marginal cost (MC):** Increase in total cost (e.g. in € per day) resulting from an increase in the production rate (e.g. in units per day).

The *fixed cost* does not change as the firm's output rate changes. Thus, the marginal cost is also equal to the *increase in variable cost* caused by increasing production rate by one unit/day.

We can therefore write marginal cost as:

$$MC = \Delta VC/\Delta q = \Delta TC/\Delta q$$

Example: Consider a service industry. (So the only production input is labour.) Let $\Delta L/\Delta q$ be the labour required to make one extra unit/day. Let w be the wage. Then $\Delta VC = w\,\Delta L$.
Thus, $MC = w\,\Delta L/\Delta q = w / MPL$, where MPL = marginal productivity of labour.

7.1 Average costs

- **average total cost (ATC):** The firm's *total cost* divided by its rate of production.
- **average fixed cost (AFC):** The *fixed cost* divided by the rate of production.
- **average variable cost (AVC):** The *variable cost* divided by the rate of production.

TABLE 7.1 Example of total, fixed, variable, marginal and average costs

Rate of production (Units per Year)	Fixed Cost (Dollars per Year)	Variable Cost (Dollars per Year)	Total Cost (Dollars per Year)	Marginal Cost (Dollars per Unit)	Average Fixed Cost (Dollars per Unit)	Average Variable Cost (Dollars per Unit)	Average Total Cost (Dollars per Unit)
	(FC) (1)	(VC) (2)	(TC) (3)	(MC) (4)	(AFC) (5)	(AVC) (6)	(ATC) (7)
0	50	0	50	--	--	--	--
1	50	50	100	50	50	50	100
2	50	78	128	28	25	39	64
3	50	98	148	20	16.7	32.7	49.3
4	50	112	162	14	12.5	28	40.5
5	50	130	180	18	10	26	36
6	50	150	200	20	8.3	25	33.3
7	50	175	225	25	7.1	25	32.1
8	50	204	254	29	6.3	25.5	31.8
9	50	242	292	38	5.6	26.9	32.4
10	50	300	350	58	5	30	35
11	50	385	435	85	4.5	35	39.5

Production Cost

- Fixed and variable cost: $C(y) = FC + VC(y)$
- Average cost: $AC(y) = \frac{C(y)}{y}$
- Average variable cost: $AVC(y) = \frac{VC(y)}{y}$
- Average fixed cost: $AFC(y) = \frac{FC}{y}$
- Marginal cost: $MC(y) = \frac{dC(y)}{dy}$

Production Costs

- Marginal and variable costs:

The area below the *marginal cost* curve from zero to the quantity produced is equal to the *variable cost* to produce that quantity

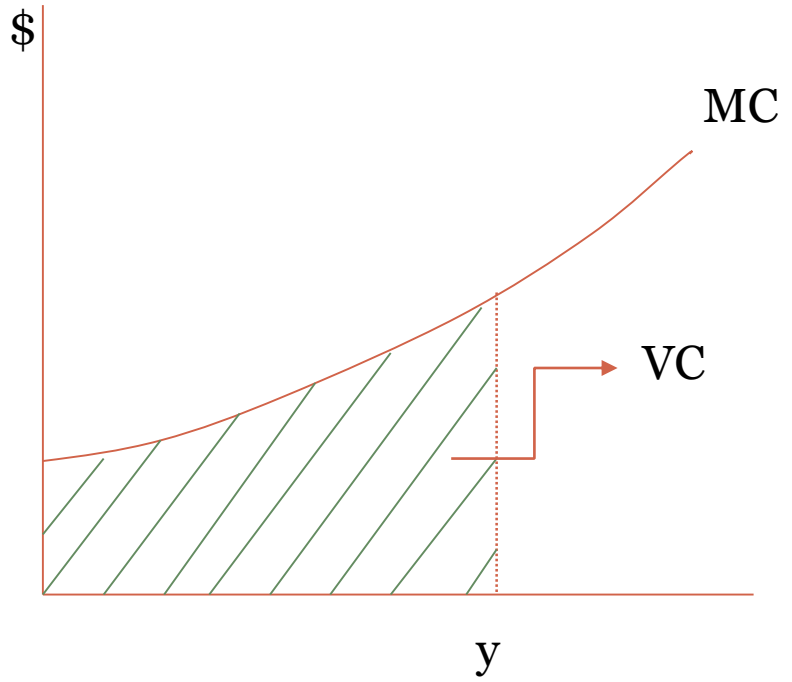
In other words,

$$VC(q) = \int_0^q MC(y)\,dy$$

Proof: Recall that $MC(y) = VC'(y)$, for all y. Thus, the Fundamental Theorem of Calculus says that

