Lesson 6: Producer behavior

1. **Profit-Maximization**
2. **Firm's supply**
3. **Industry supply**

Economic Profit

- A firm uses inputs j = 1…,m to make products i = 1,…n.
- Output levels are $y_1,\ldots,y_n$.
- Input levels are $x_1,\ldots,x_m$.
- Product prices are $p_1,\ldots,p_n$.
- Input prices are $w_1,\ldots,w_m$.

The Competitive Firm

- The competitive firm **takes** all output prices $p_1,\ldots,p_n$ and all input prices $w_1,\ldots,w_m$ as given constants.

Economic Profit

- The **economic profit** generated by the production plan $(x_1,\ldots,x_m,y_1,\ldots,y_n)$ is

$$\Pi = p_1y_1 + \Lambda + p_ny_n - w_1x_1 - \Lambda\ w_mx_m.$$

Economic Profit

- Output and input levels are typically **flows**.
- E.g. x_1 might be the number of labor units **used per hour**.
- And y_3 might be the number of cars **produced per hour**.
- Consequently, profit is typically a flow also; e.g. the number of dollars of profit earned per hour.

Economic Profit

- How do we value a firm?
- Suppose the firm's stream of periodic economic profits is $\Pi_0, \Pi_1, \Pi_2, \ldots$ and r is the rate of interest.
- Then the present-value of the firm's economic profit stream is

$$PV = \Pi_0 + \frac{\Pi_1}{1+r} + \frac{\Pi_2}{(1+r)^2} + \Lambda$$

Economic Profit

- **A competitive firm seeks to maximize its present-value.**
- **How?**

Short-Run Iso-Profit Lines

- A $\$\Pi$ **iso-profit line** contains all the production plans that yield a profit level of $\$\Pi$.
- The equation of a $\$\Pi$ iso-profit line is

$$\Pi \equiv py - w_1 x_1 - w_2 \tilde{x}_2.$$

- I.e.

$$y = \frac{w_1}{p} x_1 + \frac{\Pi + w_2 \tilde{x}_2}{p}.$$

Short-Run Iso-Profit Lines

$$y = \frac{w_1}{p} x_1 + \frac{\Pi + w_2 \tilde{x}_2}{p}$$

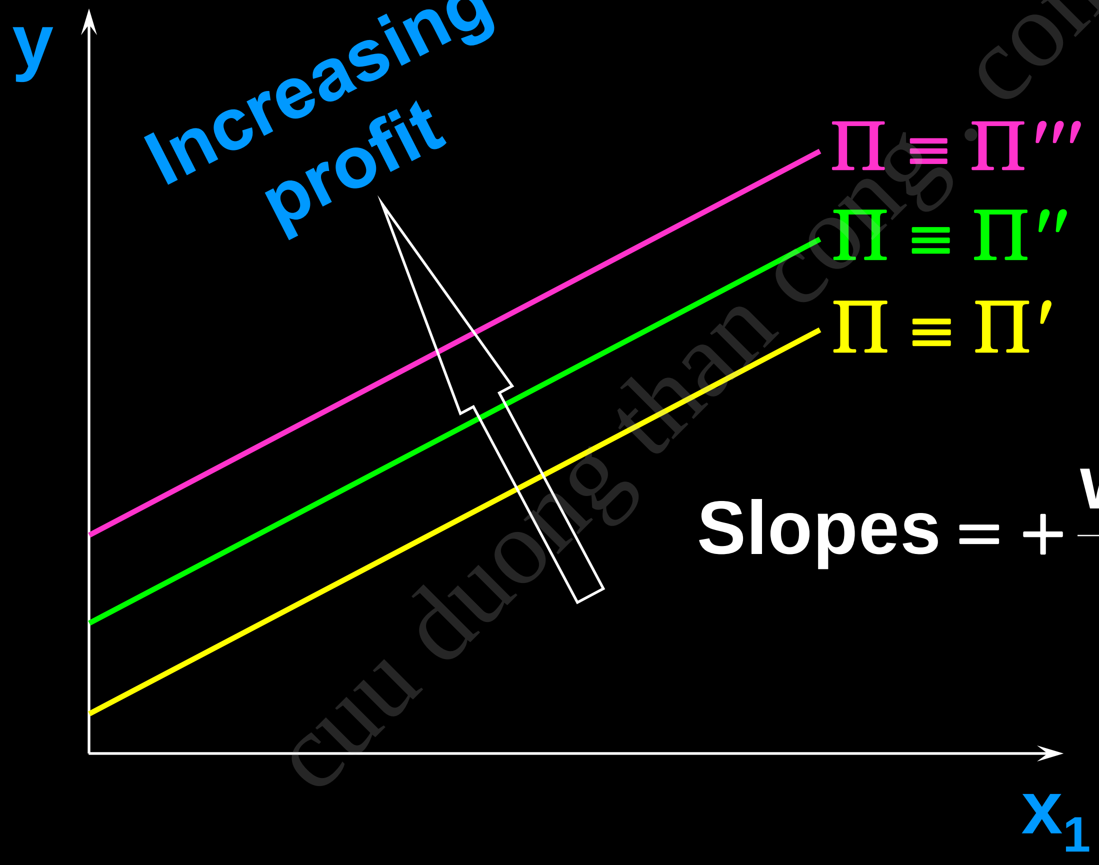
has a slope of

$$+\frac{w_1}{p}$$

and a vertical intercept of

$$\frac{\Pi + w_2 \tilde{x}_2}{p}.$$

Short-Run Iso-Profit Lines

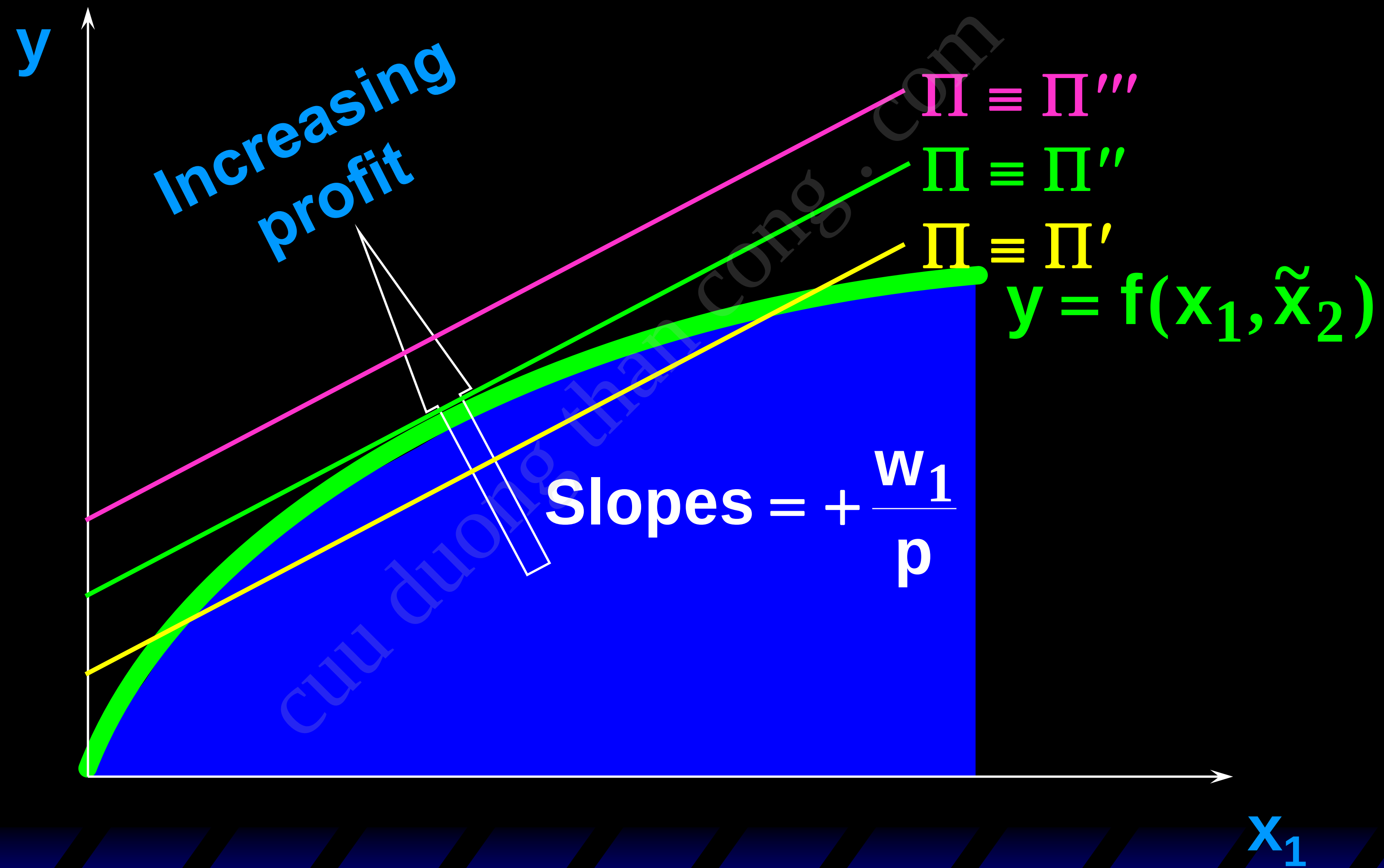


$$\text{Slopes} = +\frac{w_1}{p}$$

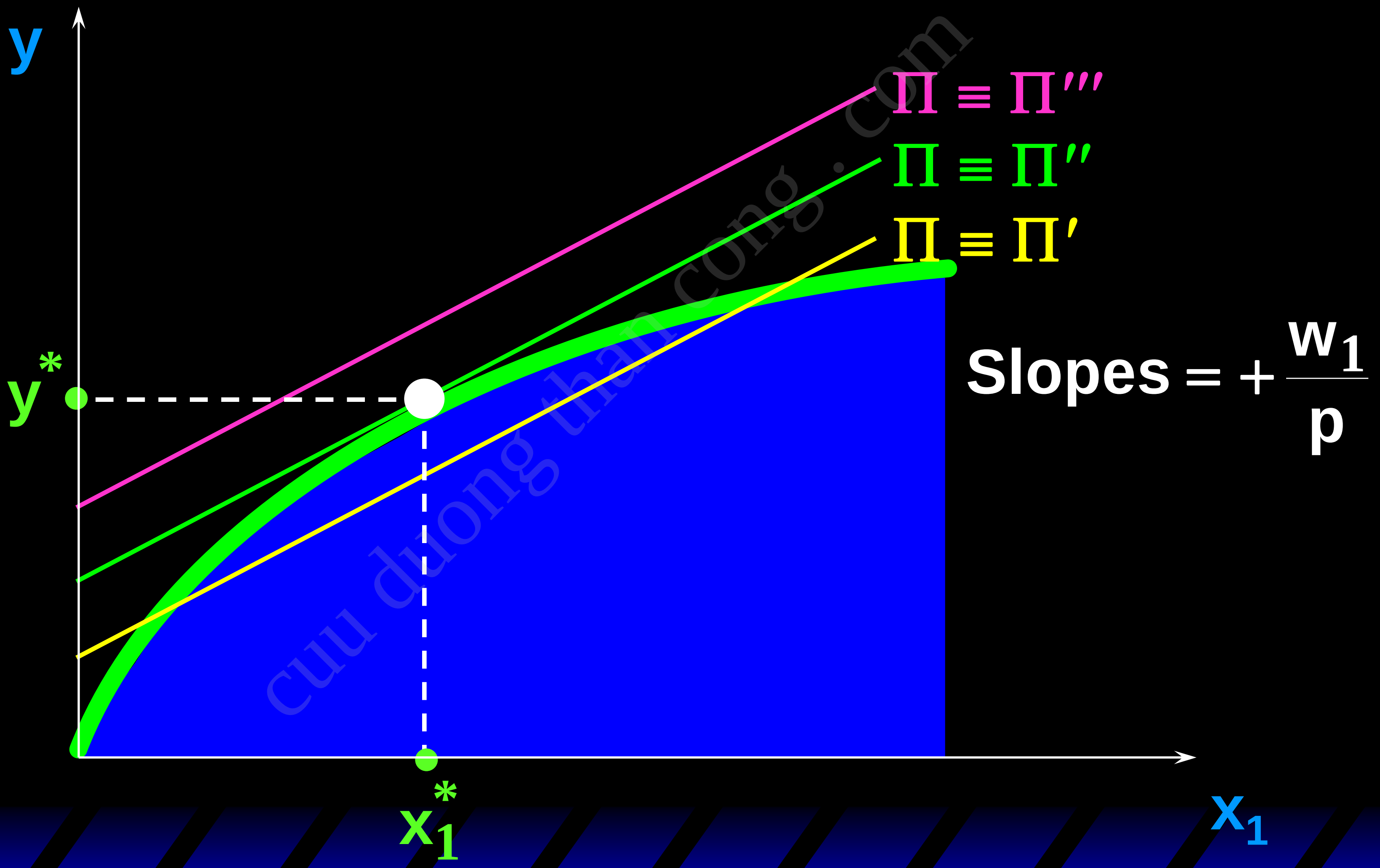
Short-Run Profit-Maximization

- **The firm's problem is to locate the production plan that attains the highest possible iso-profit line, given the firm's constraint on choices of production plans.**
- **Q: What is this constraint?**
- **A: The production function.**

Short-Run Profit-Maximization



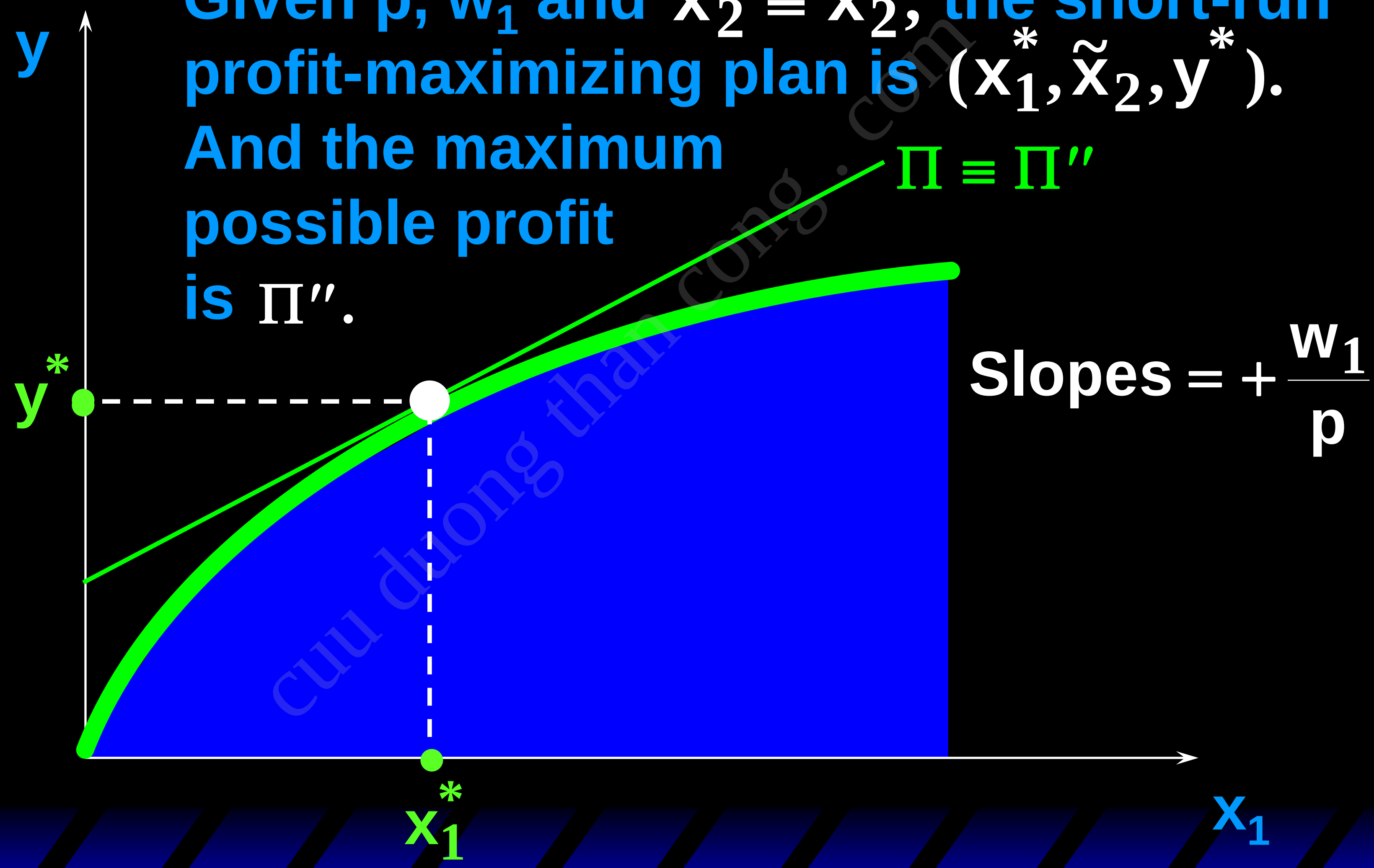
Short-Run Profit-Maximization



Short-Run Profit-Maximization

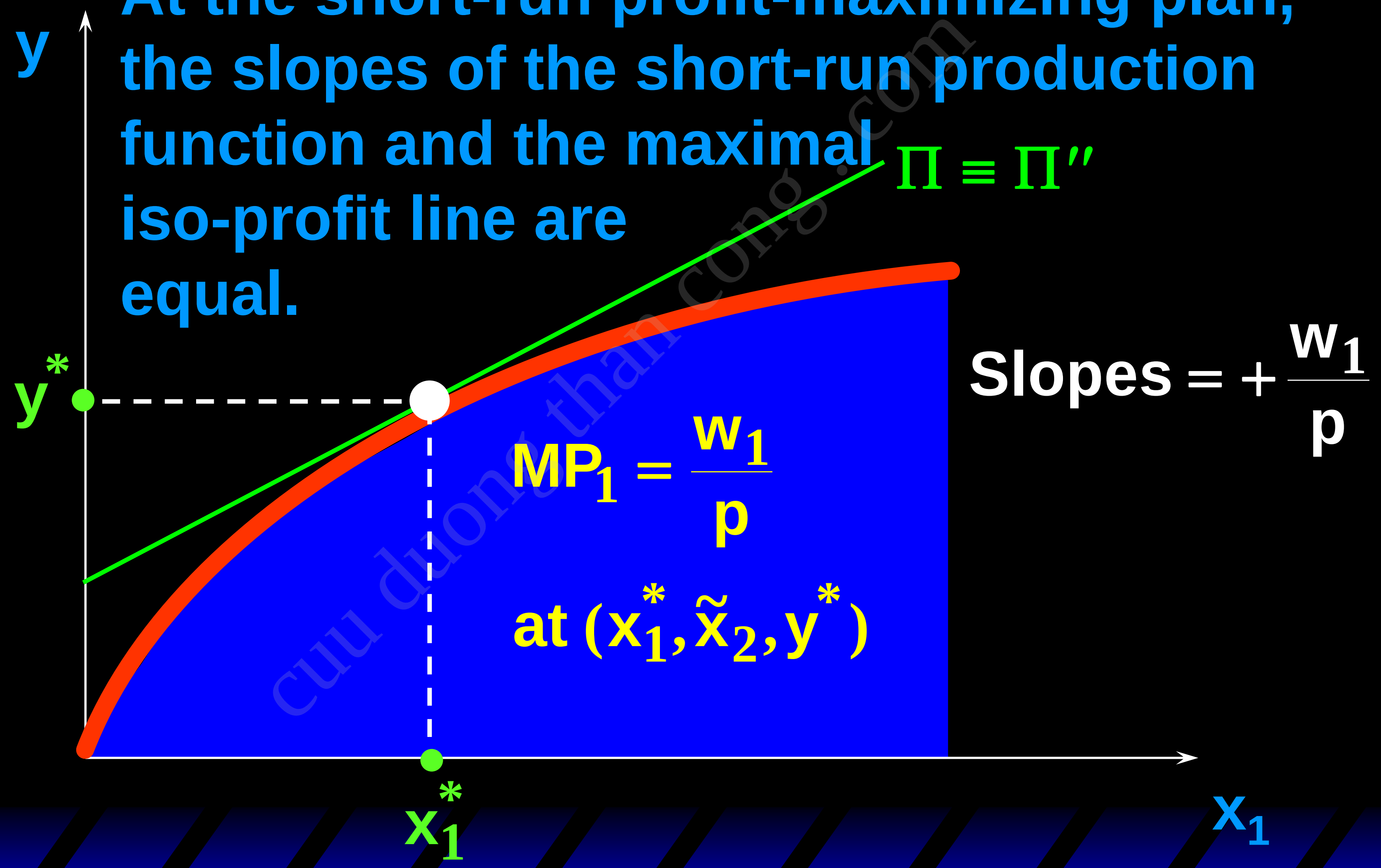
Given p, w_1 and $x_2 \equiv \tilde{x}_2$, the short-run profit-maximizing plan is $(x_1^*, \tilde{x}_2, y^*)$.

And the maximum possible profit is Π''.



Short-Run Profit-Maximization

At the short-run profit-maximizing plan, the slopes of the short-run production function and the maximal iso-profit line are equal.



Short-Run Profit-Maximization

$$MP_1 = \frac{w_1}{p} \quad \Leftrightarrow \quad p \times MP_1 = w_1$$

$p \times MP_1$ is the **marginal revenue product of input 1**, the rate at which revenue increases with the amount used of input 1.

If $p \times MP_1 > w_1$ then profit increases with x_1.

If $p \times MP_1 < w_1$ then profit decreases with x_1.

Short-Run Profit-Maximization; A Cobb-Douglas Example

Suppose the short-run production function is $y = x_1^{1/3}\tilde{x}_2^{1/3}$.

The marginal product of the variable input 1 is $MP_1 = \frac{\partial y}{\partial x_1} = \frac{1}{3}x_1^{-2/3}\tilde{x}_2^{1/3}$.

The profit-maximizing condition is

$$MRP_1 = p \times MP_1 = \frac{p}{3}(x_1^*)^{-2/3}\tilde{x}_2^{1/3} = w_1.$$

Short-Run Profit-Maximization; A Cobb-Douglas Example

Solving $\frac{p}{3}(x_1^*)^{-2/3}\tilde{x}_2^{1/3} = w_1$ for x_1 gives

$$(x_1^*)^{-2/3} = \frac{3w_1}{p\tilde{x}_2^{1/3}}.$$

That is,

$$(x_1^*)^{2/3} = \frac{p\tilde{x}_2^{1/3}}{3w_1}$$

so

$$x_1^* = \left(\frac{p\tilde{x}_2^{1/3}}{3w_1}\right)^{3/2} = \left(\frac{p}{3w_1}\right)^{3/2}\tilde{x}_2^{1/2}.$$

Short-Run Profit-Maximization; A Cobb-Douglas Example

$$x_1^* = \left(\frac{p}{3w_1}\right)^{3/2} \tilde{x}_2^{1/2}$$

is the firm's short-run demand for input 1 when the level of input 2 is fixed at $\tilde{x}_2$ units.

