Session #2

Fundamentals of Microeconomics

THEORY OF SUPPLY

October 7, 2019

- Introduction to theory of supply
- Theory of the firm
- Costs
- Profit maximization

Quantity supplied depends on the price of the good and other factors

- The firm decides what will be the quantity of good produced and supplied based on the price at which it can sell it and on its production costs.
- Higher price means higher profit and usually motivates firms to produce more.
- Higher production costs decrease the profit and the firm produces less at the same price.
- Another factor influencing supply may be different government rules and regulations (taxes, quotas, etc.).

Supply function is the relation between quantity supplied, price and other factors

- General mathematical expression of supply function, where p is price and c costs of production:

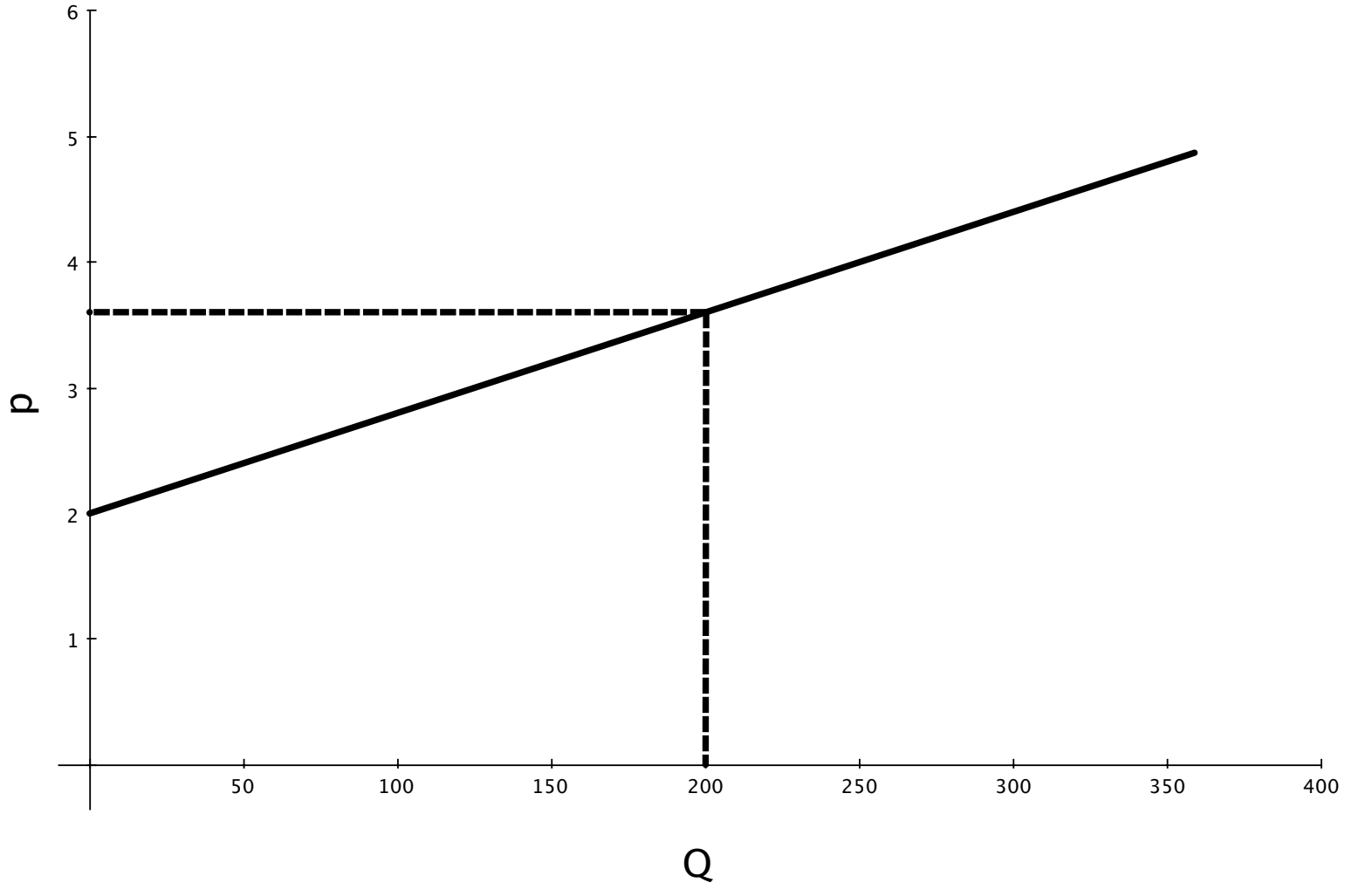
$$Q = S(p, c)$$

- Example: supply of pork meat in Canada (per year)

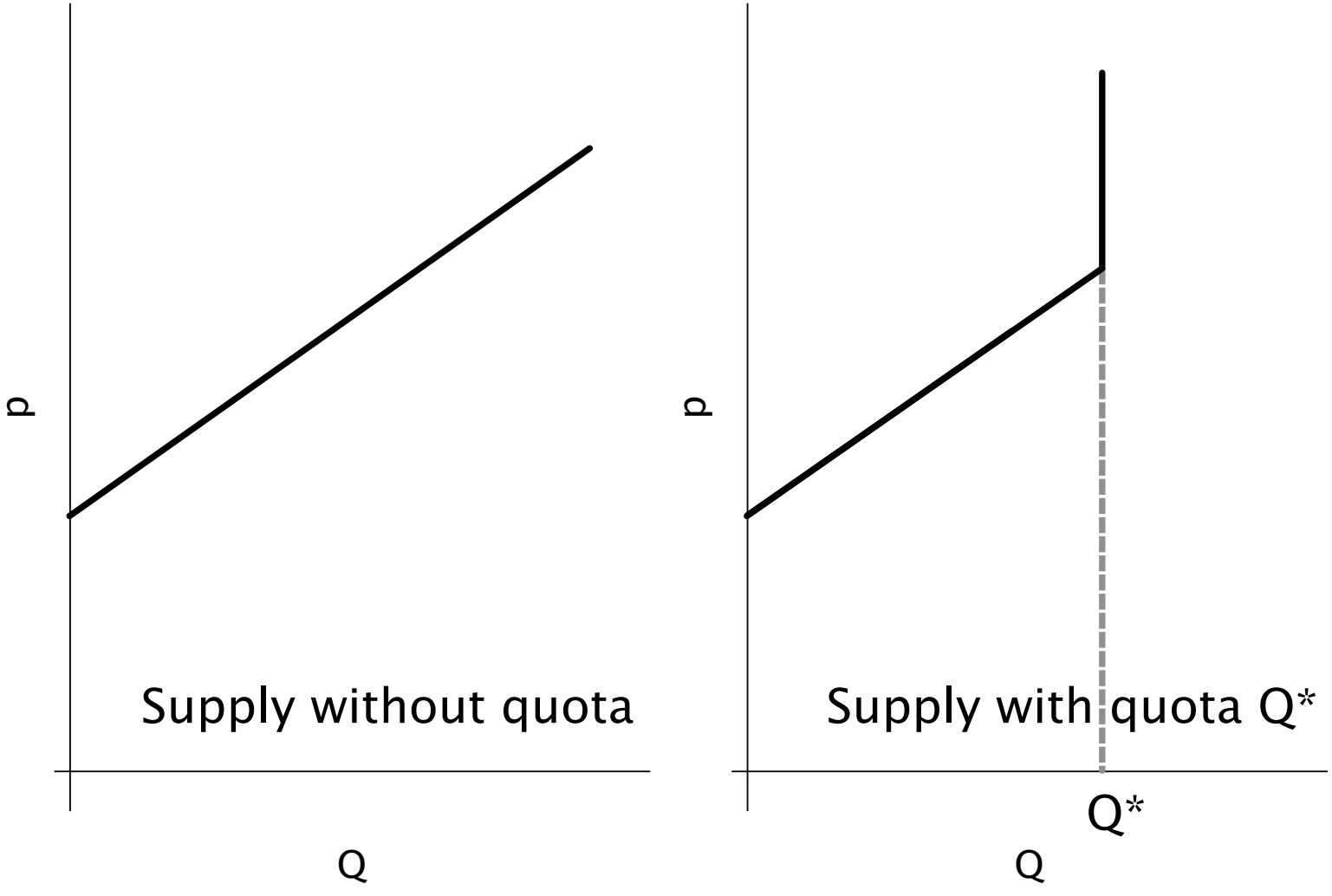
$$Q = 170 + 40p - 60c \ ,$$

where Q is quantity in millions of kilograms, p is price of pork in CAD per 1kg a c is the price of hogs in CAD per 1kg.

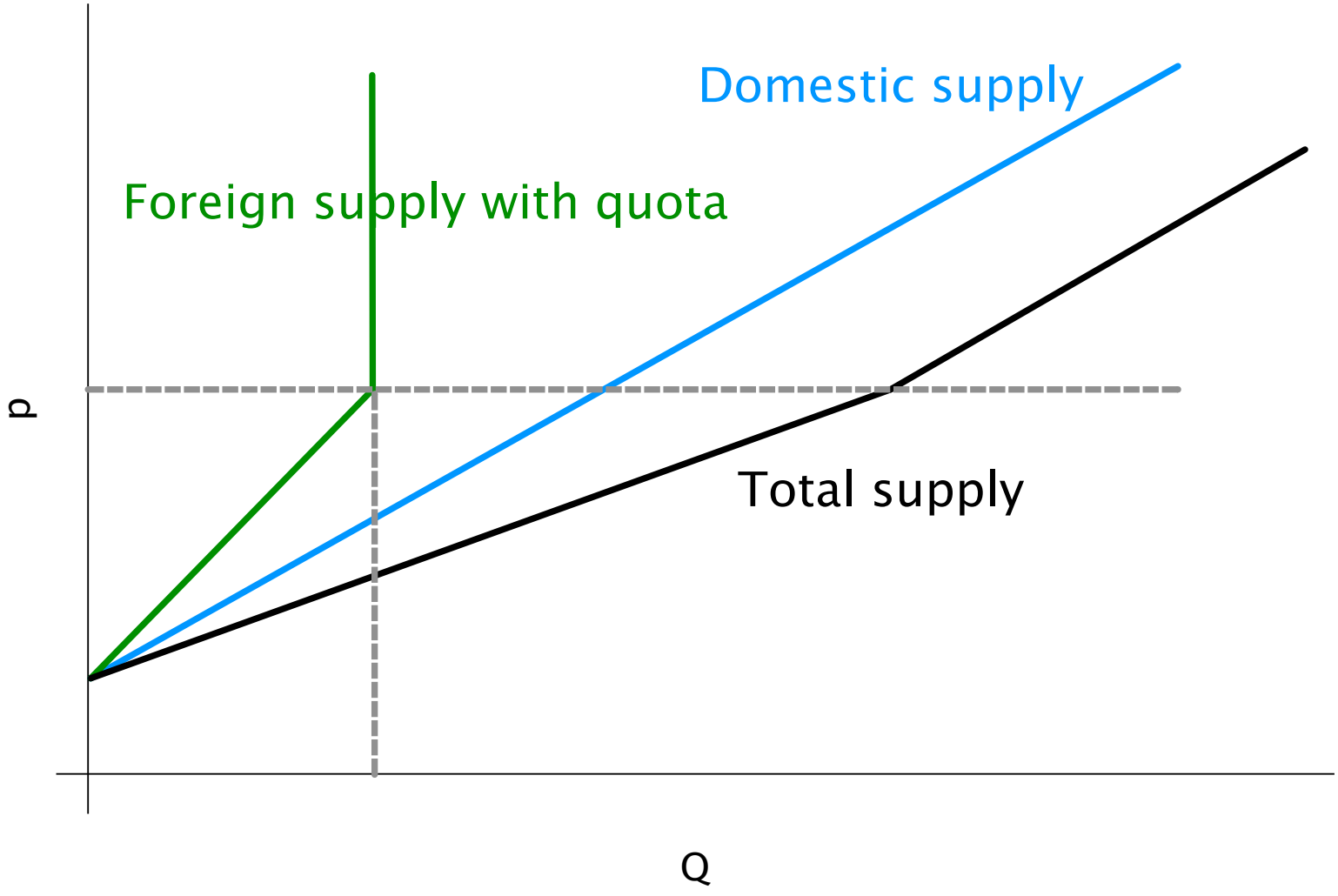
Supply curve plots the relation between price and quantity (all other factors fixed)



