Engineering Economic Analysis

2019 SPRING

Prof. D. J. LEE, SNU

Chap. 23

FIRM SUPPLY

Market Environments

- Firm's two important decisions
  - How much it should produce
  - What price it should set
- Constraints
  - Technological constraints
    - Production function
  - Economic constraints
    - Cost function
  - Market constraints
    - Demand curve facing the firm
- Market environment
  - The way that firms respond to each other when they make their pricing and output decisions

Pure competition

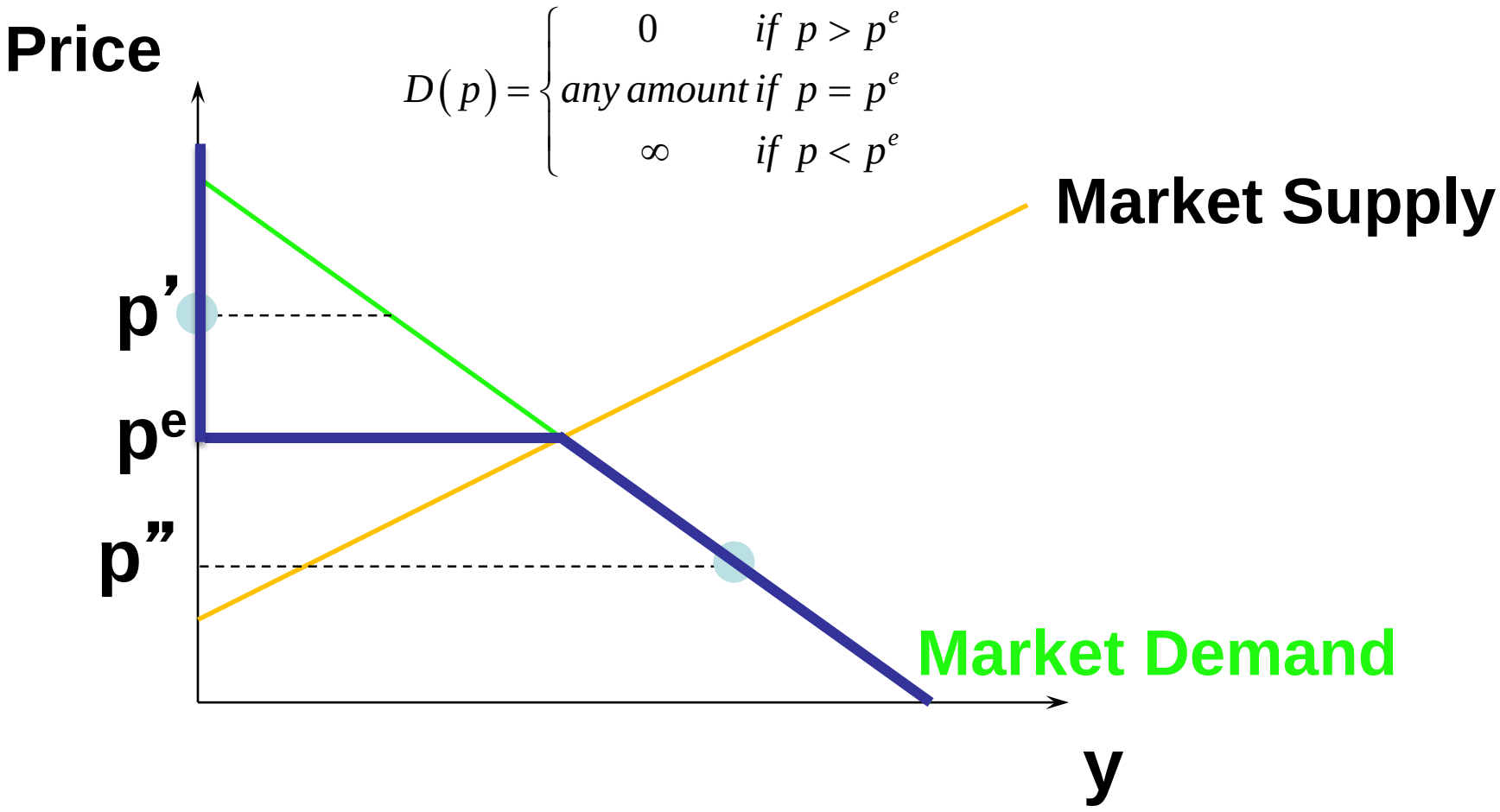
- Market is *purely competitive* if each firm assumes that the market price is independent of its own level of output
  - An industry of many firms that produce an identical good, and that each firm is a small part of the market
  - Only worry about how much output it produces (supply)
  - Price taker
- Demand curve facing a competitive firm
  - Let p^e be the market price

$$D(p) = \begin{cases} 0 & if \ p > p^e \\ any\ amount & if \ p = p^e \\ \infty & if \ p < p^e \end{cases}$$

Pure competition

- Demand curve facing a competitive firm

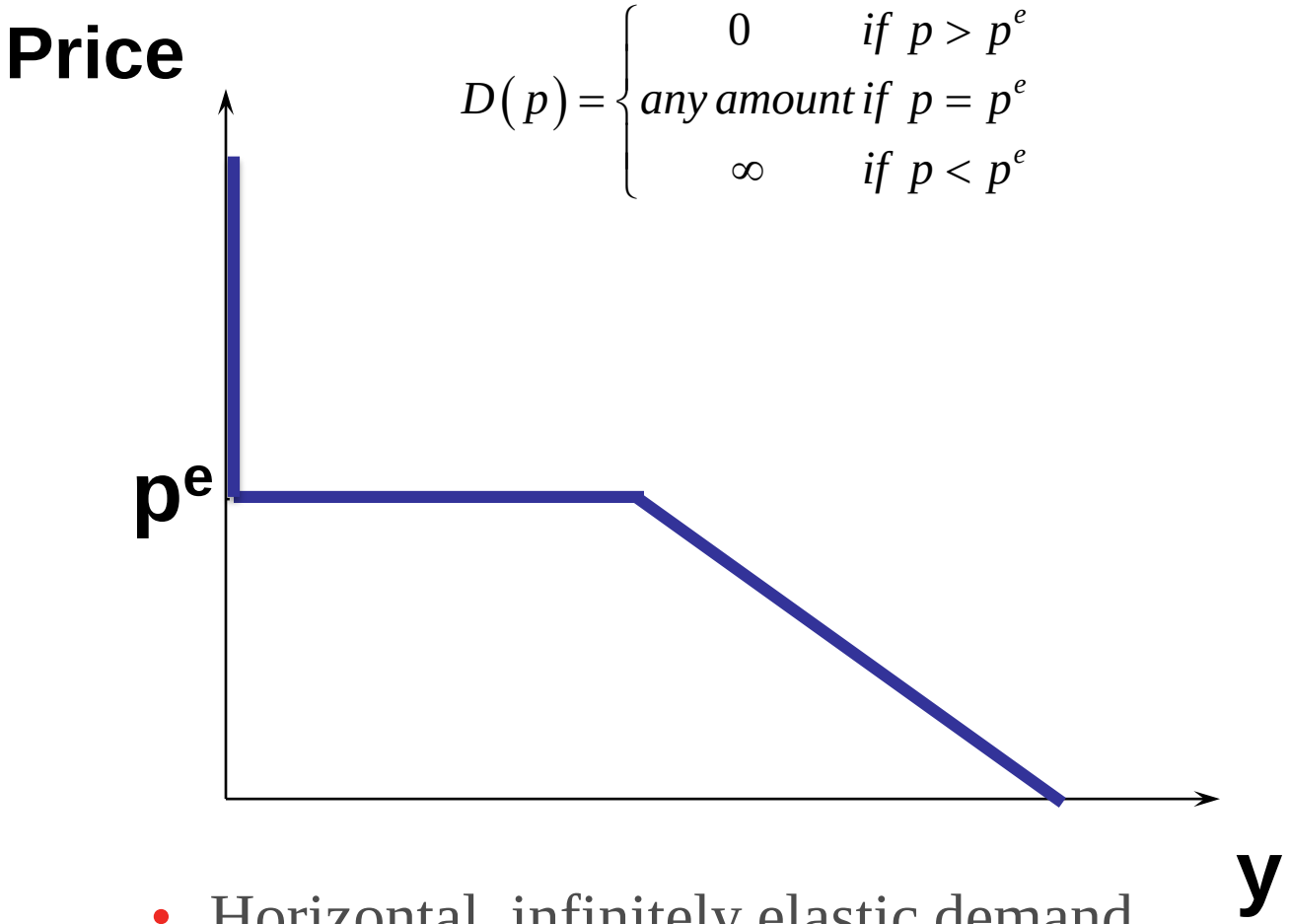
$$D(p) = \begin{cases} 0 & if\ p > p^e \\ any\ amount & if\ p = p^e \\ \infty & if\ p < p^e \end{cases}$$



Pure competition

- Demand curve facing a competitive firm

$$D(p) = \begin{cases} 0 & if\ p > p^e \\ any\ amount & if\ p = p^e \\ \infty & if\ p < p^e \end{cases}$$



- Horizontal, infinitely elastic demand

Pure competition

- What does it mean to say that an individual firm is “small relative to the industry”?

  - The individual firm’s capacity to supply can cover only a small part of the total quantity demanded at the market price

Supply decision of a competitive firm

- Profit-max problem

$$\max_{y} py - c(y)$$

- F.O.C.

$$p = c'(y^*)$$

Marginal revenue = Marginal cost

- S.O.C.

$$c''(y^*) \geq 0$$

- Inverse supply function $p(y)$: the price that must prevail in order for a firm to find it profitable to supply a given amount of output
  - By F.O.C.

$$p(y) = c'(y)$$

Supply decision of a competitive firm

- Supply function $y(p)$: the profit-maximizing output at price of p
  - Whatever the level of market price p, the competitive firm will choose a level of output where $p = c'\left(y(p)\right)$
  - In addition, by S.O.C., the firm will supply the output which satisfy $c''\left(y(p)\right) \geq 0$
- Therefore, the supply curve of the competitive firm is the upward sloping part of its marginal cost curve!

Differentiating F.O.C. ($p \equiv c'\left(y\left(p\right)\right)$) w.r.t. p

$$1 = c''\left(y\left(p\right)\right)y'\left(p\right)$$

By S.O.C. $c''(y) > 0 \Rightarrow y'\left(p\right) > 0$

Supply decision of a competitive firm

- Additionally, the competitive firm's economic profit level must not be negative since then the firm would exit the industry in the long-run. So,

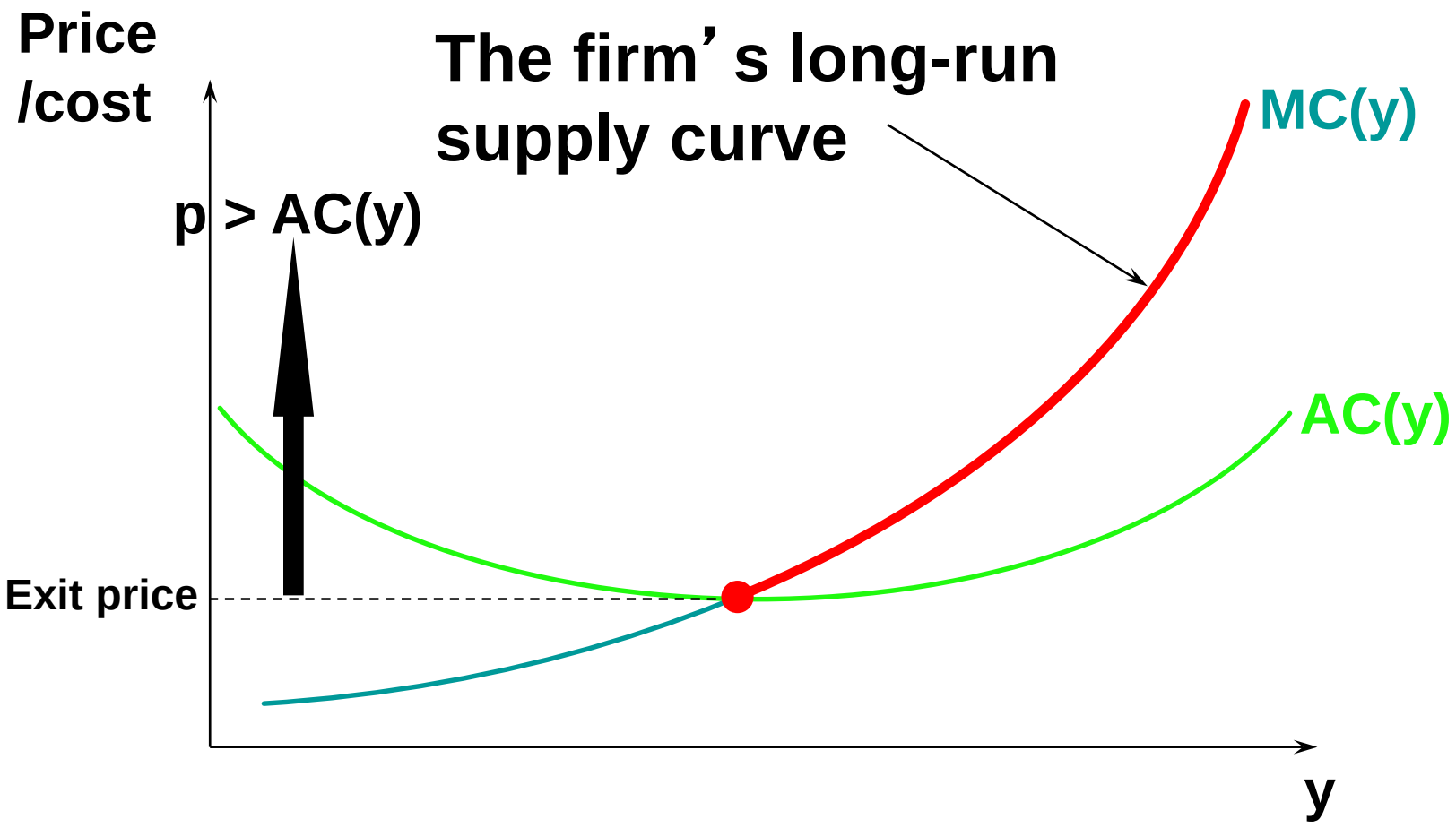
$$\pi(y) = py - c(y) > 0$$

$$\Rightarrow \; p \geq \frac{c(y)}{y} = \mathrm{AC}(y)$$

- LR Supply curve for a competitive firm

$$p(y) = \begin{cases} c'(y) & if \;\; p \geq AC(y) \\ 0 & o/w \end{cases}$$

Supply decision of a competitive firm



Supply decision of a competitive firm

- SR Supply curve considering SR cost curve
  - Let $c(y) = c_v(y) + F$
  - Then $\pi = p \cdot y(p) - c_v\left(y(p)\right) - F$
  - Producing a positive output ($y > 0$) is profitable compared with the case of producing zero if