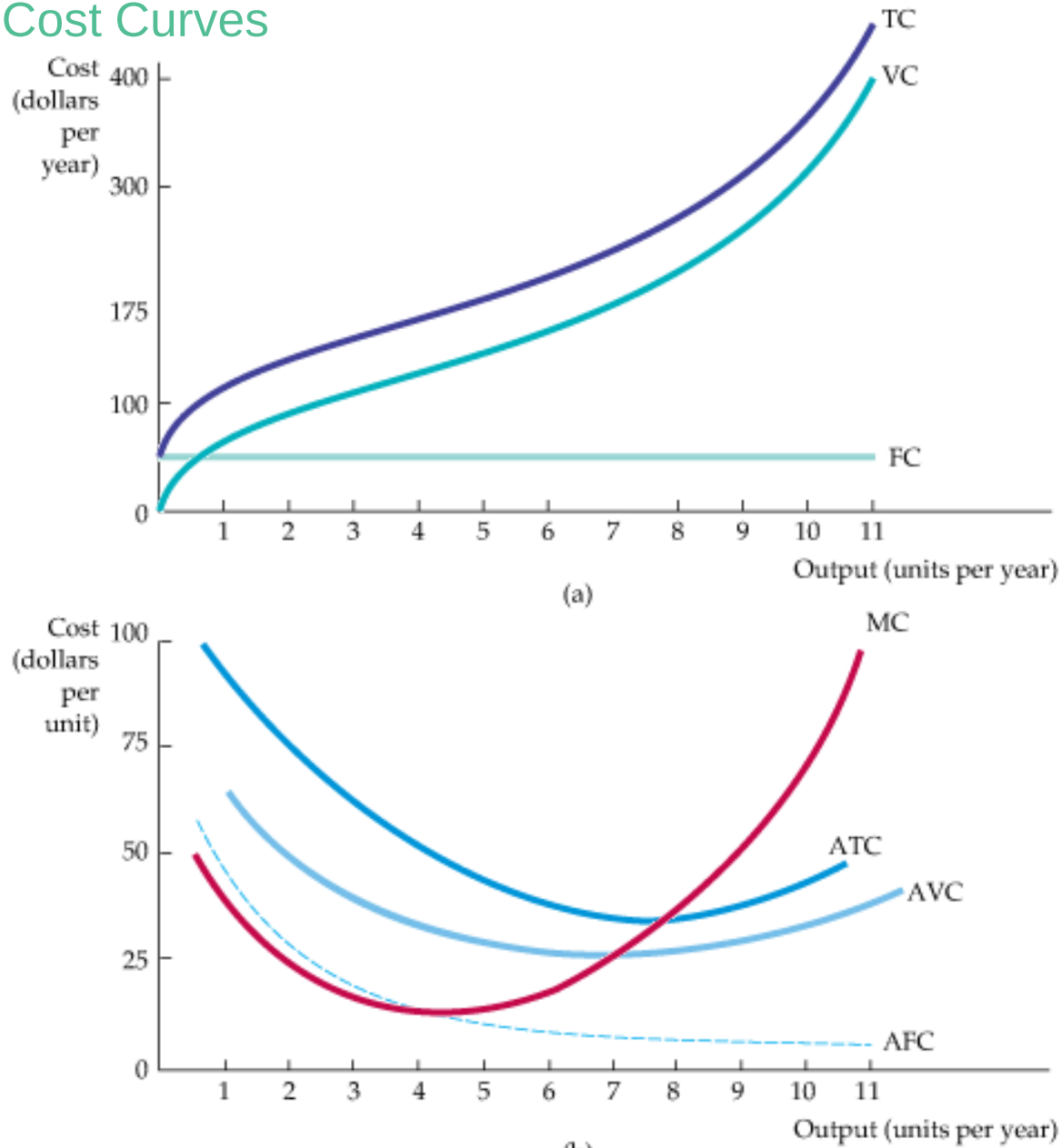
$$\int_0^q MC(y)\,dy = \int_0^q VC'(y)\,dy = VC(q) - VC(0)$$

$$= VC(q) - 0 = VC(q).$$



7.2 The Shapes of the Cost Curves

Figure 7.1 **Cost Curves for a Firm**



In **(a),** the *total cost* TC is the vertical sum of *fixed cost* FC and *variable cost* VC.

In **(b),** the *average total cost* ATC is the sum of *average variable cost* AVC and *average fixed cost* AFC.

The *marginal cost* MC crosses the average variable cost and average total cost curves ***at their minimum points*****.**

7.2 Production Costs

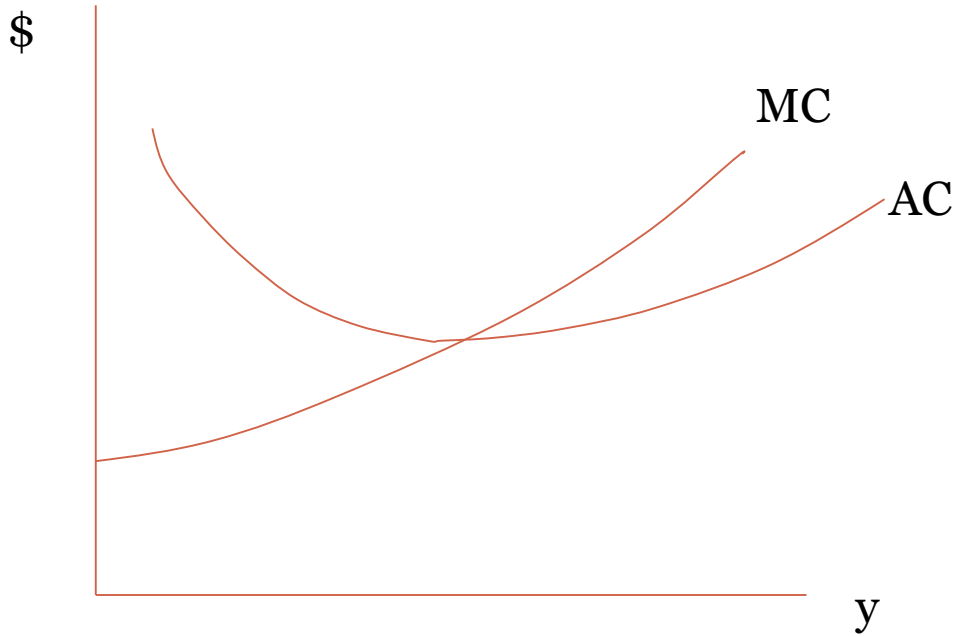
- **Marginal cost versus Average cost:**

The *marginal cost* curve (*MC*) crosses the *average cost* curve (*AC*) at its **minimum level**.

- When $MC < AC$, then the cost to produce an extra unit is *lower* than the average cost.
- In that case, if one extra unit is produced, the average cost will decrease.
- Hence, the average cost is decreasing in y.
- The opposite is true for $MC > AC$.

7.2 Production costs

- In sum:
  - If MC < AC => AC is decreasing
  - If MC > AC => AC is increasing



Chapter 8

Profit-maximizing production in a perfectly competitive market

Section 8.1 Perfect competition

- The model of **perfect competition** is a good approximation for many markets, such as the markets for fuel, agricultural products, housing, and financial products.

- The model rests on three basic assumptions:
  1. The atomicity of all actors,
  2. Product homogeneity, and
  3. Free entry and exit.