Possible government regulations (e.g. quotas) influence the shape of supply curve



As well as demand curves, supply curves are added horizontally



Elasticity of supply is defined similarly as elasticity of demand

- We define the elasticity of supply η

$$\begin{aligned} \eta &= \frac{\text{percentage change of quantity supplied}}{\text{percentage change of price}} \\ &= \frac{\Delta Q/Q}{\Delta p/p} = \frac{\Delta Q}{\Delta p}\frac{p}{Q} \quad . \end{aligned}$$

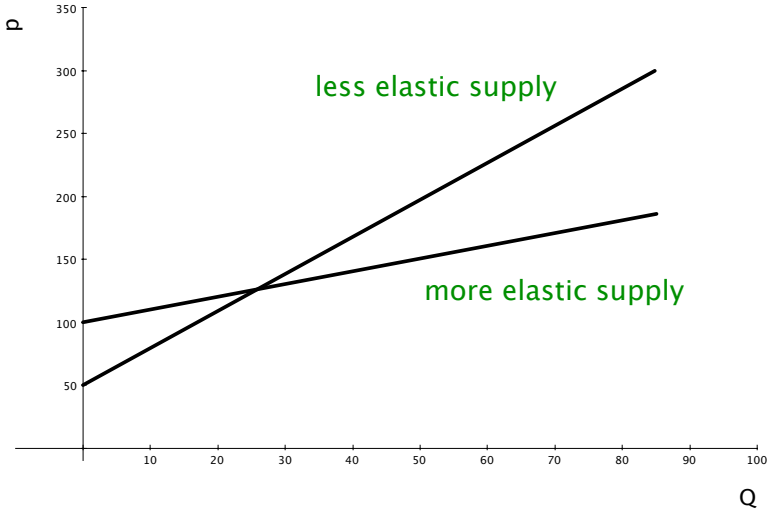
- Elasticity of supply thus expresses how sensitive to changes in price producers are.
- In applications, we will compute the elasticity using:

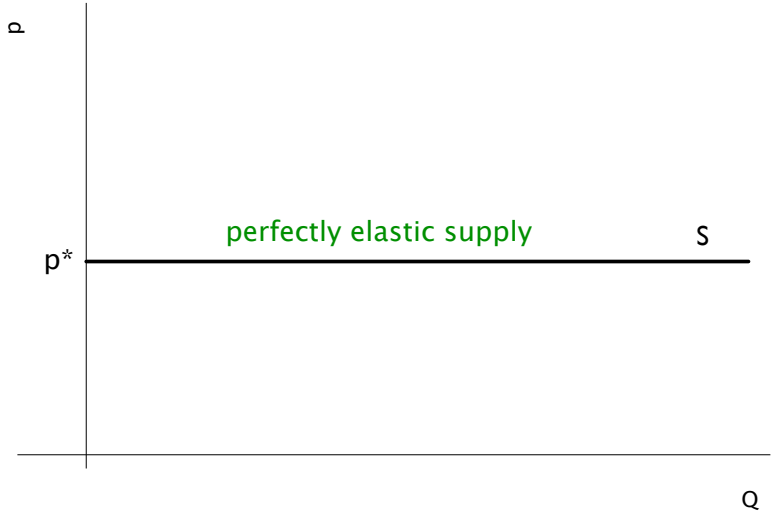
$$\eta = \frac{(Q_2 - Q_1)/Q_1}{(p_2 - p_1)/p_1} \quad .$$

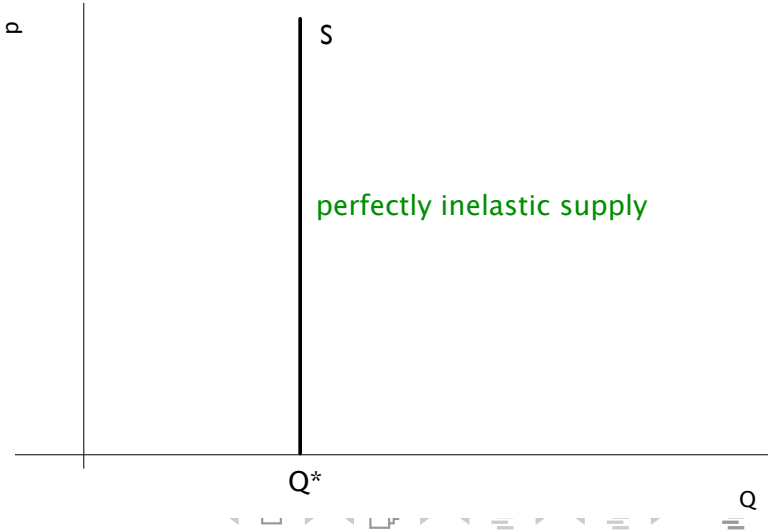
Classification of elasticity of supply is similar as in case of demand

- Given that the quantity supplied increases with price, we have $\eta > 0$.
- With respect to the value of the coefficient, we talk about:
  - perfectly elastic supply ($\eta = +\infty$)
  - elastic supply ($1 < \eta < +\infty$)
  - unit elastic supply ($\eta = 1$)
  - elastic supply ($0 < \eta < 1$)
  - perfectly inelastic supply ($\eta = 0$)
- As well as in the case of demand, the elasticity of supply is not constant along the supply curve.

We can compare different supply curves with respect to their elasticity







- Introduction to theory of supply
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Supply side of the economy is defined by decision process in firms

- Firms produce goods (services) in order to satisfy the demand given by customers' preferences and to maximize their own profit.
- Basic decision process in a firm consists of three steps:
  1. Organization of the firm and its production technology have to be defined.
  2. In the short run and long run, it has to be decided how to combine the inputs in order to increase or decrease the amount of output.
  3. It has to be determined what level of production is optimal.

Goal of a private firm is profit maximisation, conditioned by efficient production

- We define the profit (π) as the difference between revenues (R) and costs (C): $\pi = R - C$.
- Revenues arise from sales of produced quantity of the good (q) at the market price (p): $R = pq$.
- Costs arise from the necessity to pay for inputs - labor, material, etc.
- To maximise the profit, the production has to be efficient. Efficiency is achieved when it is not possible to produce the same amount of output using less inputs (given the available technology and production organisation).
- Efficiency of the production is a necessary but not sufficient condition - the management has to choose between all possible efficient allocations of inputs the one that would maximise the profit.

Firm uses the production technology to transform inputs into outputs

- Inputs (or production factors) can be divided into three main categories:
  1. Capital (K): Long-run inputs such as land, real estate (factories, stores), technical equipment (machinery, transport vehicles).
  2. Labor (L): Work done by managers and workers.
  3. Material (M): Raw materials (oil, water, wheat) and intermediary products (paper, steel, components).
- Output can be a service or a tangible product.

Production function gives the relation between the volume of inputs and output

- Different volumes of inputs and their combinations lead to different volumes of output produced.
- Maximum possible volume of output produced with a given combination of inputs is quantified by the production function.
- Example of a production function using only labor and capital:

$$q = f(L, K) = \sqrt{LK} \ .$$

- We satisfy the necessary condition of efficiency only when we consider the maximum possible volume of output produced with the given combination of inputs.

Volume of inputs can be changed with different flexibility in different time horizons

- The volume of certain factors can be changed more flexibly than of the others (unqualified workers vs. factory buildings).
- Long-run horizon is defined as a time period in which the volume of all factors can be changed.
- Short-run horizon is defined as a time period in which the volume of at least one factor can be changed.
- In the short run, we have fixed and variable factors, in the long run, all factors are variable.

In the short run, we can quantify the impact of the variable factor on production

- Let us assume that a firm uses two factors (labor and capital) and let us fix the capital at a constant level $\overline{K}$. We can analyse the impact of labor on the volume of output produced:

$$q = f(L, \overline{K}) \quad .$$

- We define the marginal product (MP) of the variable factor as the change of output given by a change of variable input:

$$MP_L = \frac{\Delta q}{\Delta L} \quad .$$

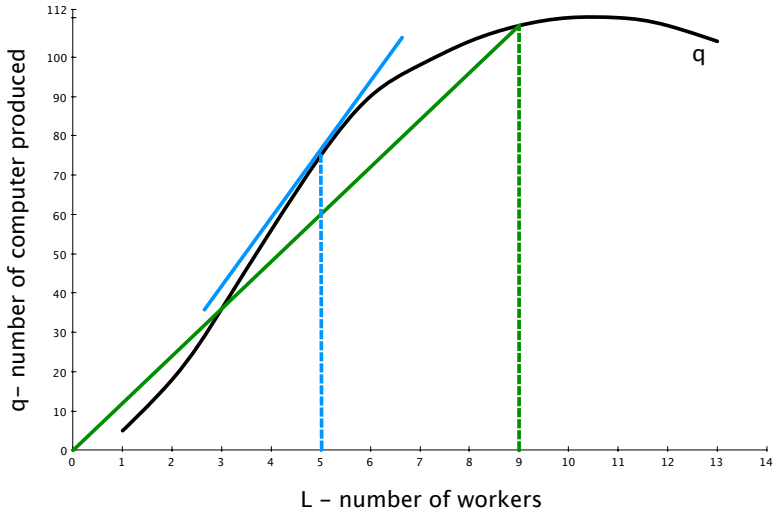
- We define the average product (AP) of the variable factor as the volume of output related to one unit of variable factor:

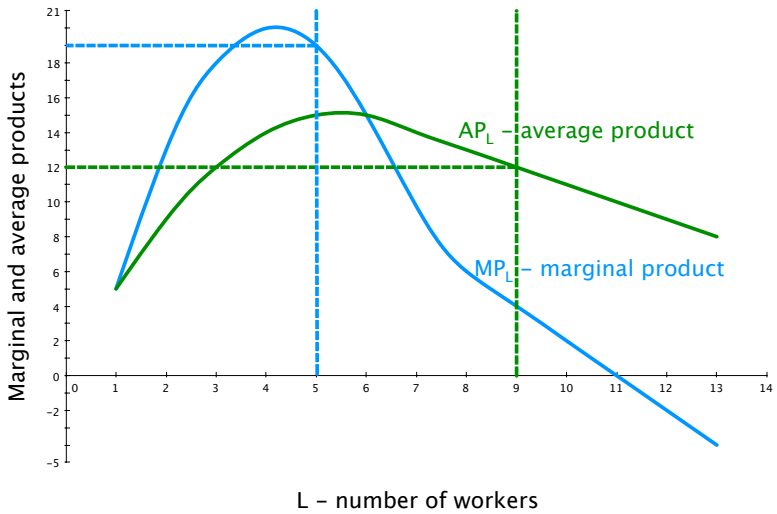
$$AP_L = \frac{q}{L} \quad .$$

Example: firm assembling computers with a fixed number of production lines

$\overline{K}$	L	q	MP_L	AP_L
8	0	0		
8	1	5	5	5
8	2	18	13	9
8	3	36	18	12
8	4	56	20	14
8	5	75	19	15
8	6	90	15	15
8	7	98	8	14
8	8	104	6	13
8	9	108	4	12
8	10	110	2	11
8	11	110	0	10
8	12	108	-2	9
8	13	104	-4	8

Shape of marginal and average products is given by the shape of production function





- If we represent graphically the production function as a function of the variable input, the segment connecting the origin with a point on the line gives the average product in that point.
- Marginal product is given by the slope of the function in that point.

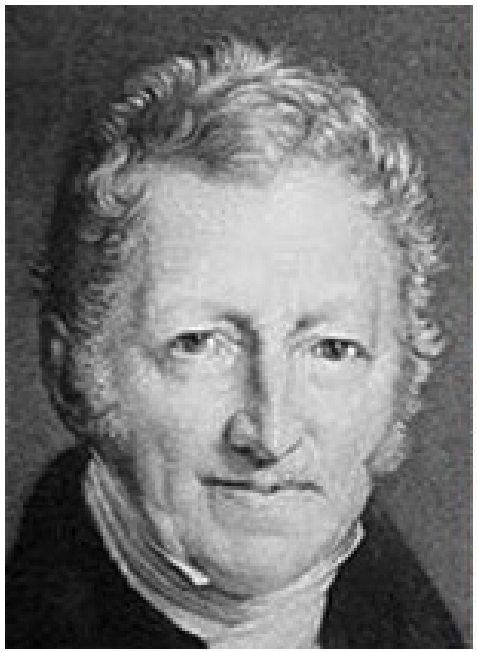
Marginal product usually decreases with increasing variable product

- The shape of MP and AP curves from the previous example is typical.
- The more we increase the volume of variable factor, the less we get from each additional unit (other factors being fixed), and therefore

$$\frac{\Delta MP_L}{\Delta L} < 0 \ .$$

- This rule is know as “the law of diminishing marginal returns” and was discovered by Thomas Malthus (1766-1834).

Marginal products of inputs can be increased by changing technology of production




- Given limited area of farmable land and the law of diminishing marginal returns, Thomas Malthus warned in 1798 against the danger of worldwide famine.
- Despite his predictions, there are 7$\times$ more people on Earth than in Malthus' era. Why?

The same output can be produced with different combinations of inputs (in long run)

- Given that in the long run, all factors are variable, their different combinations can be use to achieve the same level of production.
- If we consider e.g. the production function

$$q = f(L, K) = \sqrt{LK} \ ,$$

  then combinations $(L = 4, K = 25)$, $(L = 5, K = 20)$, $(L = 10, K = 10)$ give the same level of production $q = 10$.
- The different combinations are associated with different costs.
- The firm always choses the combination that represents minimal cost .

Production function changes with development of technology and organisation

- Technological development allows to increase the volume of production using the same amount of inputs.
- A neutral technological change does not affect the ratio of used capital and labor.
- A non-neutral technological change leads to a different ratio of used capital and labor.
- The change of organisation of production has the same effect as technological change:
  `http://www.youtube.com/watch?v=3RaIT-VeG3M`

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Firm that wants to maximize its profit has to minimize its costs

- Firm's decision about production of output demanded consists of two stages:
  1. Firm decides how to produce so that it is technologically efficient - it defines its production function.
  2. Firms decides which of the technologically efficient procedures is economically efficient - the firm minimizes its costs given its production function and prices of inputs.
- By minimizing its costs while producing a given level of output the firm maximizes its profit.
- For cost minimization, one has to understand what types of costs the firm has to face.

In economics, we distinguish direct costs and opportunity costs

- Direct costs represent the money that is spent on production (wages, cost of material, etc.).
- We cannot evaluate all costs so easily, we have to considered also the *opportunity costs*.
- Such costs represent the value of the item that the firm has to give up in order to obtain the item whose cost we are evaluating.
- We use this method for example when evaluating the cost of capital - we consider e.g. that instead of buying the machines, the firm would invest the money and obtain interest payments.

Increase of quantity produced usually leads to increasing costs

- Total costs of the firm (TC) can be decomposed into fixed costs (FC) and variable costs (VC):

$$TC = VC + FC \ .$$

- Variable costs depend on the volume produced, fixed costs are constant at all levels of production.

- In the short run, fixed costs include the costs given by the production factor that is not variable.

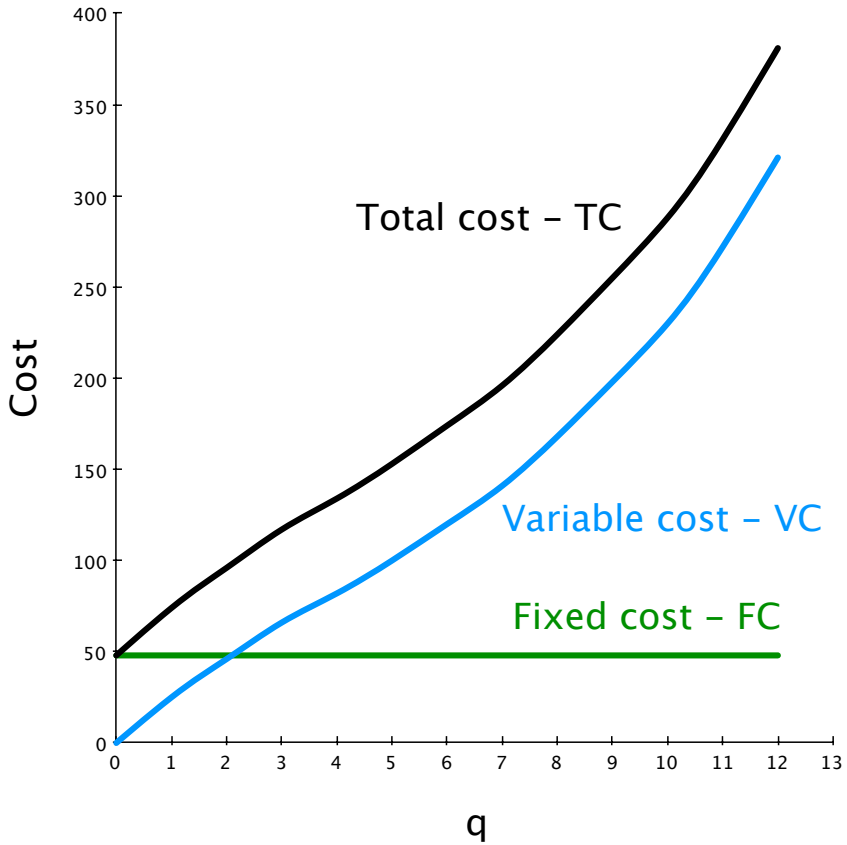
Impact of quantity produced on costs can be quantified using different measures

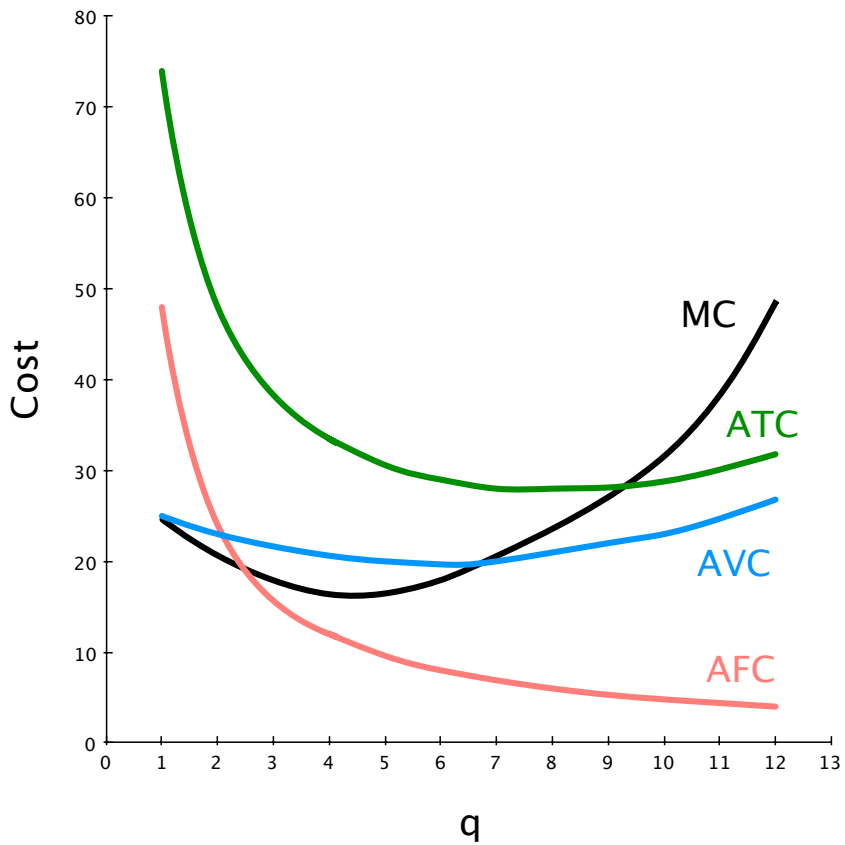
- We define marginal cost (MC) as a change of total cost given by change of quantity produced: $MC = \frac{\Delta C}{\Delta q}$.
- We define average variable cost (AVC) as variable cost related to one unit of quantity produced: $AVC = \frac{VC}{q}$.
- We define average fixed cost (AFC) as fixed cost related to one unit of quantity produced: $AFC = \frac{FC}{q}$.
- We define average total cost (ATC) as total cost related to one unit of quantity produced: : $ATC = \frac{TC}{q}$.