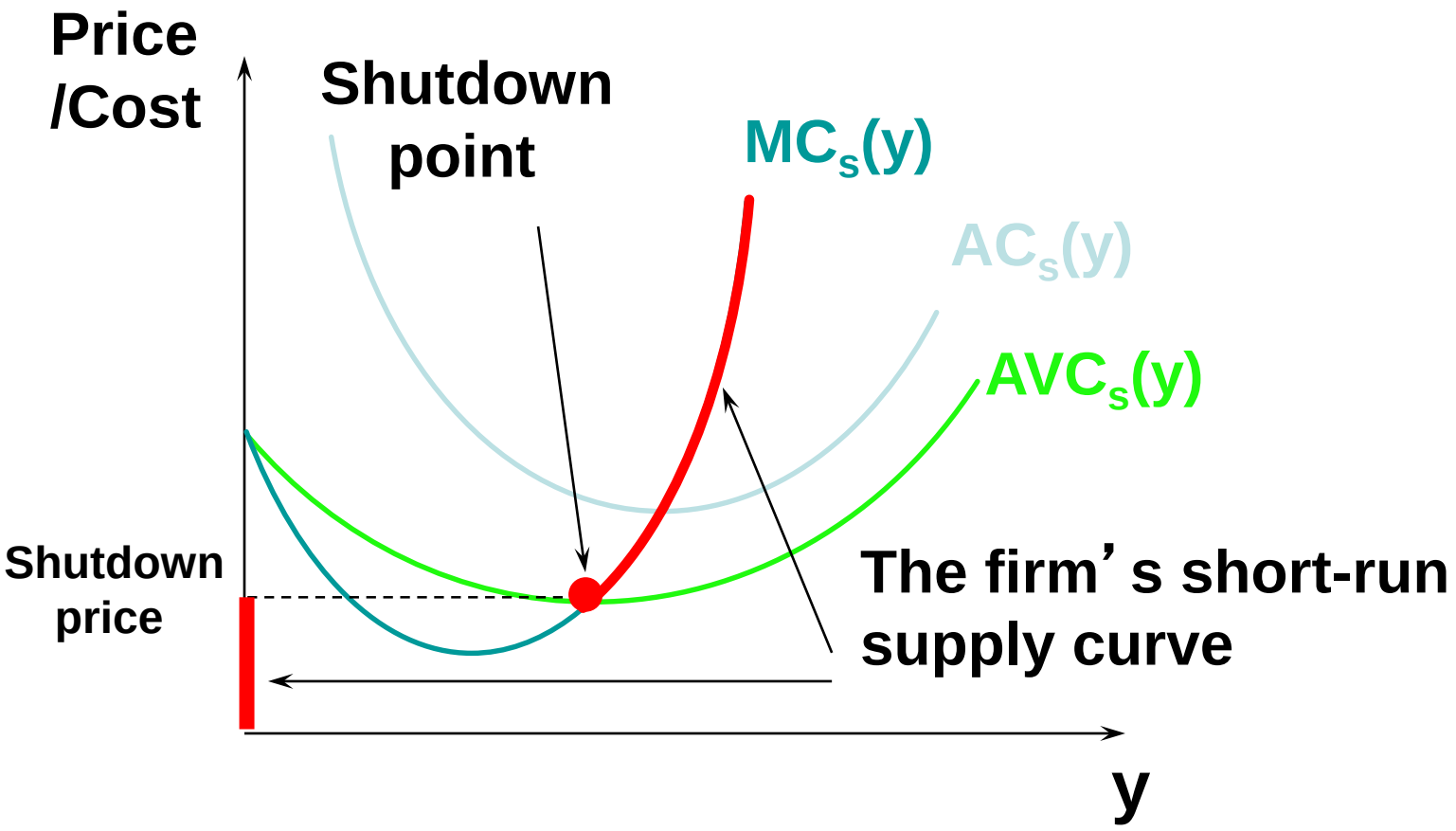
$$p \cdot y(p) - c_v\left(y(p)\right) - F \geq -F$$

$$p \geq \frac{c_v\left(y(p)\right)}{y(p)} = AVC\left(y(p)\right)$$

- SR Supply curve for a competitive firm

$$p(y) = \begin{cases} c'(y) & if \;\; p \geq AVC(y) \\ 0 & o/w \end{cases}$$

SR Supply curve of a competitive firm

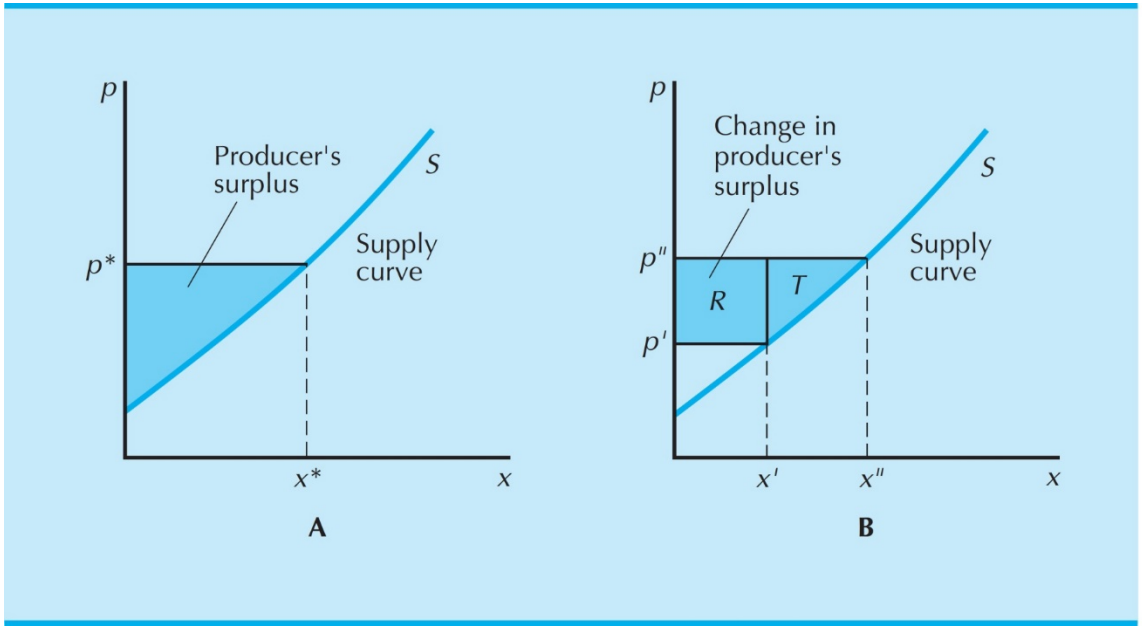


SR Supply decision of a competitive firm

- Shut-down is not the same as exit.
- Shutting-down means producing no output (but the firm is still in the industry and suffers its fixed cost because exit is impossible in the short-run).
- Exiting means leaving the industry, which the firm can do only in the long-run.

Profits and Producer's surplus

- Producer's surplus
  - Supply curve measures the amount that will be supplied at each price
  - The area above the supply curve measures the surplus enjoyed by the suppliers of a good



Profits and Producer's surplus

- Producer's surplus

$$\begin{aligned} \text{PS}(p) &= \int_0^y [p - c'(x)]dx \\ &= p \cdot y - \int_0^y c'(x)dx \\ &= p \cdot y - c_v(y) \end{aligned}$$

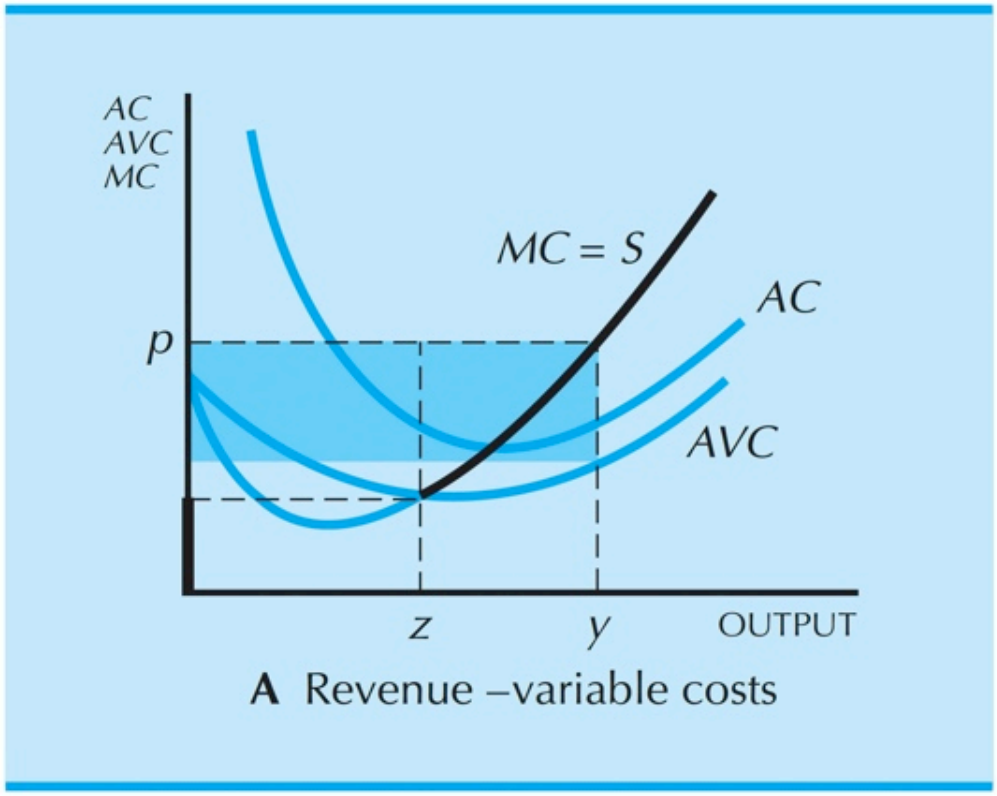
- Profit and Producer's surplus

$$\text{Profit} = p \cdot y - c_v\left(y\right) - F$$

$$\text{Producer's surplus} = p \cdot y - c_v\left(y\right)$$

Profits and Producer's surplus

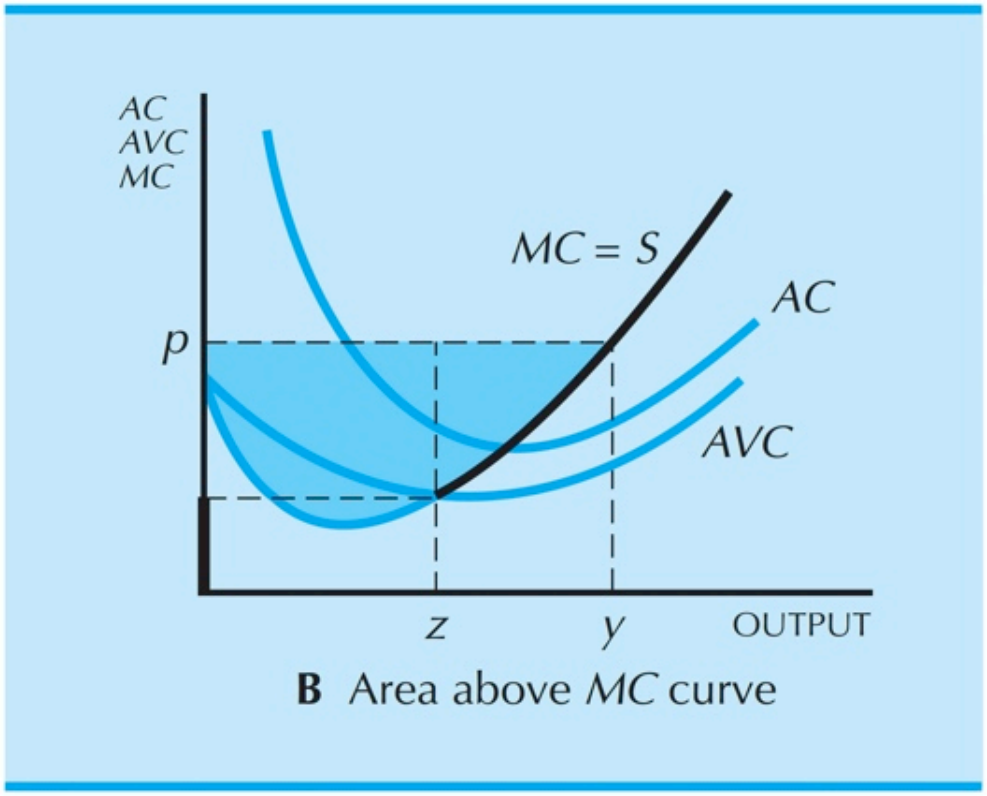
- Measuring Producer's surplus
  - measuring revenue minus variable cost.



A Revenue –variable costs

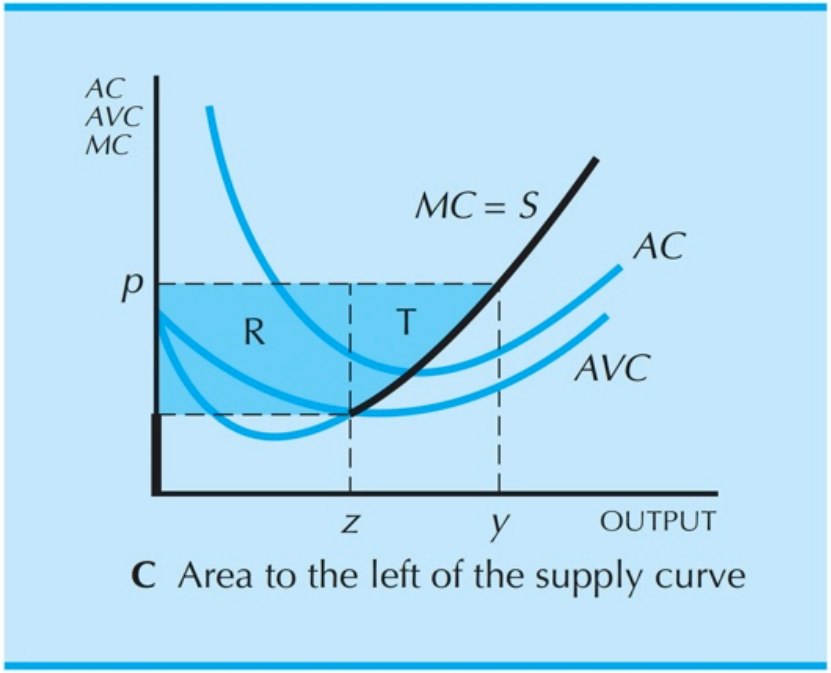
Profits and Producer's surplus

- Measuring Producer's surplus
  - Measuring $c_v(y) = \int_0^y MC(z)dz$



Profits and Producer's surplus

- Measuring Producer's surplus
  - Measuring the box up until output *z* (area *R*) and then uses the area above the marginal cost curve (area *T*).