The firm's short-run output level is thus

$$y^* = (x_1^*)^{1/3} \tilde{x}_2^{1/3} = \left(\frac{p}{3w_1}\right)^{1/2} \tilde{x}_2^{1/2}.$$

Comparative Statics of Short-Run Profit-Maximization

- **What happens to the short-run profit-maximizing production plan as the output price p changes?**

Comparative Statics of Short-Run Profit-Maximization

The equation of a short-run iso-profit line is

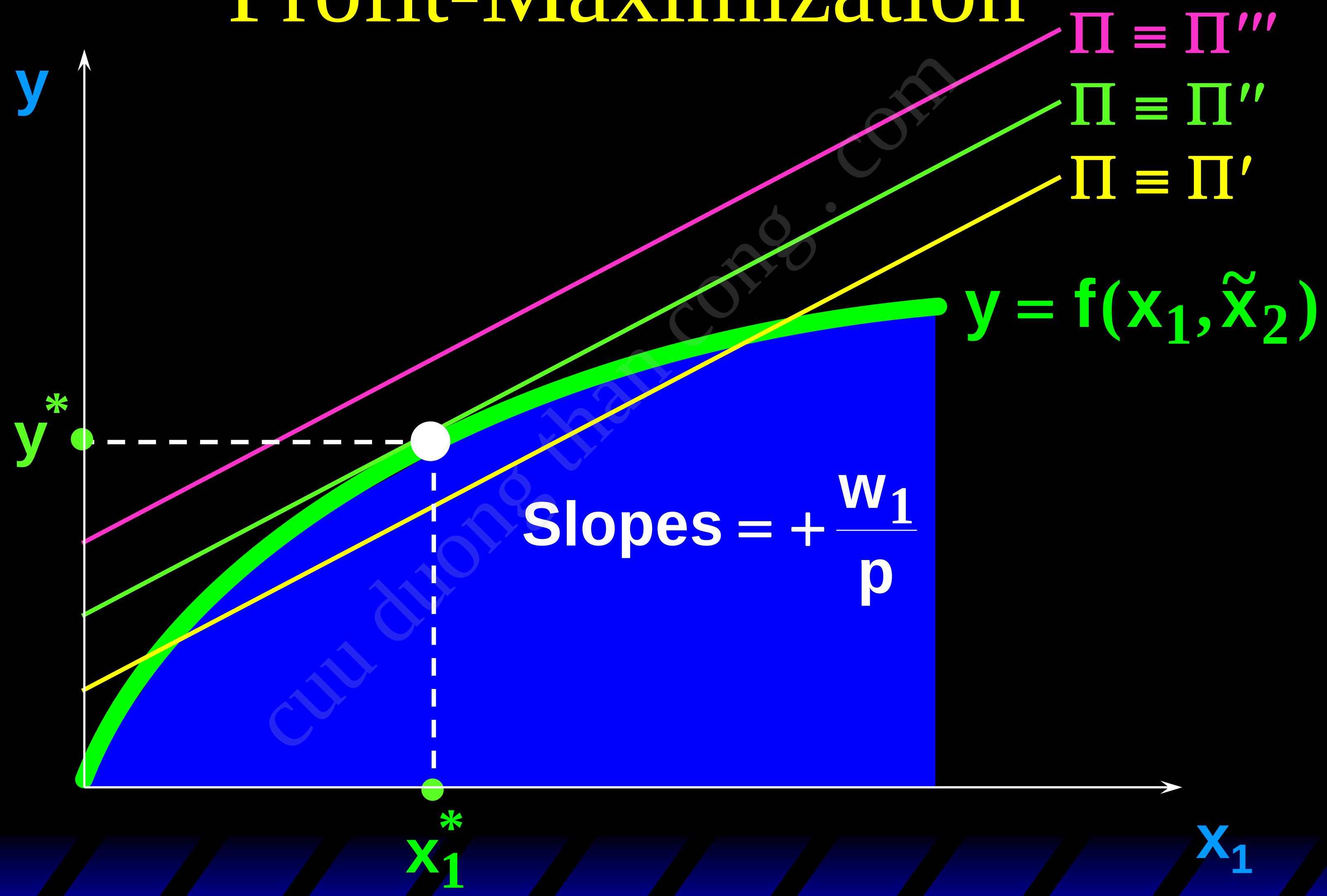
$$y = \frac{w_1}{p} x_1 + \frac{\Pi + w_2 \tilde{x}_2}{p}$$

so an increase in p causes

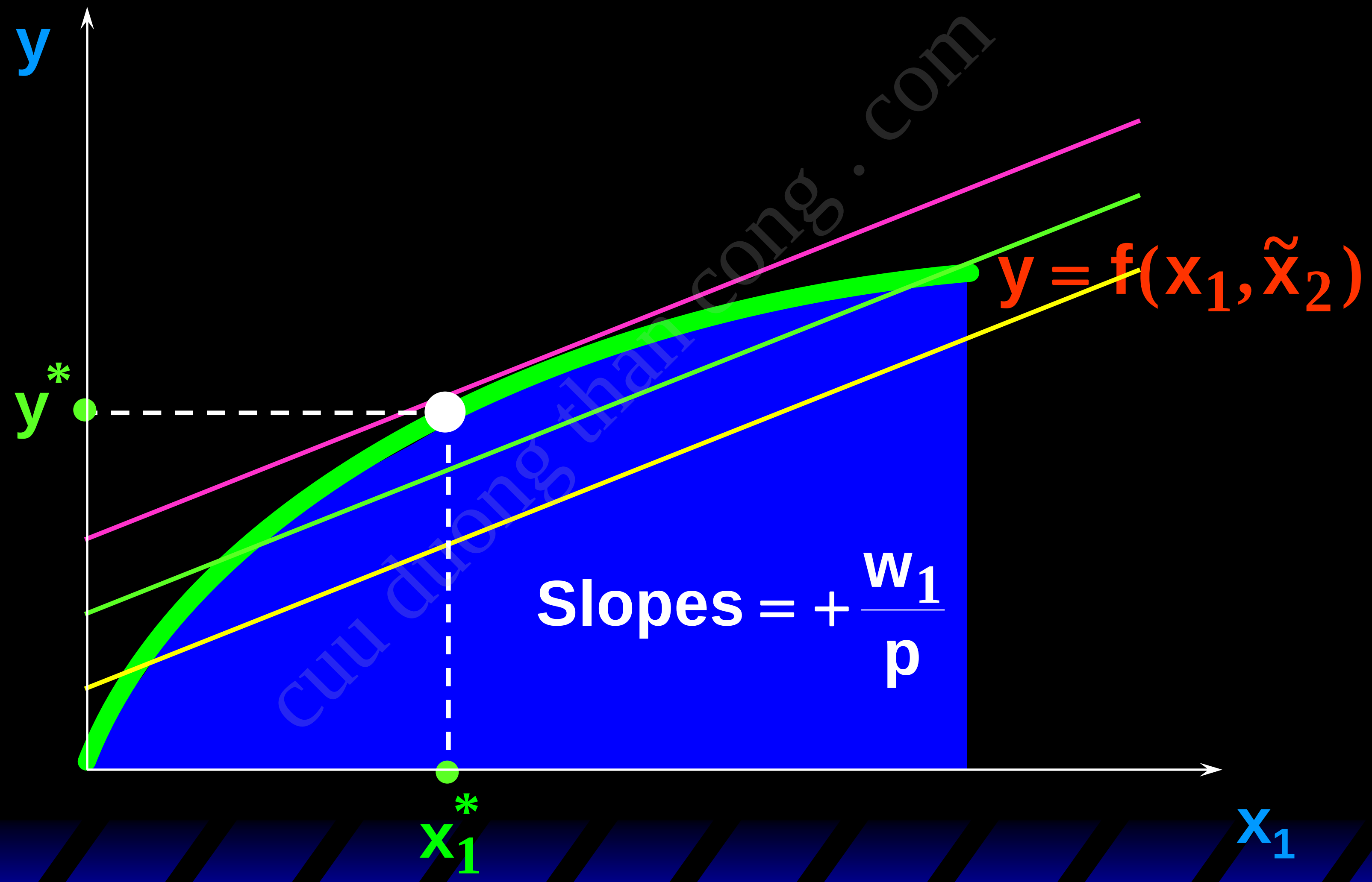
-- a reduction in the slope, and

-- a reduction in the vertical intercept.

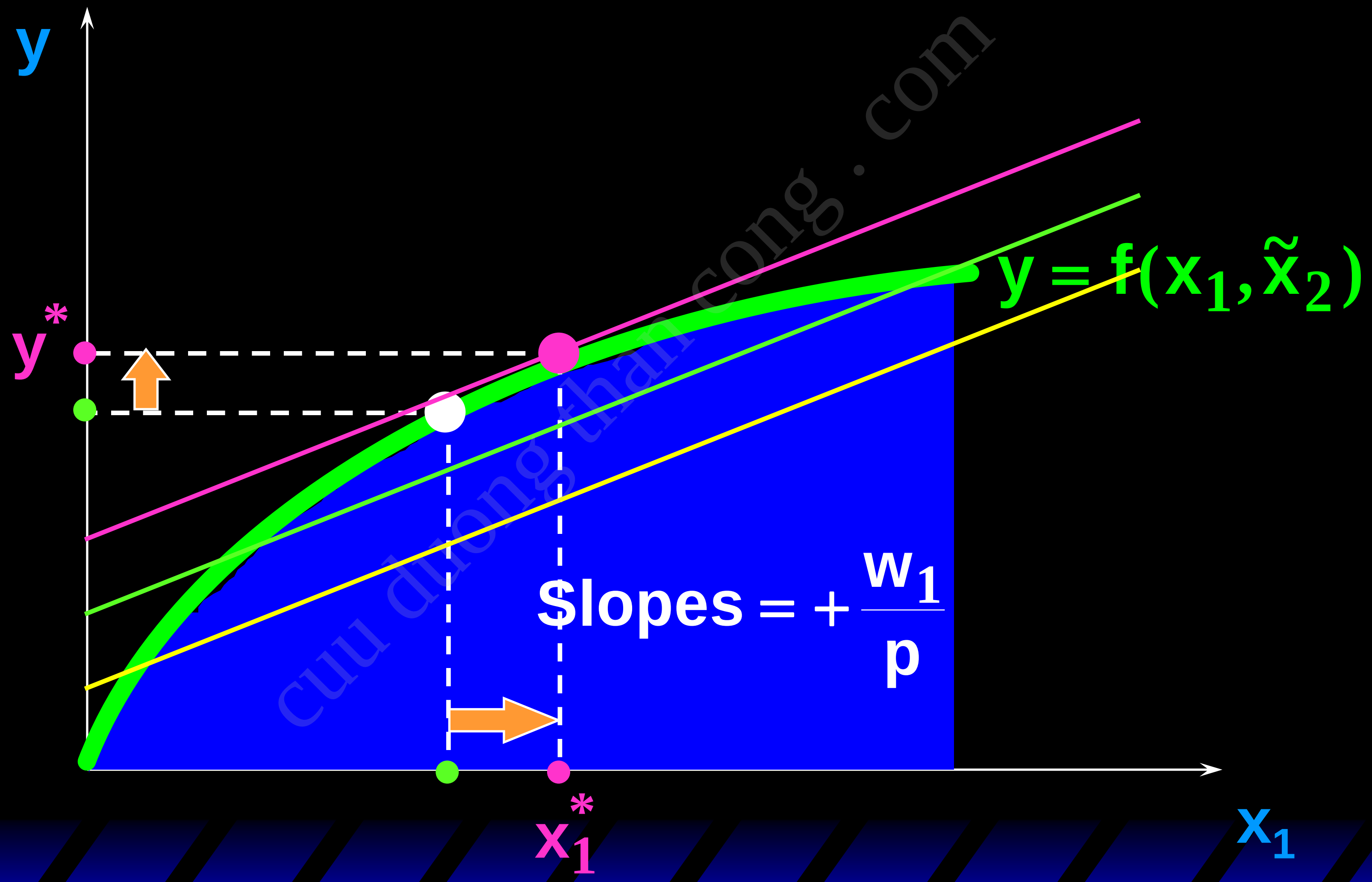
Comparative Statics of Short-Run Profit-Maximization



Comparative Statics of Short-Run Profit-Maximization



Comparative Statics of Short-Run Profit-Maximization



Comparative Statics of Short-Run Profit-Maximization

- An increase in p, the price of the firm's output, causes
  - an increase in the firm's output level (the firm's supply curve slopes upward), and
  - an increase in the level of the firm's variable input (the firm's demand curve for its variable input shifts outward).

Comparative Statics of Short-Run Profit-Maximization

- The Cobb-Douglas example: When $y = x_1^{1/3}\tilde{x}_2^{1/3}$ then the firm's short-run demand for its variable input 1 is

$$x_1^* = \left(\frac{p}{3w_1}\right)^{3/2}\tilde{x}_2^{1/2}$$

and its short-run supply is

$$y^* = \left(\frac{p}{3w_1}\right)^{1/2}\tilde{x}_2^{1/2}.$$

- x_1^* increases as p increases.
- y^* increases as p increases.

Comparative Statics of Short-Run Profit-Maximization

- **What happens to the short-run profit-maximizing production plan as the variable input price w_1 changes?**

Comparative Statics of Short-Run Profit-Maximization

The equation of a short-run iso-profit line is

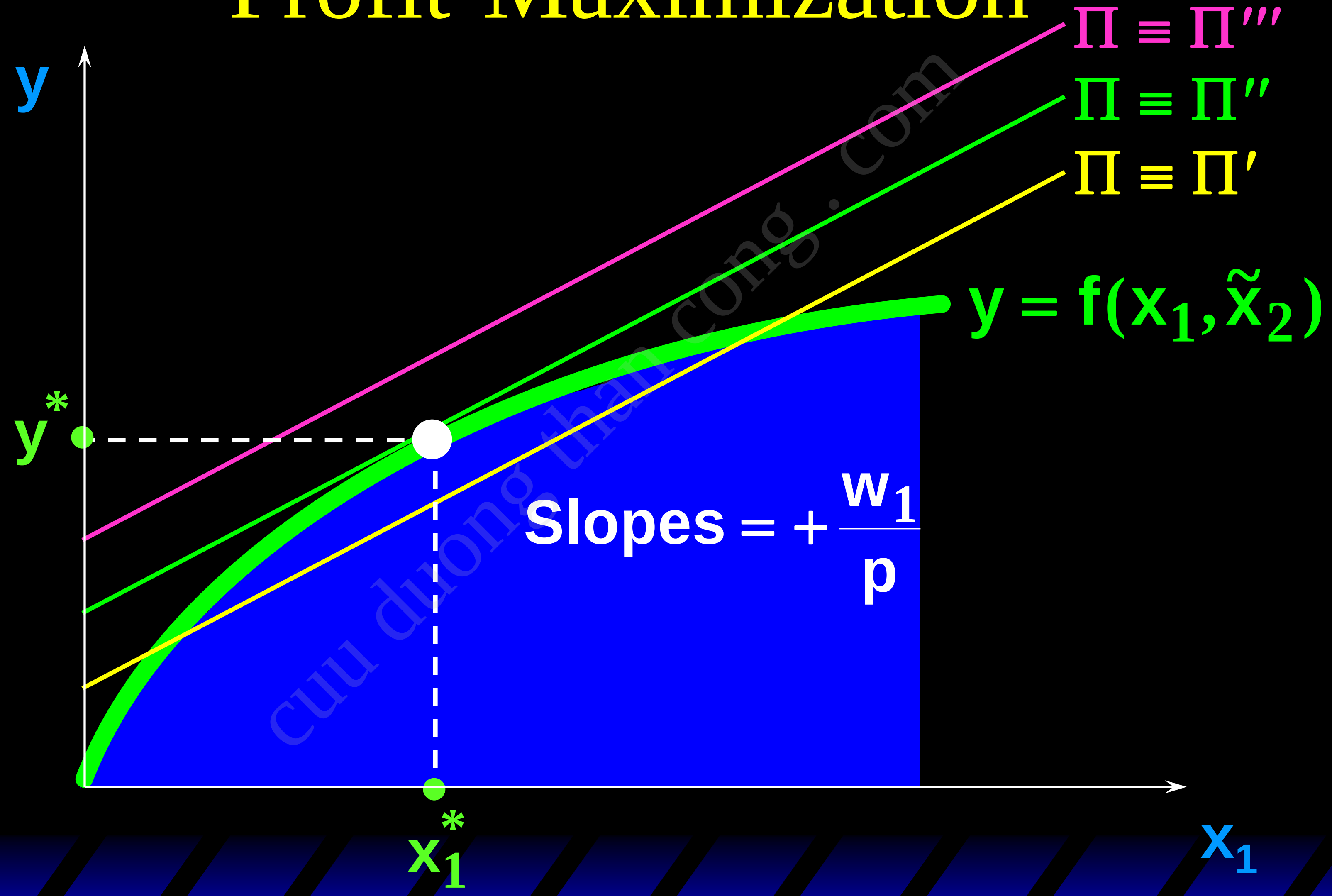
$$y = \frac{w_1}{p} x_1 + \frac{\Pi + w_2 \tilde{x}_2}{p}$$

so an increase in w_1 causes

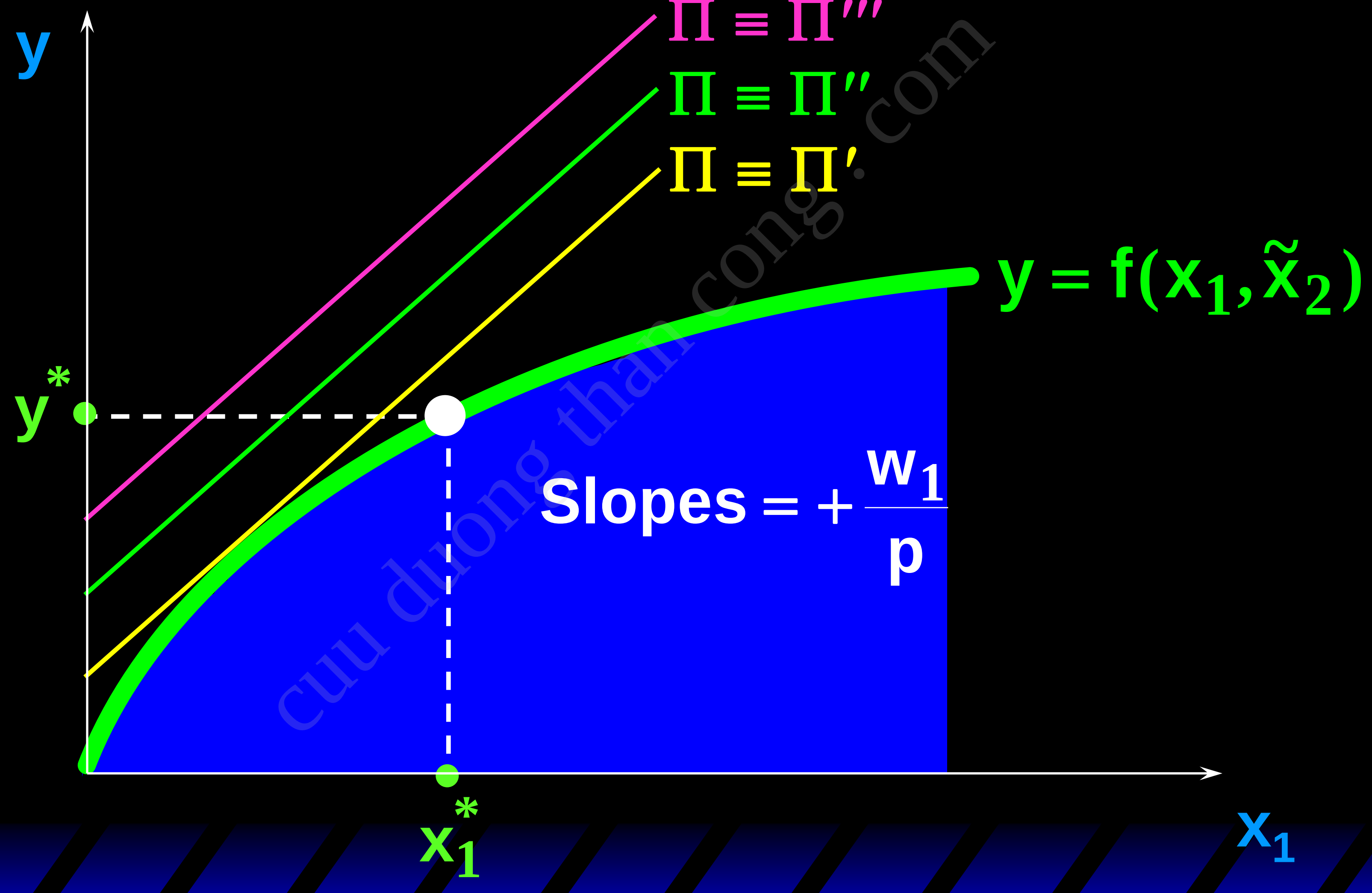
-- an increase in the slope, and

-- no change to the vertical intercept.

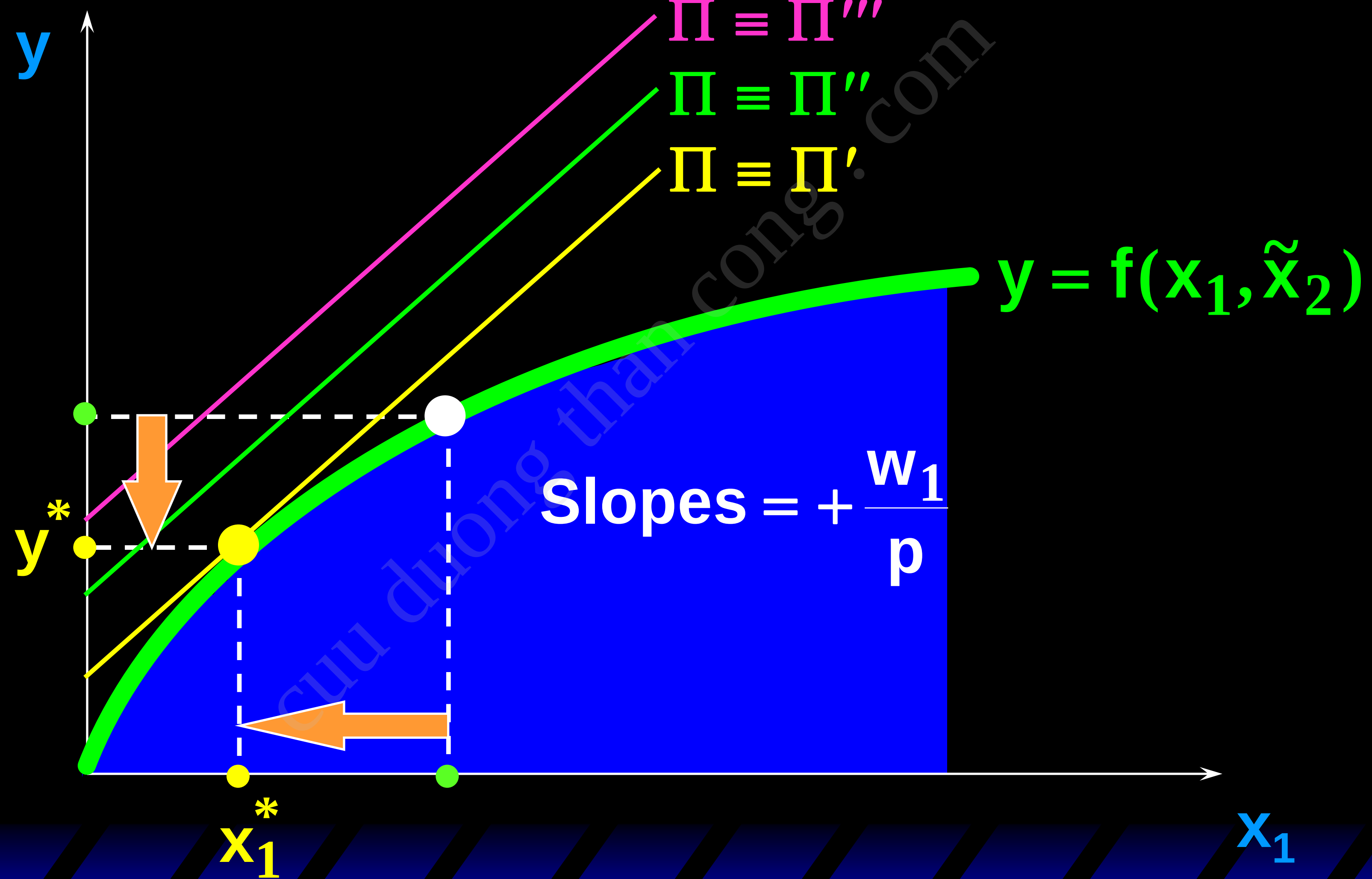
Comparative Statics of Short-Run Profit-Maximization



Comparative Statics of Short-Run Profit-Maximization



Comparative Statics of Short-Run Profit-Maximization



Comparative Statics of Short-Run Profit-Maximization

- An increase in w_1, the price of the firm's variable input, causes
  - a decrease in the firm's output level (the firm's supply curve shifts inward), and
  - a decrease in the level of the firm's variable input (the firm's demand curve for its variable input slopes downward).