Numerical example:

q	FC	VC	TC	MC	AFC	AVC	ATC
0	48	0	48				
1	48	25	73	25	48	25	73
2	48	46	94	21	24	23	47
3	48	66	114	20	16	22	38
4	48	82	130	16	12	20.5	32.5
5	48	100	148	18	9.6	20	29.6
6	48	120	168	20	8	20	28
7	48	141	189	21	6.9	20.1	27
8	48	168	216	27	6	21	27
9	48	198	246	30	5.3	22	27.3
10	48	230	278	32	4.8	23	27.8
11	48	272	320	42	4.4	24.7	29.1
12	48	321	369	49	4.0	26.8	30.8

All types of costs can be represented graphically as functions of output produced

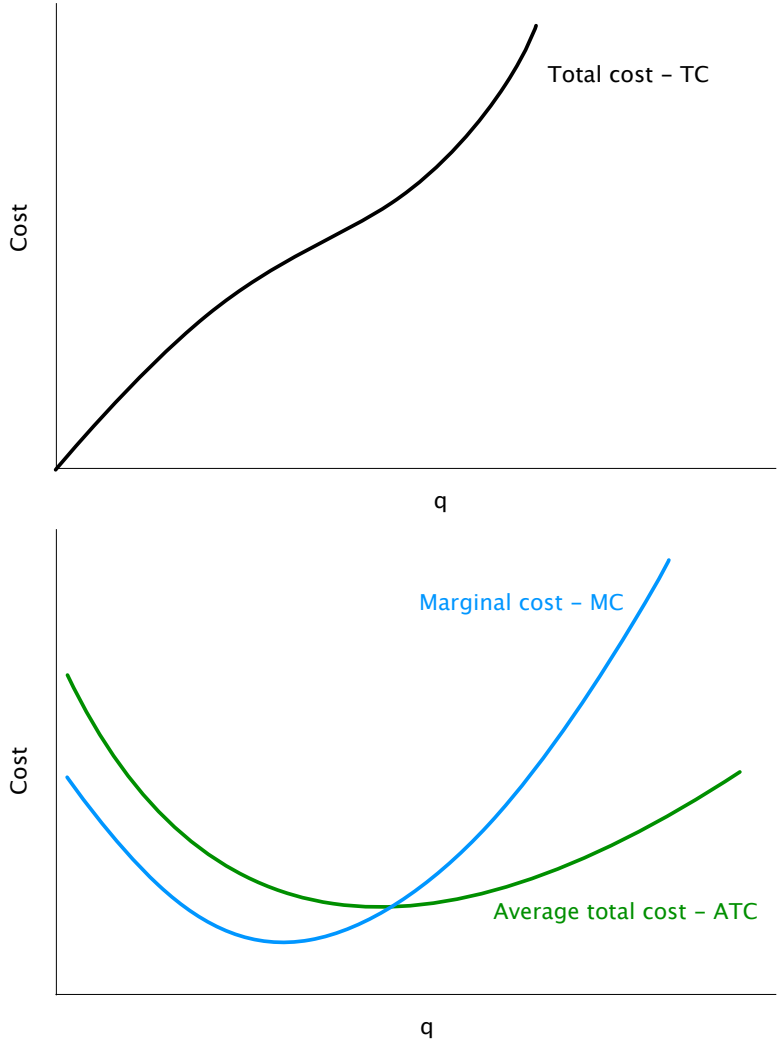




In the long run, firm can minimize its costs by optimally choosing all inputs

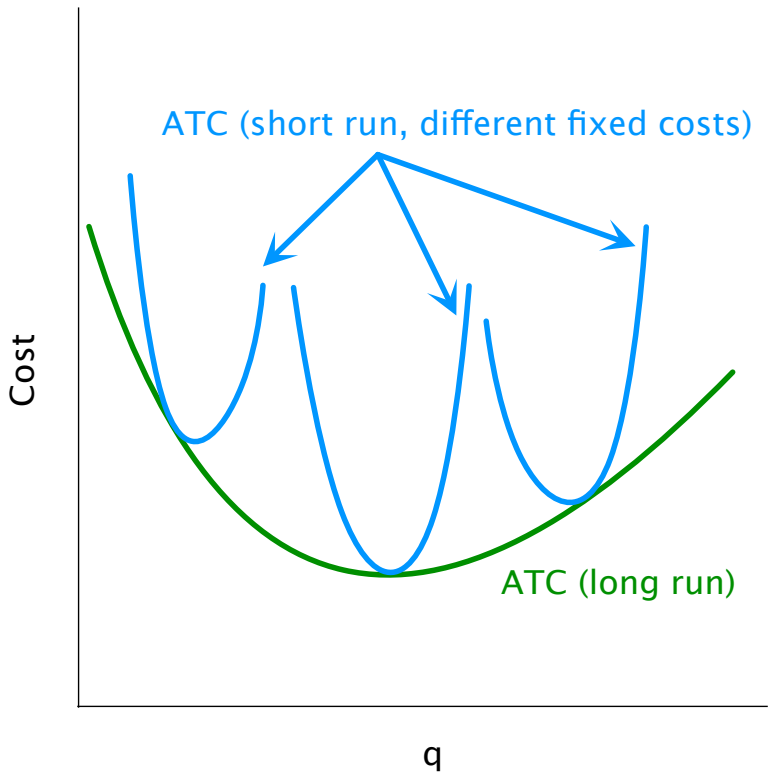
- From the long-run perspective, there are no fixed costs (all inputs are variable and the production can be stopped).
- Therefore, in the long run, we consider only total cost (equal to variable cost), average total cost and marginal cost.
- To optimize the costs, firm choses the optimal combination of inputs, i.e. the combination which allows to produced the required level of output (given the production function) and which is the less costly given prices of these inputs.
- Total cost is then the cost of this optimal production for given levels of output.

When represented graphically, cost curves of typical firms have particular shapes



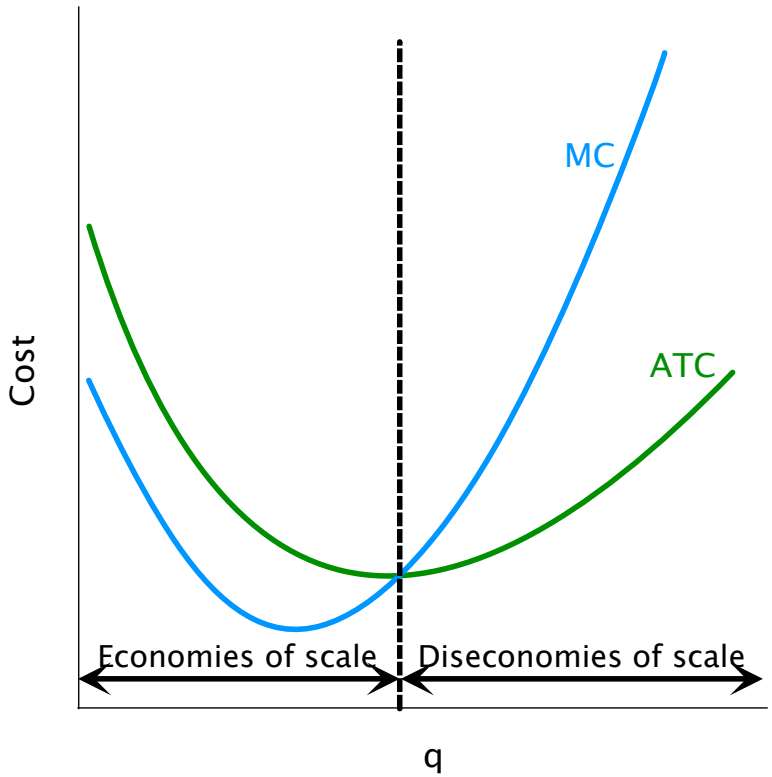
- Marginal-cost eventually rises with the quantity of output.
- Average-cost curve is typically U-shaped.
- Marginal-cost curve crosses the average-cost curve at the minimum of average cost.

Average total cost is always lower in the long run than in the short run



- In the short run, average total cost always corresponds to the given level of fixed cost.
- In the long run, all costs are variable - the cost can be optimized flexibly.
- Therefore, long-run ATC curve is always below the short-run ATC curve.

U-shaped ATC curve shows how costs of production vary with output level



- Economies of scale: long-run ATC falls as the quantity of output increases.
- Diseconomies of scale: long-run ATC rises as the quantity of output increases.

EXCERCISE

The only variable input a janitorial service firm uses to clean offices is workers who are paid a wage, w, of \$8 an hour. Each worker can clean four offices in an hour. Determine the variable cost, the average variable cost, and the marginal cost of cleaning one more office. Draw a diagram to show the variable cost, average variable cost, and marginal cost curves.

- Introduction to theory of supply
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The goal of each firm (in all market regimes) is to maximize profit

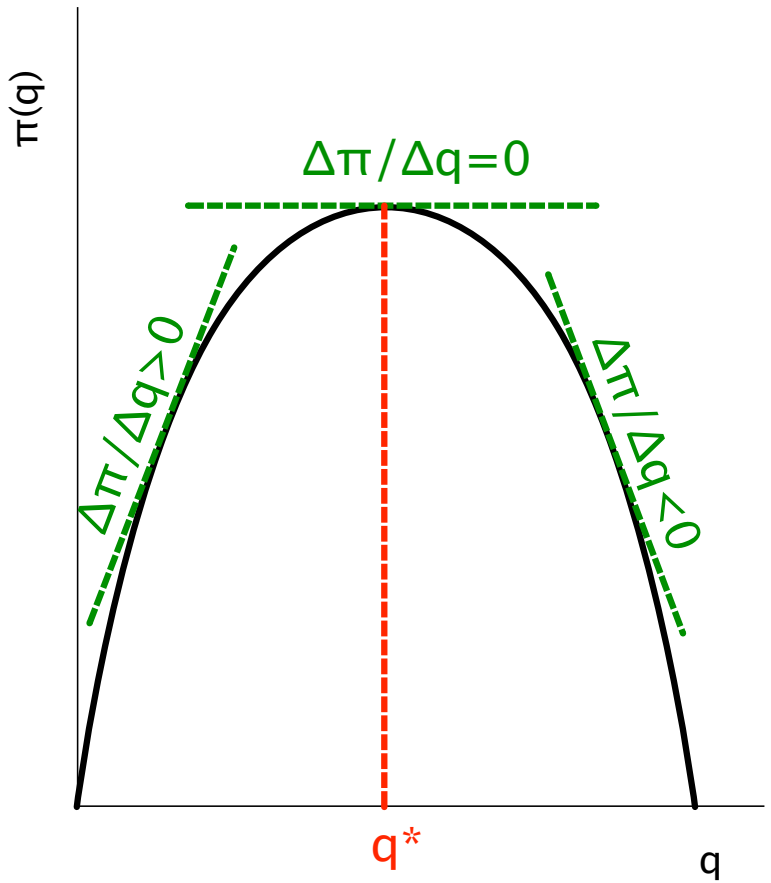
- The profit (π) is defined as the difference between revenues (R) and total costs (C) and depends on the quantity of output produced by the firm (q):

$$\pi(q) = R(q) - C(q) \quad .$$

- The firm decides about its optimal production in two steps:
  1. What level of output q^* maximizes the profit of the firm?
  2. At this level, is it optimal to produce or to interrupt (stop) the production?
- The firm thus maximizes its profit (given market conditions), and if this maximal profit at least lowers the necessary costs, then the firm produces the optimal quantity of output.