C Area to the left of the supply curve

Supply curve

- Example:

$$c(y) = y^2 + 1$$

  - Price = Marginal cost

$$p = 2y$$

  - Supply curve

$$S(p) = y = \frac{p}{2}$$

  - Max. profits for each price

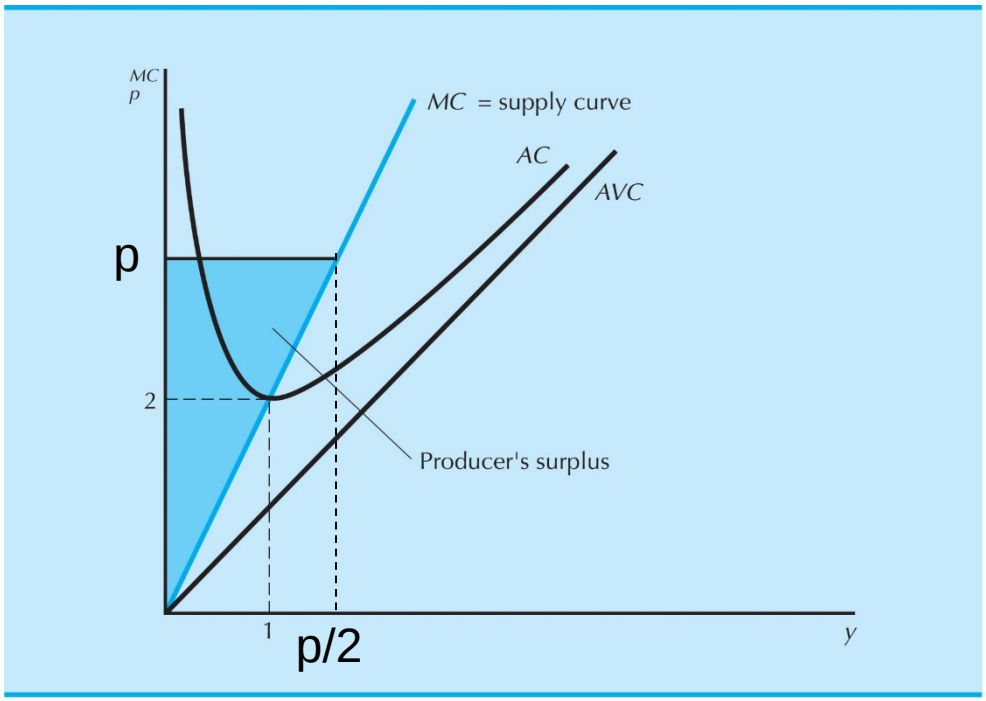
$$\pi(p) = py - c(y)$$

$$= p\frac{p}{2} - \left(\frac{p}{2}\right)^2 - 1$$

$$= \frac{p^2}{4} - 1$$

Supply curve

- Example:



- Producer's surplus

$$A = \left(\frac{1}{2}\right)\left(\frac{p}{2}\right)p = \frac{p^2}{4}$$

- Producer's surplus = Profits + Fixed cost

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Chap. 24

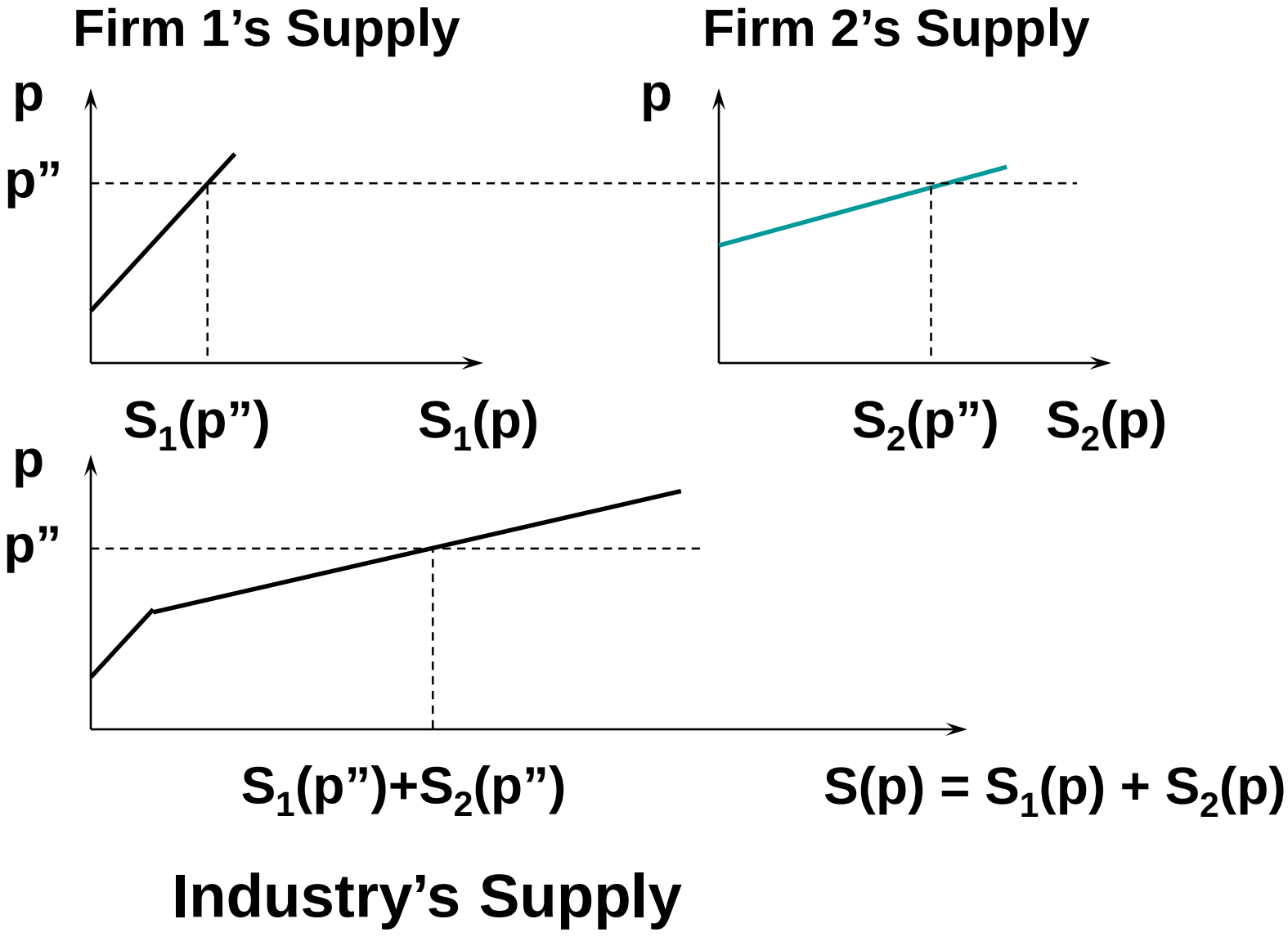
INDUSTRY SUPPLY

Supply From A Competitive Industry

- Short-run industry supply curve
  - Since every firm in the industry is a price-taker, total quantity supplied at a given price is the sum of quantities supplied at that price by the individual firms.
  - In a short-run, the number of firms in the industry is, temporarily, fixed.
  - Let *n* be the number of firms, then the industry supply function is the sum of the individual firm supply function

$$S(p) = \sum_{i=1}^{n} S_i(p)$$

Supply From A Competitive Industry



Supply From A Competitive Industry

- Example: *n* firms with common cost $c(y) = y^2 + 1$
  - Inverse supply function $p(y) = MC(y) = 2y$
    - Note that $MC(y) = 2y \geq AVC(y) = y$ for all $y \geq 0$
  - Individual supply function $S_i(p) = \frac{p}{2}$
  - Industry supply function $S(p) = \sum_{i=1}^{n} S_i(p) = Y = \frac{p}{2} n$
  - Inverse industry supply function $p(Y) = \frac{2}{n} Y$

Supply From A Competitive Industry

- Example: Firm 1: $c_1(y) = y^2$, Firm 2: $c_2(y) = 2y^2$
  - Each firm chooses a level of output where *p*=MC

$$p(y_1) = 2y_1,\ p(y_2) = 4y_2$$

  - Individual supply function

$$y_1(p) = \frac{p}{2},\ y_2(p) = \frac{p}{4}$$

  - Industry supply function

$$Y(p) = \frac{p}{2} + \frac{p}{4} = \frac{3p}{4}$$

  - Note that each firm that produces a positive amount of output must have the same MC

$$MC_1(y) = MC_2(y) = p = \frac{4}{3}y$$

Short-Run Industry Equilibrium

- In a short-run, neither entry nor exit can occur.

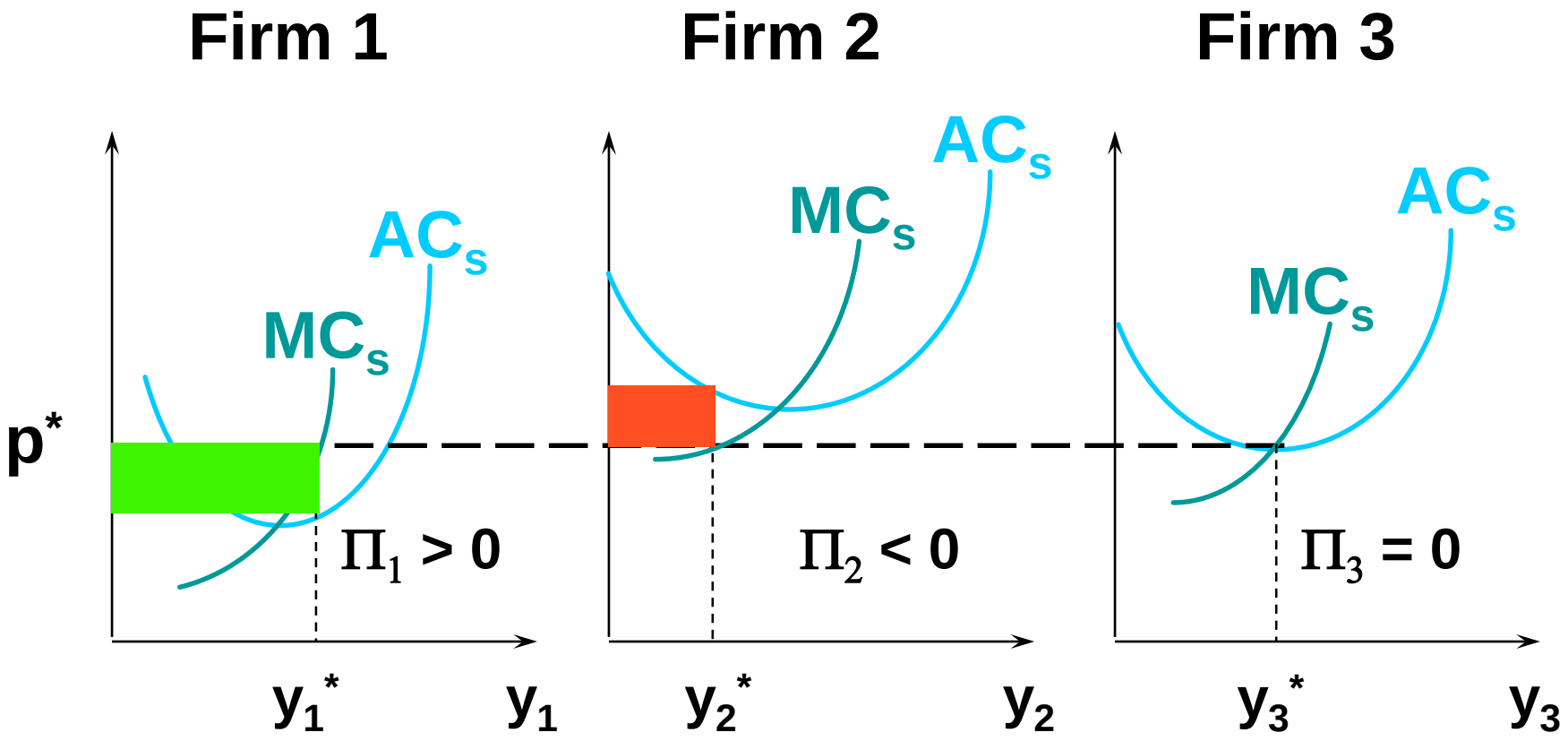
  $x_i(p)$: individual i's demand function, $i = 1, \ldots, n$

  $y_j(p)$: supply function of firm j, $j = 1, \ldots, m$

  - Equilibrium price p^*

$$\sum_i x_i(p^*) = \sum_j y_j(p^*)$$

Short-Run Industry Equilibrium



Firm 1 wishes to remain in the industry.

Firm 2 wishes to exit from the industry.

Firm 3 is indifferent.

Short-Run Industry Equilibrium

- In a short-run, neither entry nor exit can occur.