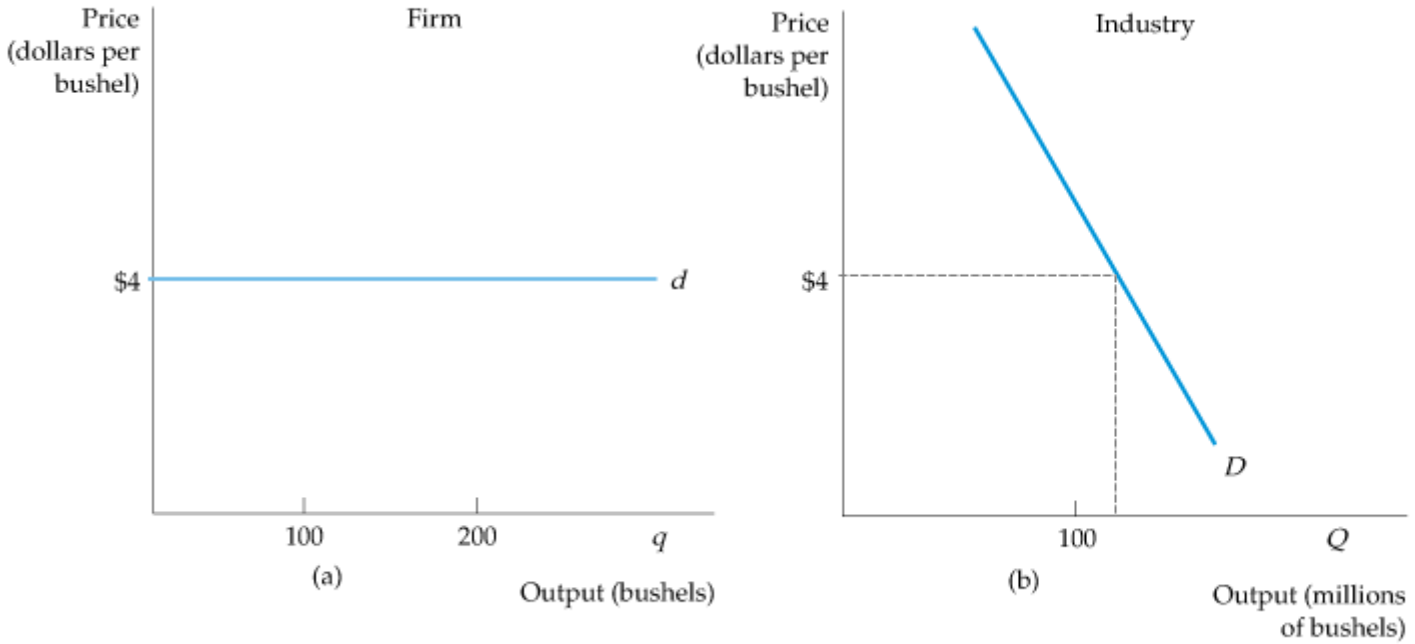
Section 8.1 Perfect competition

Assumption 1: Atomicity of actors

- We assume that each firm faces a very large number of direct competitors.
- Each individual firm sells a very small proportion of the total market supply, so its decisions have no impact on market price.
- Thus, each firm is a ***price taker***: it has no influence over market price. Thus, it takes the price as given.
- Likewise, each consumer only purchases a tiny proportion of the total supply on the market, so her purchase decisions cannot influence the price. She is also a ***price taker***: she takes the market price as given.

Small firms are price-takers

Figure 8.2



A small firm is a **price taker,** so the market price is independent of its production level. In other words, the effective "demand curve" facing a small firm is *horizontal*, as shown in **(a)**. It can sell as much product as it wants at $4, but cannot sell *any* product at any higher price.

This is true even though the *market* demand curve in **(b)** is downward sloping. (The curve in **(a)** is a "horizontal magnification" of the curve in **(b)**.)

Section 8.1 Perfect competition

Assumption 2: Product homogeneity

- We assume that the products of all of the firms in a market are ***perfectly substitutable*** with one another.
- This means that the quality and the characteristics of the products are relatively *homogeneous*.
- Examples include: agricultural products (wheat, soy), metals (iron, copper), minerals (potash), crude oil, and other commodities.
- In this situation, no firm can raise the price of its product above the price of other firms without losing most or all of its business.

However, if the goods are *heterogenous*, then firms can sell them for higher prices, either because they are not perfect substitutes, or because some brands are perceived to have better quality. Examples include clothing, prepared foods, consumer electronics, brand-name products.

(Indeed, firms often seek a way to "differentiate" their product from competitors, precisely so that they are no longer perceived by consumers as perfect substitutes, so that the firm can charge a higher price.)

Section 8.1 Perfect competition

Assumption 3: Free Entry and Exit

This means there are no special costs that make it difficult for a firm to enter an industry with exceptionally high profits (or exit and industry with exceptionally low profits).

Also, consumers can easily switch from one firm to another.

Examples of ***barriers to entry***: government regulations (permits, licences, paperwork, etc.); nonrecoverable "up-front costs" (e.g. training workers).

Examples of ***switching costs***: technological "lock-in" (e.g. for computers); network effects (e.g. the need to coordinate with other people).

Section 8.1 Perfect competition

Very few markets are *perfectly* competitive, but many markets are *highly* competitive nevertheless, because they approximately satisfy the three conditions just listed.

When Is a Market Highly Competitive?

- Because firms can implicitly or explicitly collude in setting prices, the presence of many firms is not sufficient for an industry to approximate perfect competition.
- Conversely, the presence of only a few firms in a market does not rule out competitive behaviour.
- For example, if demand is *very elastic*, then even an **oligopoly** (a market controlled by a small number of firms) will have to set its prices *close* to the perfectly competitive price, in order to maximize profits.

8.2 Profit maximization

- Do Firms Maximize Profit?
  - The assumption of ***profit maximization*** is frequently used in microeconomics because it predicts firms' behaviour reasonably accurately, and avoids analytical complications.
  - For smaller firms managed by their owners, profit is likely to dominate almost all decisions.
  - In larger firms, however, managers who make day-to-day decisions usually have little contact with the owners (i.e. the stockholders). Managers might have other motives besides profit-maximization (e.g. maximizing their own salaries, or the size of the company).
  - Nevertheless, firms that do not come close to maximizing profit are not likely to survive in the long term.
  - Firms that *do* survive in competitive industries make long-run profit maximization one of their highest priorities.

8.3 Profit maximization: marginal cost vs. marginal revenue

- ***profit***: Difference between total revenue and total cost. $\pi(q) = R(q) - C(q)$
- ***marginal revenue***: Change in revenue due to a one-unit increase in output.

A firm chooses output q^*, so that profit, the difference AB between revenue R and cost C, is maximized.