At optimal production level, the profit is maximized - marginal profit is equal to zero

- We assume that with increasing quantity produced, the profit first increases and than decreases.
- At the point where the profit stops increasing and starts decreasing, it is maximized, and this point thus corresponds to the optimal production q^*.
- Marginal profit $\frac{\Delta\pi(q)}{\Delta q}$ is equal to zero at this point.



At optimal production level, marginal revenues are equal to marginal costs

- Necessary condition for the production q^* to be optimal:

$$\frac{\Delta\pi(q^*)}{\Delta q} = \frac{\Delta R(q^*)}{\Delta q} - \frac{\Delta C(q^*)}{\Delta q} = 0 \ .$$

- If we denote marginal revenues $MR = \frac{\Delta R}{\Delta q}$ and marginal costs $MC = \frac{\Delta C}{\Delta q}$, we have the condition

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

- This condition tells us that at the optimal production level, the change of costs has to be just compensated by the change of revenues.

The firm produces if revenues in optimum are larger than variable costs

- At the optimal solution q^*, the profit of the firm (generated by production) has to be larger than the loss given by fixed costs (that the firm has to pay even if it does not produce):

$$\pi(q^*) = R(q^*) - C(q^*) \geq -FC \ ,$$

  where FC are necessary fixed costs.

- It holds then:

$$R(q^*) \geq C(q^*) - FC = VC(q^*) \ ,$$

  where $VC(q)$ are variable costs.

- This condition as well as the condition

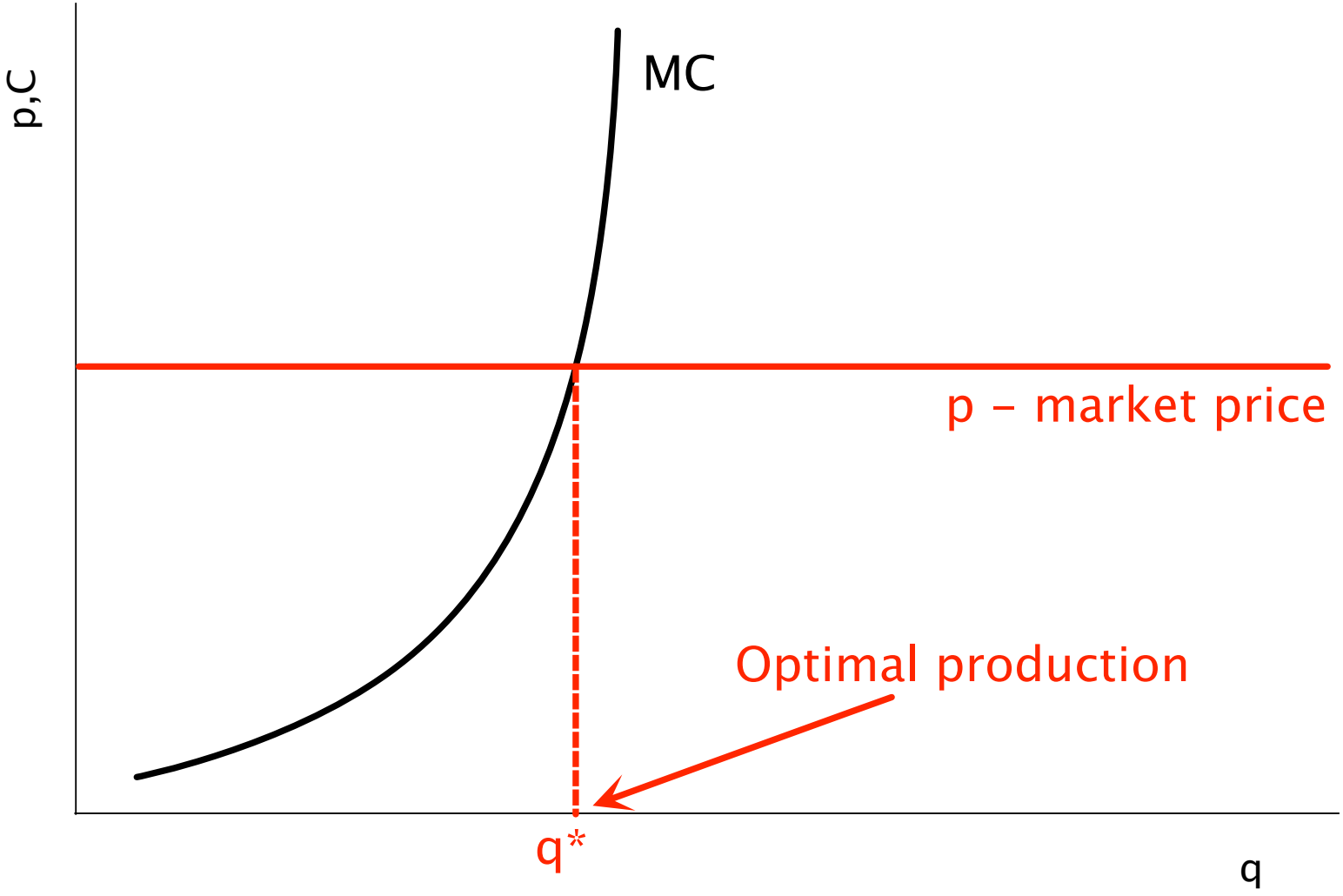
$$MR(q^*) = MC(q^*)$$

  has to be satisfied in the short run as well as in the long run and under all market regimes.

Under perfect competition, profit maximizing firm has to take market price as given

- Marginal costs are given by the production technology of the firm.
- Marginal revenues depend on the market structure.
- Market structure is defined by the number of firms in the market, conditions under which firms can enter the market and leave it, and the ability of firms to differentiate their products from the products of their competitors.
- In the regime of perfect competition, there is a large number of firms in the market, they all sell identical products and can leave and enter the market freely.
- In this regime, each individual firm has the accept the price given by the market.
- The market price also includes all information that the firm needs to decide about optimal production.

In perfect competition regime, marginal costs in the optimum are equal to the price



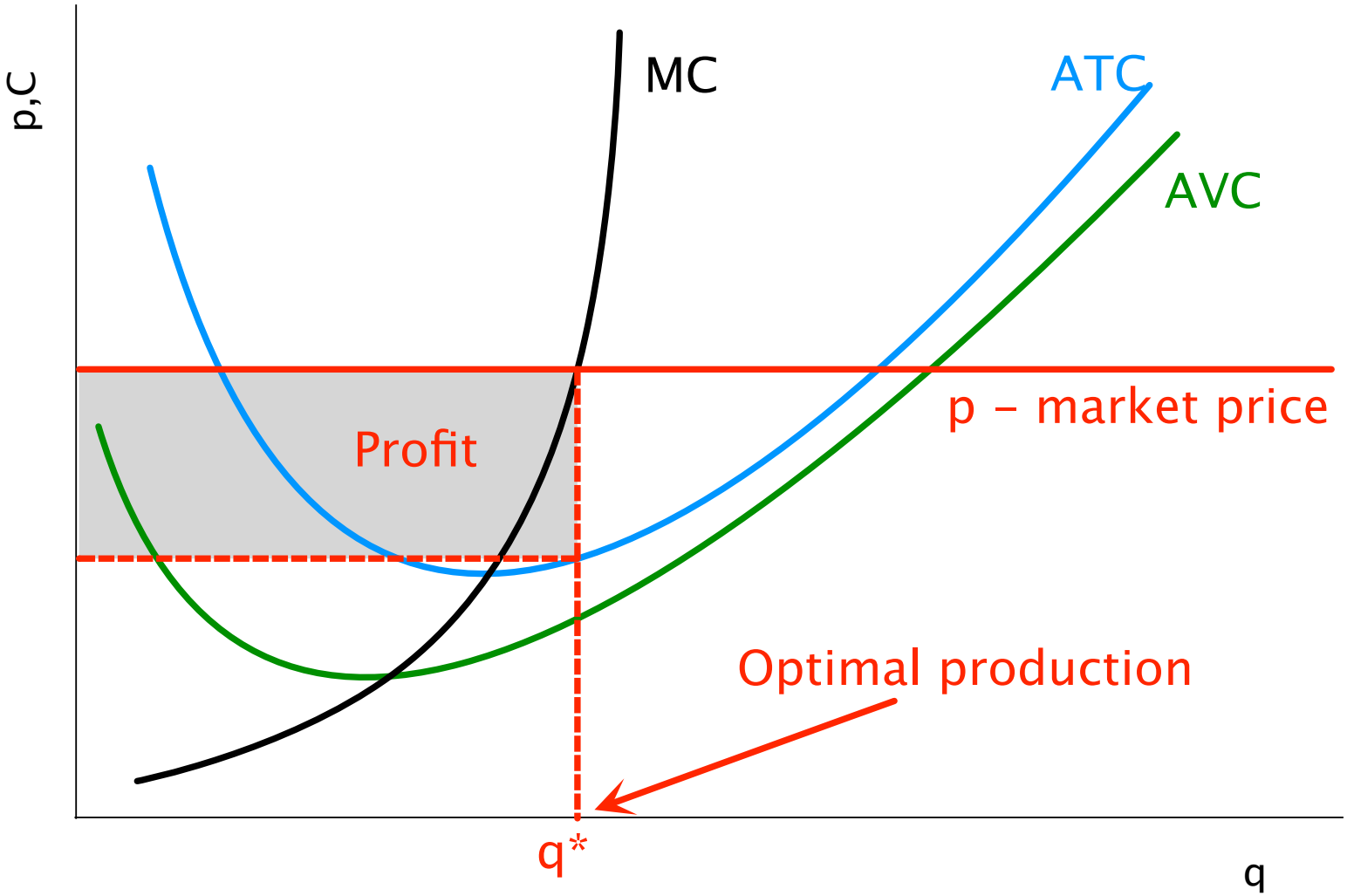
We can represent the profit of a competitive firm graphically using cost curves