  $x_i(p)$: individual i's demand function, $i = 1, \ldots, n$

  $y_j(p)$: supply function of firm j, $j = 1, \ldots, m$

  - Equilibrium price p^*

$$\sum_i x_i(p^*) = \sum_j y_j(p^*)$$

- Consequently, in a short-run equilibrium, some firms may earn positive economics profits, others may suffer economic losses, and still others may earn zero economic profit

Short-Run Industry Equilibrium

- Relationship between SR equilibrium price and the number of firms in a competitive market
  - Regard p as an implicit function of n, i.e., $p(n)$
  - Let $X(p)$ be the arbitrary industry demand function and $y(p)$ is a common supply function of individual n firms in a competitive market
  - Equilibrium condition: $X(p)=ny(p)$
  - Differentiating Eq. condition $X(p(n))=ny(p(n))$ w.r.t. n

$$X'(p)\,p'(n) = y(p) + n \cdot y'(p)\,p'(n)$$

$$\therefore\ p'(n) = \frac{y(p)}{X'(p) - n \cdot y'(p)}$$

As the number of firms increases, SR equil. price decreases

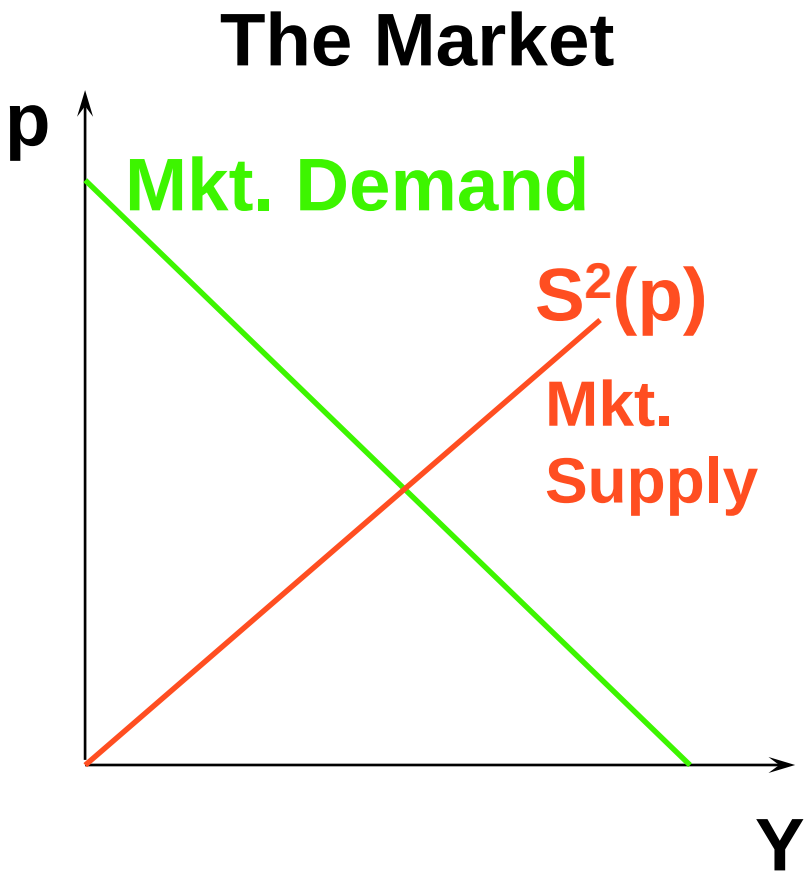
Since $X'(p) < 0, y'(p) > 0 \quad \Rightarrow p'(n) < 0$

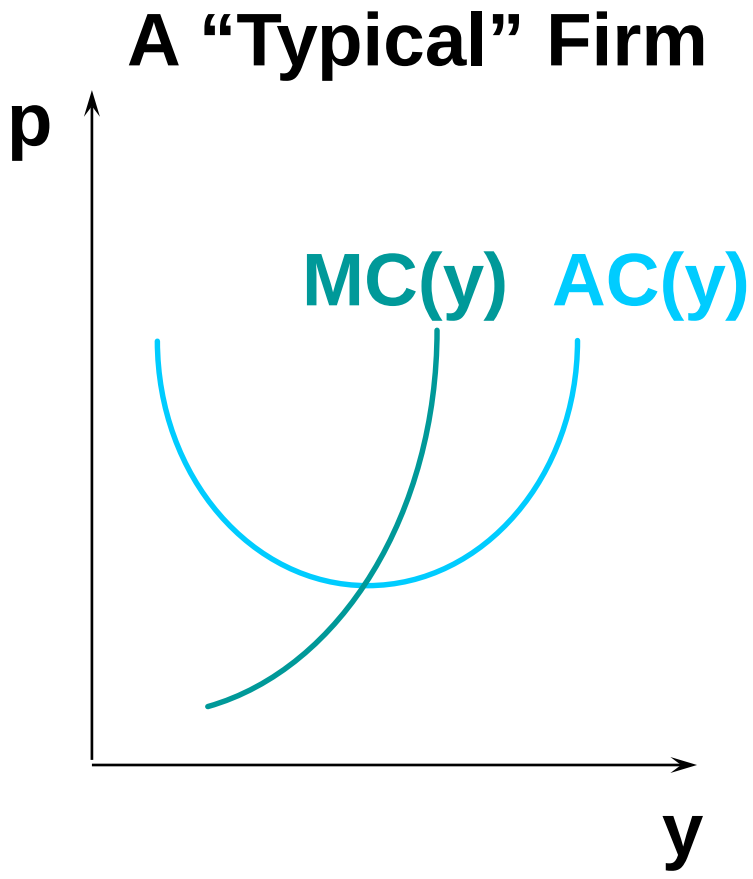
Entry & Long-Run Equilibrium

- In the long-run, every firm now in the industry is free to exit and firms now outside the industry are free to enter.
- The industry's long-run supply function must account for entry and exit as well as for the supply choices of firms that choose to be in the industry.
  - Positive economic profit induces entry.
  - Economic profit is positive when $p^* > \min AC(y)$.
  - Entry increases the number of firms, causing p^* to fall. ($dp^*/dn<0$)
  - When does entry cease?

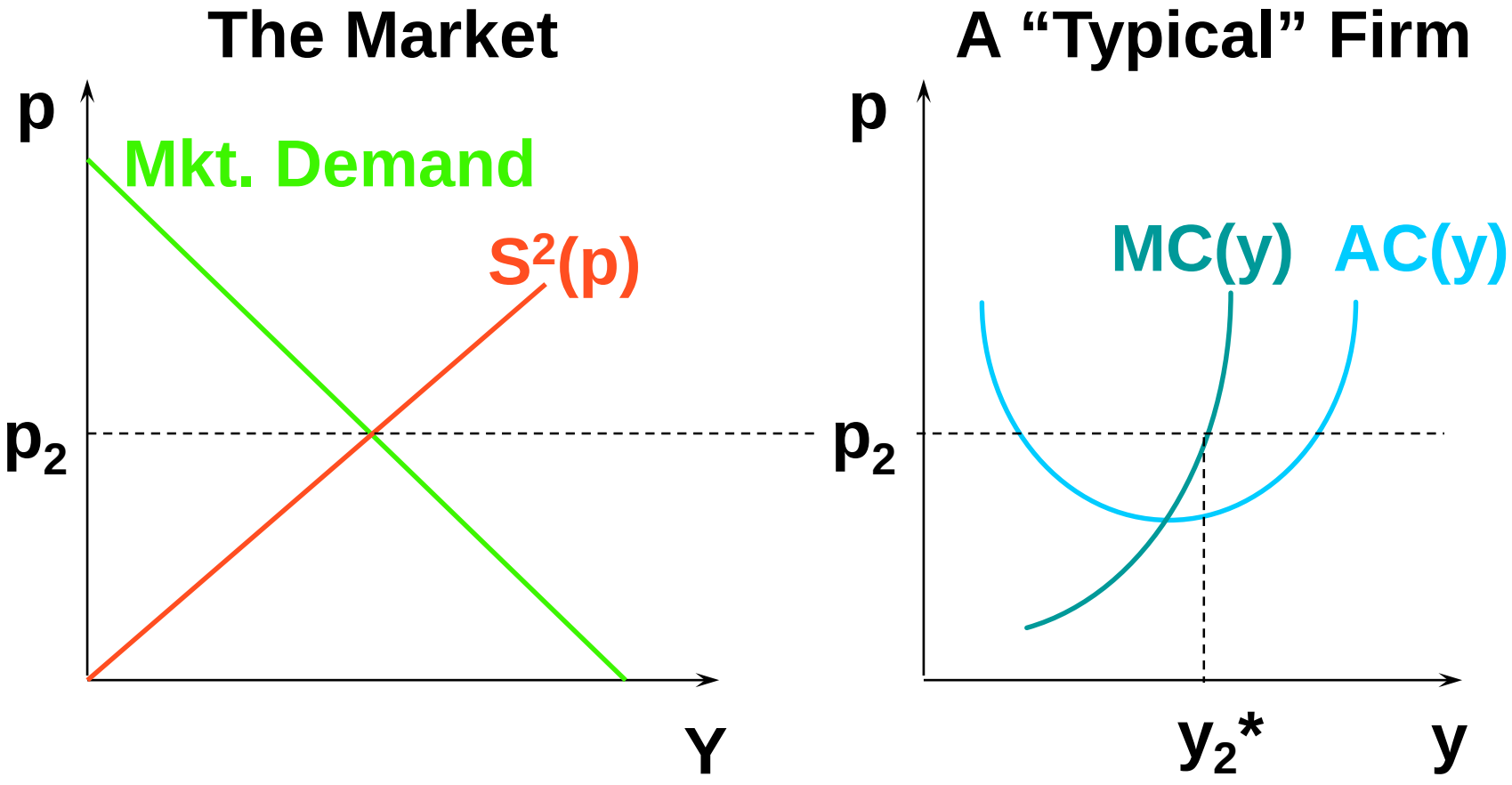
Entry & Long-Run Equilibrium

- Suppose the industry initially contains only two firms.