Comparative Statics of Short-Run Profit-Maximization

The Cobb-Douglas example: When $y = x_1^{1/3}\tilde{x}_2^{1/3}$ then the firm's short-run demand for its variable input 1 is

$$x_1^* = \left(\frac{p}{3w_1}\right)^{3/2}\tilde{x}_2^{1/2}$$

and its short-run supply is

$$y^* = \left(\frac{p}{3w_1}\right)^{1/2}\tilde{x}_2^{1/2}.$$

x_1^* decreases as w_1 increases.

y^* decreases as w_1 increases.

Long-Run Profit-Maximization

- Now allow the firm to vary both input levels.
- Since no input level is fixed, there are no fixed costs.

Long-Run Profit-Maximization

- Both x_1 and x_2 are variable.
- Think of the firm as choosing the production plan that maximizes profits for a given value of x_2, and then varying x_2 to find the largest possible profit level.

Long-Run Profit-Maximization

The equation of a long-run iso-profit line is

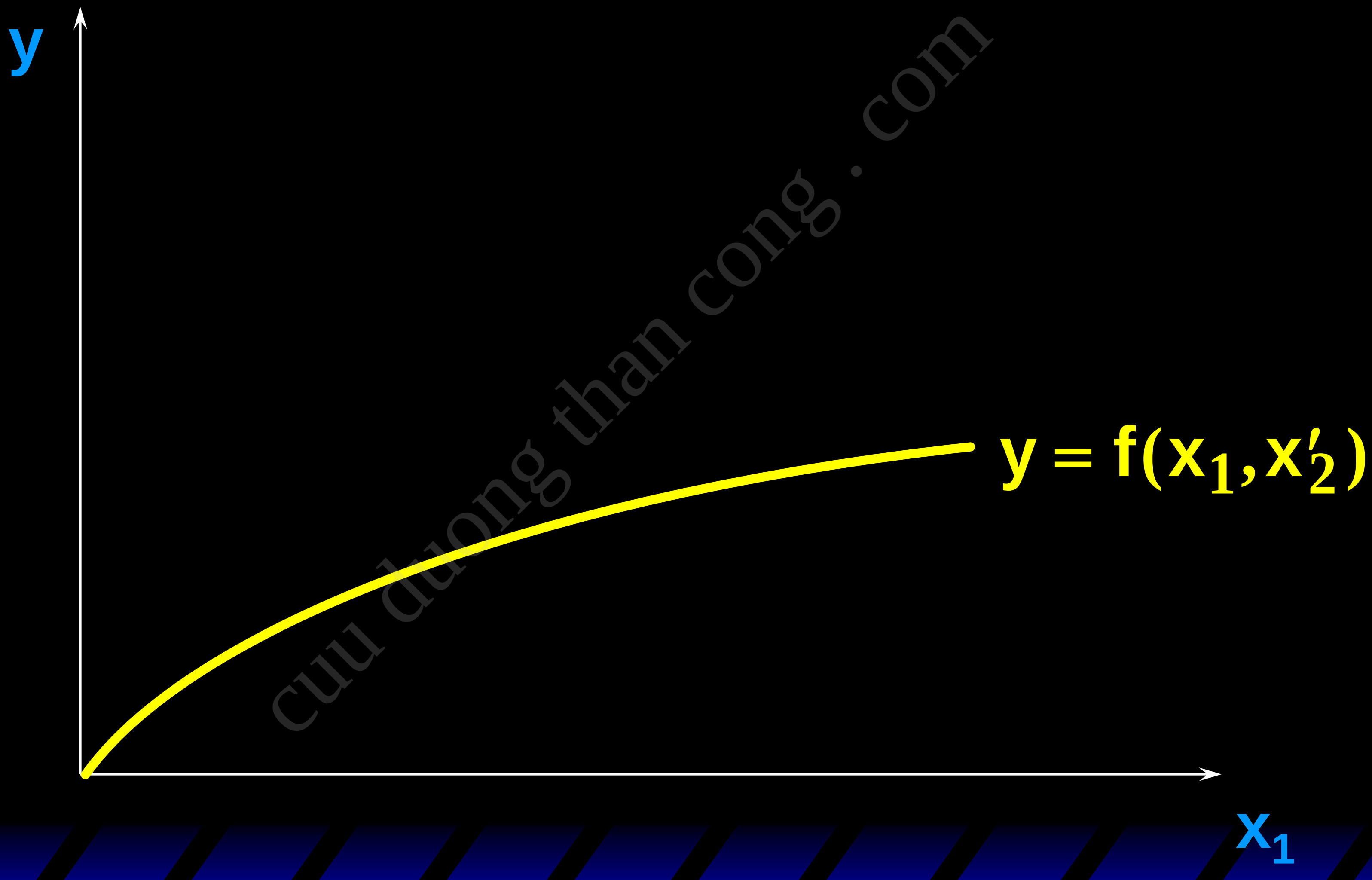
$$y = \frac{w_1}{p} x_1 + \frac{\Pi + w_2 x_2}{p}$$

so an increase in x_2 causes

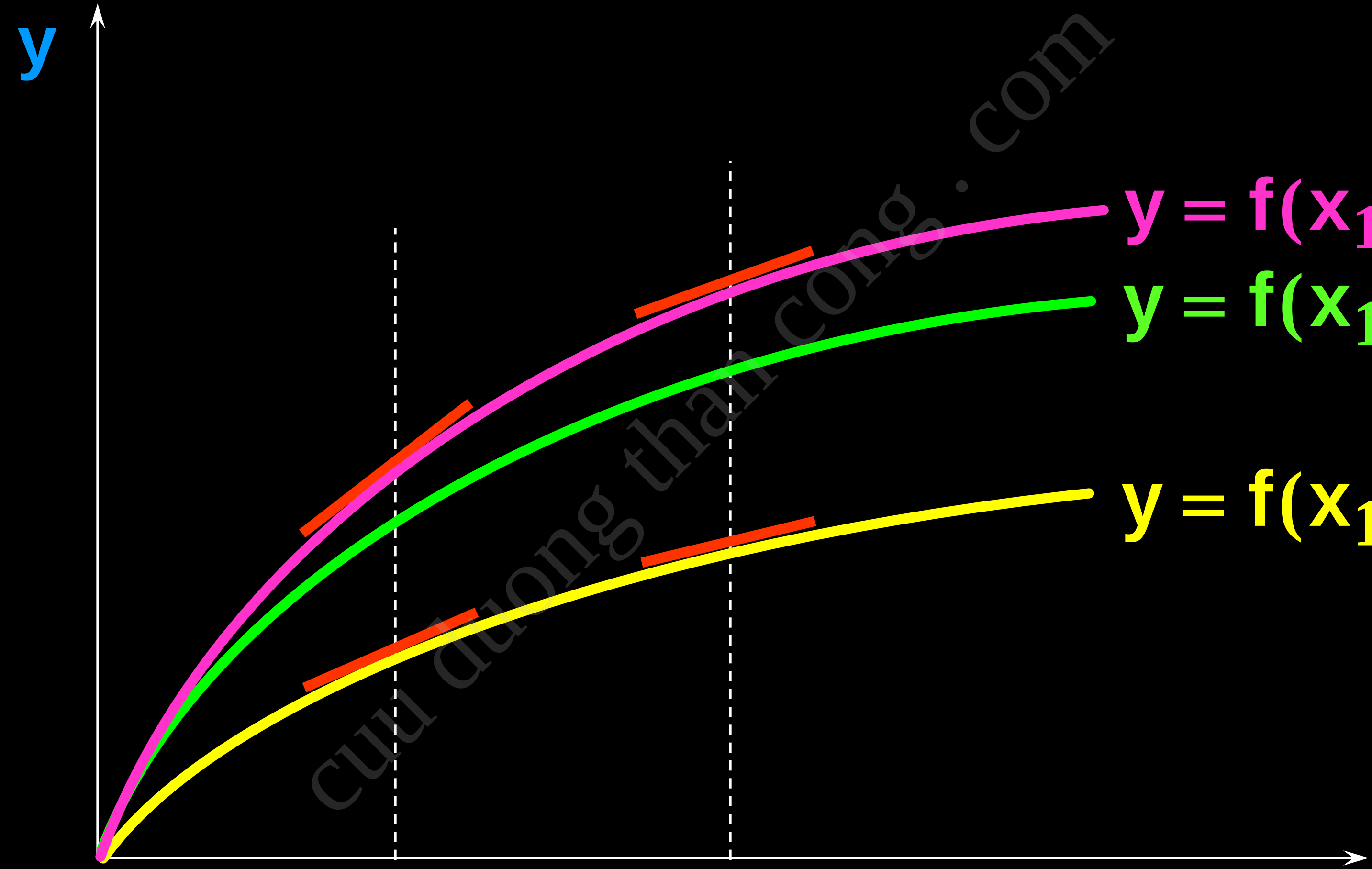
-- no change to the slope, and

-- an increase in the vertical intercept.

Long-Run Profit-Maximization

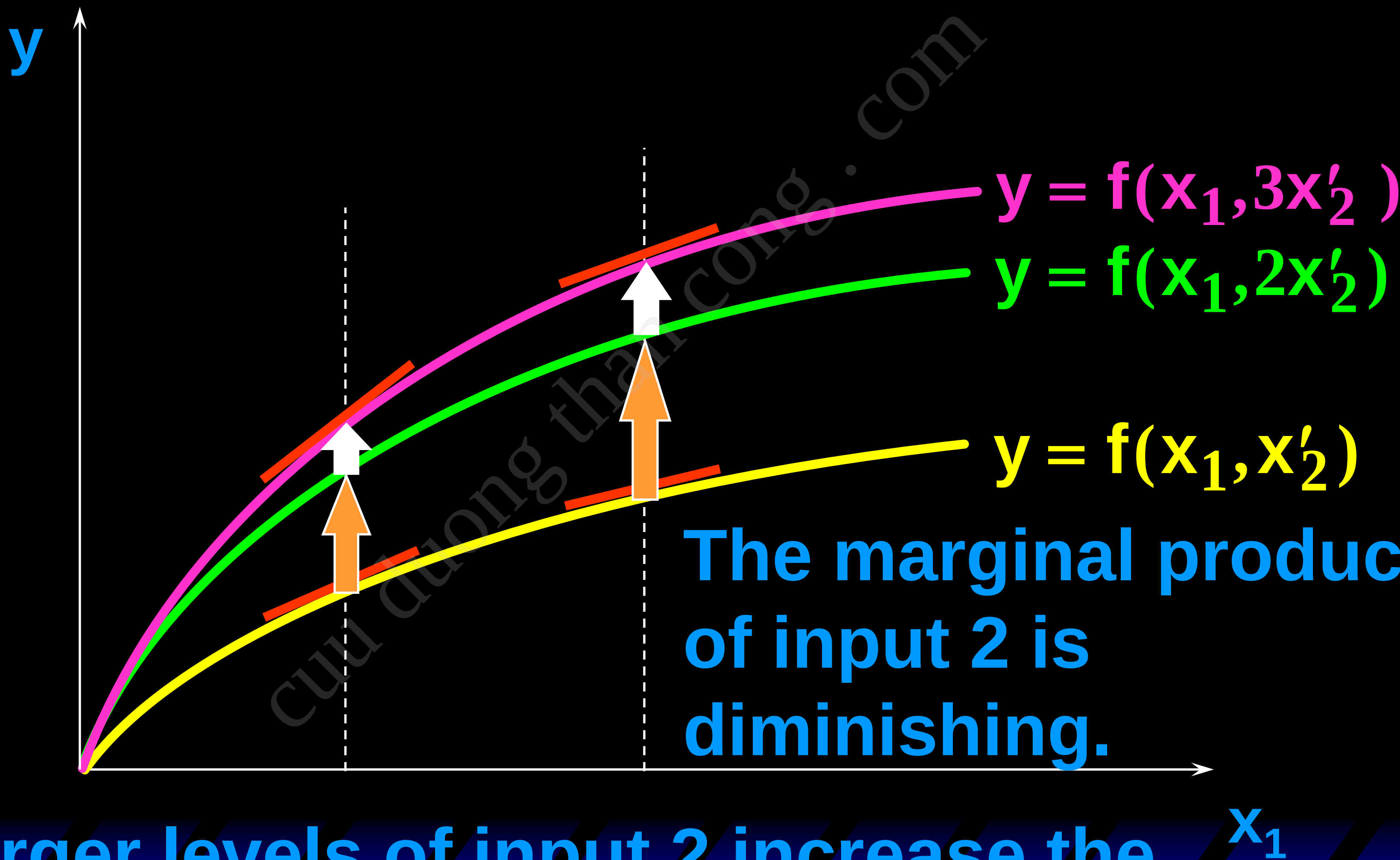


Long-Run Profit-Maximization



Larger levels of input 2 increase the productivity of input 1.

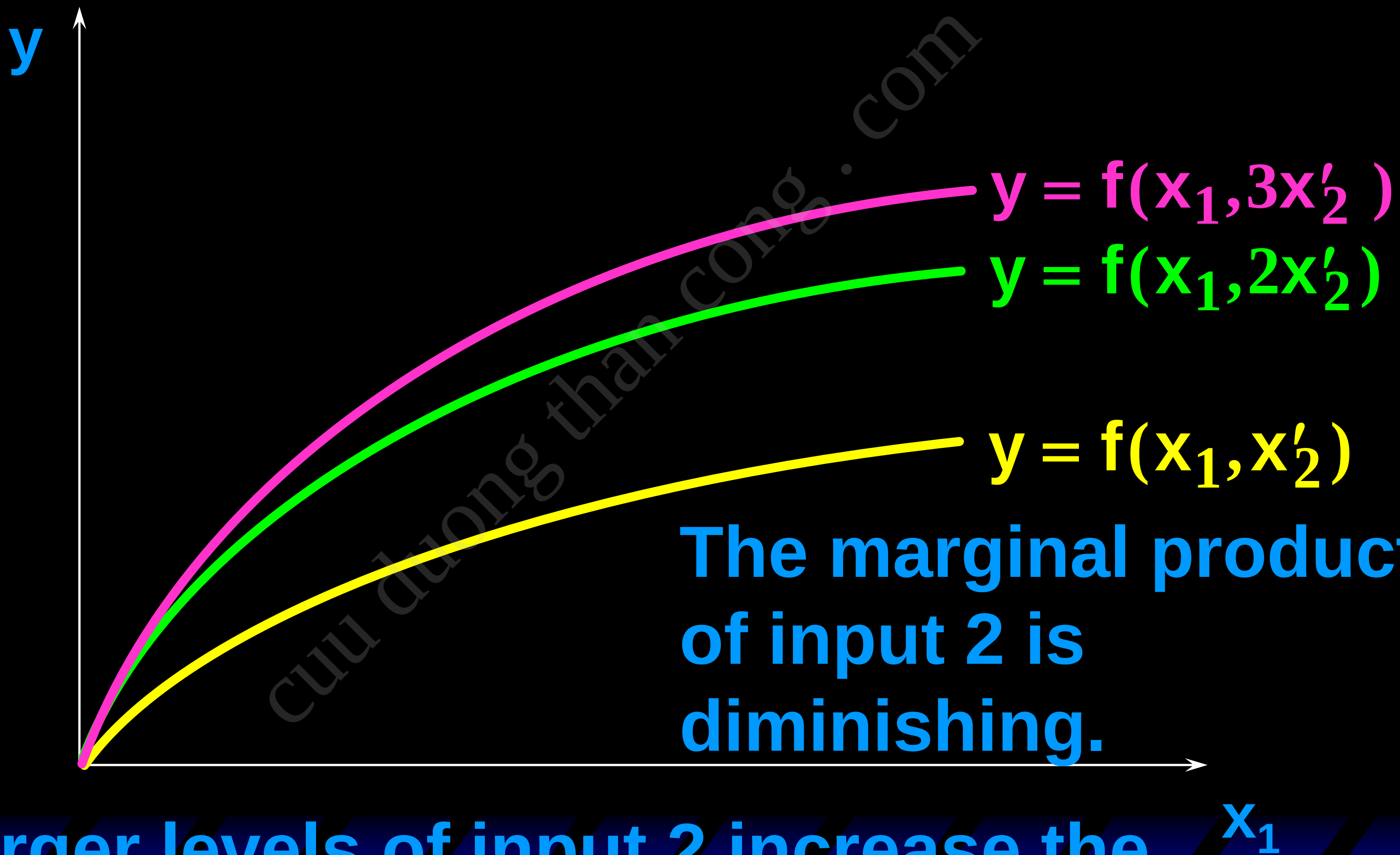
Long-Run Profit-Maximization



The marginal product of input 2 is diminishing.

Larger levels of input 2 increase the productivity of input 1.

Long-Run Profit-Maximization



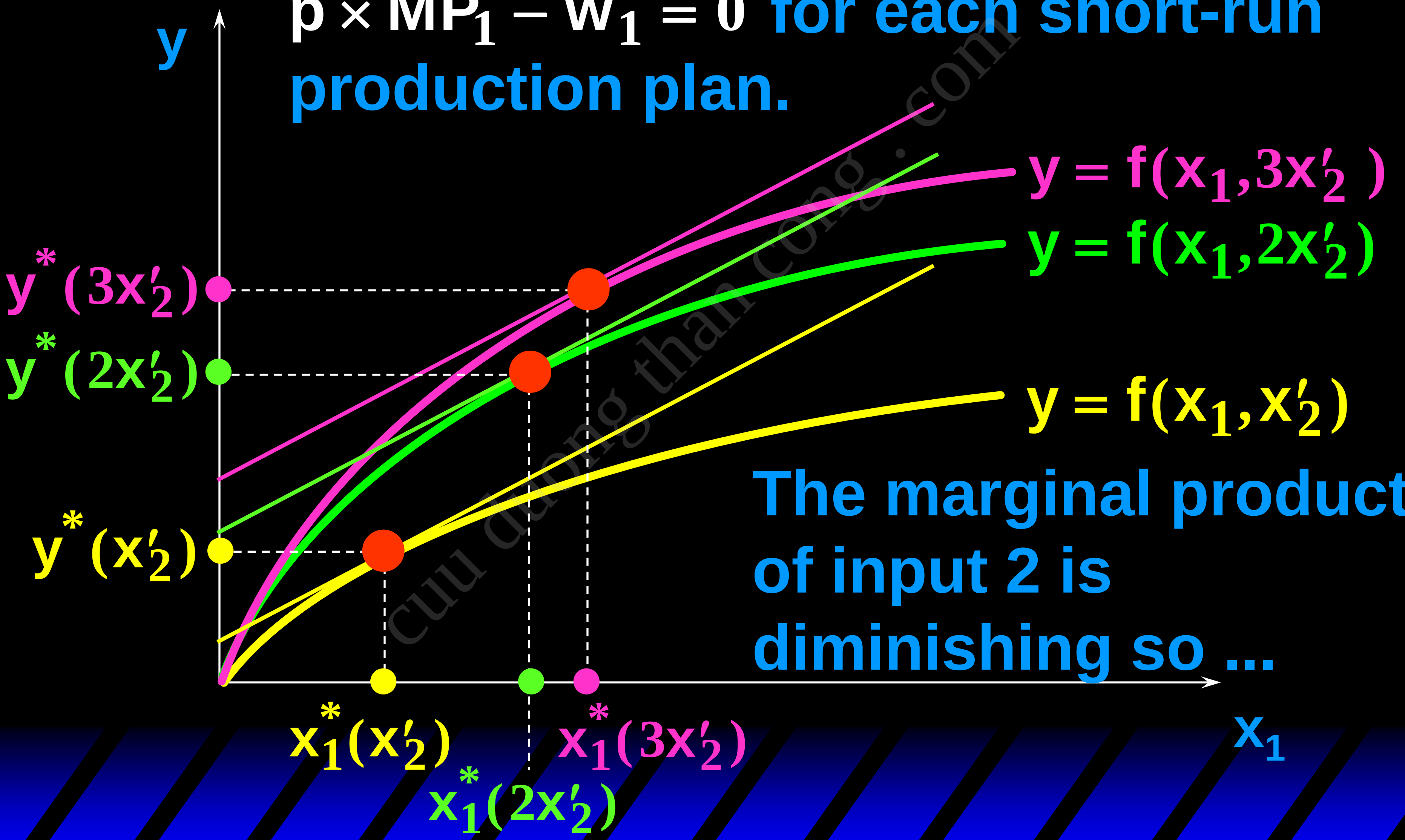
The marginal product of input 2 is diminishing.

Larger levels of input 2 increase the productivity of input 1.