- Profit of the firm can be written as

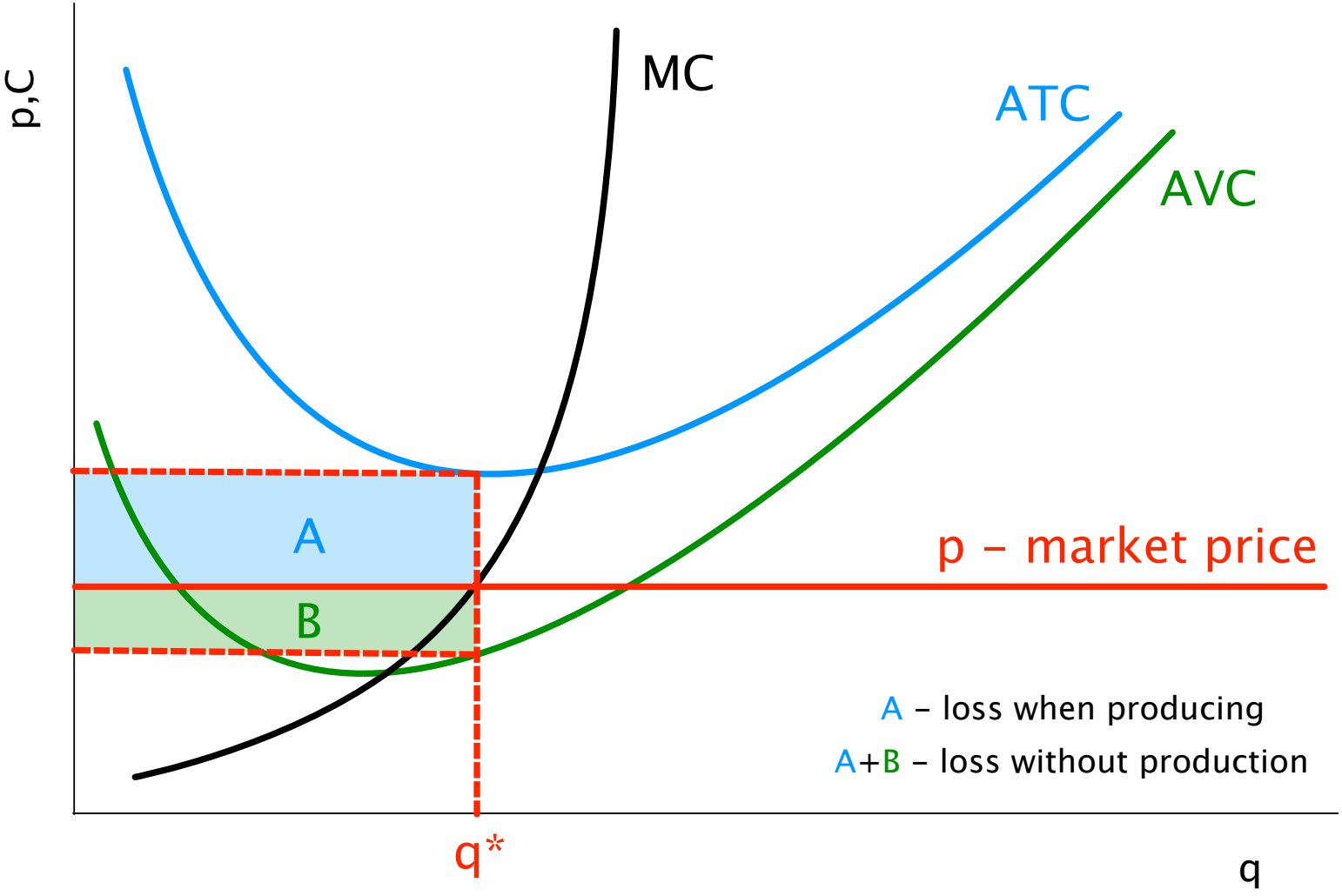
$$\begin{aligned} \pi(q) &= pq - \frac{TC(q)}{q} q = pq - ATC(q)q \\ &= (p - ATC(q))\, q \ . \end{aligned}$$

- Profit in optimum is thus equal to the area of a rectangle with one side of length q^* and the second side of length given by the difference between the market price and the average-total-cost curve in optimum $(p - ATC(q^*))$.
- This optimum is given by the intersection of marginal-cost curve and market price (horizontal demand).

We can represent the profit of a competitive firm graphically using cost curves



In short run, firm can make loss, but it has to be smaller than the loss given by fixed costs



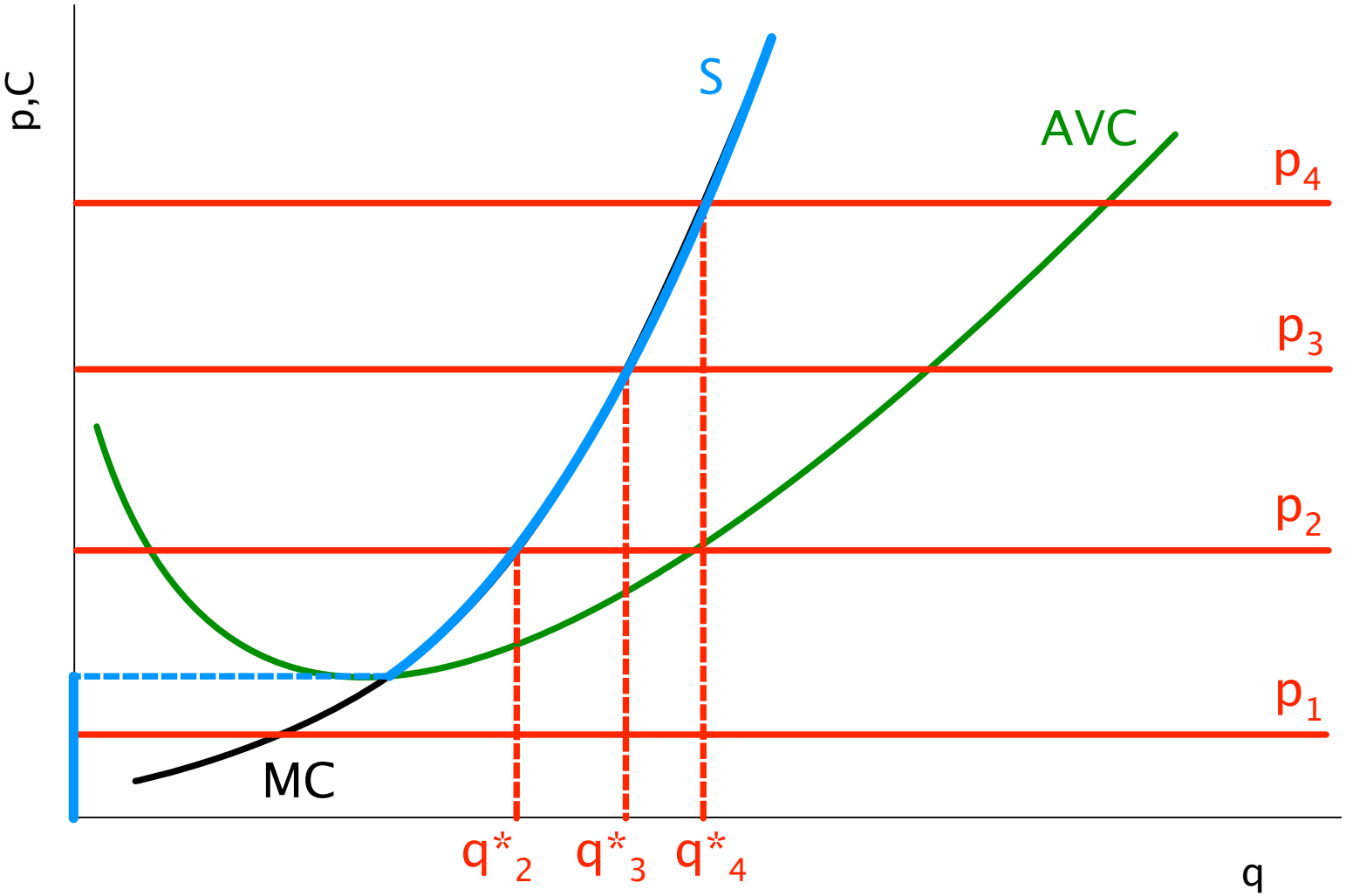
Firm's supply curve coincides with MC curve for q for which MC curve is above AVC curve

- If the price is higher than average variable costs in optimum, then the profit is higher than the loss given by fixed costs and the firm produces.
- We have the condition of the non-null production:

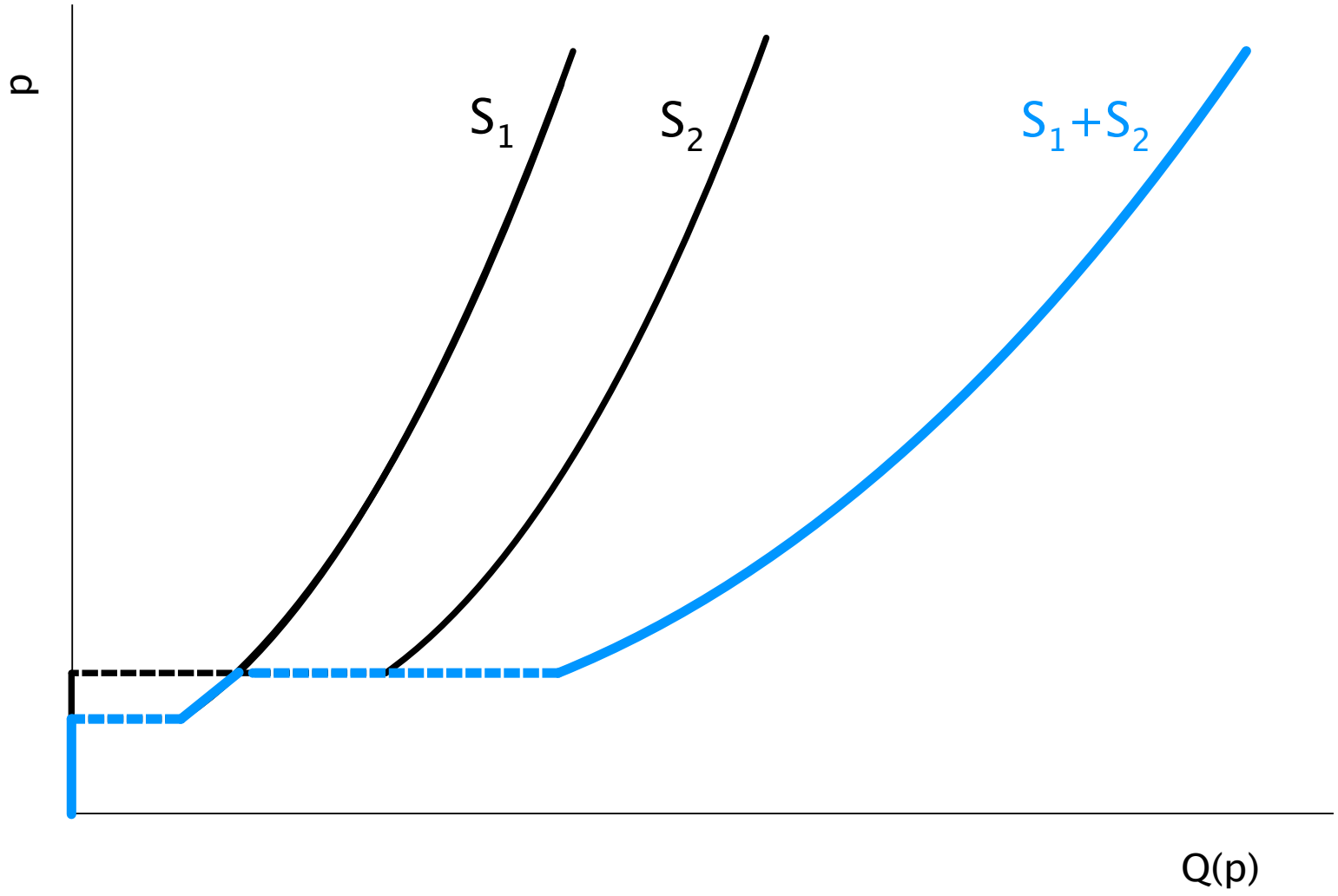
$$\begin{aligned} R(q^*) = pq^* &\geq VC(q^*) = \frac{VC(q^*)}{q^*}q^* \\ pq^* &\geq AVC(q^*)q^* \\ p &\geq AVC(q^*) \end{aligned}$$