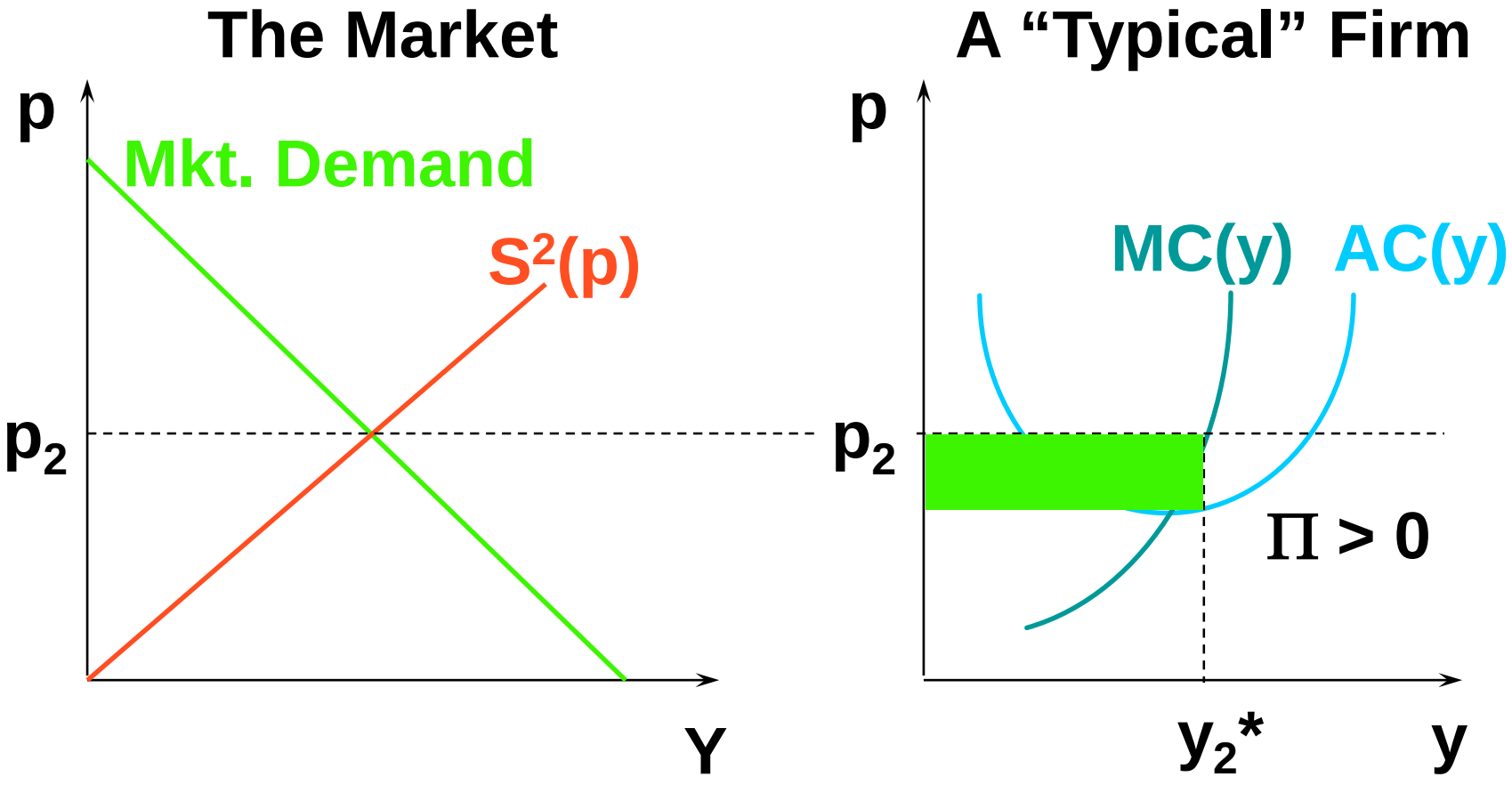


Long-Run Industry Supply



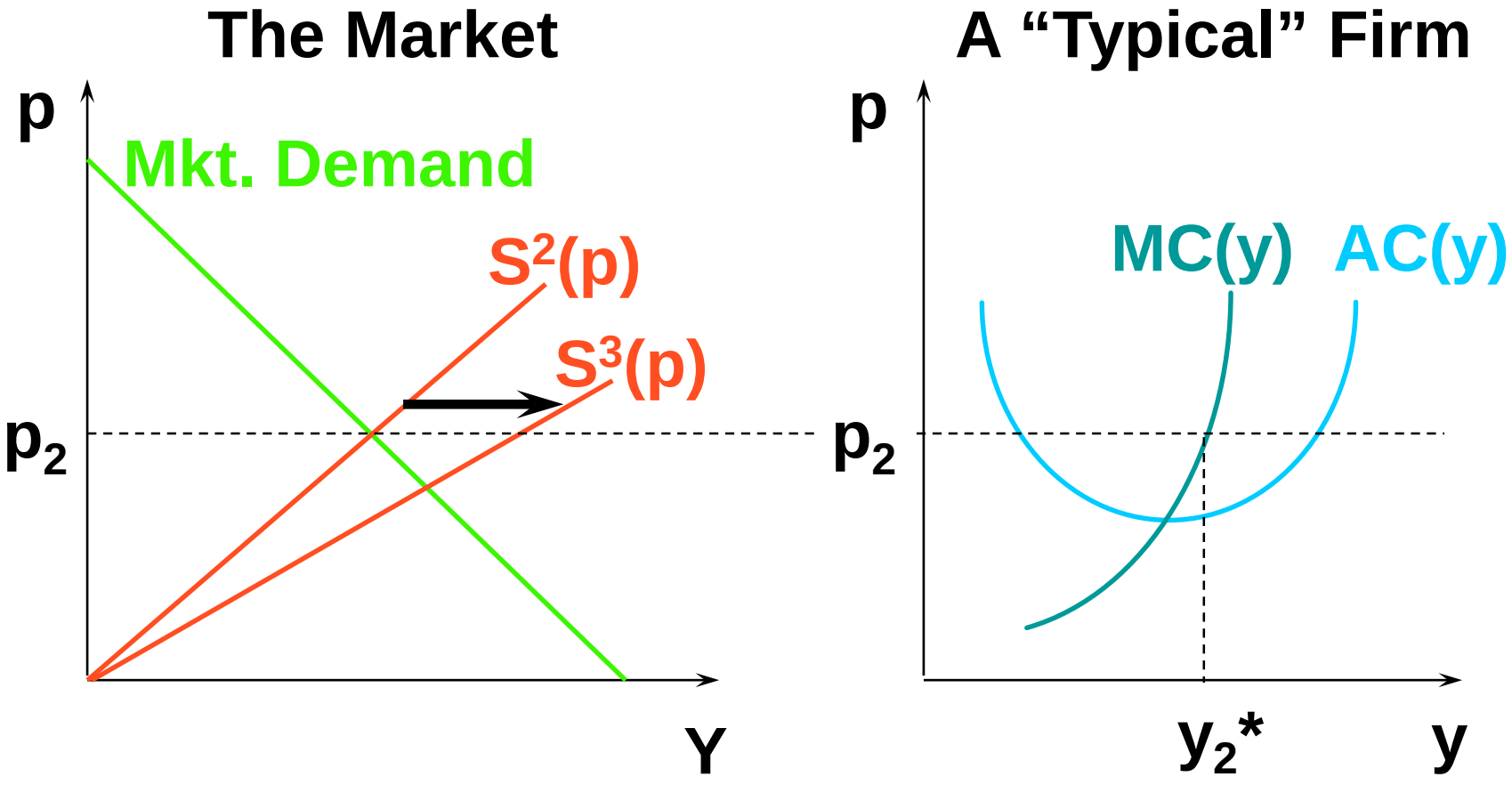
- Then the market-clearing price is p_2.
- Each firm produces y_2^* units of output.

Long-Run Industry Supply



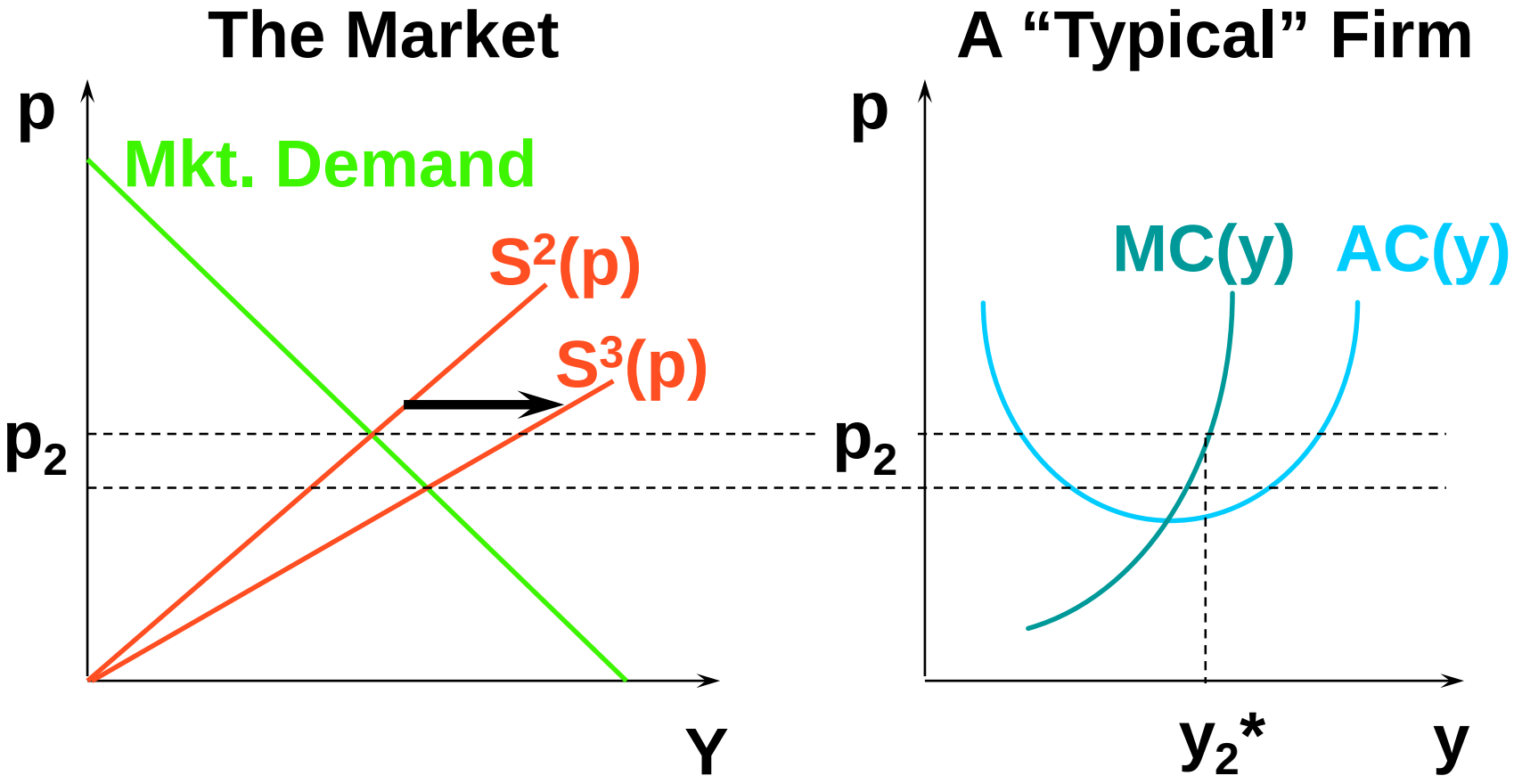
- Each firm makes a positive economic profit, inducing entry by another firm.

Long-Run Industry Supply



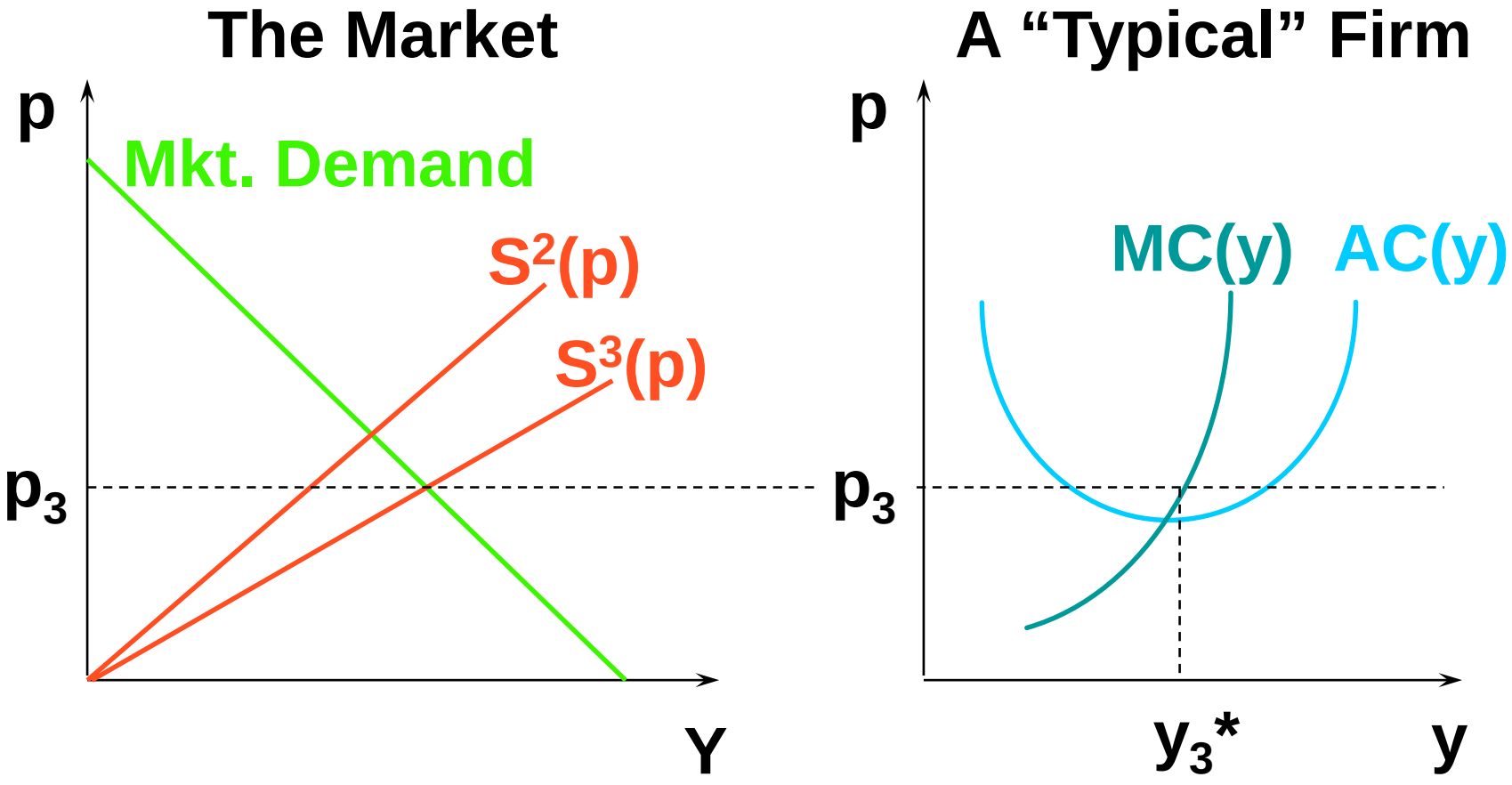
- **Market supply shifts outwards.**

Long-Run Industry Supply



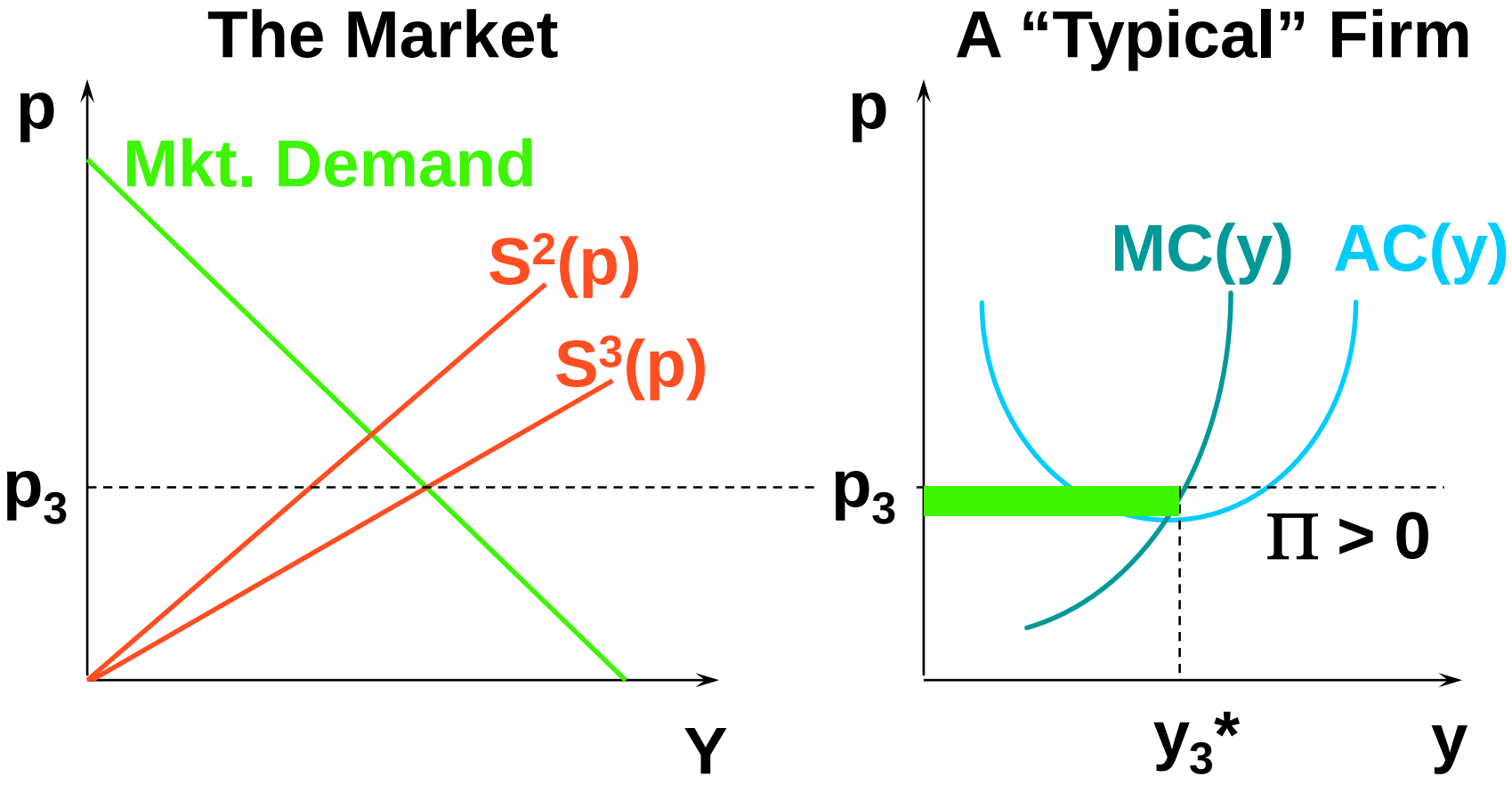
- **Market supply shifts outwards.**
- **Market price falls.**