At that output, *marginal revenue* (the slope of the revenue curve) is equal to *marginal cost* (the slope of the cost curve).

$$\Delta\pi/\Delta q = \Delta R/\Delta q - \Delta C/\Delta q = 0$$

Thus, the firm chooses q to solve the equation:

$$MR(q) = MC(q)$$

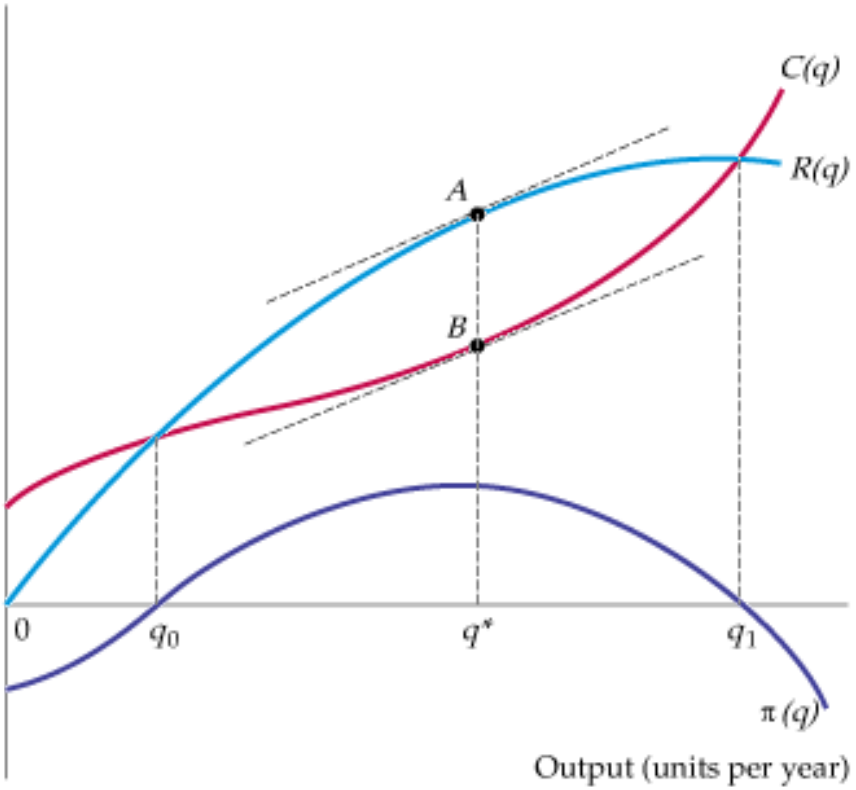


Figure 8.1 **Profit Maximization in the Short Run**

8.3 Profit maximization: marginal cost vs. marginal revenue

- The profit is *negative* for low production, since the revenue is not sufficient to cover fixed and variable costs.
- As production increases, revenue increases faster than costs, and profits become *positive*.
- Profits keep increasing until production reaches q^*.
- At the profit maximizing production level q^*, we have: $MR(q^*) = MC(q^*)$.
  In other words, the slopes of $R(q^*)$ and $C(q^*)$ are equal.

This is true *whether or not* the firm operates in a competitive market.

8.3 Profit maximization: marginal cost vs. marginal revenue

- At profit maximizing production level q^*, we have

$$MR(q^*) = MC(q^*).$$

- To compute MR(q), we need a bit of calculus. Recall $R(q)=p(q)\times q$,

where $p(q)$ = price and q= quantity. Thus, $MR(q) = \frac{\partial(p.q)}{\partial q} = p + q\frac{\partial p}{\partial q}$

Thus, if $MR(q) = MC(q)$,

then it follows that $p + q\frac{\partial p}{\partial q} = MC(q)$. (★)

If the firm is a **price taker**, then dp/dq=0, so (★) becomes: $p = MC(q)$.
That is: **marginal cost equals market price**, at profit-maximizing level.

(*Note*: Equation (★) will also be important later, for studying monopolies.)

Profit maximization: competitive firm

Short-Run Profit Maximization by a Competitive Firm

Output Rule: If a firm (in a competitive market) is producing any output, it should produce at the level q^* at which *marginal cost* equals *marginal revenue*, which in turn equals *market price*:

$$MC(q^*) = MR(q^*) = P.$$

Section 8.4: Optimal production level in the short term

- It is important to distinguish between *short term* and *long term* when identifying the profit-maximizing production level.
- In the ***long term***, the firm can invest in new capital (e.g. new machines, factories, etc.) to obtain an optimal labour/capital mix.
- Furthermore, in the ***very long term***, competitors can enter (or leave) the market if it offers unusually high (or low) levels of profit. (That is: if the *economic profit* is nonzero, which means that the *accounting profit* is not equal to the *opportunity cost* of participating in this market.)
- However, in the ***short term***, the firm's capital is *fixed*, so it can only vary production by varying labour and other inputs.
- Furthermore, in the ***short term***, competitors cannot easily enter or leave the market, so abnormally high (or low) profit levels can exist.

8.4 The Short-Run Profit of a Competitive Firm

In the short run, the competitive firm maximizes its profit by choosing an output q^* at which its marginal cost MC is equal to the price P (or marginal revenue MR) of its product.

The **profit** $\pi(q)$ of the firm is the area of the green rectangle *ABCD*. In other words,

$$\pi(q) = (P - \text{ATC}(q)) \cdot q$$

Any change in output, whether lower at q_1 or higher at q_2, will lead to lower profit.