Long-Run Profit-Maximization

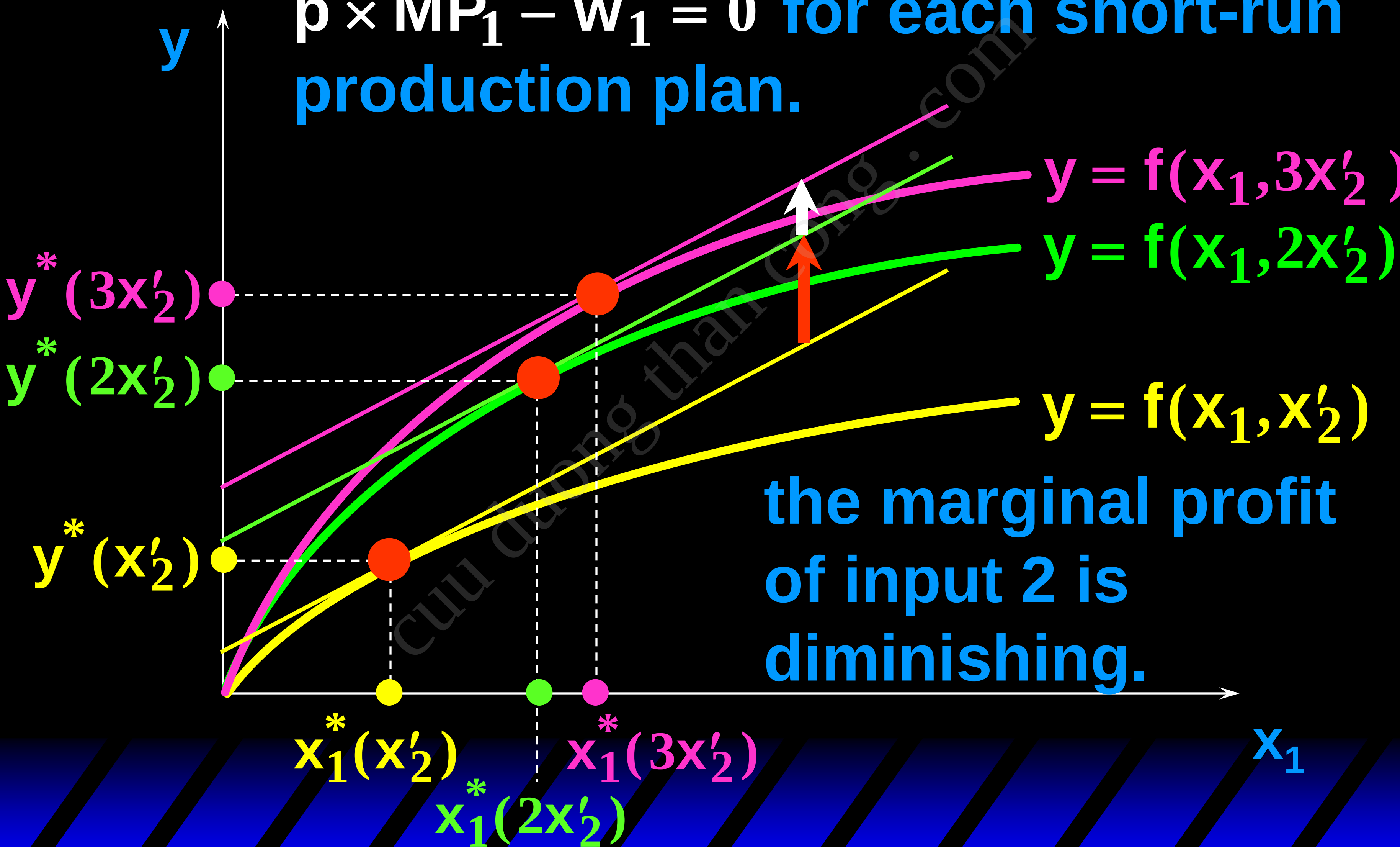
$p \times MP_1 - w_1 = 0$ for each short-run production plan.

The marginal product of input 2 is diminishing so ...



Long-Run Profit-Maximization

$p \times MP_1 - w_1 = 0$ for each short-run production plan.



the marginal profit of input 2 is diminishing.

Long-Run Profit-Maximization

- Profit will increase as x_2 increases so long as the marginal profit of input 2

$$p \times MP_2 - w_2 > 0.$$

- The profit-maximizing level of input 2 therefore satisfies

$$p \times MP_2 - w_2 = 0.$$

Long-Run Profit-Maximization

- **Profit will increase as x_2 increases so long as the marginal profit of input 2**

$$p \times MP_2 - w_2 > 0.$$

- **The profit-maximizing level of input 2 therefore satisfies**

$$p \times MP_2 - w_2 = 0.$$

- **And $p \times MP_1 - w_1 = 0$ is satisfied in any short-run, so ...**

Long-Run Profit-Maximization

- **The input levels of the long-run profit-maximizing plan satisfy**

$$p \times MP_1 - w_1 = 0 \quad \text{and} \quad p \times MP_2 - w_2 = 0.$$

- **That is, marginal revenue equals marginal cost for all inputs.**

Long-Run Profit-Maximization

The Cobb-Douglas example: When $y = x_1^{1/3}\tilde{x}_2^{1/3}$ then the firm's short-run demand for its variable input 1 is

$$x_1^* = \left(\frac{p}{3w_1}\right)^{3/2}\tilde{x}_2^{1/2}$$

and its short-run supply is

$$y^* = \left(\frac{p}{3w_1}\right)^{1/2}\tilde{x}_2^{1/2}.$$

Short-run profit is therefore …

Long-Run Profit-Maximization

$$\Pi = py^* - w_1x_1^* - w_2\tilde{x}_2$$

$$= p\left(\frac{p}{3w_1}\right)^{1/2}\tilde{x}_2^{1/2} - w_1\left(\frac{p}{3w_1}\right)^{3/2}\tilde{x}_2^{1/2} - w_2\tilde{x}_2$$

$$= p\left(\frac{p}{3w_1}\right)^{1/2}\tilde{x}_2^{1/2} - w_1\frac{p}{3w_1}\left(\frac{p}{3w_1}\right)^{1/2} - w_2\tilde{x}_2$$

$$= \frac{2p}{3}\left(\frac{p}{3w_1}\right)^{1/2}\tilde{x}_2^{1/2} - w_2\tilde{x}_2$$

$$= \left(\frac{4p^3}{27w_1}\right)^{1/2}\tilde{x}_2^{1/2} - w_2\tilde{x}_2.$$

Long-Run Profit-Maximization

$$\Pi = \left(\frac{4p^3}{27w_1}\right)^{1/2} \tilde{x}_2^{1/2} - w_2\tilde{x}_2.$$

What is the long-run profit-maximizing level of input 2? Solve

$$0 = \frac{\partial \Pi}{\partial \tilde{x}_2} = \frac{1}{2}\left(\frac{4p^3}{27w_1}\right)^{1/2} \tilde{x}_2^{-1/2} - w_2$$

to get

$$\tilde{x}_2 = x_2^* = \frac{p^3}{27w_1w_2^2}.$$

Long-Run Profit-Maximization

What is the long-run profit-maximizing input 1 level? Substitute

$$x_2^* = \frac{p^3}{27w_1w_2^2} \quad \text{into} \quad x_1^* = \left(\frac{p}{3w_1}\right)^{3/2} \tilde{x}_2^{1/2}$$

to get

$$x_1^* = \left(\frac{p}{3w_1}\right)^{3/2} \left(\frac{p^3}{27w_1w_2^2}\right)^{1/2} = \frac{p^3}{27w_1^2w_2}.$$

Long-Run Profit-Maximization

What is the long-run profit-maximizing output level? Substitute

$$x_2^* = \frac{p^3}{27w_1w_2^2} \quad \text{into} \quad y^* = \left(\frac{p}{3w_1}\right)^{1/2} \tilde{x}_2^{1/2}$$

to get

$$y^* = \left(\frac{p}{3w_1}\right)^{1/2} \left(\frac{p^3}{27w_1w_2^2}\right)^{1/2} = \frac{p^2}{9w_1w_2}.$$

Long-Run Profit-Maximization

So given the prices p, w_1 and w_2, and the production function $y = x_1^{1/3} x_2^{1/3}$

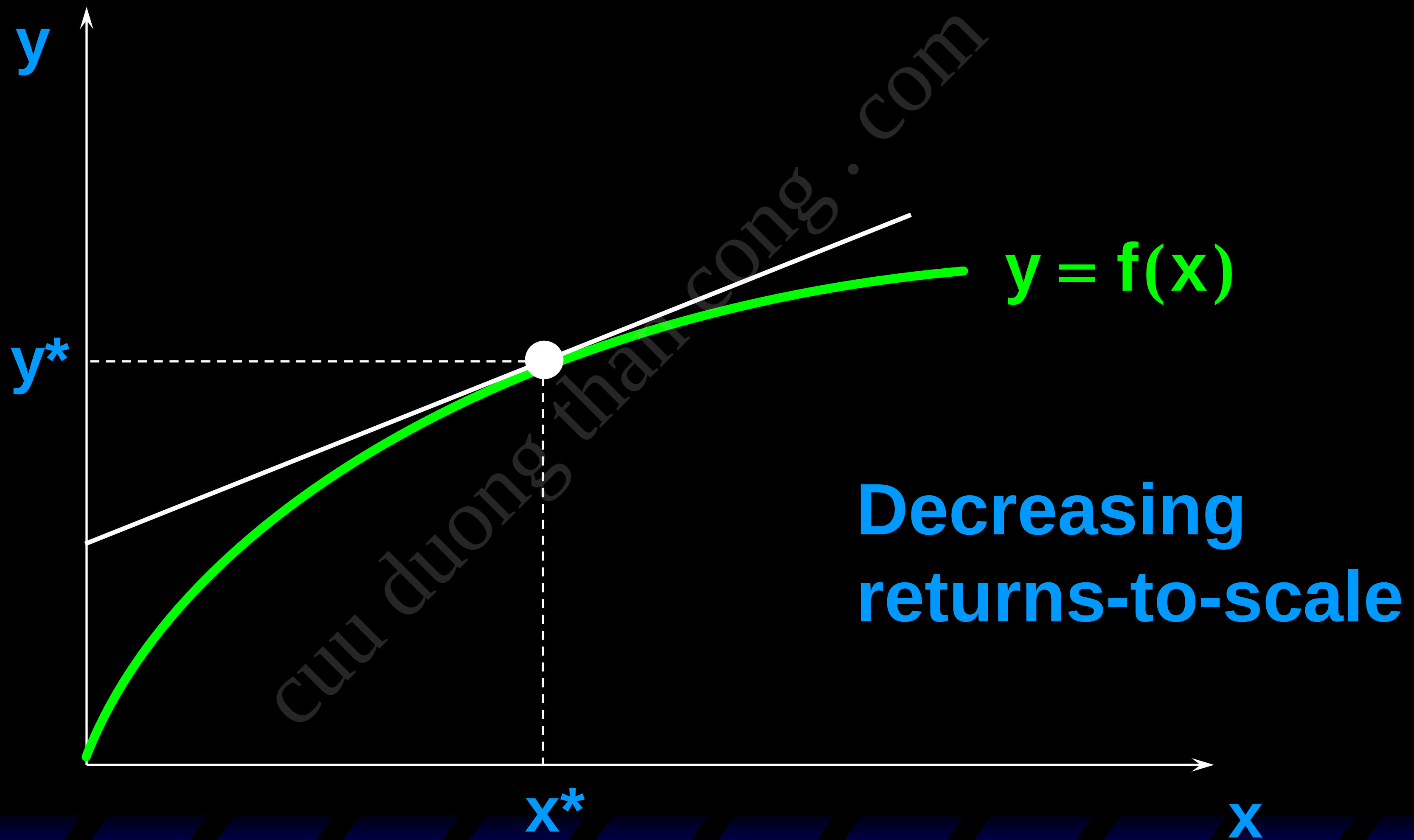
the long-run profit-maximizing production plan is

$$(x_1^*, x_2^*, y^*) = \left(\frac{p^3}{27 w_1^2 w_2}, \frac{p^3}{27 w_1 w_2^2}, \frac{p^2}{9 w_1 w_2} \right).$$

Returns-to-Scale and Profit-Maximization

- If a competitive firm's technology exhibits decreasing returns-to-scale then the firm has a single long-run profit-maximizing production plan.

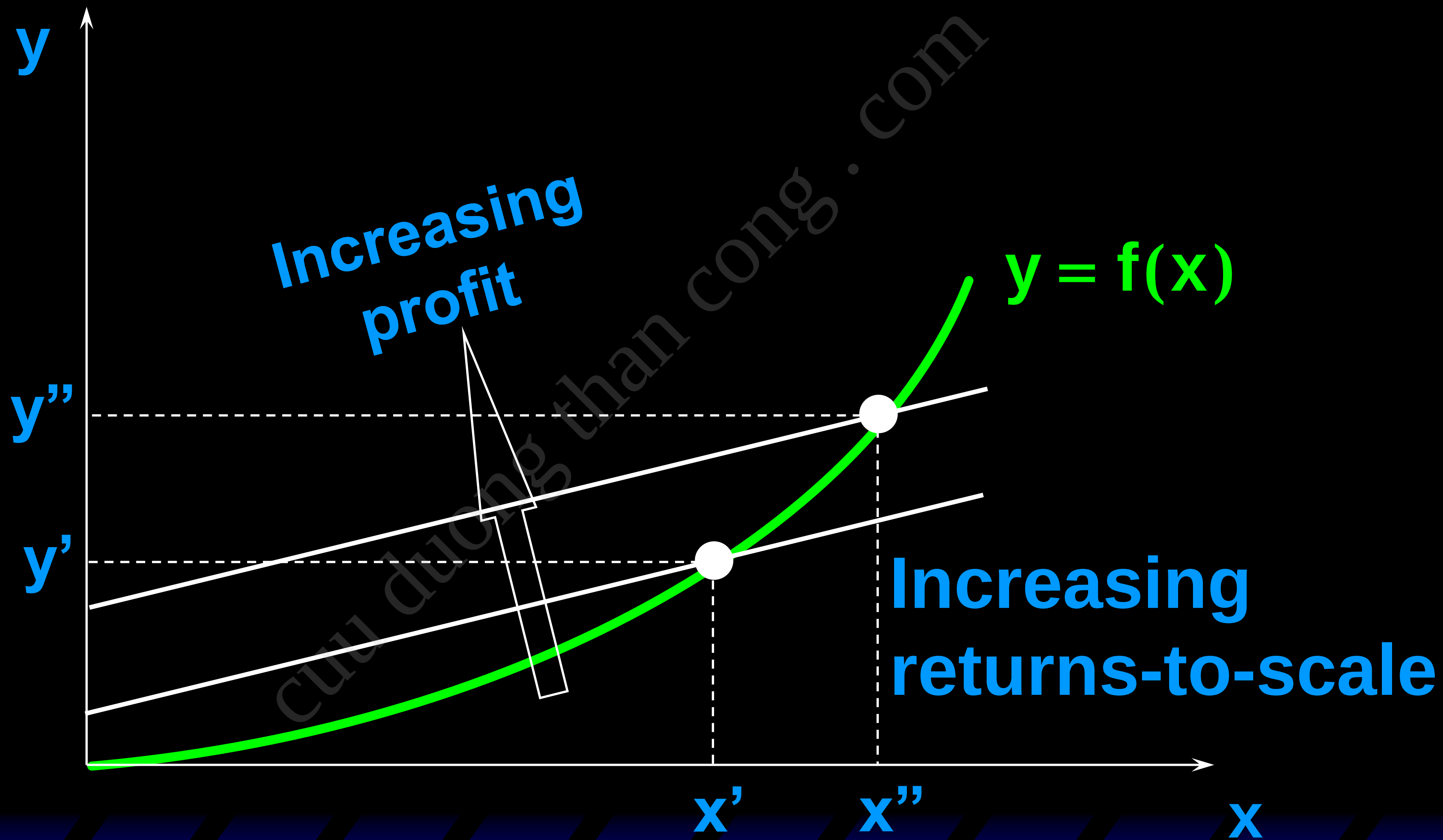
Returns-to Scale and Profit-Maximization



Returns-to-Scale and Profit-Maximization

- If a competitive firm's technology exhibits exhibits increasing returns-to-scale then the firm does not have a profit-maximizing plan.

Returns-to Scale and Profit-Maximization



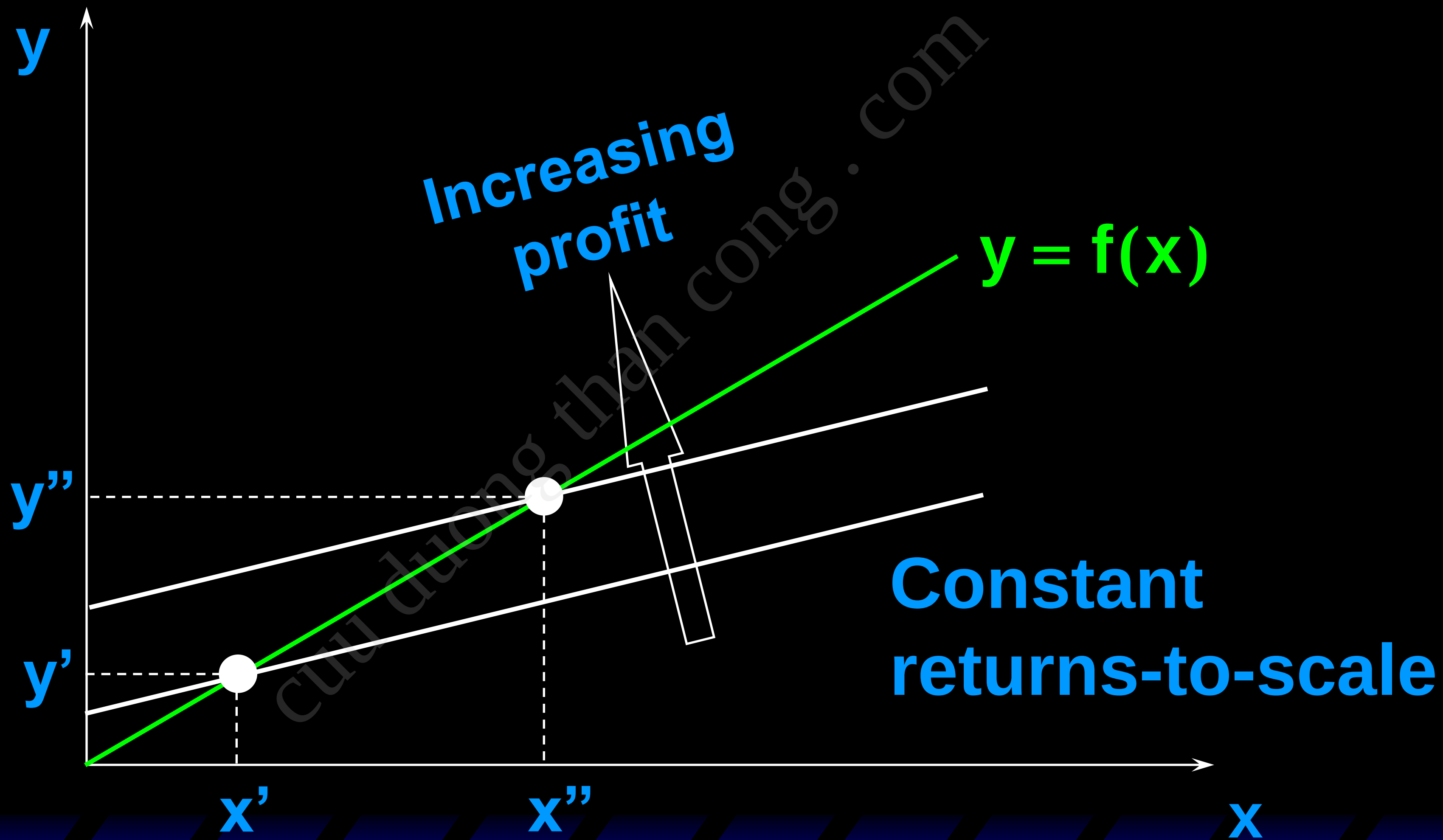
Returns-to-Scale and Profit-Maximization

- So an increasing returns-to-scale technology is inconsistent with firms being perfectly competitive.

Returns-to-Scale and Profit-Maximization

- **What if the competitive firm's technology exhibits constant returns-to-scale?**

Returns-to Scale and Profit-Maximization



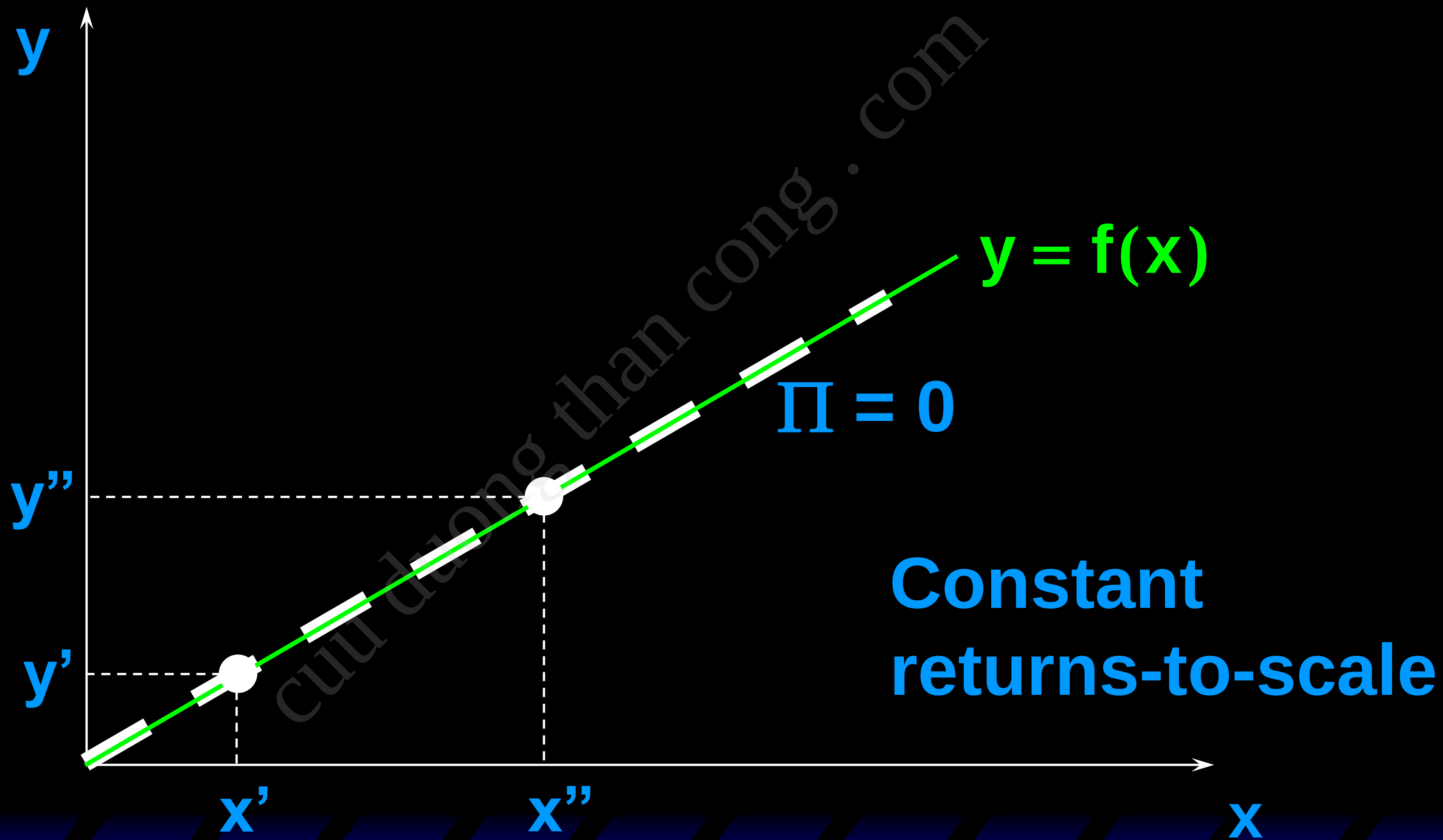
Returns-to Scale and Profit-Maximization

- **So if any production plan earns a positive profit, the firm can double up all inputs to produce twice the original output and earn twice the original profit.**

Returns-to Scale and Profit-Maximization

- Therefore, when a firm's technology exhibits constant returns-to-scale, earning a positive economic profit is inconsistent with firms being perfectly competitive.
- Hence **constant returns-to-scale requires that competitive firms earn economic profits of zero**.