Long-Run Industry Supply



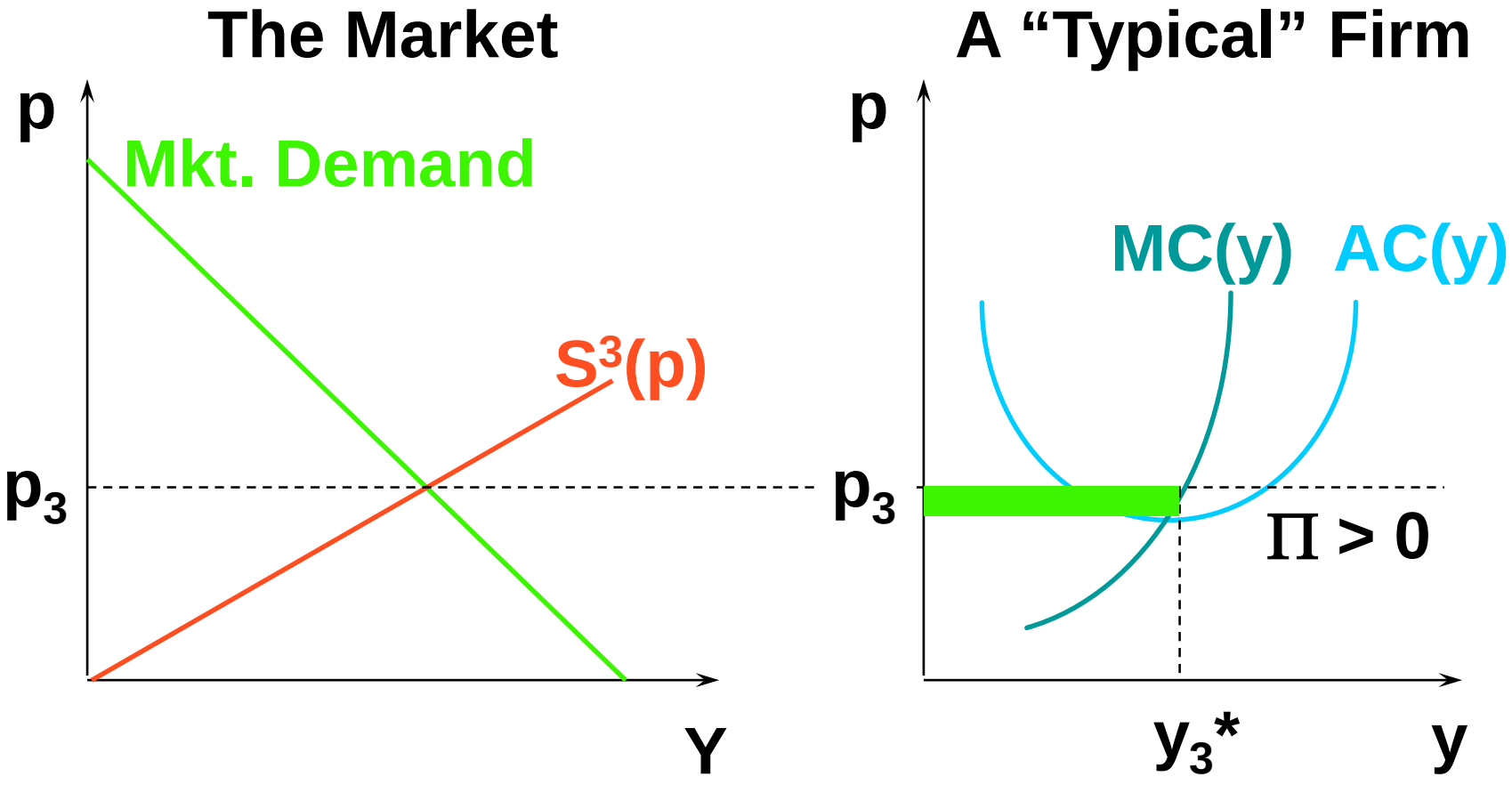
- **Each firm produces less.**

Long-Run Industry Supply



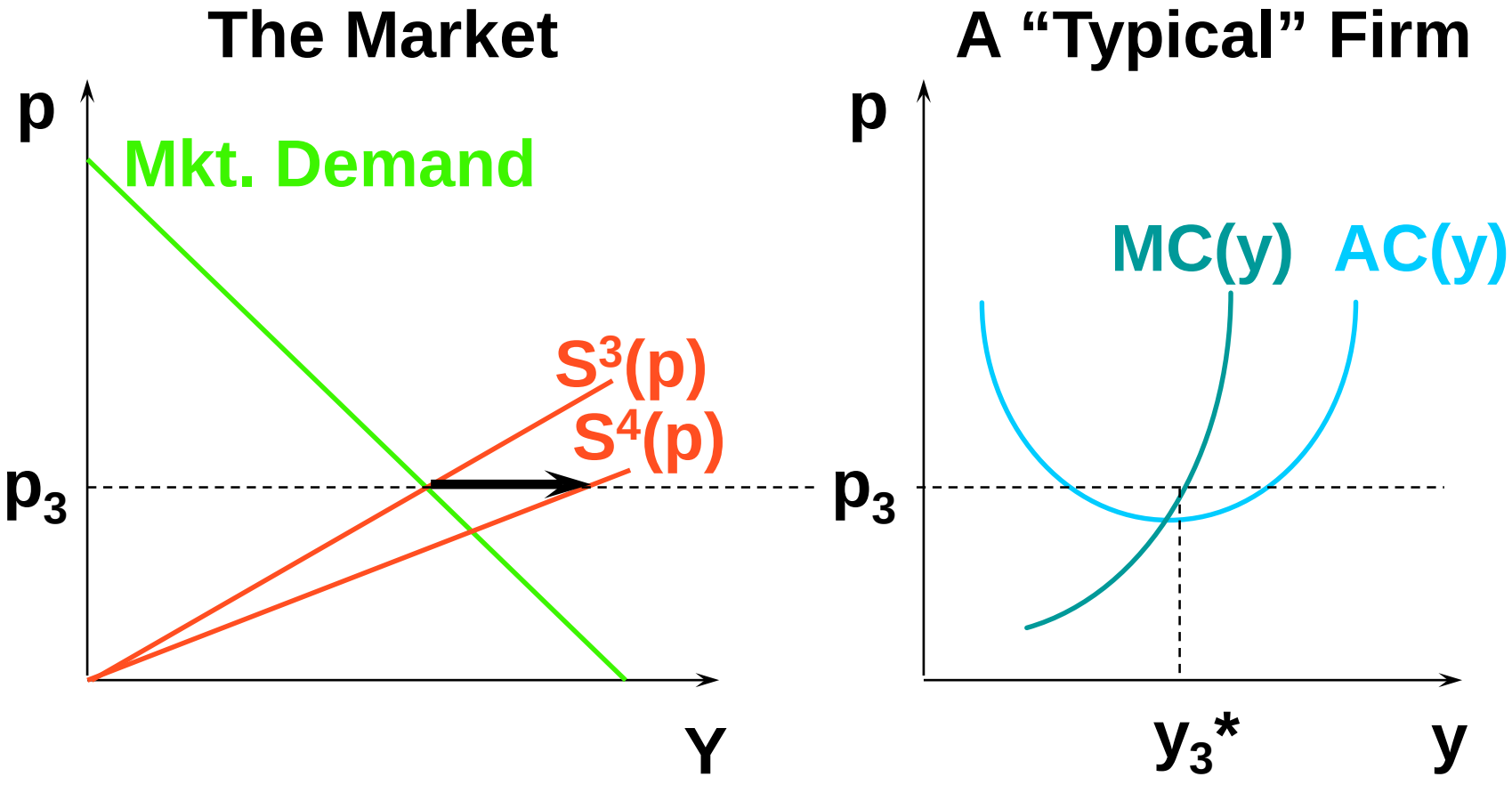
- **Each firm produces less.**
- **Each firm's economic profit is reduced.**

Long-Run Industry Supply



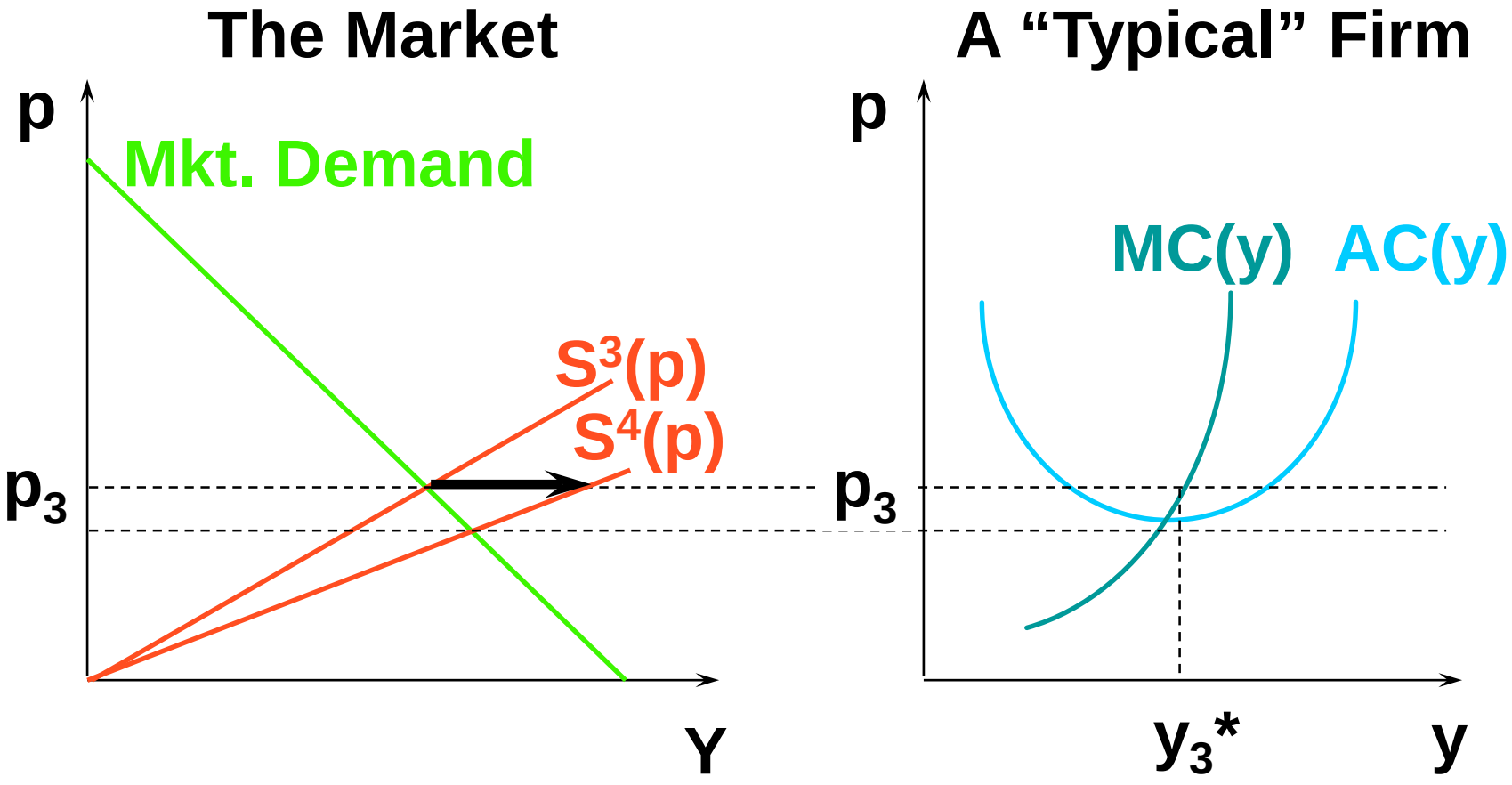
- **Each firm's economic profit is still positive. Will another firm enter?**

Long-Run Industry Supply



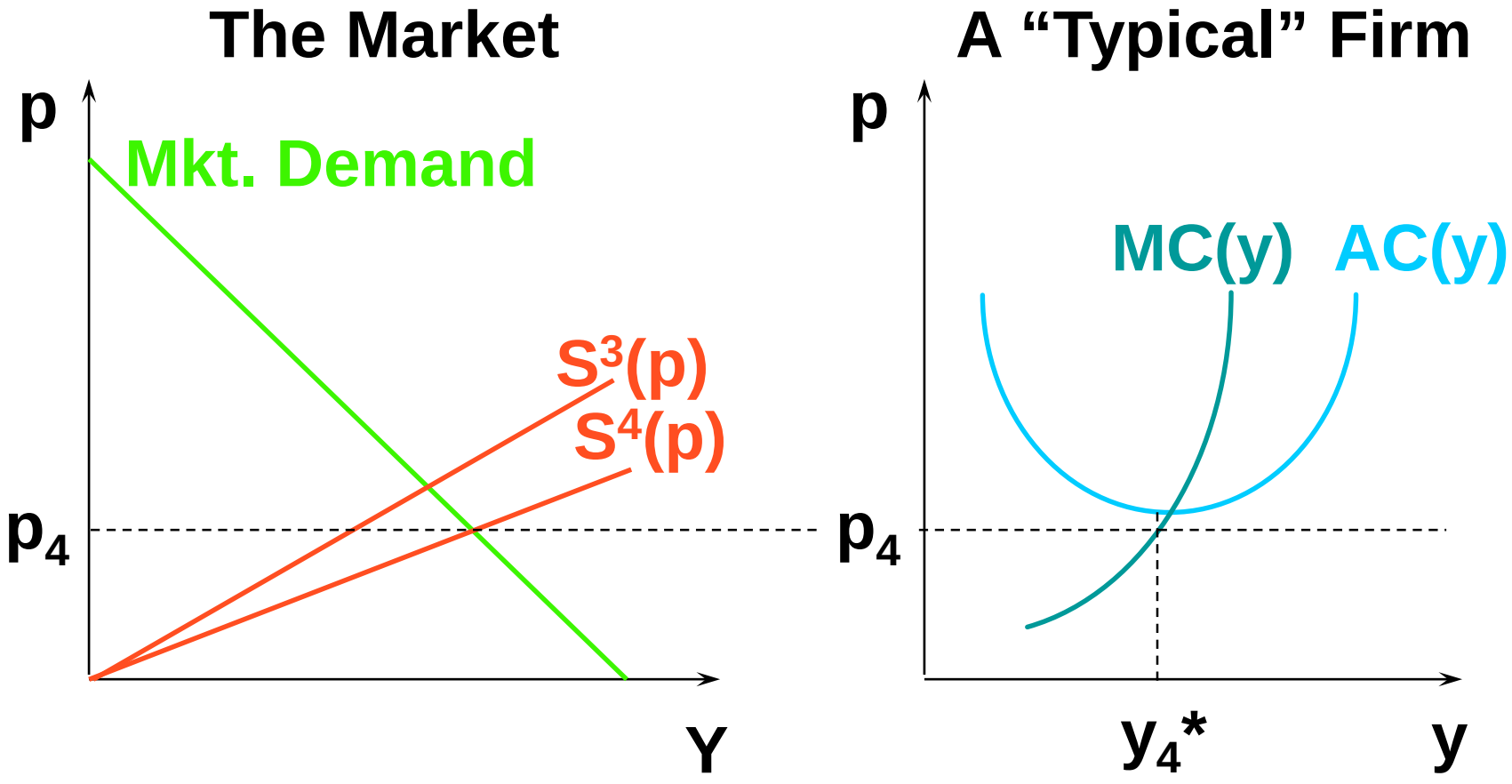
- **Market supply would shift outwards again.**