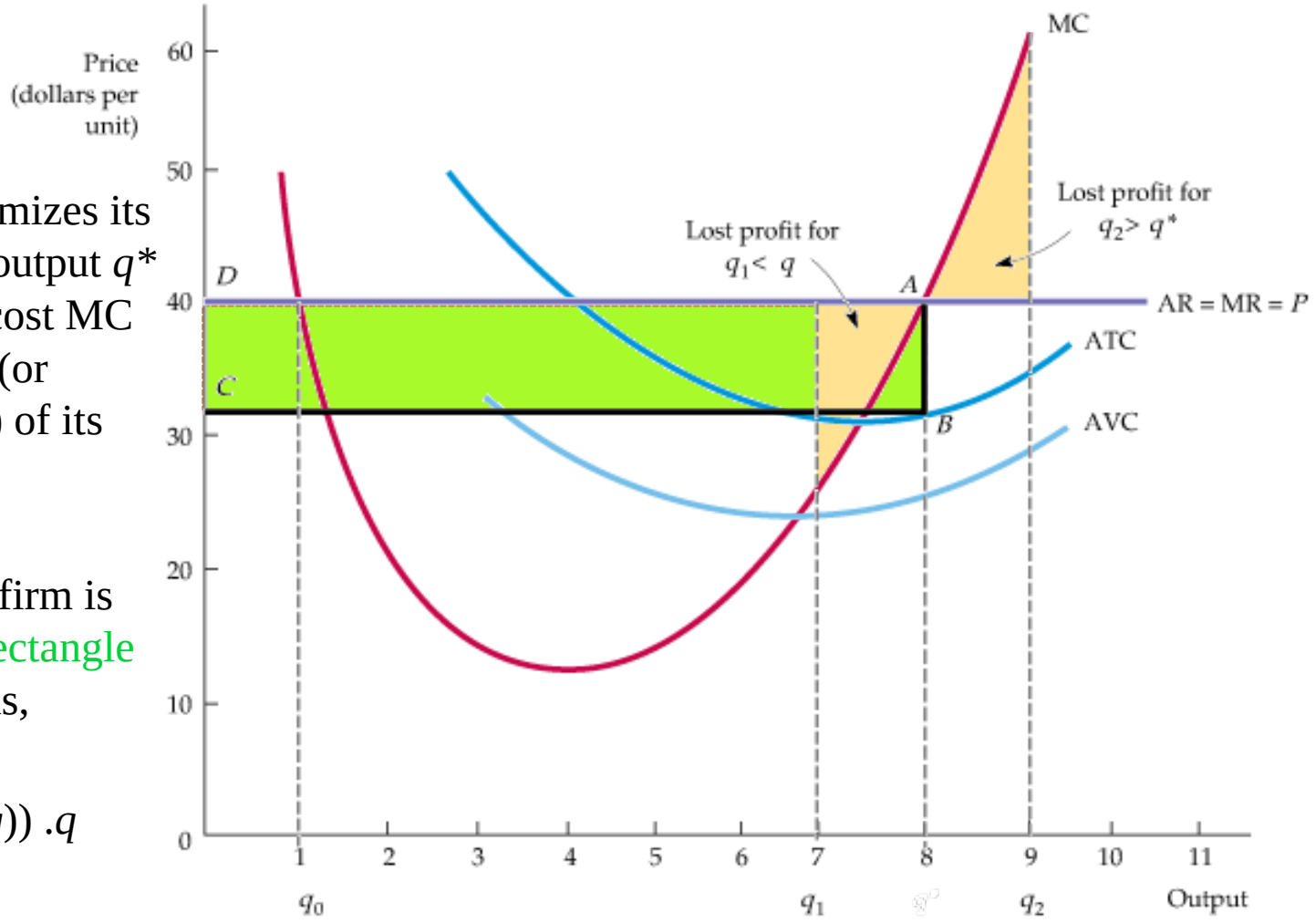


Figure 8.3 **A Competitive Firm Making a Positive Profit**

8.4 CHOOSING OUTPUT IN THE SHORT RUN

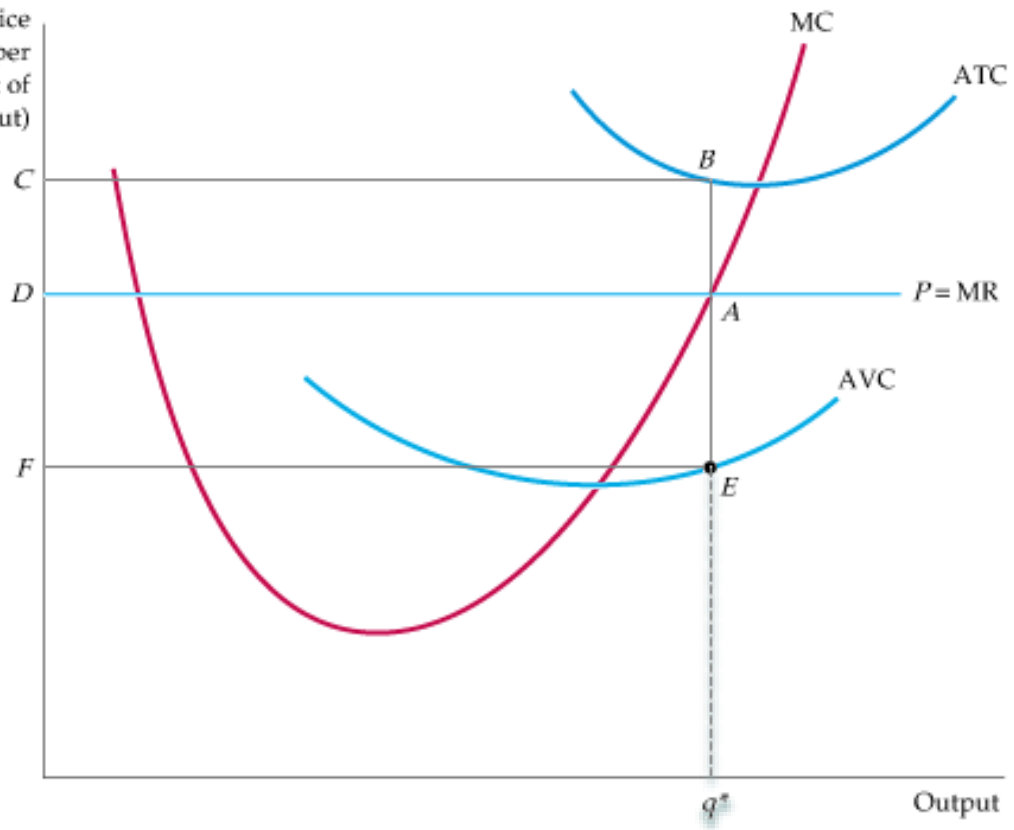
This firm is **losing money**, because price *P* is **below** average total cost *ATC(q)*. Should it shut down?

Answer: *No*. In the *short term*, it is *still better* to keep operating, as long as $P > AVC(q^*)$ (this *minimizes losses*).

If $P > AVC(q^*)$, then at least the revenue will cover all the *variable costs*, and a *part* of the fixed cost.

However, if $P < AVC(q^*)$, then revenue won't even cover variable costs. In this case, the firm would *lose less money* if it just *shut down completely*.

Figure 8.4 **A Competitive Firm Incurring Losses**



Shut-Down Rule: The firm should shut down if the price *P* of the product is less than the *average variable cost AVC*(*q**) of production at the profit-maximizing output.