Returns-to Scale and Profit-Maximization



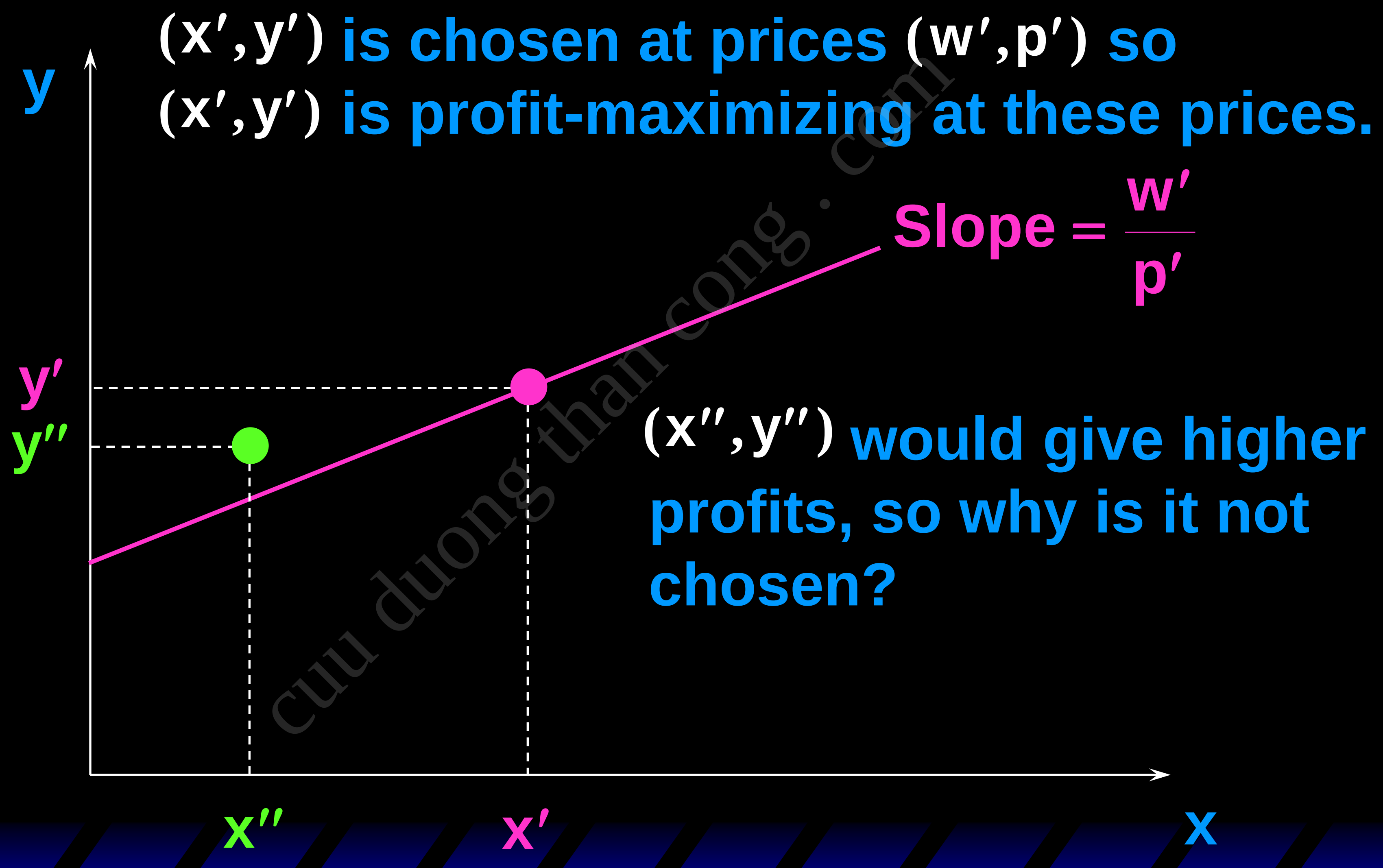
Revealed Profitability

- Consider a competitive firm with a technology that exhibits decreasing returns-to-scale.
- For a variety of output and input prices we observe the firm's choices of production plans.
- What can we learn from our observations?

Revealed Profitability

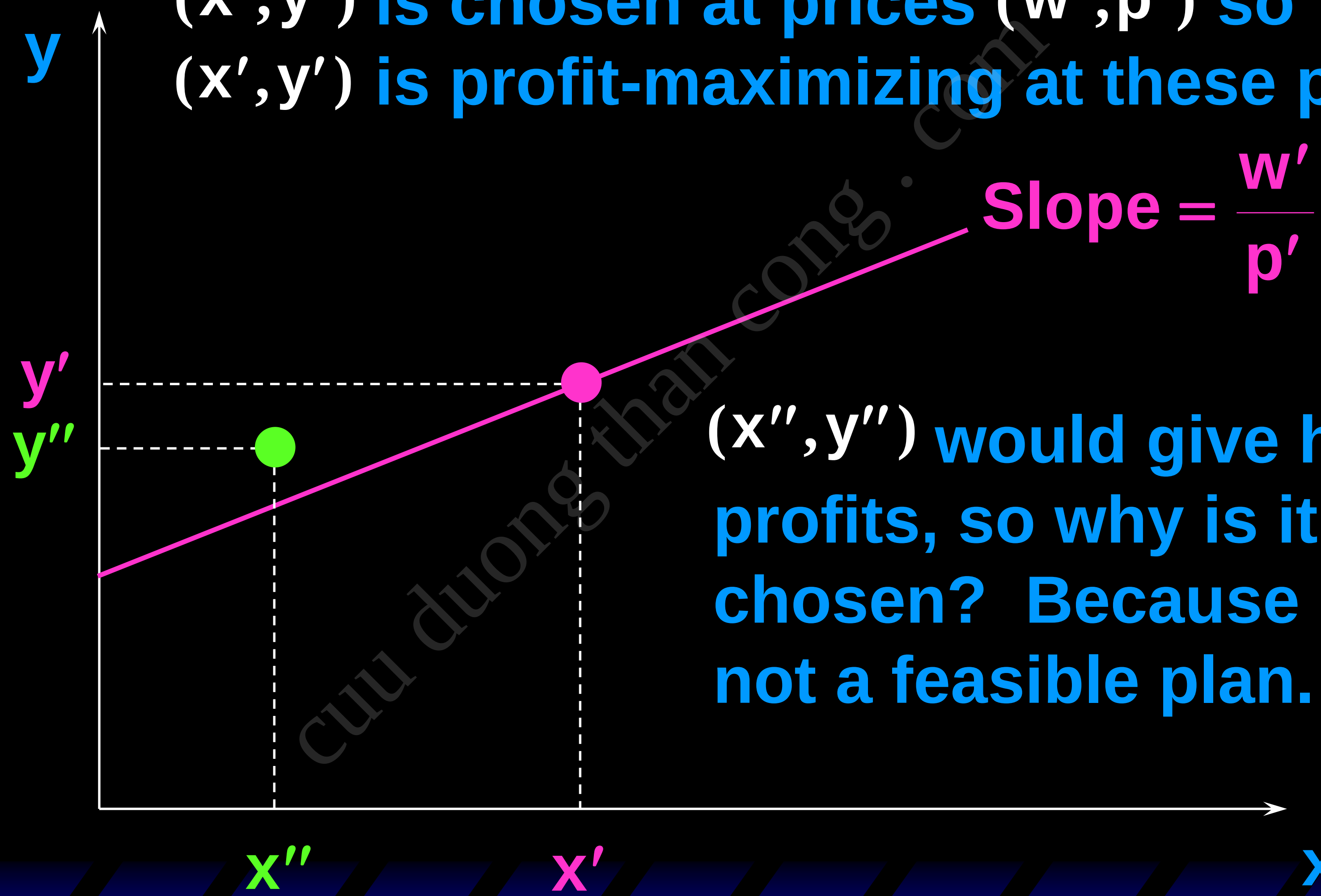
- If a production plan (x',y') is chosen at prices (w',p') we deduce that the plan (x',y') is revealed to be profit-maximizing for the prices (w',p').

Revealed Profitability



Revealed Profitability

(x',y') is chosen at prices (w',p') so (x',y') is profit-maximizing at these prices.



(x'',y'') would give higher profits, so why is it not chosen? Because it is not a feasible plan.

So the firm’s technology set must lie under the iso-profit line.

Revealed Profitability

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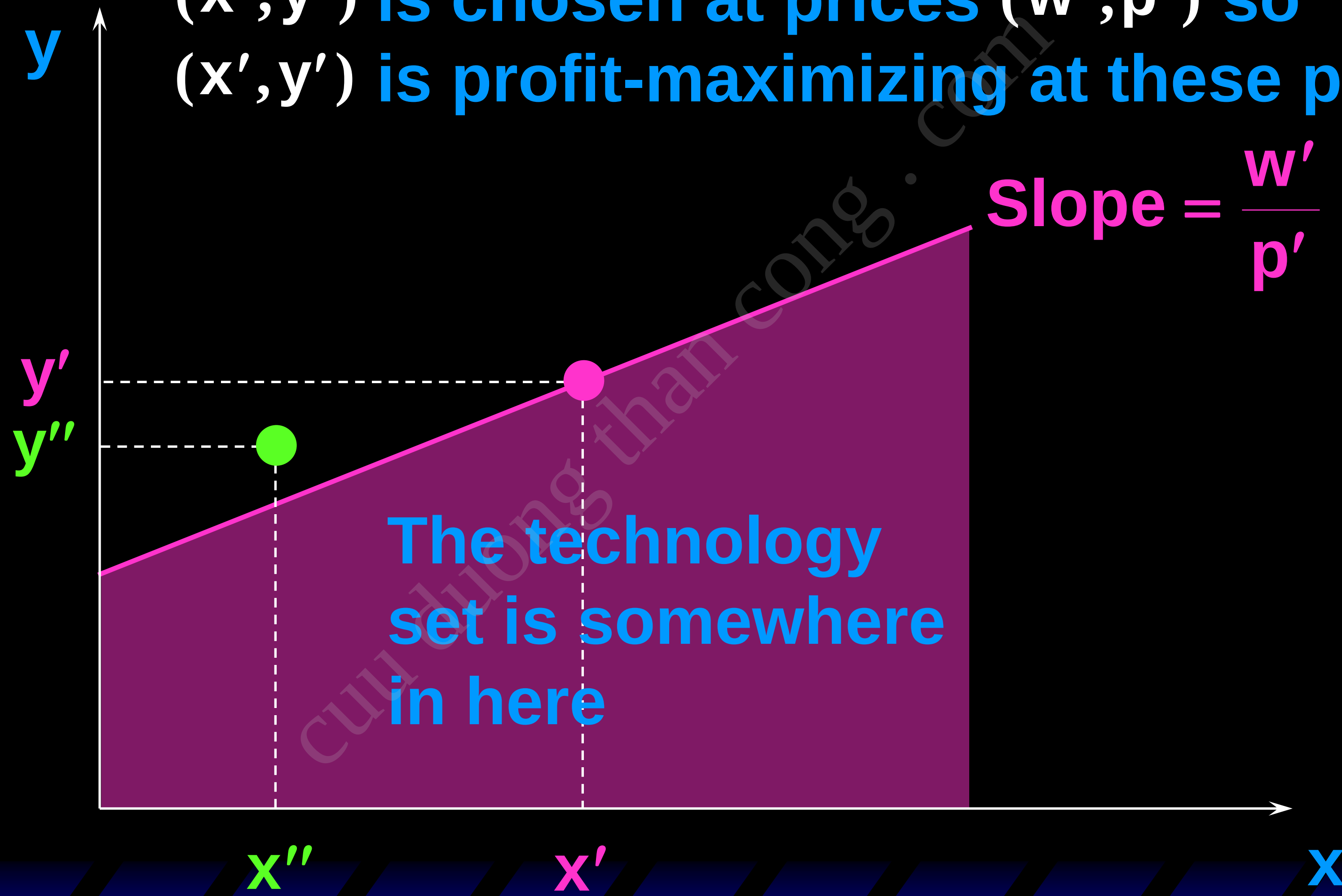

So the firm's technology set must lie under the iso-profit line.

Revealed Profitability

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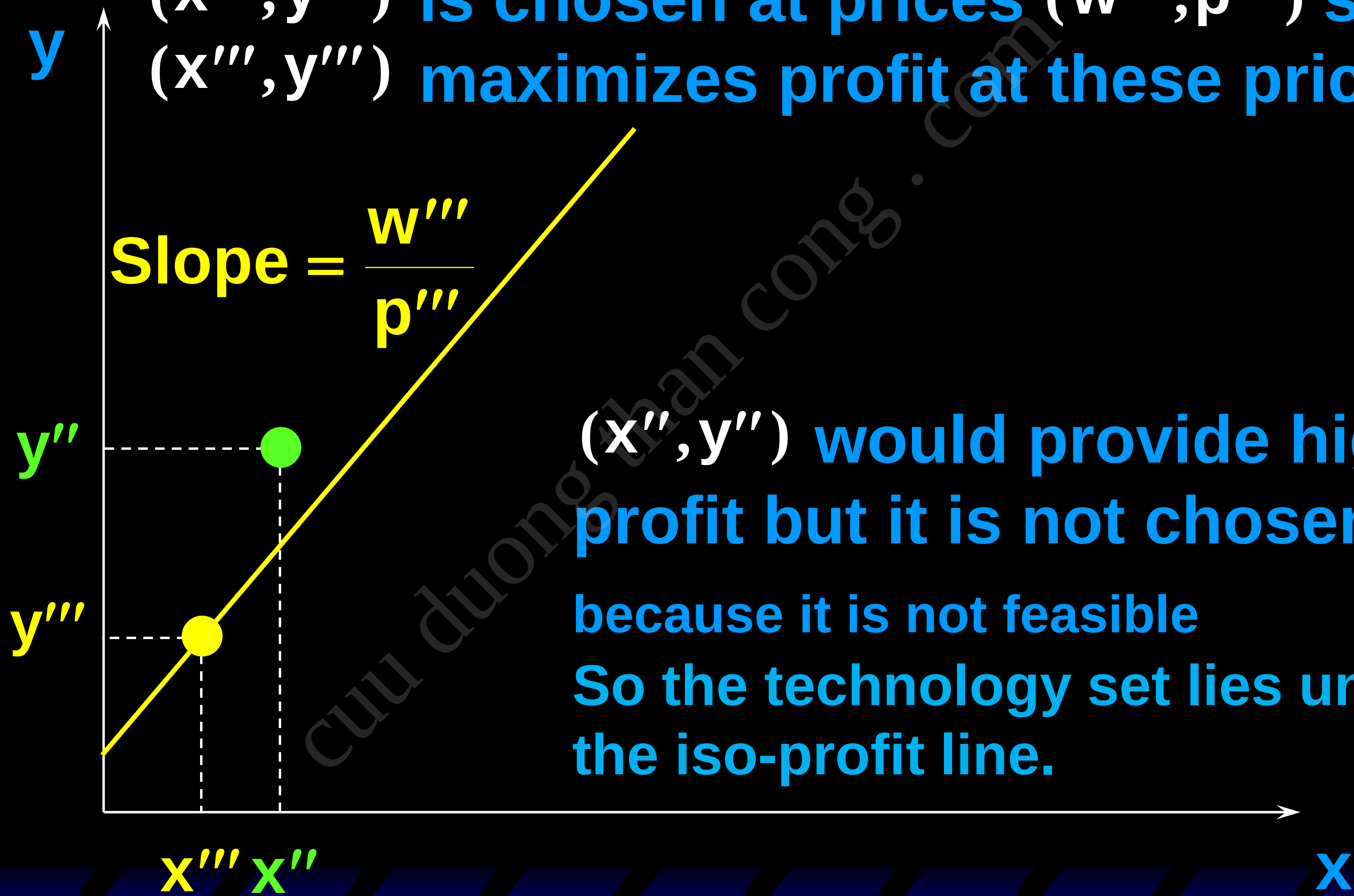

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Revealed Profitability

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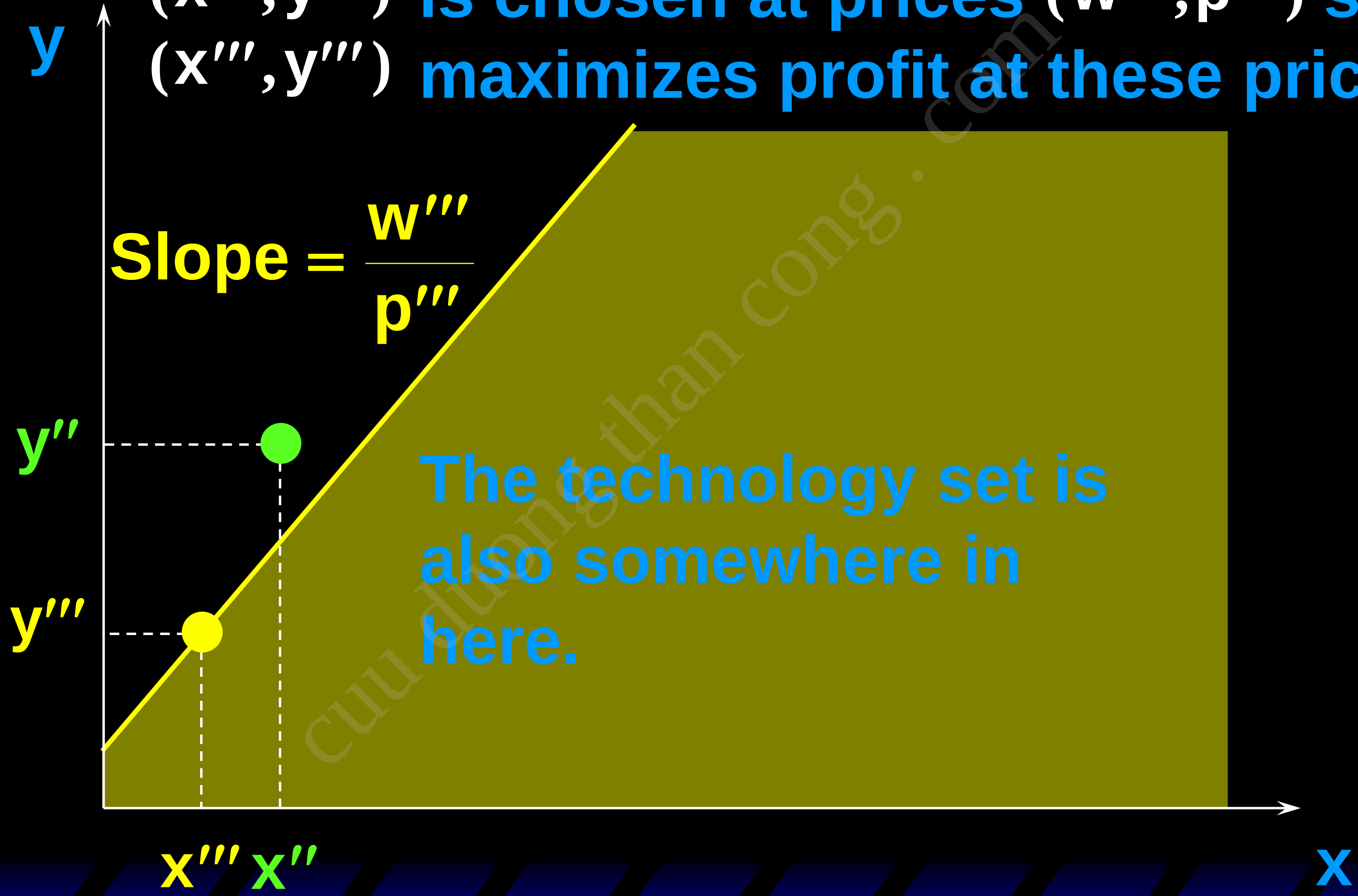
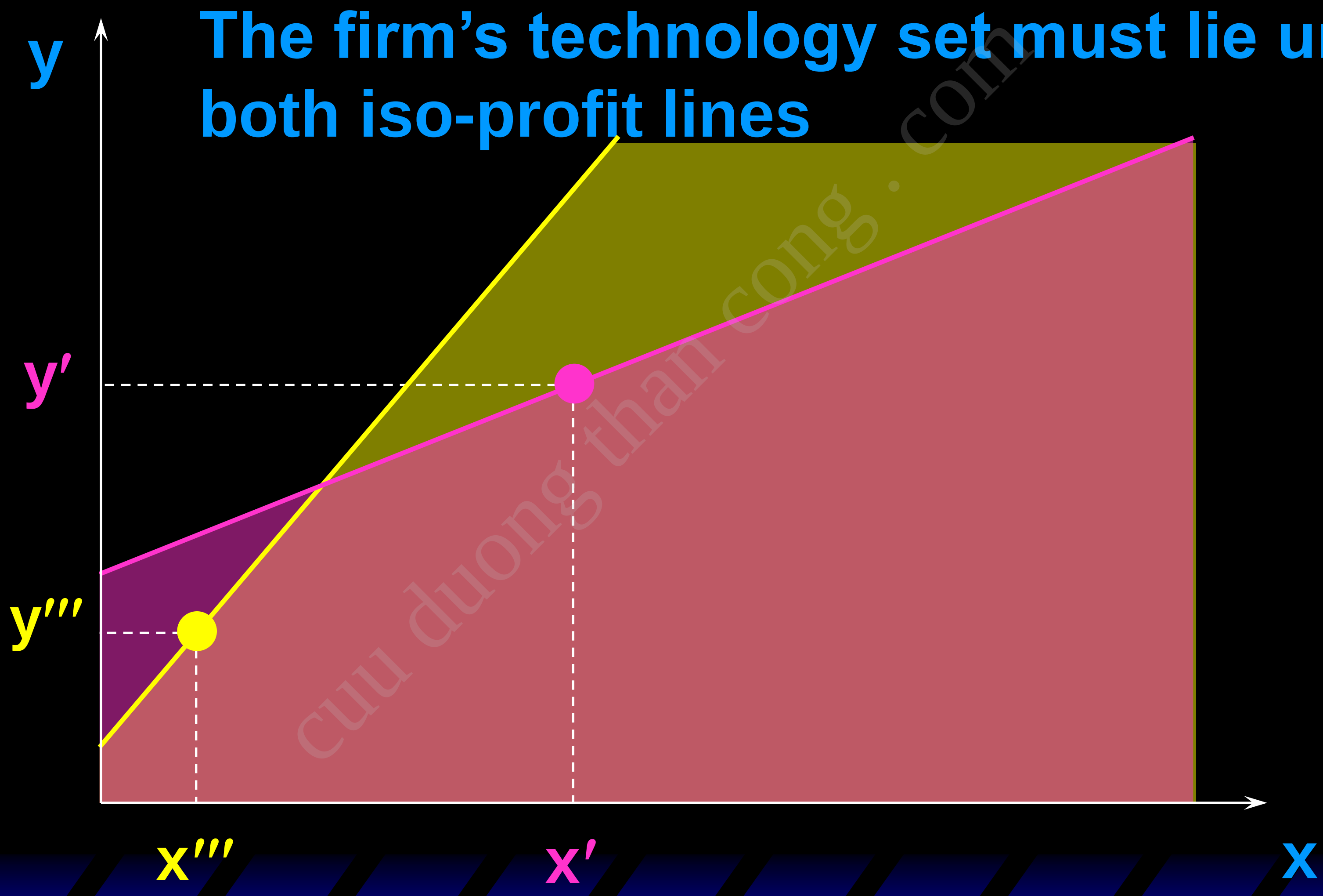
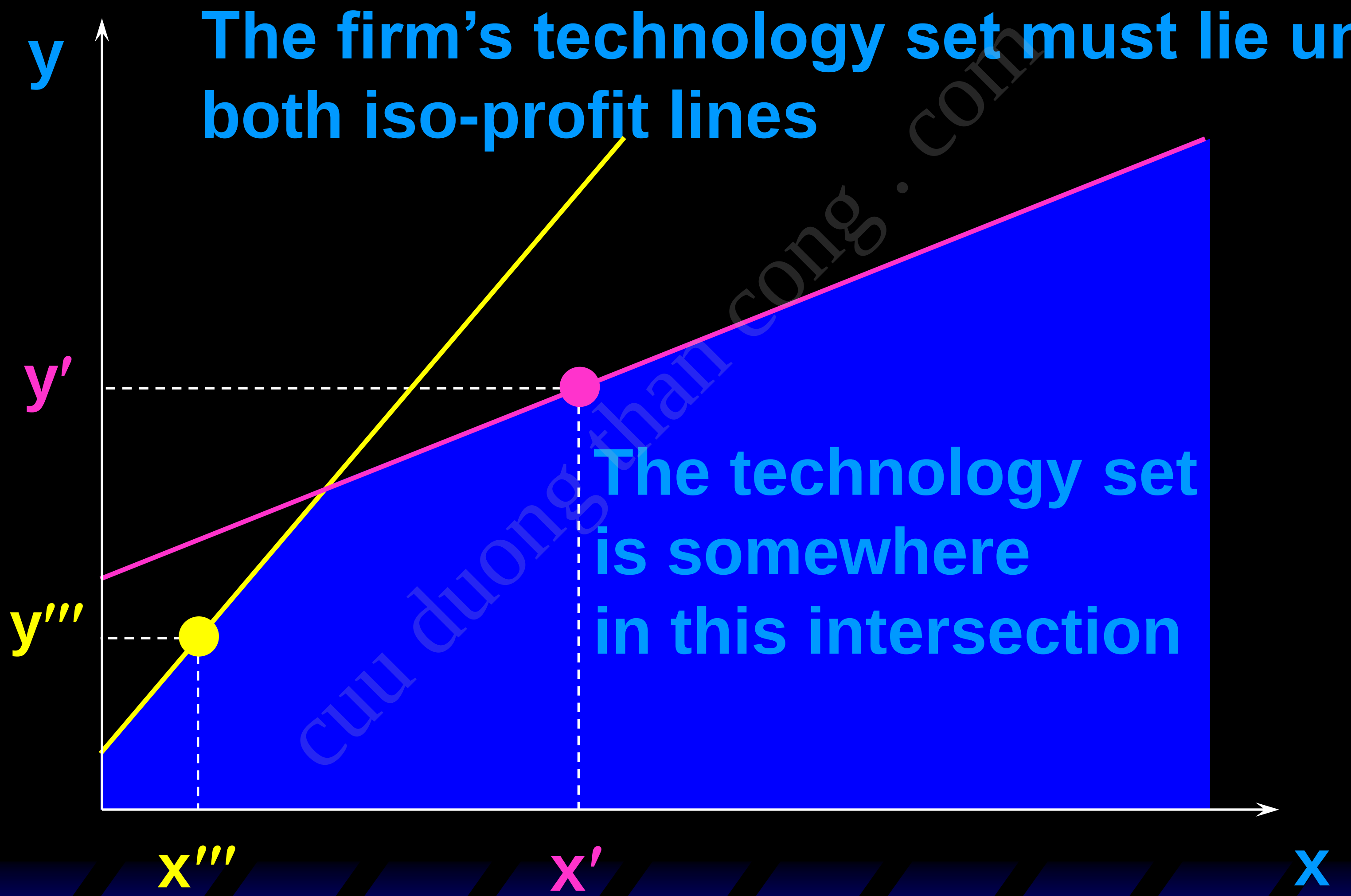