Long-Run Industry Supply



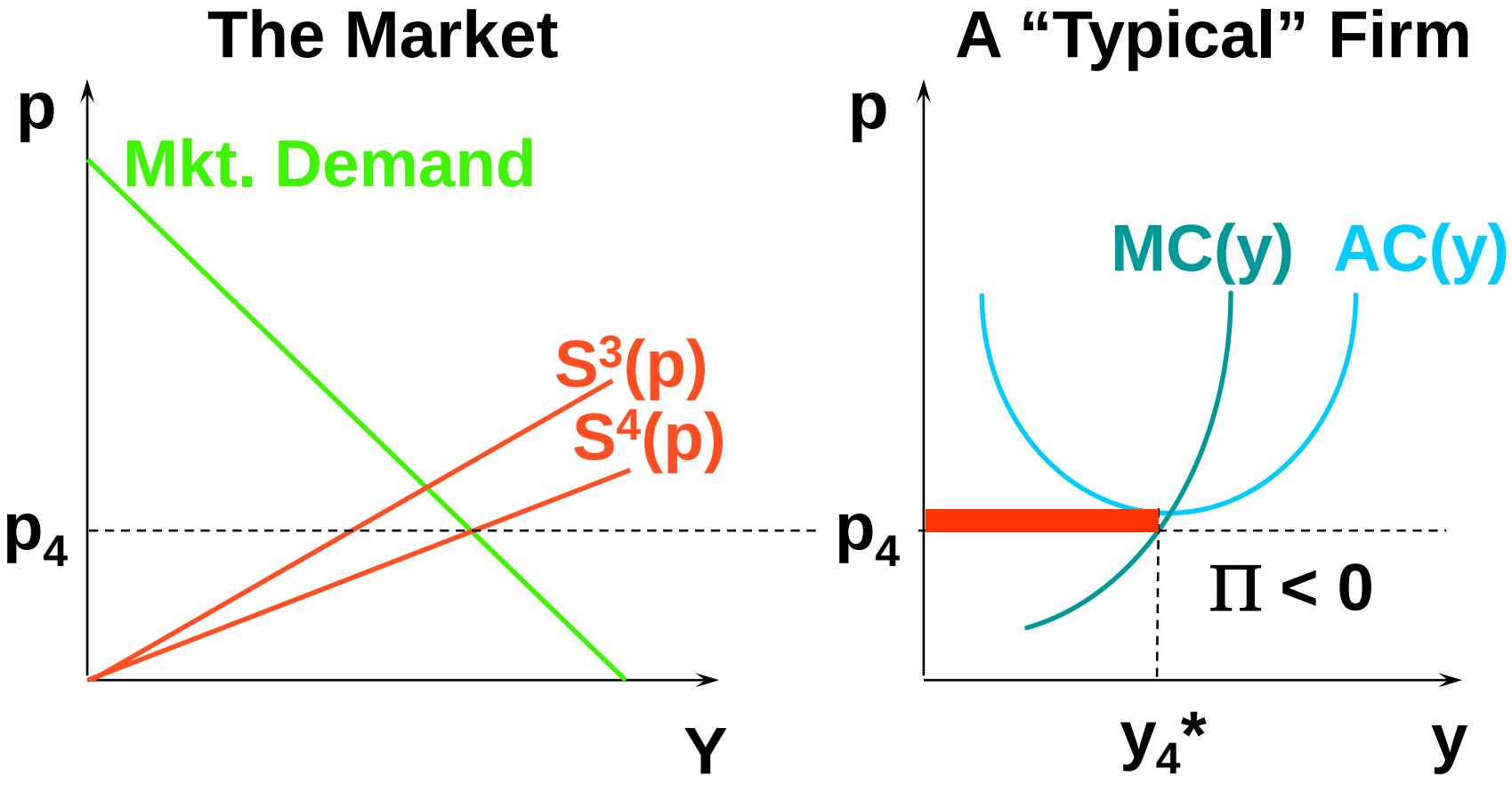
- **Market supply would shift outwards again.**
- **Market price would fall again.**

Long-Run Industry Supply



- **Each firm would produce less again.**

Long-Run Industry Supply



- **Each firm's economic profit would be negative.**
- **So the fourth firm would not enter.**

Long-Run Industry Supply

- The long-run number of firms in the industry is the largest number for which the market price is at least as large as min AC(y).
- Example: cost function $c(y) = y^2 + 1$
  - Break-even level of output is p=AC(y)
  - Since p=MC(y) in an equilibrium of competitive market, the break-even output is where p=AC(y)=MC(y)

$$2y = y + \frac{1}{y} \quad \Rightarrow \quad y = 1$$

$$Then\ p = MC(1) = 2$$

  - Thus firms will enter the industry as long as they will not drive the equilibrium price below 2

Long-Run Industry Supply

- Example: cost function $c(y) = y^2 + 1$
  - Recall that market supply curve is $Y(p) = \frac{p}{2} n$
  - If the market demand function is $X(p) = a - bp$
  - Equilibrium price

$$p^* = \frac{a}{b + n/2}$$

  - For the firms in the market to be profitable,

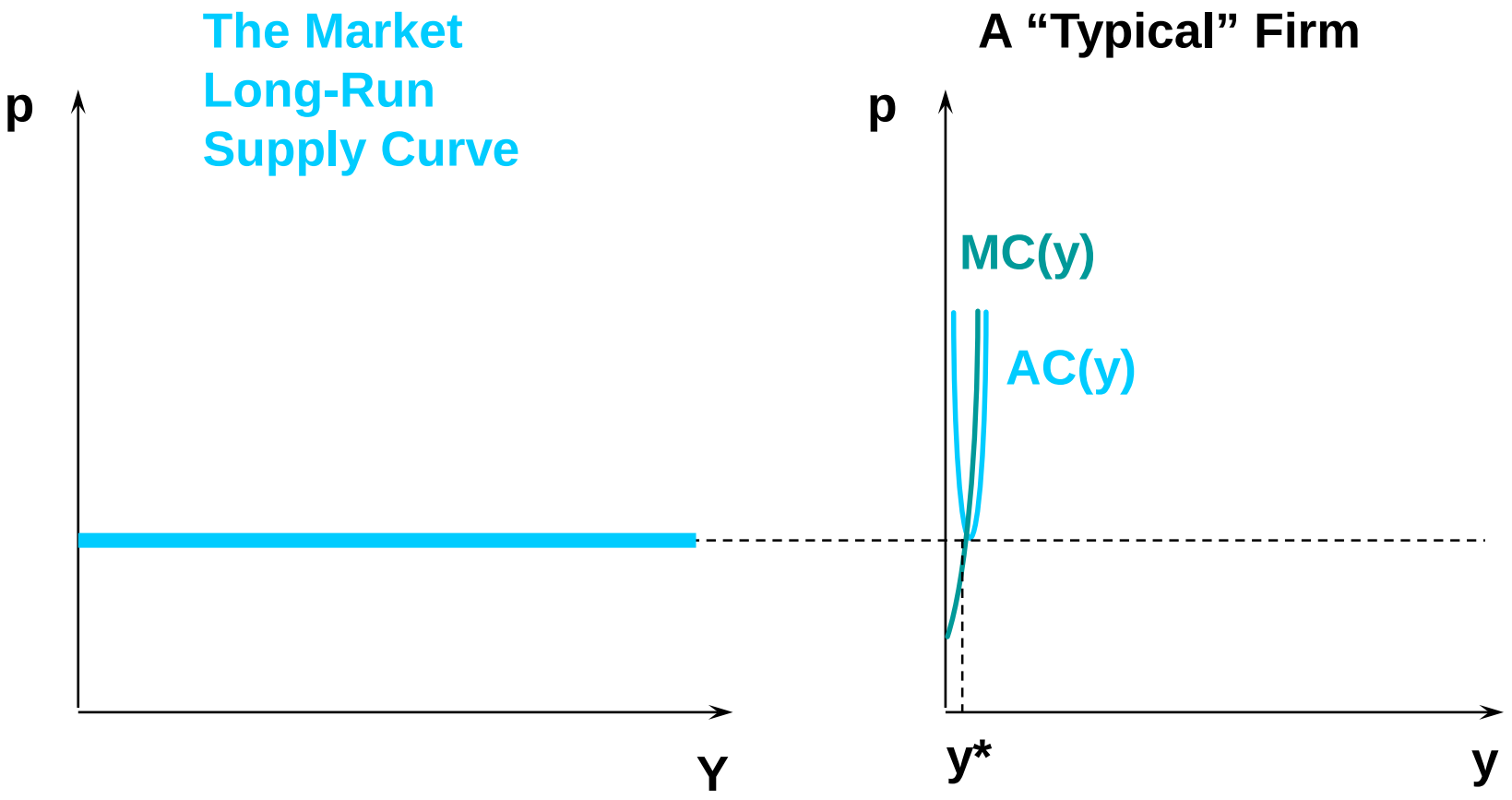
$$p^* = \frac{a}{b + n/2} \geq 2$$

  - Thus, in the long-run the number of firms in the market is the largest integer n satisfying

$$n \leq a - 2b$$

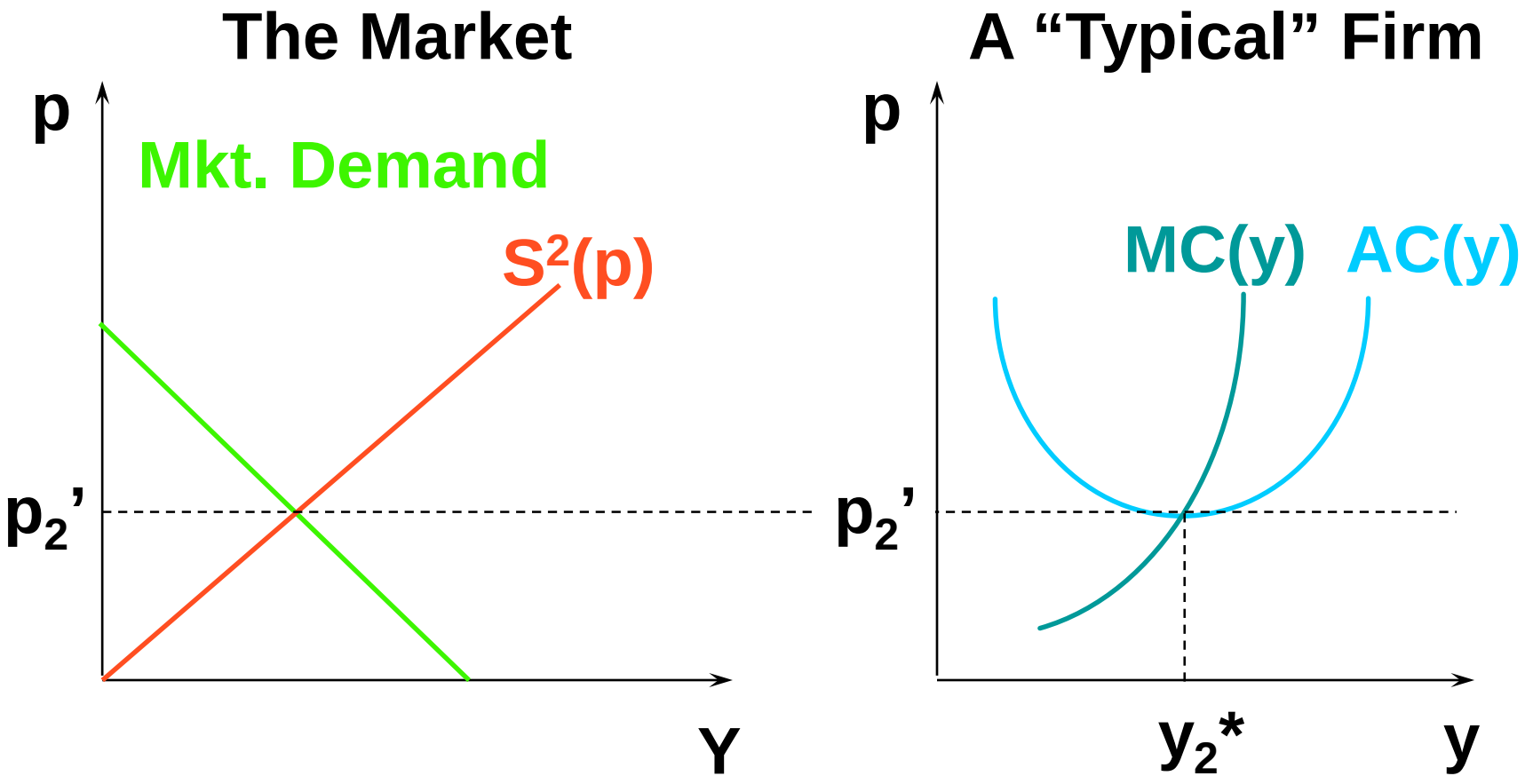
Long-Run Supply Curve

- The competitive industry's long-run supply curve is horizontal at min AC(y).