8.5 THE COMPETITIVE FIRM'S SHORT-RUN SUPPLY CURVE

The firm's supply curve is *the portion of the marginal cost curve for which marginal cost is greater than average variable cost.*

Recall: q^* = production level such that marginal cost = market price

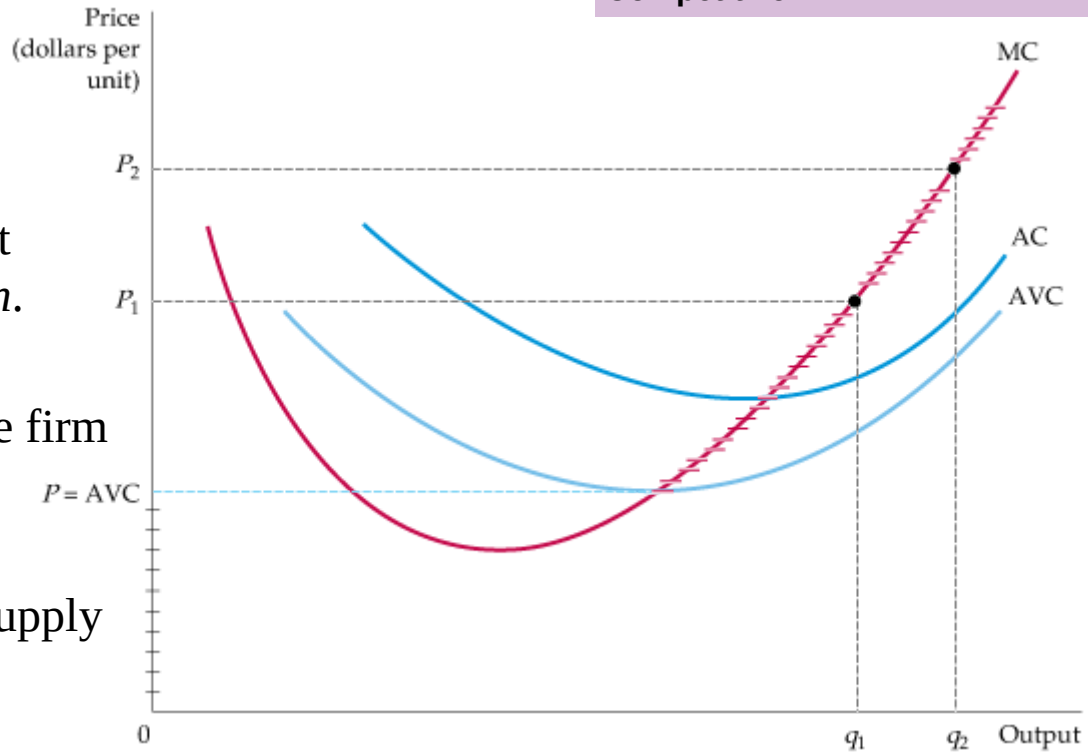
$MC(q^*) = P$.

If $P < AVC(q^*)$, then as we have just seen, the firm should just *shut down*.

Otherwise, if $P > AVC(q^*)$, then the firm should produce q^* units.

Conclusion: The firm's short-run supply curve is given by the **crosshatched portion** of the marginal cost curve.

Figure 8.6 **The Short-Run Supply Curve for a Competitive Firm**



8.5 THE COMPETITIVE FIRM'S SHORT-RUN SUPPLY CURVE

- The short term supply curve (a segment of marginal cost curve) has a positive slope because of *decreasing returns*, due to the declining marginal productivity of one or more inputs.

- As production level q increases, a higher price is necessary to compensate the firm for the marginal cost of producing each additional unit.

- Increasing q also *increases total profits*, because it increases the gap between the price $P(q)$ and the average total cost $ATC(q)$, and as we have seen,

$$\pi(q) = (P(q) - \text{ATC}(q)) \,.q$$

8.5 THE SHORT-RUN MARKET SUPPLY CURVE

Suppose the price of all inputs is *constant*. Then the short-run industry supply curve is the summation of the supply curves of the individual firms.

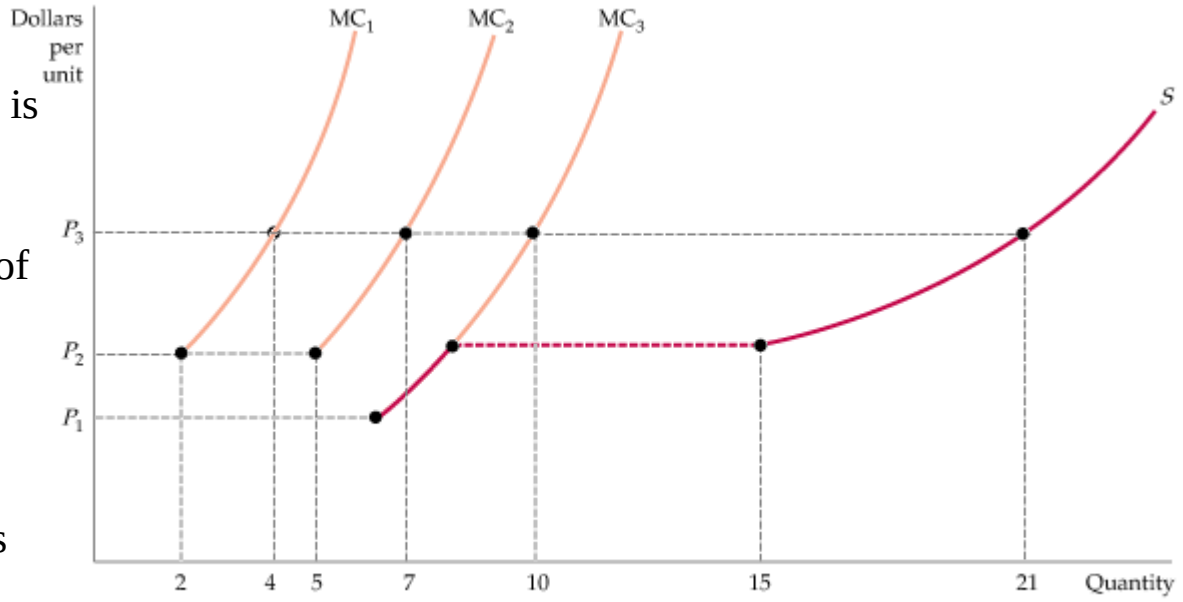
Because the third firm has a lower average variable cost curve than the first two firms, the market supply curve S begins at price P_1 and follows the marginal cost curve of the third firm MC_3 until price equals P_2, when there is a kink.