Revealed Profitability



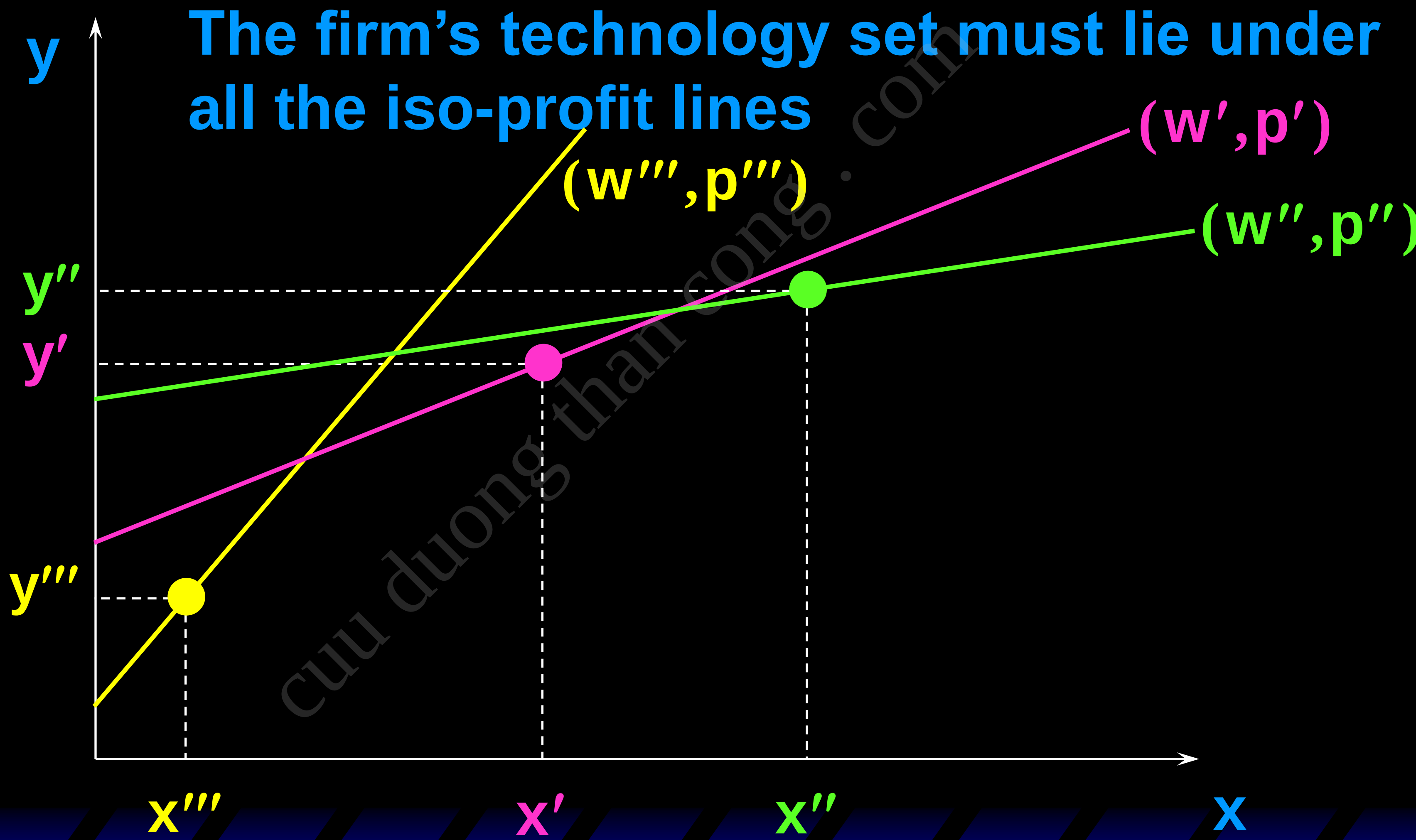
Revealed Profitability



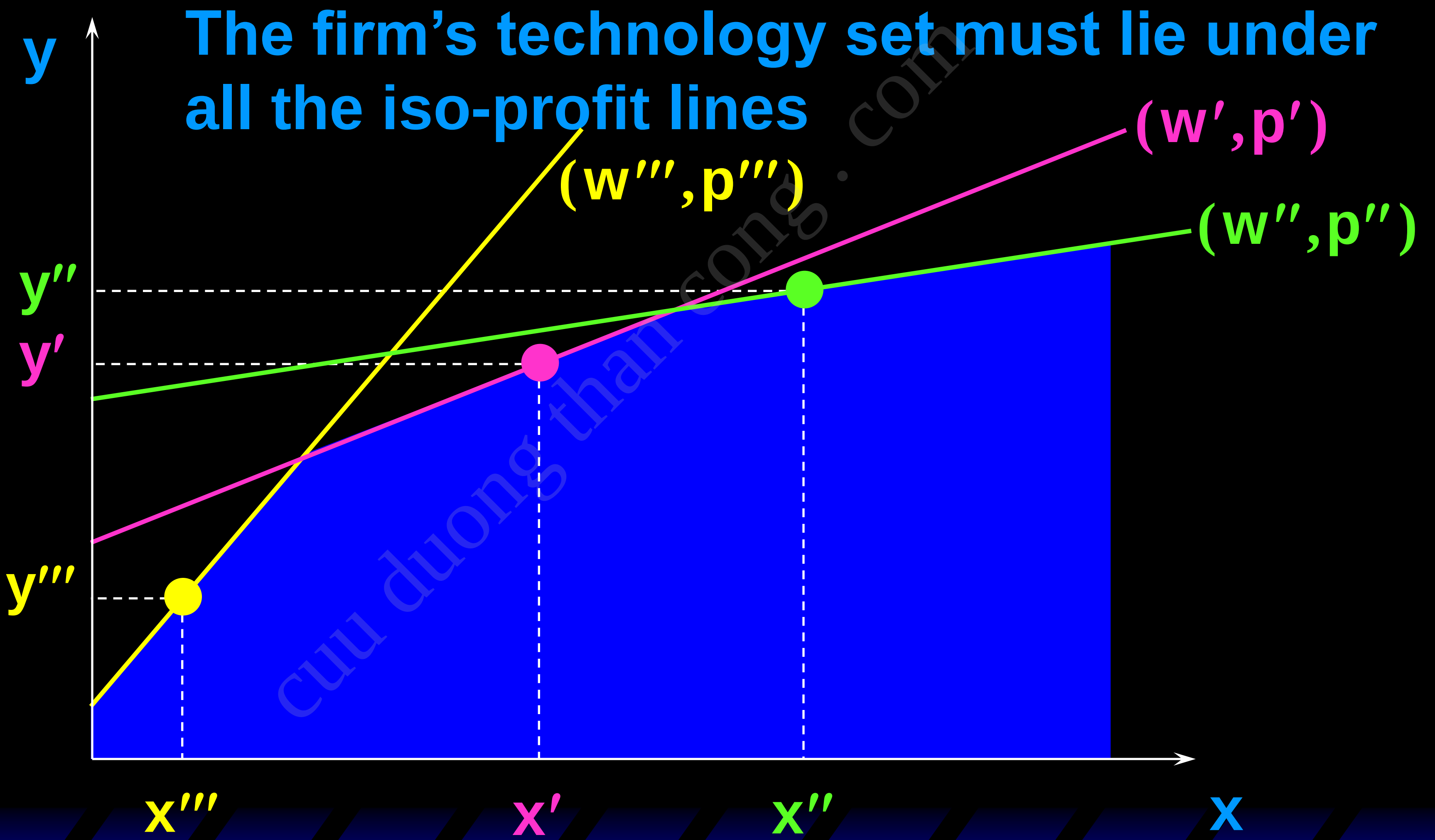
Revealed Profitability

- **Observing more choices of production plans by the firm in response to different prices for its input and its output gives more information on the location of its technology set.**

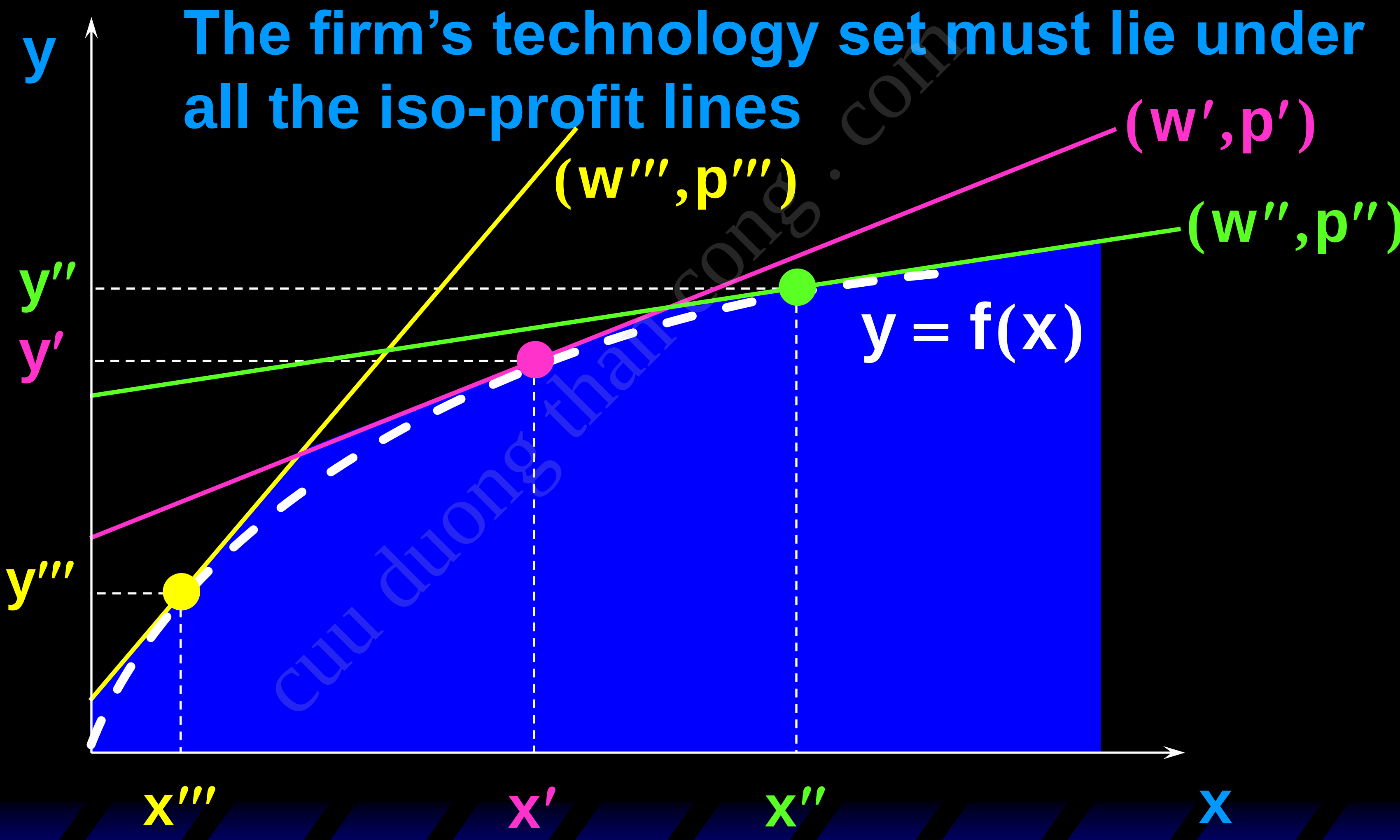
Revealed Profitability



Revealed Profitability



Revealed Profitability

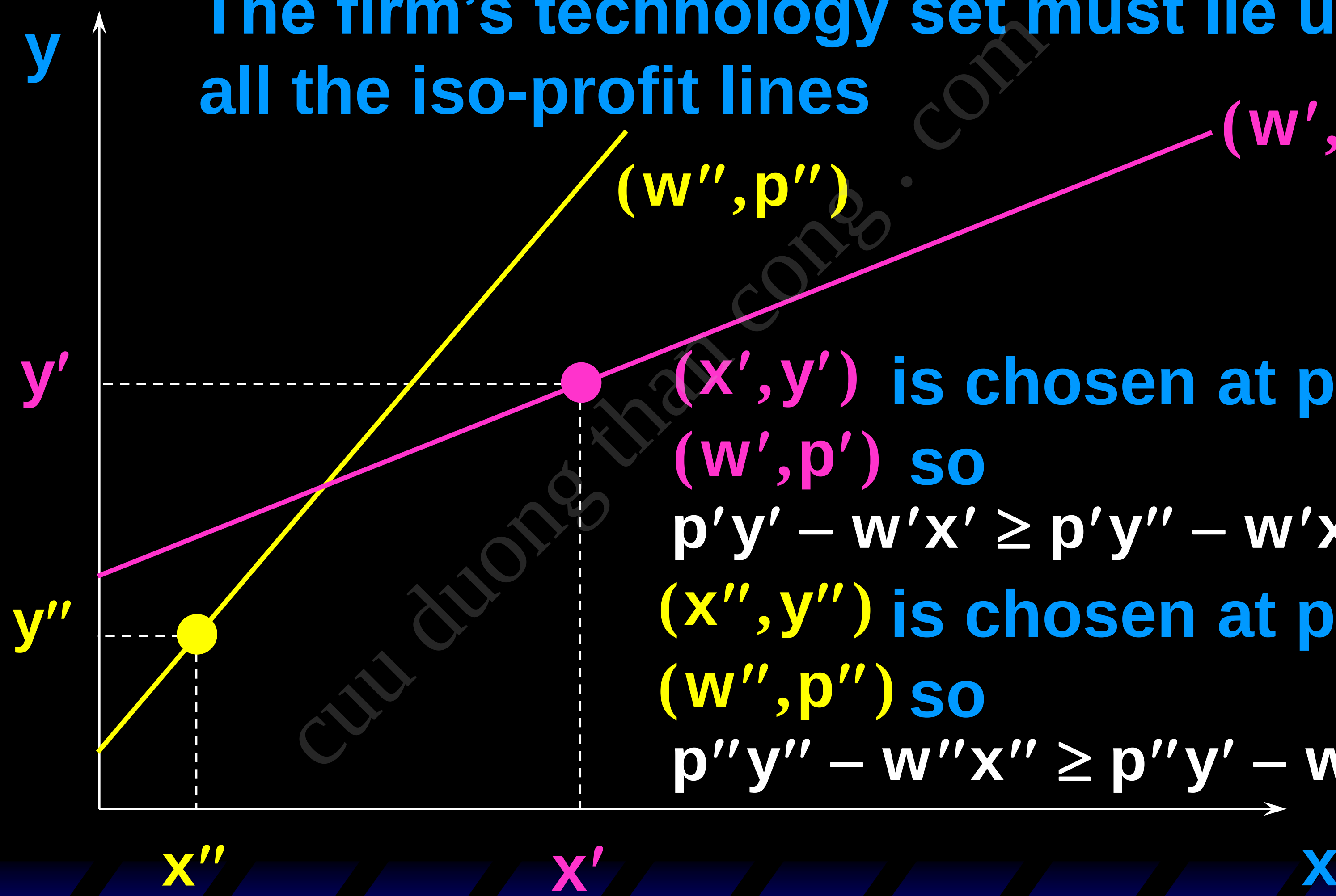


Revealed Profitability

- What else can be learned from the firm's choices of profit-maximizing production plans?

Revealed Profitability

The firm's technology set must lie under all the iso-profit lines



(x', y') is chosen at prices (w', p') so

$$p'y' - w'x' \geq p'y'' - w'x''.$$

(x'', y'') is chosen at prices (w'', p'') so

$$p''y'' - w''x'' \geq p''y' - w''x'.$$

Revealed Profitability

$$p'y' - w'x' \geq p'y'' - w'x''$$ and

$$p''y'' - w''x'' \geq p''y' - w''x'$$ so

$$p'y' - w'x' \geq p'y'' - w'x''$$ and

$$-p''y' + w''x' \geq -p''y'' + w''x''.$$

Adding gives

$$(p' - p'')y' - (w' - w'')x' \geq (p' - p'')y'' - (w' - w'')x''.$$

Revealed Profitability

$$(p' - p'')y' - (w' - w'')x' \geq$$

$$(p' - p'')y'' - (w' - w'')x''$$

so

$$(p' - p'')(y' - y'') \geq (w' - w'')(x' - x'')$$

That is,

$$\Delta p \Delta y \geq \Delta w \Delta x$$

is a necessary implication of profit-maximization.

Revealed Profitability

$$\Delta p \Delta y \geq \Delta w \Delta x$$

is a necessary implication of profit-maximization.

Suppose the input price does not change. Then $\Delta w = 0$ and profit-maximization implies $\Delta p \Delta y \geq 0$; *i.e.*, a competitive firm's output supply curve cannot slope downward.

Revealed Profitability

$$\Delta p \Delta y \geq \Delta w \Delta x$$

is a necessary implication of profit-maximization.

Suppose the output price does not change. Then $\Delta p = 0$ and profit-maximization implies $0 \geq \Delta w \Delta x$; *i.e.*, a competitive firm's input demand curve cannot slope upward.

2. Firm Supply

Firm Supply

- How does a firm decide how much product to supply? This depends upon the firm's
  - technology
  - market environment
  - goals
  - competitors' behaviors

Market Environments

- Are there many other firms, or just a few?
- Do other firms’ decisions affect our firm’s payoffs?
- Is trading anonymous, in a market? Or are trades arranged with separate buyers by middlemen?

Market Environments

- **Monopoly**: Just one seller that determines the quantity supplied and the market-clearing price.
- **Oligopoly**: A few firms, the decisions of each influencing the payoffs of the others.

Market Environments

- **Dominant Firm**: Many firms, but one much larger than the rest. The large firm's decisions affect the payoffs of each small firm. Decisions by any one small firm do not noticeably affect the payoffs of any other firm.

Market Environments

- **Monopolistic Competition**: Many firms each making a slightly different product. Each firm's output level is small relative to the total.
- **Pure Competition**: Many firms, all making the same product. Each firm's output level is small relative to the total.

Market Environments

- Later chapters examine monopoly, oligopoly, and the dominant firm.
- This chapter explores only pure competition.

Pure Competition

- A firm in a perfectly competitive market knows it has no influence over the market price for its product. The firm is a **market price-taker**.
- The firm is free to vary its own price.