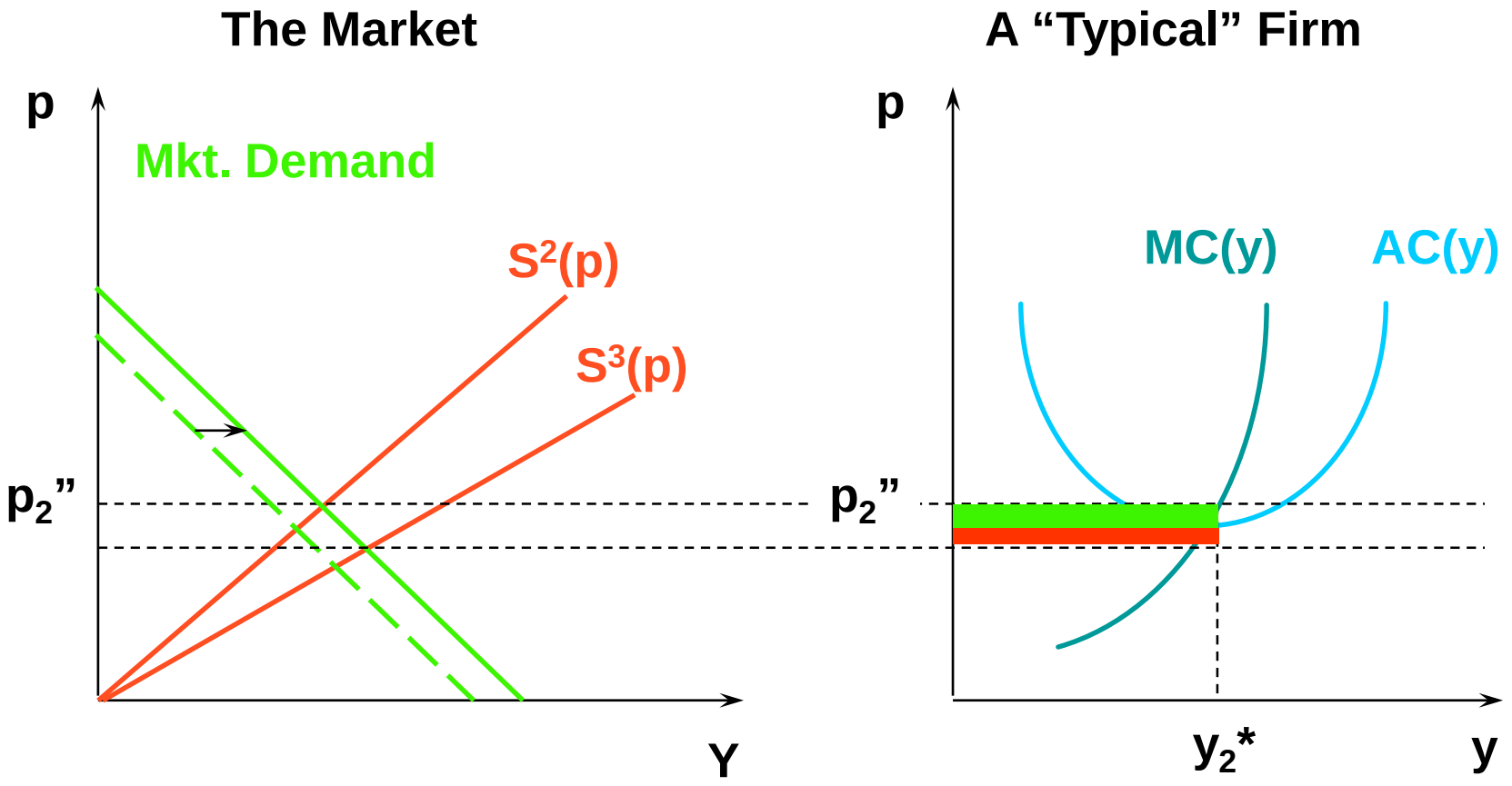
Long-Run Supply Curve

- Now market demand is large enough to sustain only two firms in the industry.



Long-Run Supply Curve

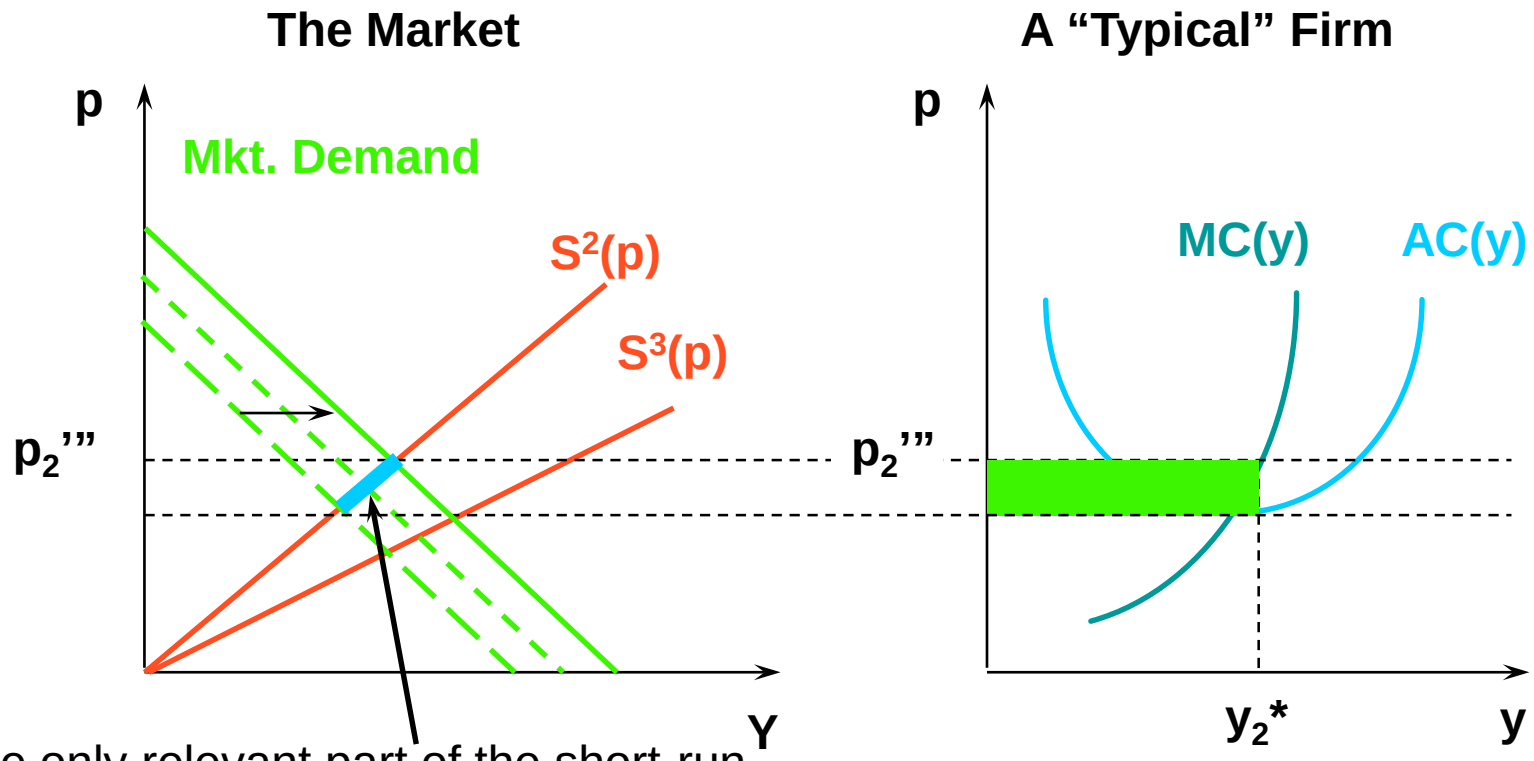
- Suppose that market demand increases, then the market price rises, each firm produces more, and earns a higher profit.



- Will the 3rd firm enter? ➢ No! since negative profits.

Long-Run Supply Curve

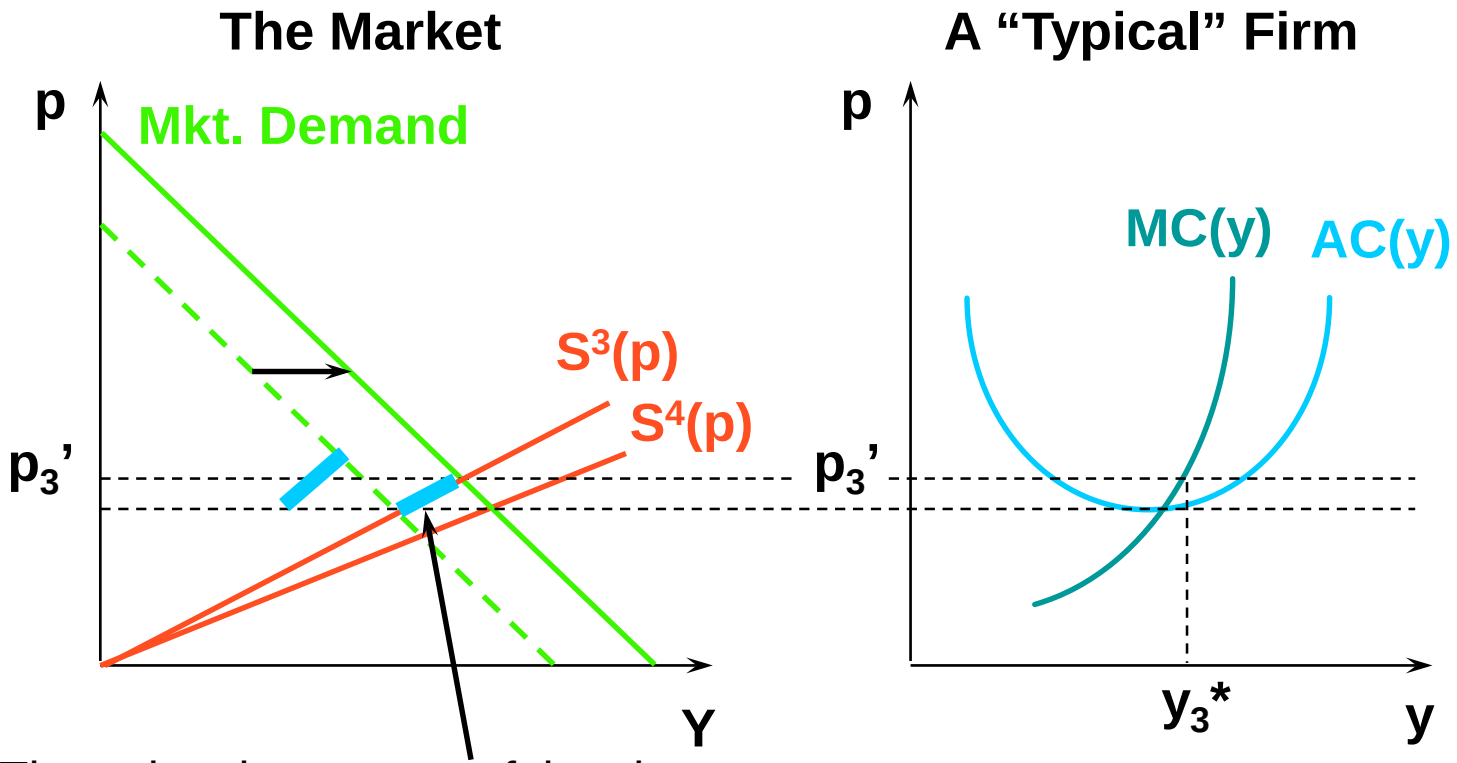
- As market demand increases further, the market price rises further, the two incumbent firms each earn still higher economic profits -- until the 3rd firm becomes indifferent between entering and staying out.



The only relevant part of the short-run supply curve for n = 2 firms in the industry.

Long-Run Supply Curve

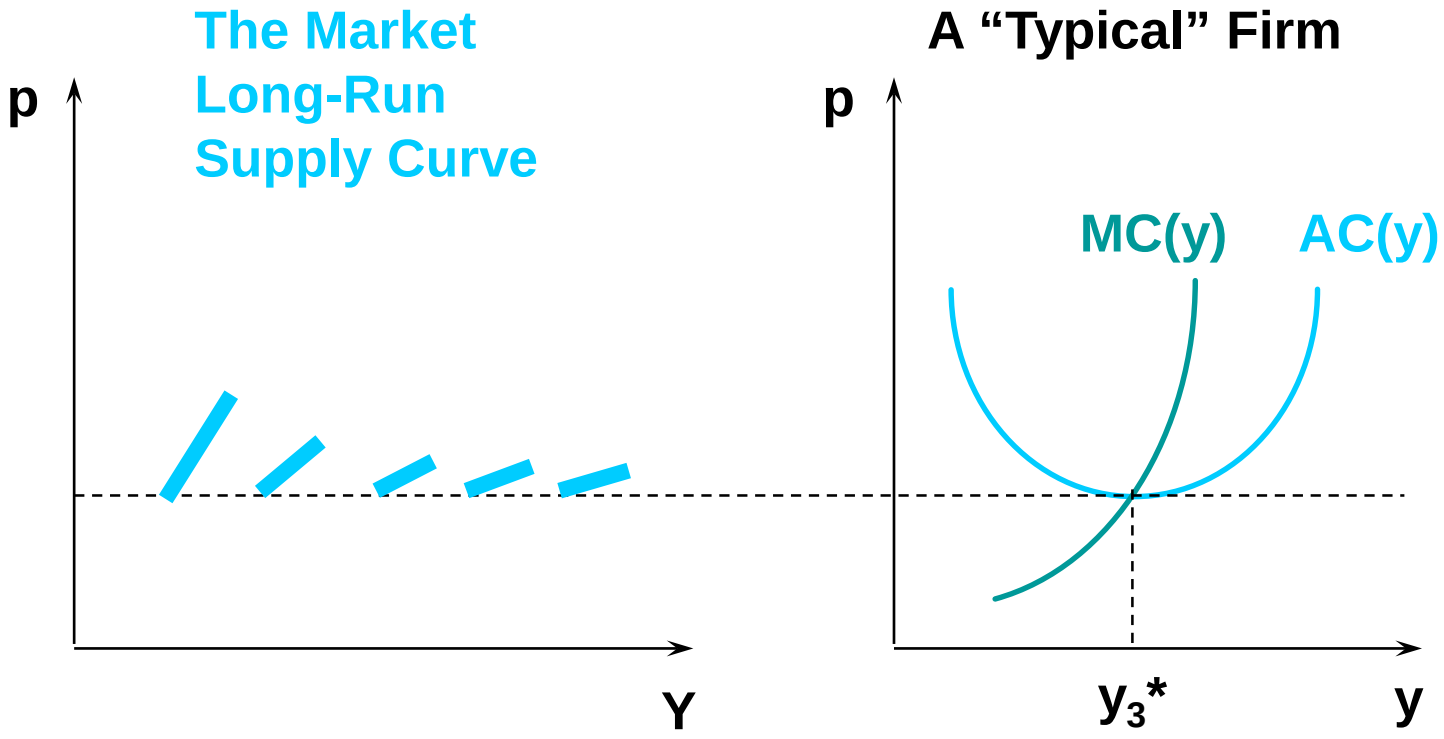
- How much further can market demand increase before a fourth firm enters the industry?



The only relevant part of the short-run supply curve for n = 3 firms in the industry.

Long-Run Supply Curve

- Continuing in this manner builds the industry's long-run supply curve, one section at-a-time from successive short-run industry supply curves.



Notice that the bottom of each segment of the supply curve is min AC(y).

Long-Run Supply Curve

- In the long-run, if there are a reasonable number of firms in the industry(or as firms become sufficiently small), the industry's long-run supply curve is horizontal at min AC(y).