- Together with the condition $p = MC(q^*)$, this means that firm's supply curve coincides with the marginal-cost curve for quantities q for which this curve is above the average-variable-cost curve. For other quantities, the supply is zero.

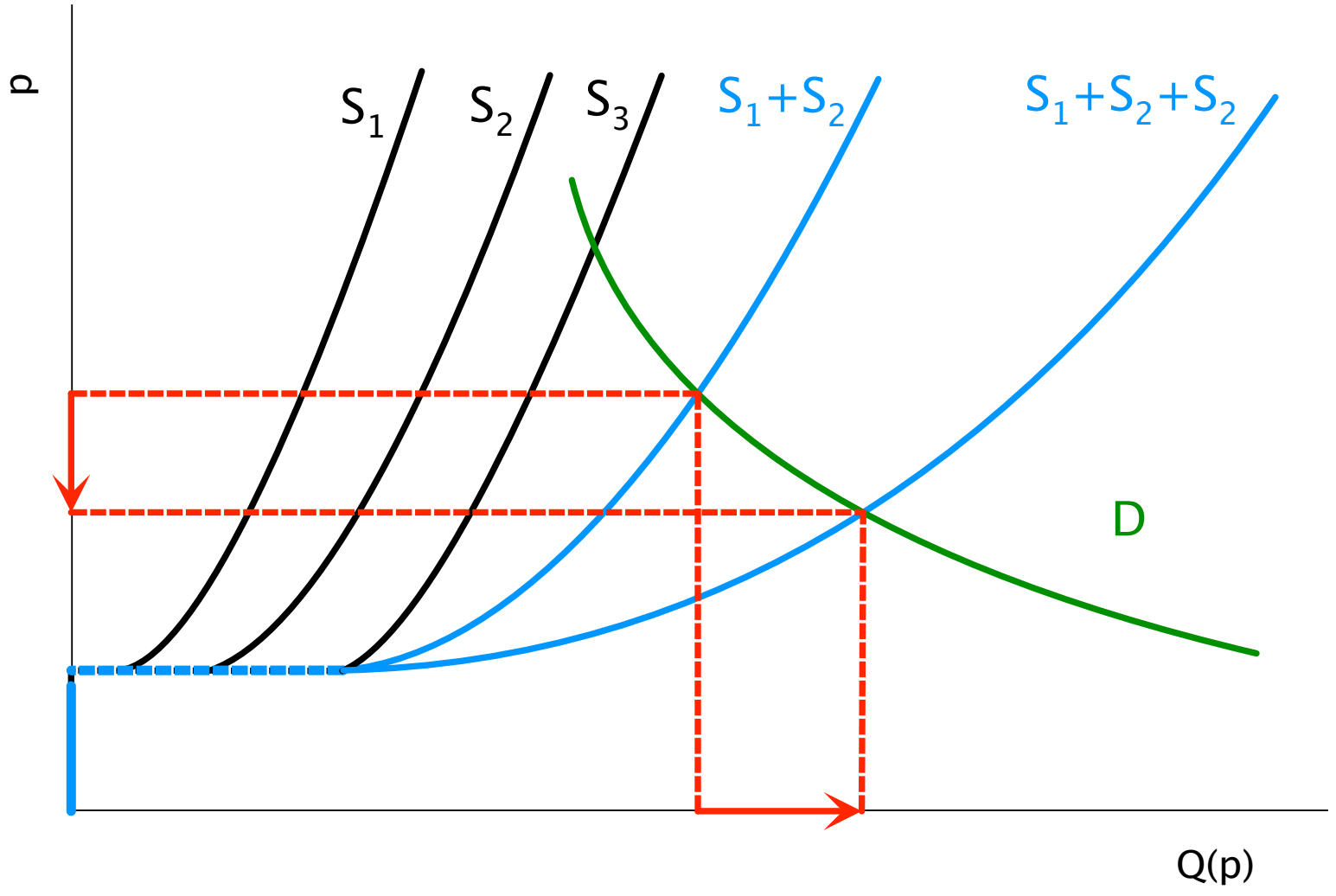
Firm's supply curve coincides with MC curve for q for which MC curve is above AVC curve



Market supply curve equals to horizontal sum of supply curves of individual firms



With increasing number of firms, price decreases and production increases



In the short run, production can be temporarily interrupted

HOME > GLOBAL ECONOMY > COMPETITIVENESS > VOLVO CARS STOPS PRODUCTION AT SWEDISH PLANT

Volvo Cars Stops Production at Swedish Plant

Decline in European automotive market prompts one-week suspension.

Agence France-Presse — Oct. 15, 2012

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Volvo Cars, part of China's Geely group, said on Monday that production at one of its main plants would be suspended for a week due to a slowdown in the European auto market.

Production at Torslanda, next to the company's Gothenburg headquarters, will be temporarily halted from Oct. 29 until Nov. 2.

"The measure is taken based on a continued decline of the automotive market, primarily in Europe. Therefore a further adjustment to Volvo Car Corp.'s manufacturing operation is necessary," the company said in a statement.

On Oct. 1 Volvo reduced the production pace at Torslanda to 50 cars per hour, down from 57.

During the week-long suspension, "Torslanda plant employees will be on leave with pay through a combination of utilizing time banks and leave of absence," it said.

Volvo Car Corp. is a separate entity from Volvo Trucks, the maker of trucks, buses and construction machinery, since the auto company was sold in 1999.

In the long run, a firm produces only if it does not make loss

- In the long run, all costs are variable, therefore, the non-null production condition is reduced:

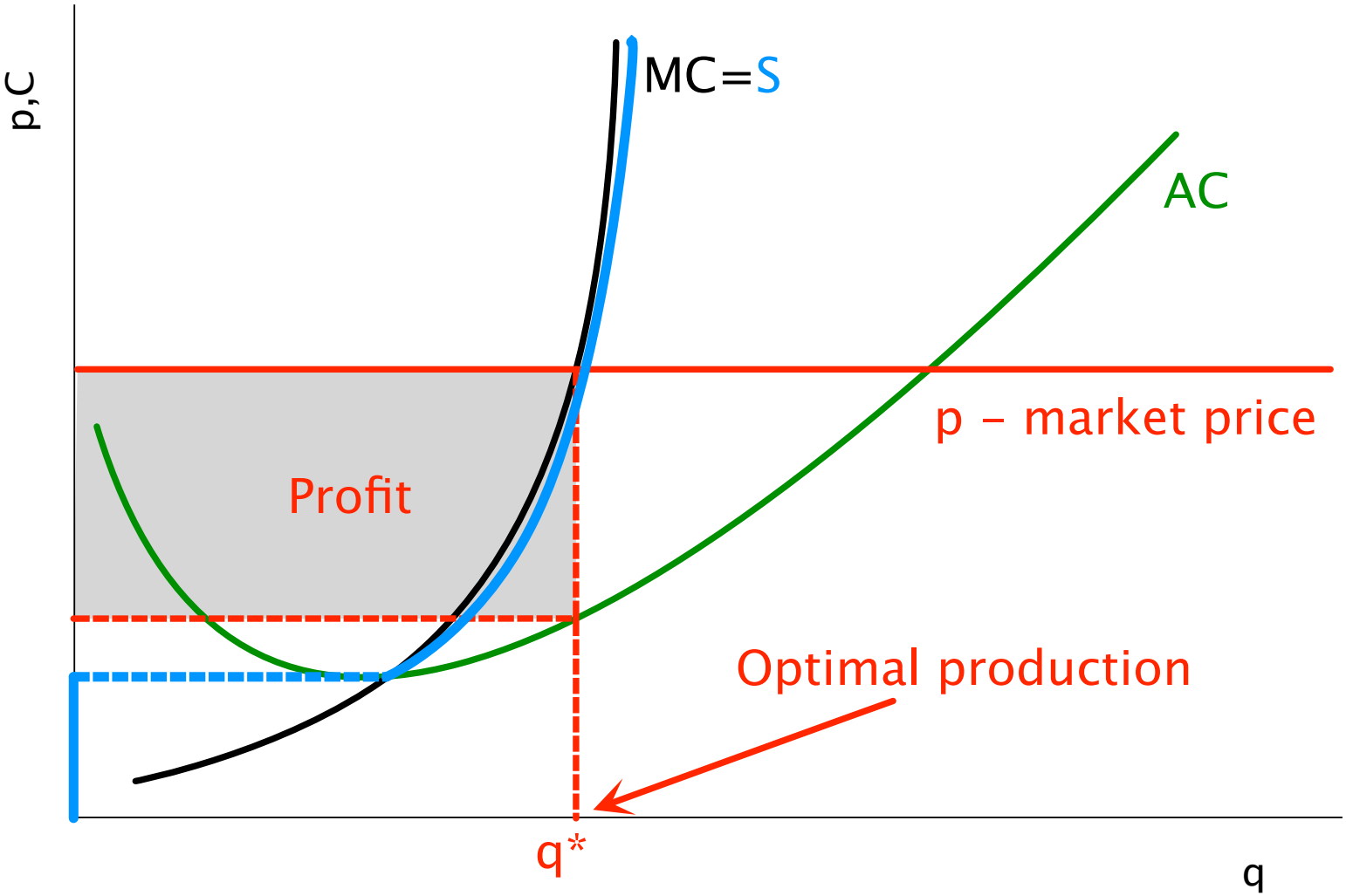
$$\pi(q^*) \geq -F = 0 \ .$$

- The firm then produces only if it does not make loss, and it optimizes its production in order to maximize the profit, which leads again to the condition

$$MC(q^*) = p \ .$$

- Long run supply curve coincides with the marginal-cost curve for quantities q for which this curve is above the average-cost curve.