For P_2 and all prices above it, the industry quantity supplied is the sum of the quantities supplied by each of the three firms.

However, the price of inputs may *increase with demand*. In this case, as each firm increases production, the price of their inputs will increase.

Result: The supply curve will be *steeper* than what is portrayed here, due to a *price externality* between firms.

Figure 8.9 **Industry Supply in the Short Run**



EXAMPLE 8.5 The Short-Run World Supply of Copper

Table 8.1 The World Copper Industry (2006)

Country	Annual Production (Thousand Metric Tons)	Marginal Cost (Dollars Per Pound)
Australia	950	1.15
Canada	600	1.30
Chile	5,400	0.80
Indonesia	800	0.90
Peru	1,050	0.85
Poland	530	1.20
Russia	720	0.65
US	1,220	0.85
Zambia	540	0.75

Source for Annual Production Data: U.S. Geological Survey, Mineral Commodity Summaries, January 2007.
http://minerals.usgs.gov/minerals/pubs/mcs/2007/mcs2007.pdf.
Source for Marginal Cost Data: Charles River Associates' Estimates.

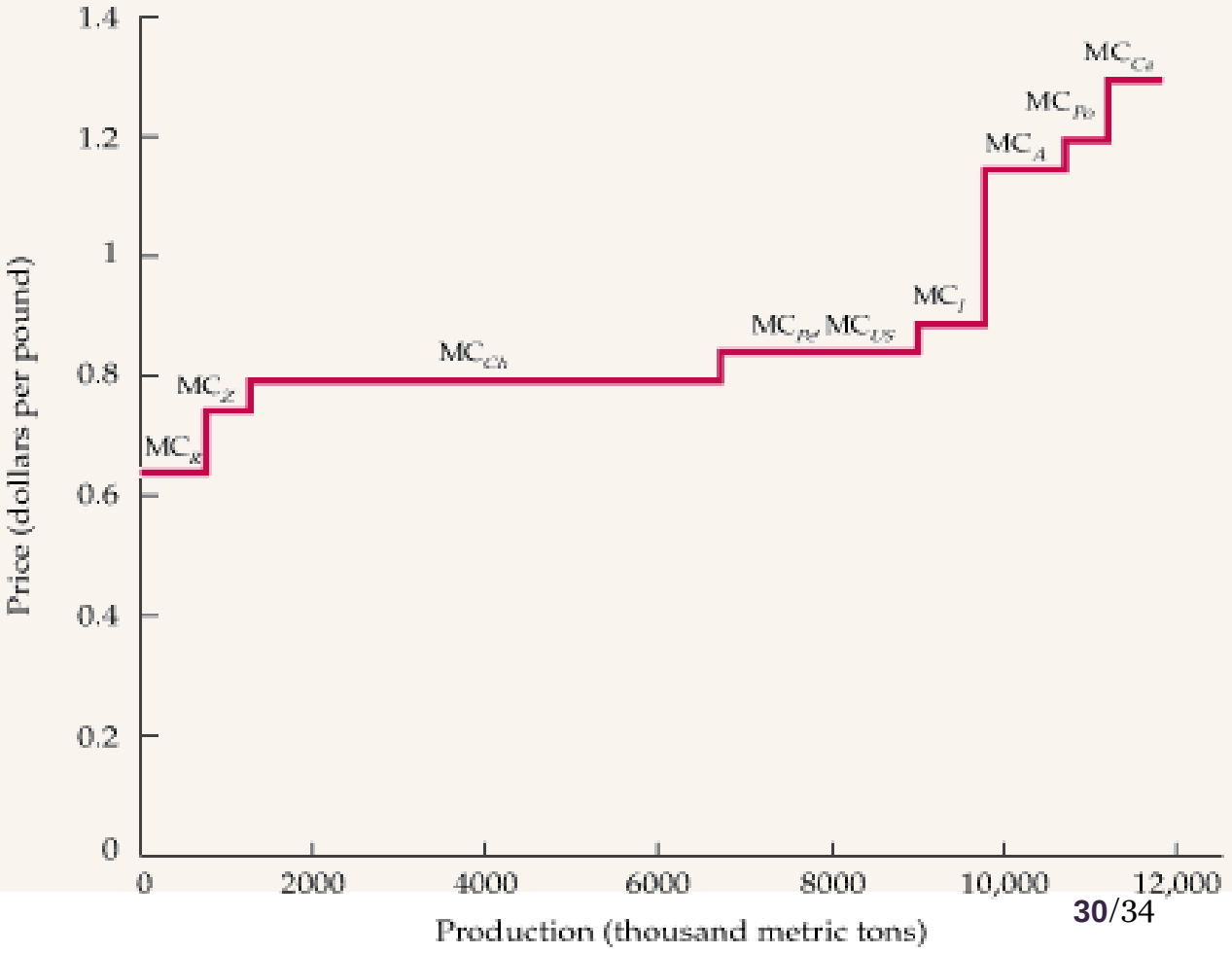
EXAMPLE 8.5 The Short-Run World Supply of Copper (continued)

Figure 8.10

The Short-Run World Supply of Copper

The supply curve for world copper is obtained by summing the marginal cost curves for each of the major copper-producing countries.

The supply curve slopes upward because the marginal cost of production ranges from a low of 65 cents in Russia to a high of $1.30 in Canada.



8.6 THE SHORT-TERM MARKET SUPPLY CURVE AND SHORT-TERM PRODUCER SURPLUS FOR A FIRM

- **Producer surplus:** Sum over all units produced by a firm of differences between the market price of a good and the marginal cost of production.

The producer surplus for each unit sold is the difference between the *market price* and the *marginal cost of production* for that unit.

Thus, the total ***producer surplus*** for a firm is measured by the yellow area below the market price and above the marginal cost curve, between outputs 0 and q^*, the profit-maximizing output.