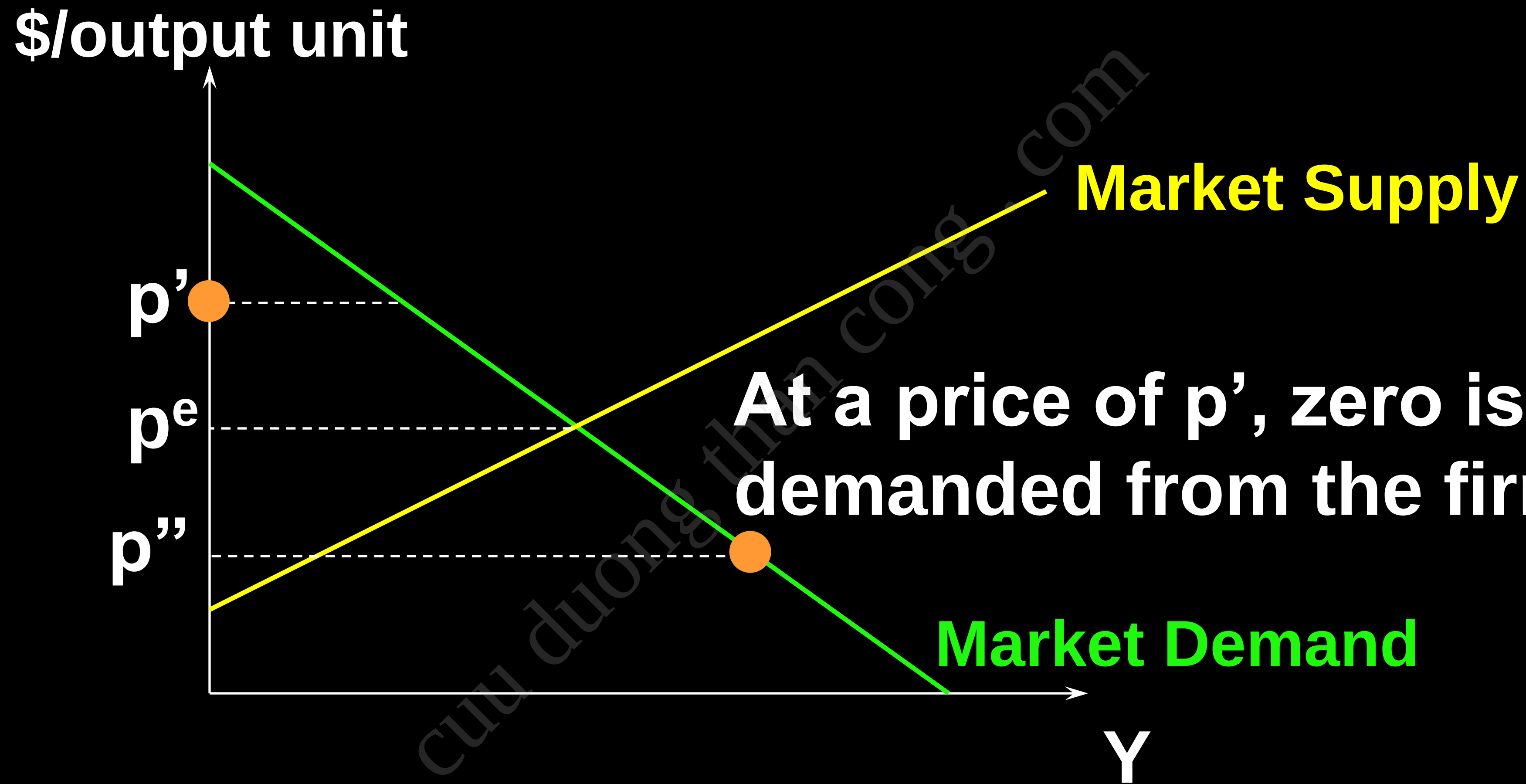
Pure Competition

- If the firm sets its own price above the market price then the quantity demanded from the firm is zero.
- If the firm sets its own price below the market price then the quantity demanded from the firm is the entire market quantity-demanded.

Pure Competition

- So what is the demand curve faced by the individual firm?

Pure Competition



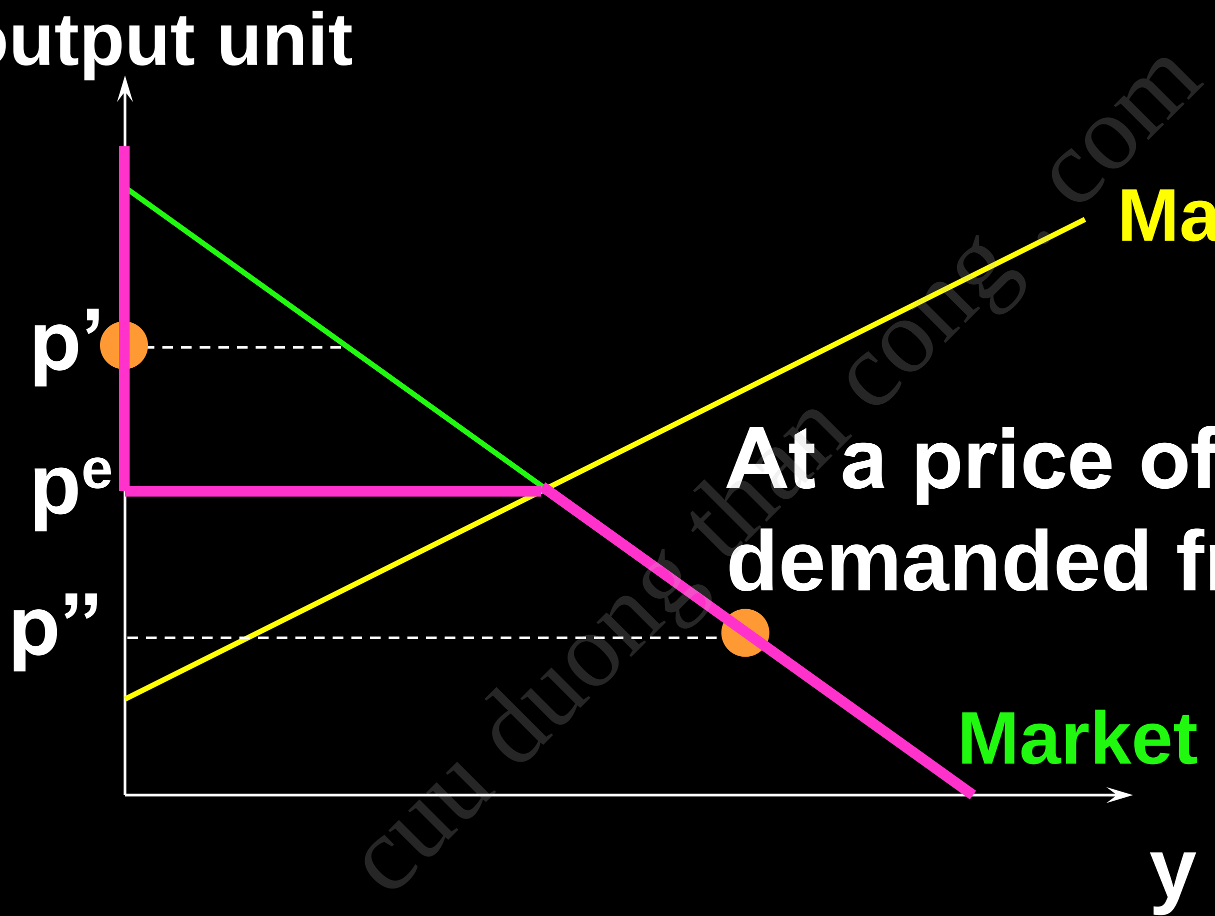
At a price of p’, zero is demanded from the firm.

At a price of p” the firm faces the entire market demand.

Pure Competition

- **So the demand curve faced by the individual firm is ...**

Pure Competition



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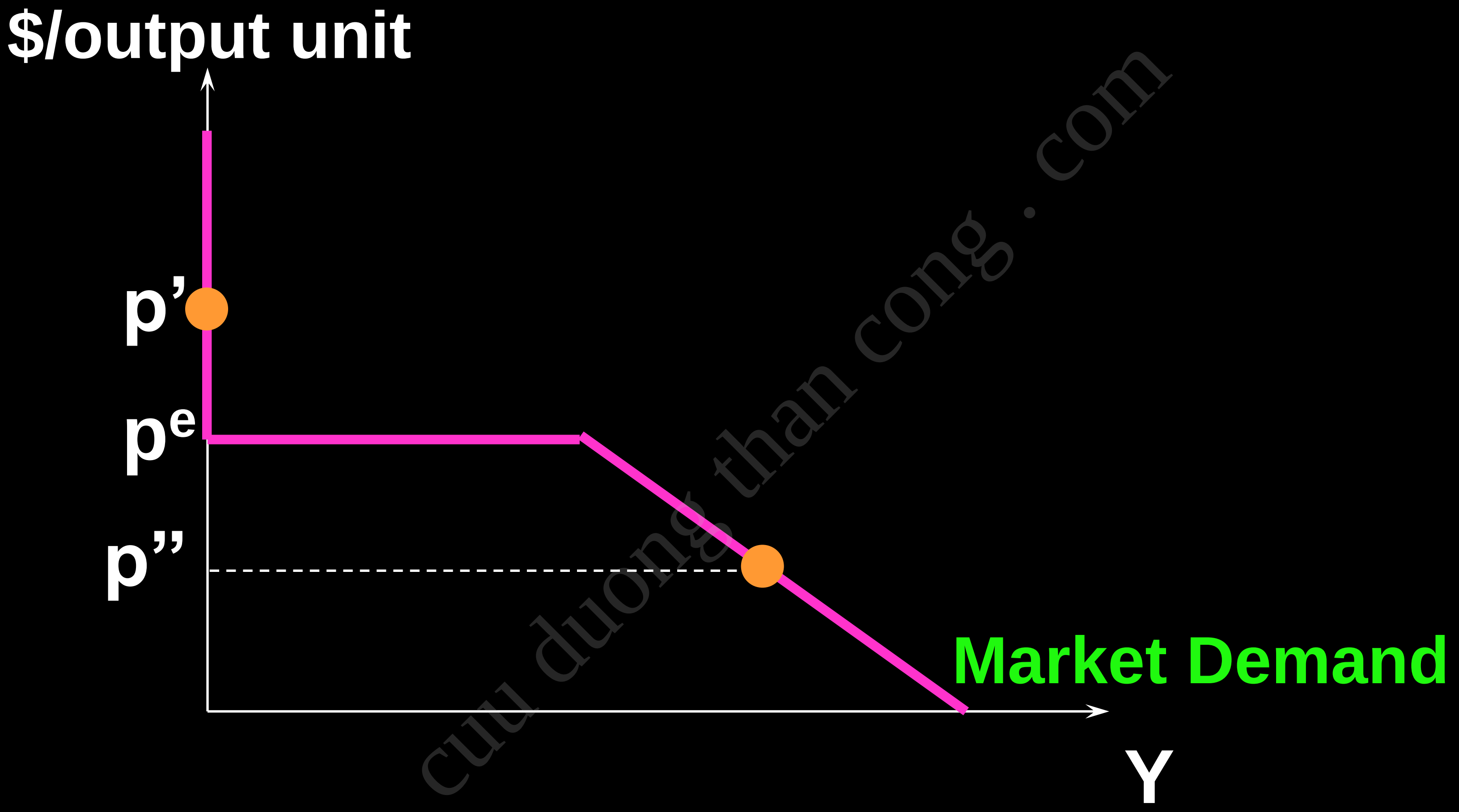
Pure Competition



Smallness

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

Smallness

The individual firm's technology causes it always to supply only a small part of the total quantity demanded at the market price.

The Firm's Short-Run Supply Decision

- **Each firm is a profit-maximizer and in a short-run.**
- **Q: How does each firm choose its output level?**

  A: By solving

$$\max_{y \geq 0} \Pi_s(y) = py - c_s(y).$$

The Firm's Short-Run Supply Decision

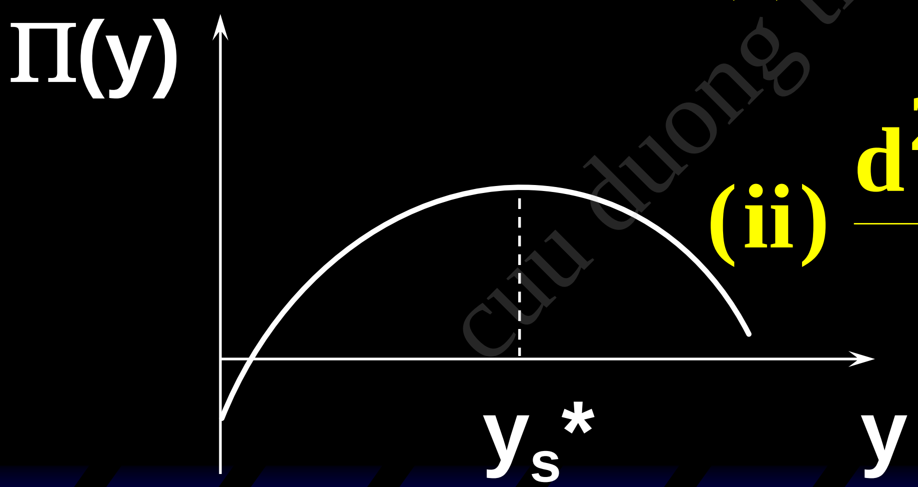
$$\max_{y \geq 0} \Pi_s(y) = py - c_s(y).$$

What can the solution y_s^* look like?

(a) $y_s^* > 0$:

$$\text{(i)} \quad \frac{d\Pi_s(y)}{dy} = p - MC_s(y) = 0$$

$$\text{(ii)} \quad \frac{d^2\Pi_s(y)}{dy^2} < 0 \text{ at } y = y_s^*.$$



The Firm's Short-Run Supply Decision

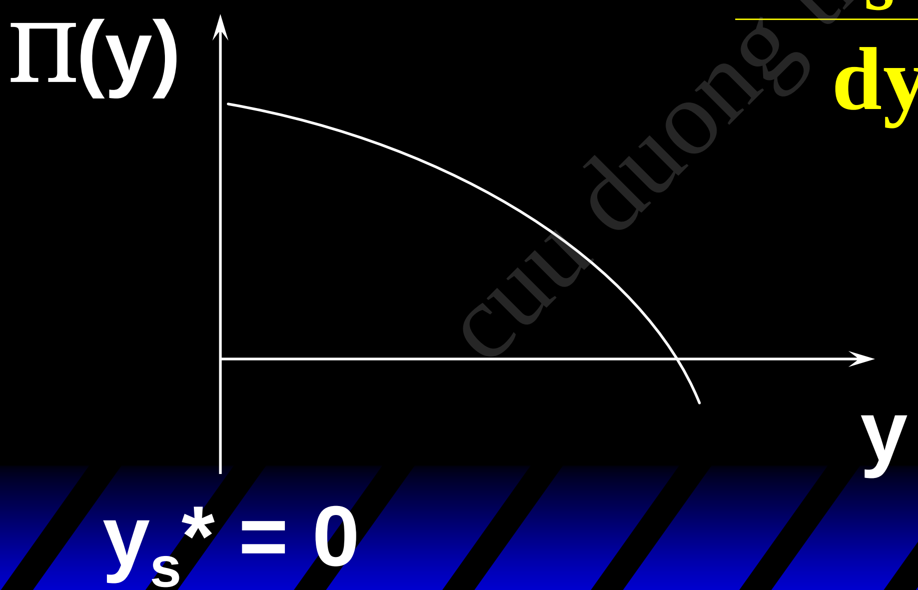
$$\max_{y \geq 0} \Pi_s(y) = py - c_s(y).$$

What can the solution y* look like?

(b) $y_s^* = 0$:

$$\frac{d\Pi_s(y)}{dy} = p - MC_s(y) \leq 0$$

$$\text{at } y = y_s^* = 0.$$



The Firm's Short-Run Supply Decision

For the interior case of $y_s^* > 0$, the **first-order maximum profit condition** is

$$\frac{d\Pi_s(y)}{dy} = p - MC_s(y) = 0.$$

That is, $p = MC_s(y_s^*)$.

So at a profit maximum with $y_s^* > 0$, the market price p equals the marginal cost of production at $y = y_s^*$.

The Firm's Short-Run Supply Decision

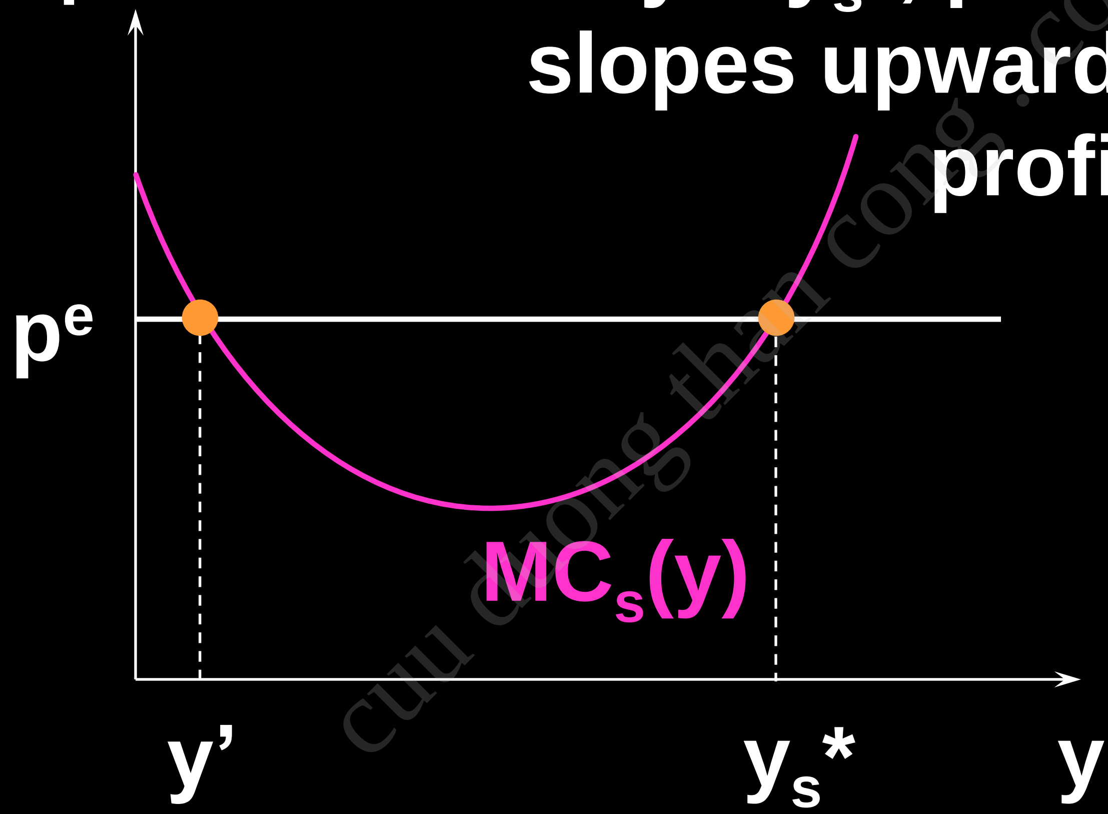
For the interior case of $y_s^* > 0$, the **second-order maximum profit condition** is

$$\frac{d^2\Pi_s(y)}{dy^2} = \frac{d}{dy}\left(p - MC_s(y)\right) = -\frac{dMC_s(y)}{dy} < 0.$$

That is, $\frac{dMC_s(y_s^*)}{dy} > 0.$

So at a profit maximum with $y_s^* > 0$, the firm's MC curve must be upward-sloping.

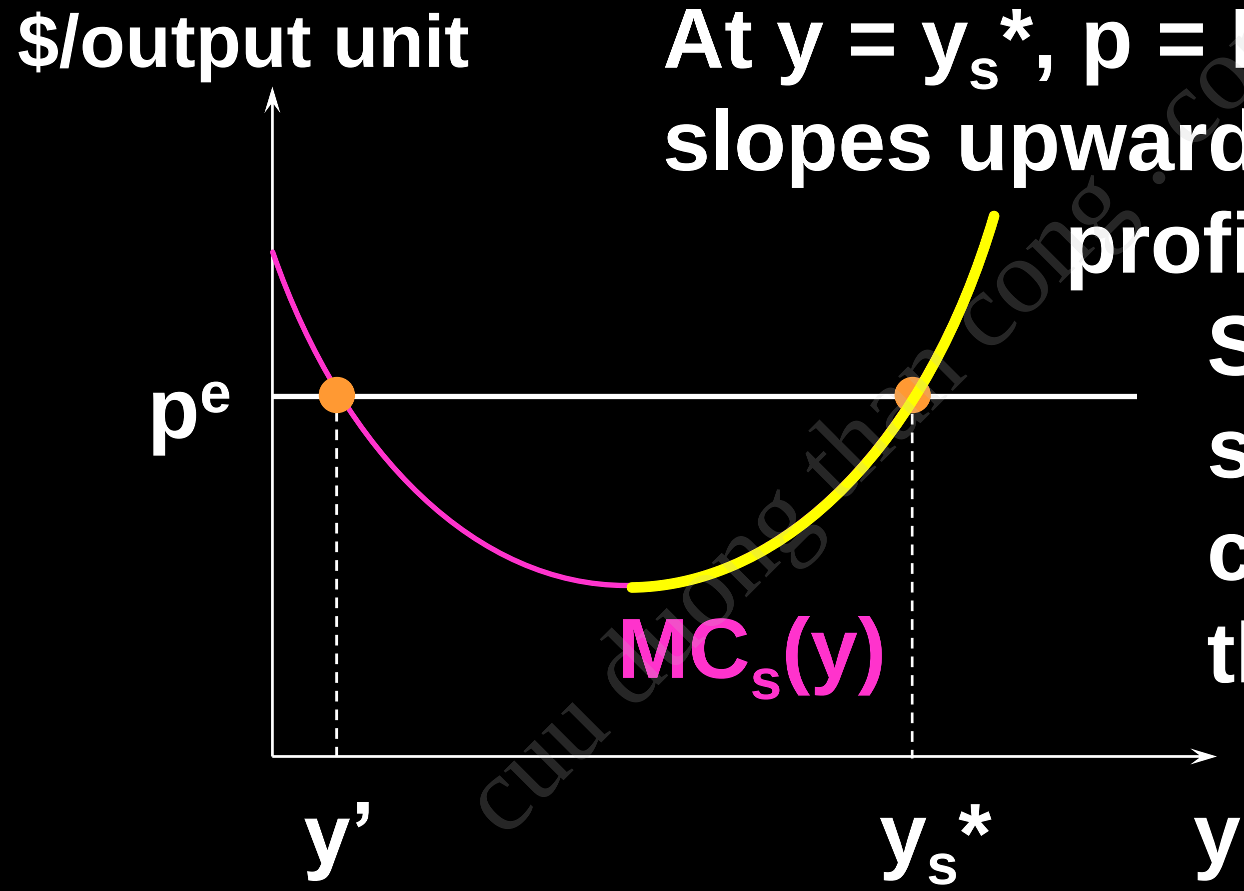
The Firm's Short-Run Supply Decision



At $y = y_s^*$, p = MC and MC slopes upwards. $y = y_s^*$ is profit-maximizing.

At y = y', p = MC and MC slopes downwards. y = y' is profit-minimizing.

The Firm's Short-Run Supply Decision



At $y = y_s^*$, p = MC and MC slopes upwards. $y = y_s^*$ is profit-maximizing.

So a profit-max. supply level can lie only on the upwards sloping part of the firm's MC curve.

The Firm's Short-Run Supply Decision

- But not every point on the upward-sloping part of the firm's MC curve represents a profit-maximum.