Firm's supply curve coincides with MC curve for q for which MC curve is above AC curve



Under certain assumptions, overall market supply curve is horizontal

- In the long run, the firm decides to enter the market if its production will not lead to loss.
- Hence, we assume that all firms that enter the market will satisfy the condition

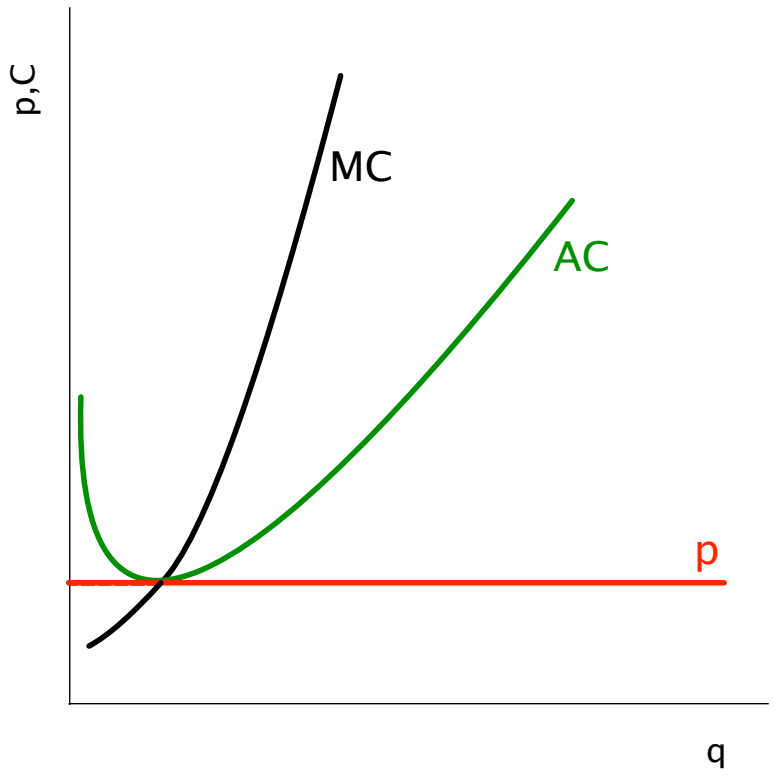
$$\pi(q^*) \geq 0$$

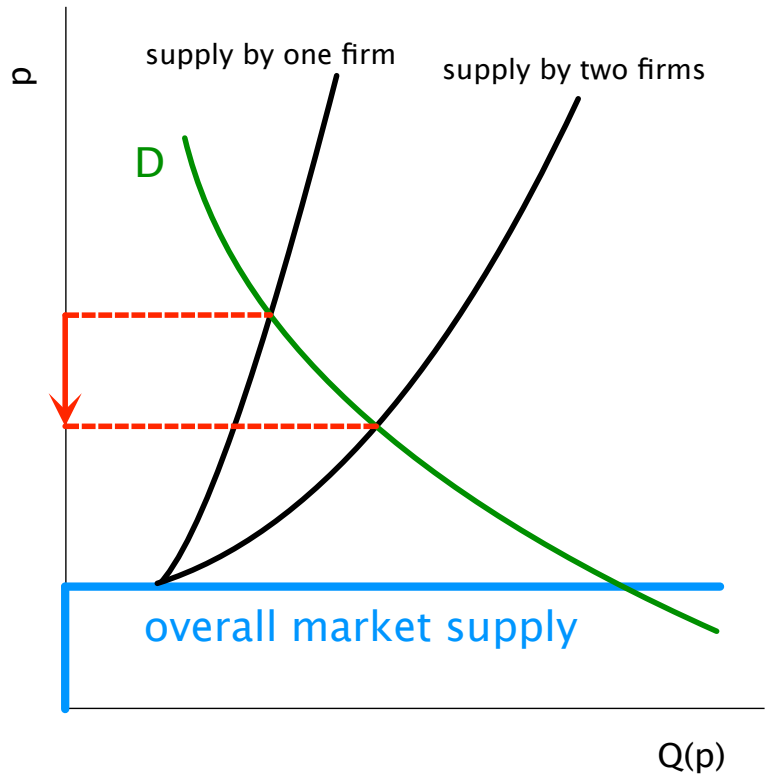
  at the given market price and costs of production factors.
- In theoretical model, we can assume that all these firms have the same costs and thus also the same supply curve, and that costs of input factors do not vary with to volume of production.

Under certain assumptions, overall market supply curve is horizontal

- If we assume that there is an infinite number of potential firms that are ready to enter the market and we sum their supply curves, then the resulting market supply curve will be horizontal.
- With each additional firm entering the market, the supply curve becomes flatter (more elastic).
- The price given by intersection of supply and demand curve decreases gradually (and so thus the profit of each individual firm).
- With the infinite number of firms the price thus decreases till it reaches the minimum price at which firms are willing to produce - this price is given by intersection of their marginal-cost and average-cost curves.

Under certain assumptions, overall market supply curve is horizontal





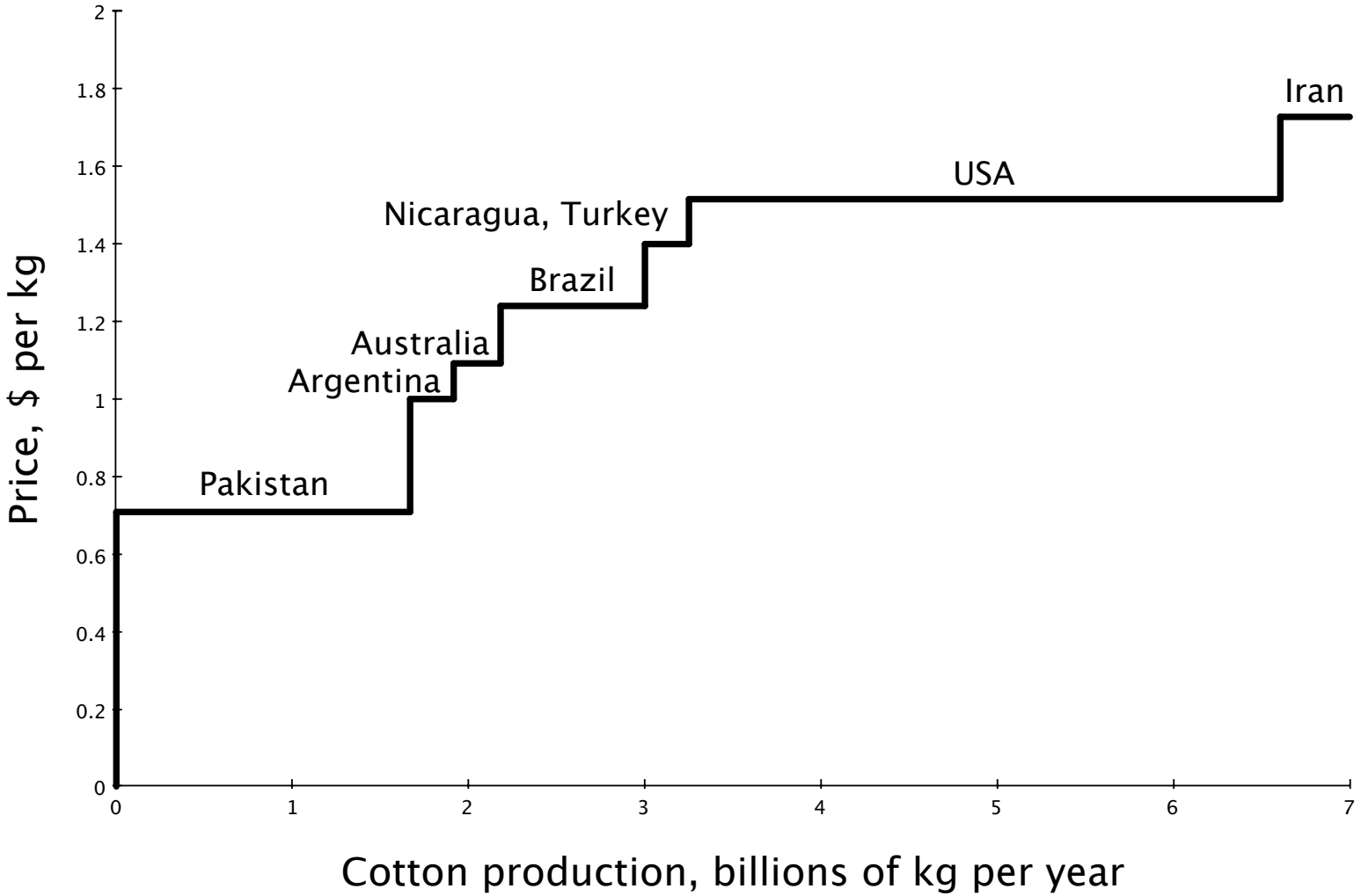
Horizontal supply curve leads to unlimited supply at very low prices

- Chinese artists produce thousands of copies of famous paintings for a monthly wage of $200.

In reality, we do not often encounter horizontal supply curve

- Firms have different production costs and there is not an infinite number of firms with low costs.

In reality, we do not often encounter horizontal supply curve



Overall market supply depends also on changing prices of inputs

- Till now, we have assumed that prices of inputs do not change with level of production and that the cost curves thus do not shift.
- In certain situations, prices of inputs can increase with increasing production as the demand for them rises. This shifts the supply curves of the firms and thus also the resulting equilibrium price up.
  - Example: jet engines and production of airplanes.
- In other cases, prices of inputs can decrease with increasing production due to economies of scale in the sector producing inputs. This shifts the cost curves and thus also the resulting equilibrium price down.
  - Example: CD drives and computers.

EXERCISE

An industry currently has 100 firms, all of which have fixed costs of $12 and average variable cost as follows:

Quantity	Average variable costs (in USD)
1	1
2	2
3	3
4	4
5	5
6	6

1. Compute marginal cost and average total cost.
2. The price is currently $9. What is the total quantity supplied in the market? Is this market in long-run equilibrium?
3. As this market makes the transition to its long-run equilibrium, will the price rise or fall? Will the quantity demanded rise or fall? Will the quantity supplied by each firm rise or fall?