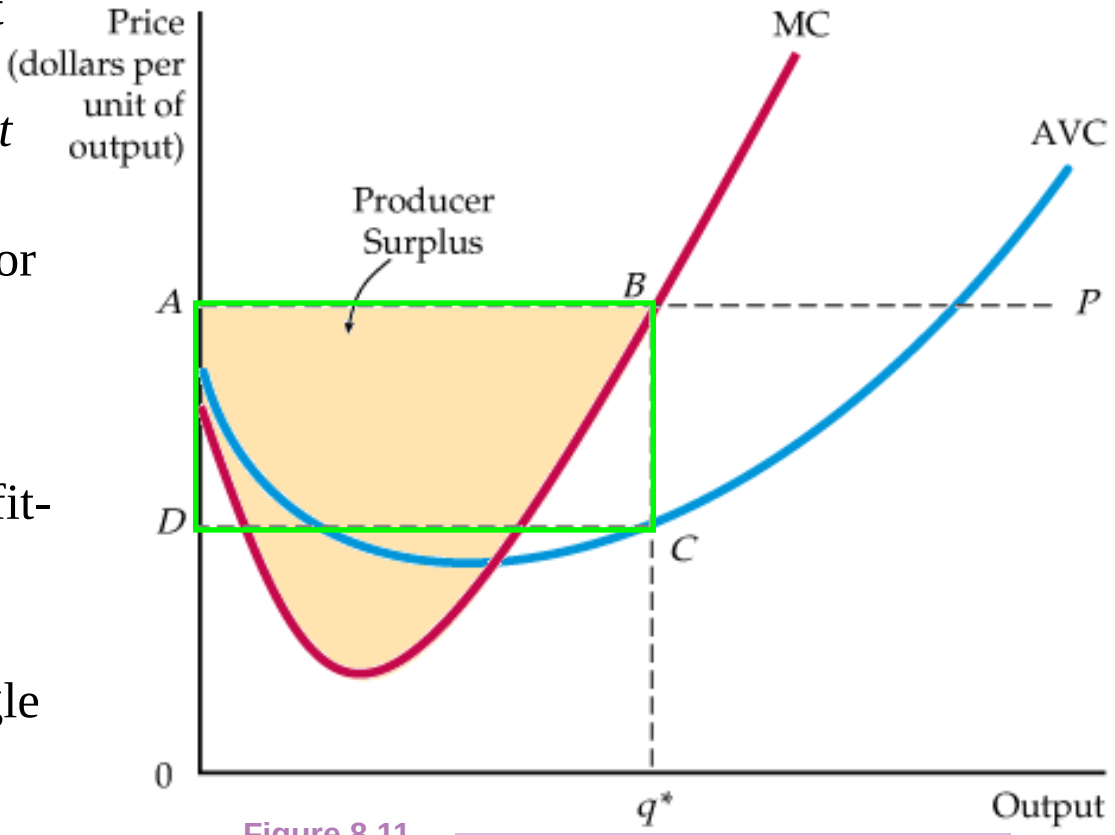


Figure 8.11 Producer Surplus for a Firm

Alternatively, it is equal to rectangle *ABCD* because the integral of marginal costs up to q^* is equal to the variable costs of producing q^*.

In other words, $\text{Surplus} = P\,q^* - \int_0^{q^*} \text{MC}(y)\,dy = \text{R}(q^*) - \text{VC}(q^*)$.

Producer surplus versus Profit

- **Profit** is the difference between total revenue and total cost (not just variable cost). Formally:

Profit = (revenue)- (total cost)
= (revenue)-(var. cost) - (fixed cost)

$$\pi = R - VC - FC.$$

- In contrast, **producer surplus** is the difference between revenue and variable cost:

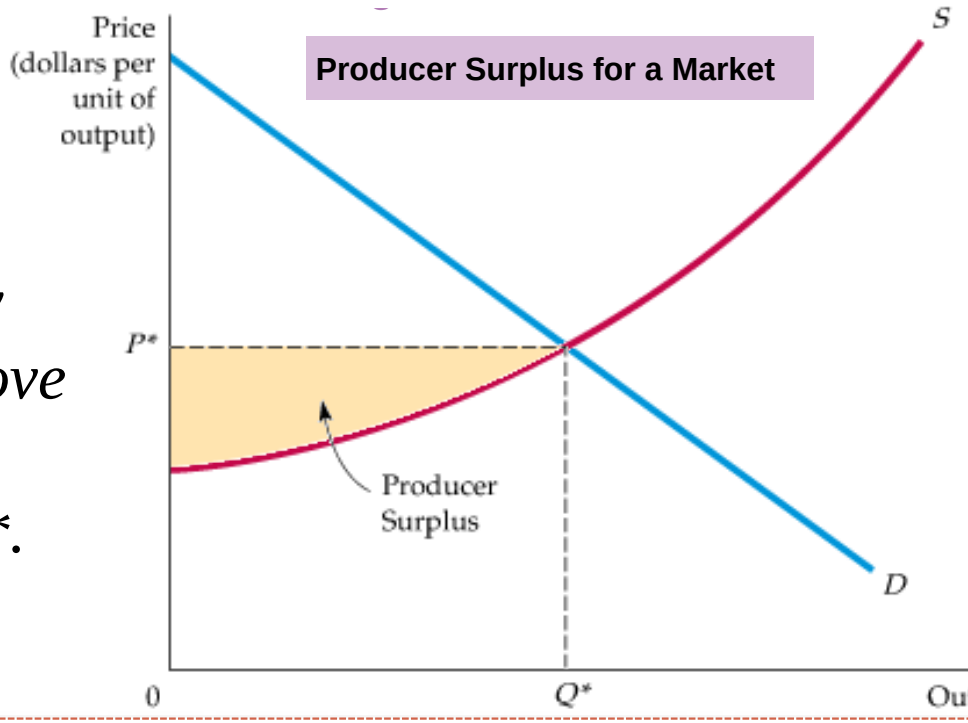
$$S = R - VC.$$

- Thus, $S = \pi + FC$. Thus, when the fixed cost *FC* is positive, *the producer surplus is greater than profit.*

8.6 THE SHORT-TERM MARKET SUPPLY CURVE AND SHORT-TERM PRODUCER SURPLUS FOR THE MARKET

The **market producer surplus** is the sum of the producer surplus for *all firms*. Each firm's producer surplus is the area between its marginal cost curve and the price line. But the industry supply curve is the *horizontal sum* of all these marginal cost curves. Thus, we conclude…

The market producer surplus is *the area below the market price and above the market supply curve*, between 0 and output *Q**.



8.1-8.6: Main results

- Since firms are **price takers**, we have that MR = P.
- Given a fixed price P, a price-taking firm will choose output q^* so that MC(q^*) = P, as long as this covers its average variable cost (i.e. as long as P > AVC(q^*)).
- Thus, the **short-run supply curve** is given by the portion of the marginal cost curve above the average variable cost curve.
- The **producer surplus** corresponds to the area between the market price and the marginal cost of production.