The firm's profit function is

$$\Pi_s(y) = py - c_s(y) = py - F - c_v(y).$$

If the firm chooses y = 0 then its profit is

$$\Pi_s(y) = 0 - F - c_v(0) = -F.$$

The Firm's Short-Run Supply Decision

- So the firm will choose an output level y > 0 only if

$$\Pi_s(y) = py - F - c_v(y) \geq -F.$$

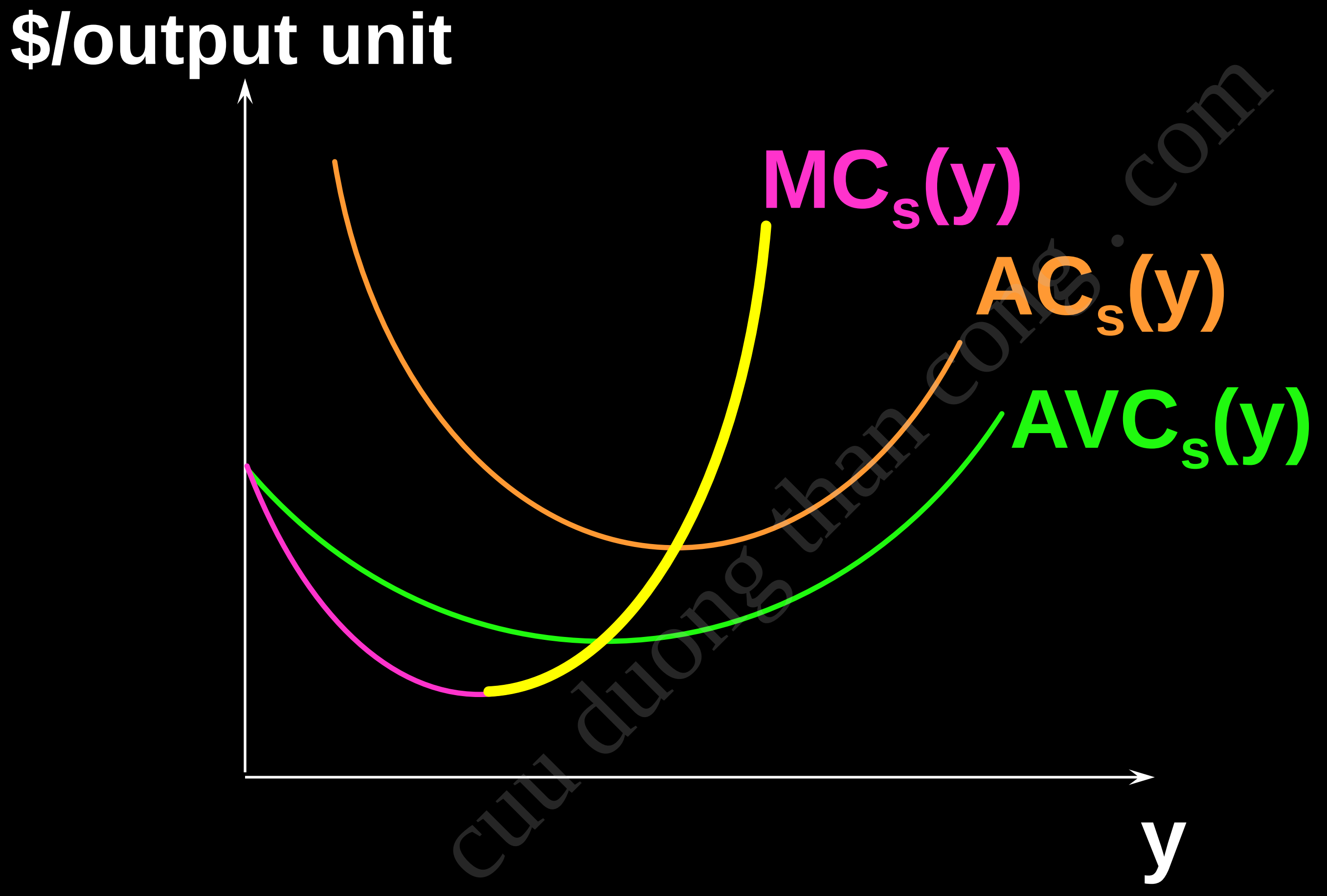
I.e., only if

$$py - c_v(y) \geq 0$$

Equivalently, only if

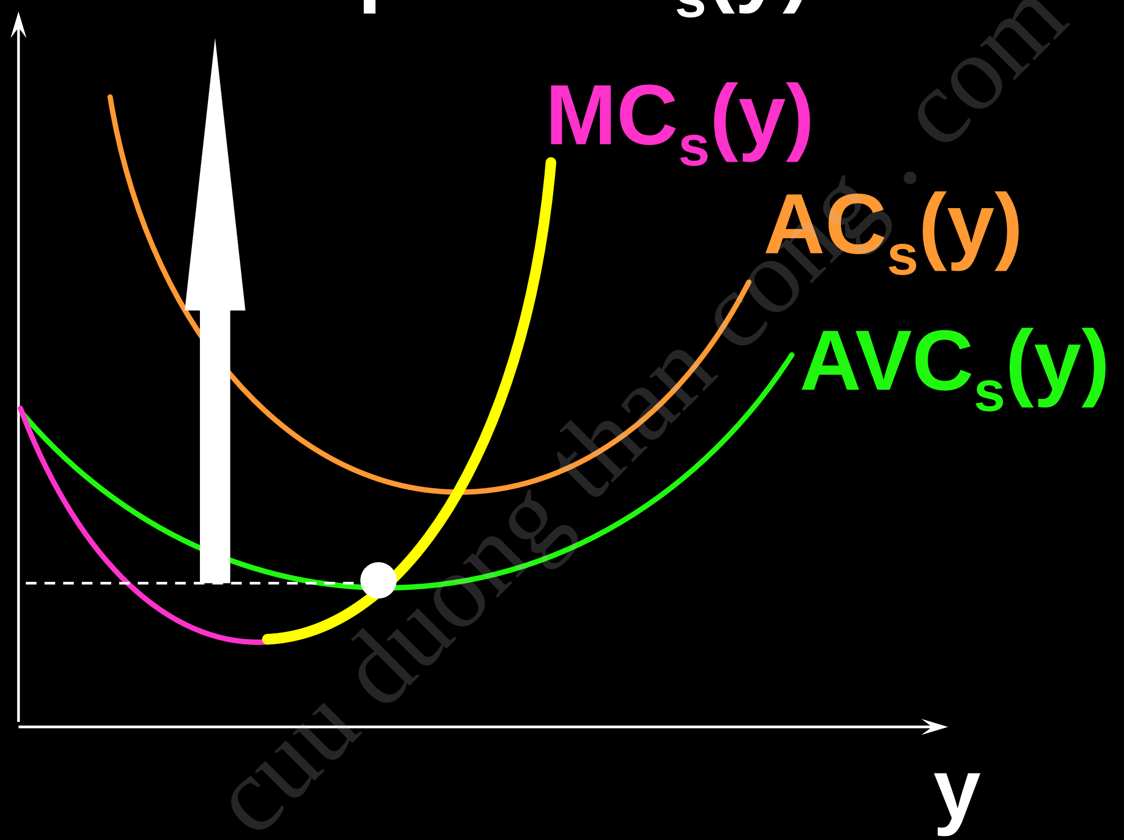
$$p \geq \frac{c_v(y)}{y} = AVC_s(y).$$

The Firm’s Short-Run Supply Decision



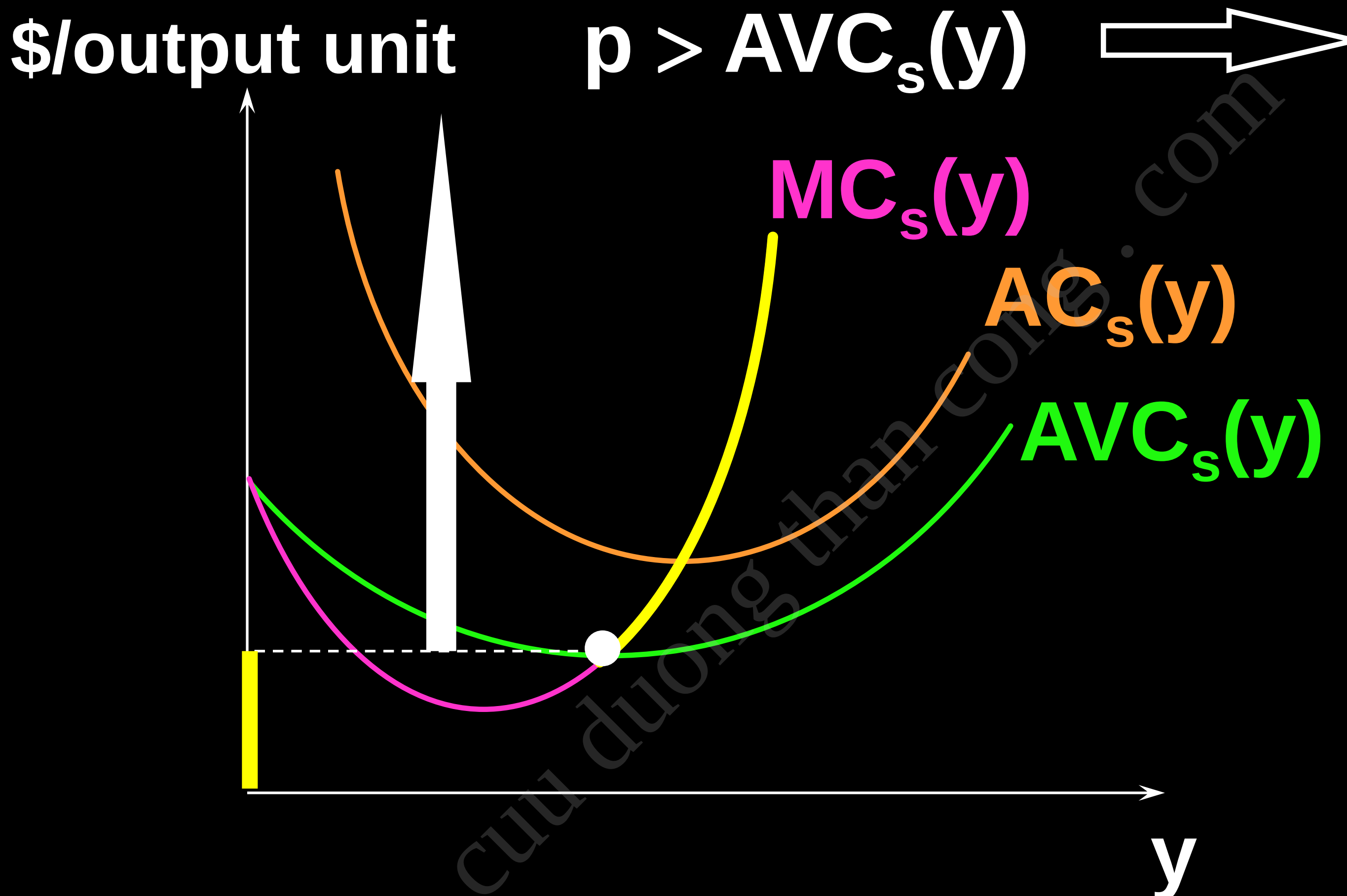
The Firm's Short-Run Supply Decision

$p > AVC_s(y) \Rightarrow y_s^* > 0.$



The Firm’s Short-Run Supply Decision

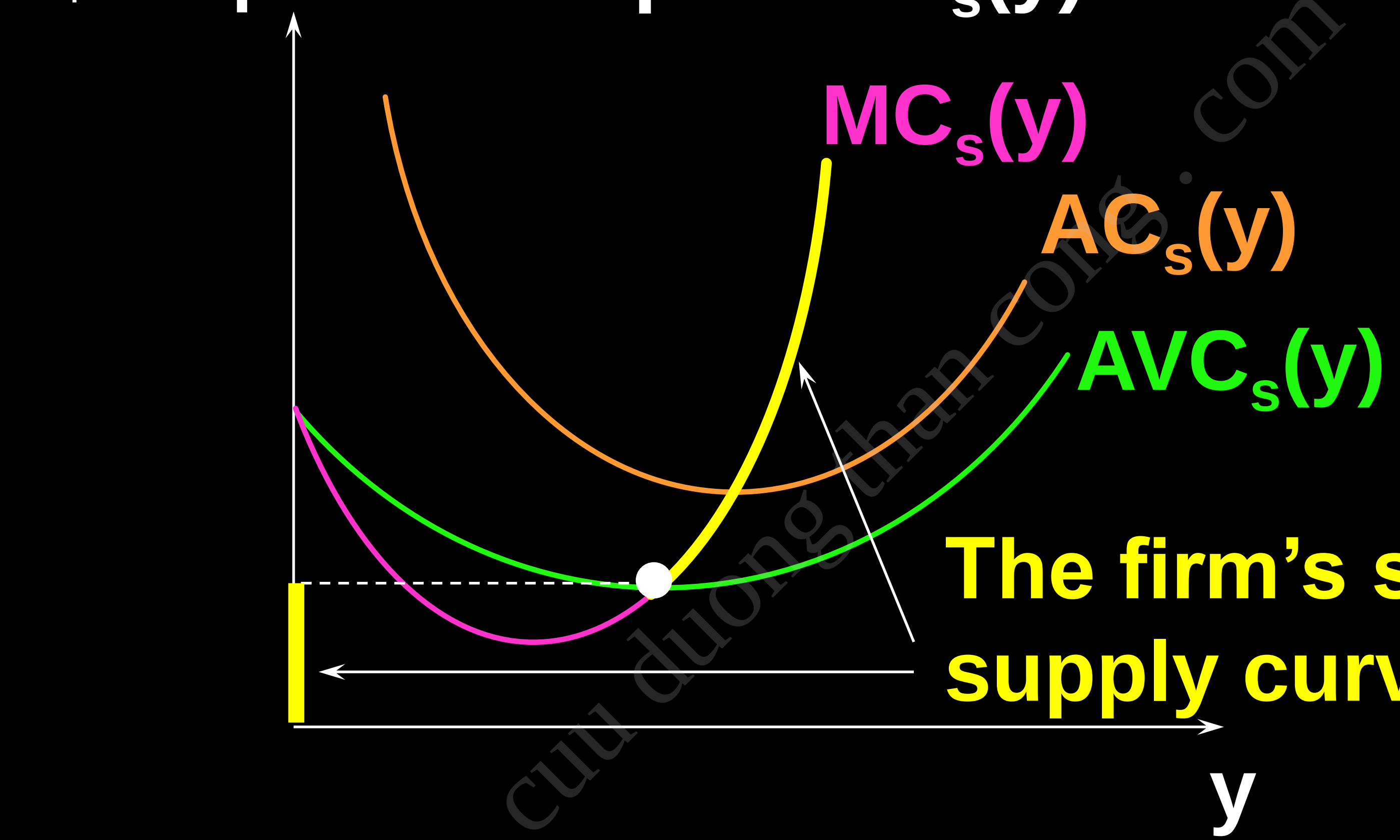
$p > AVC_s(y) \Rightarrow y_s^* > 0.$



$p < AVC_s(y) \Rightarrow y_s^* = 0.$

The Firm's Short-Run Supply Decision

$p > AVC_s(y) \Rightarrow y_s^* > 0.$



$p < AVC_s(y) \Rightarrow y_s^* = 0.$

The Firm's Short-Run Supply Decision

- 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).
- Exiting means leaving the industry, which the firm can do only in the long-run.

The Firm's Long-Run Supply Decision

- The long-run is the circumstance in which the firm can choose amongst all of its short-run circumstances.
- How does the firm's long-run supply decision compare to its short-run supply decisions?

The Firm's Long-Run Supply Decision

- A competitive firm's long-run profit function is

$$\Pi(y) = py - c(y).$$

- The long-run cost c(y) of producing y units of output consists only of variable costs since all inputs are variable in the long-run.

The Firm's Long-Run Supply Decision

- The firm's long-run supply level decision is to
$$\max_{y \geq 0} \Pi(y) = py - c(y).$$
- The 1st and 2nd-order maximization conditions are, for y* > 0,
$$p = MC(y) \text{ and } \frac{dMC(y)}{dy} > 0.$$

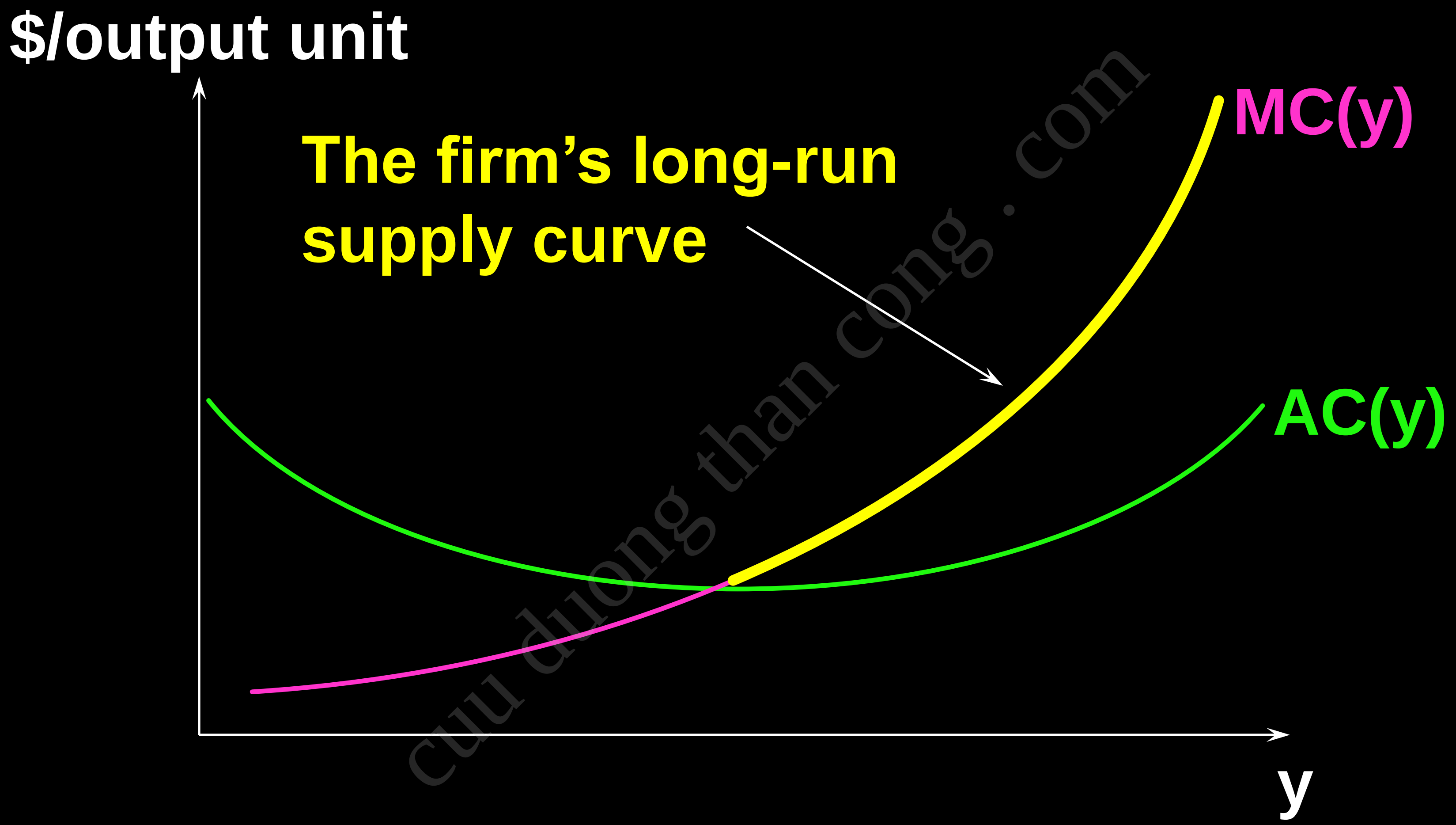
The Firm's Long-Run Supply Decision

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

$$\Pi(y) = py - c(y) \geq 0$$

$$\Rightarrow \quad p \geq \frac{c(y)}{y} = AC(y).$$

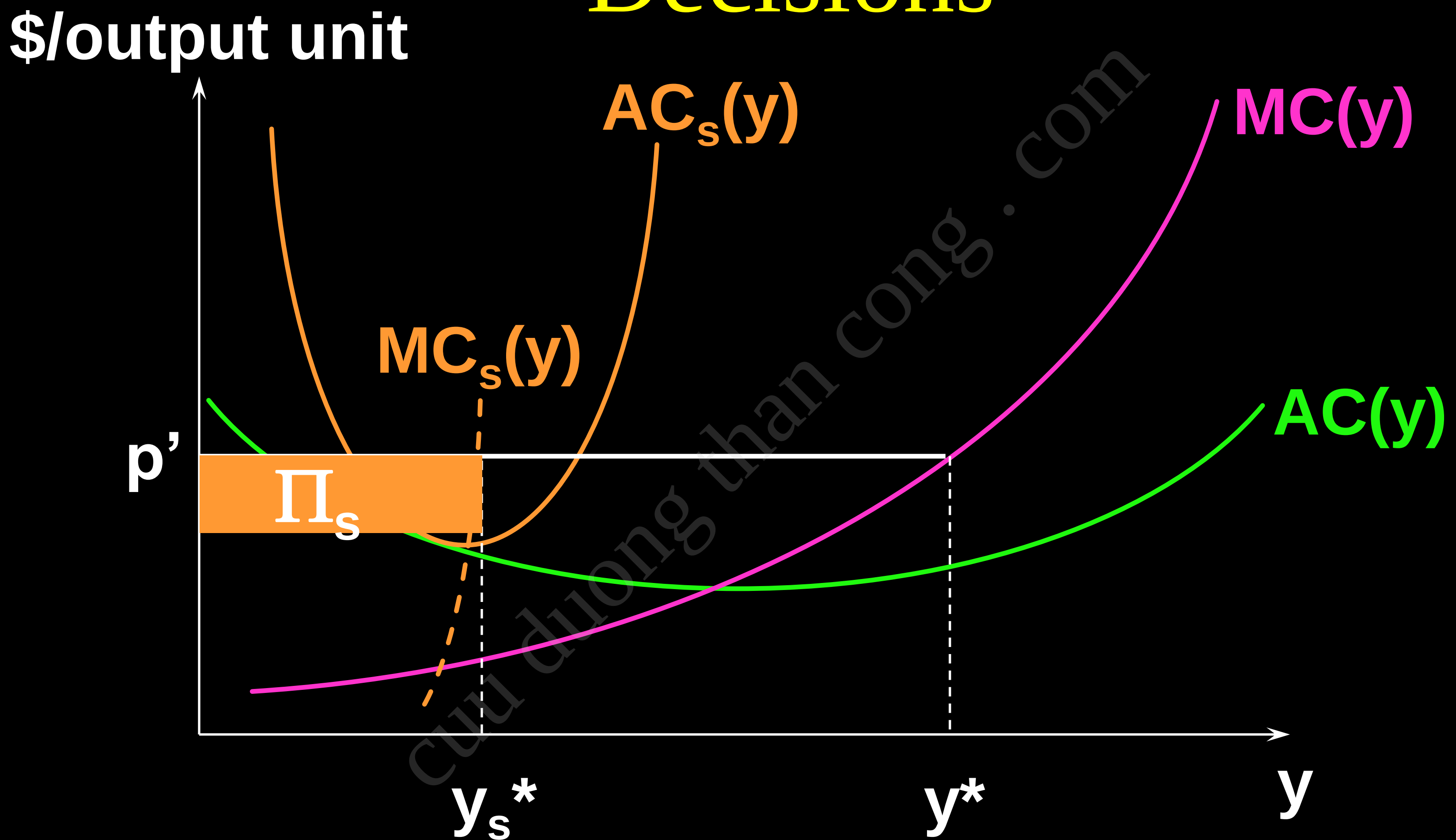
The Firm's Long-Run Supply Decision



The Firm's Long-Run Supply Decision

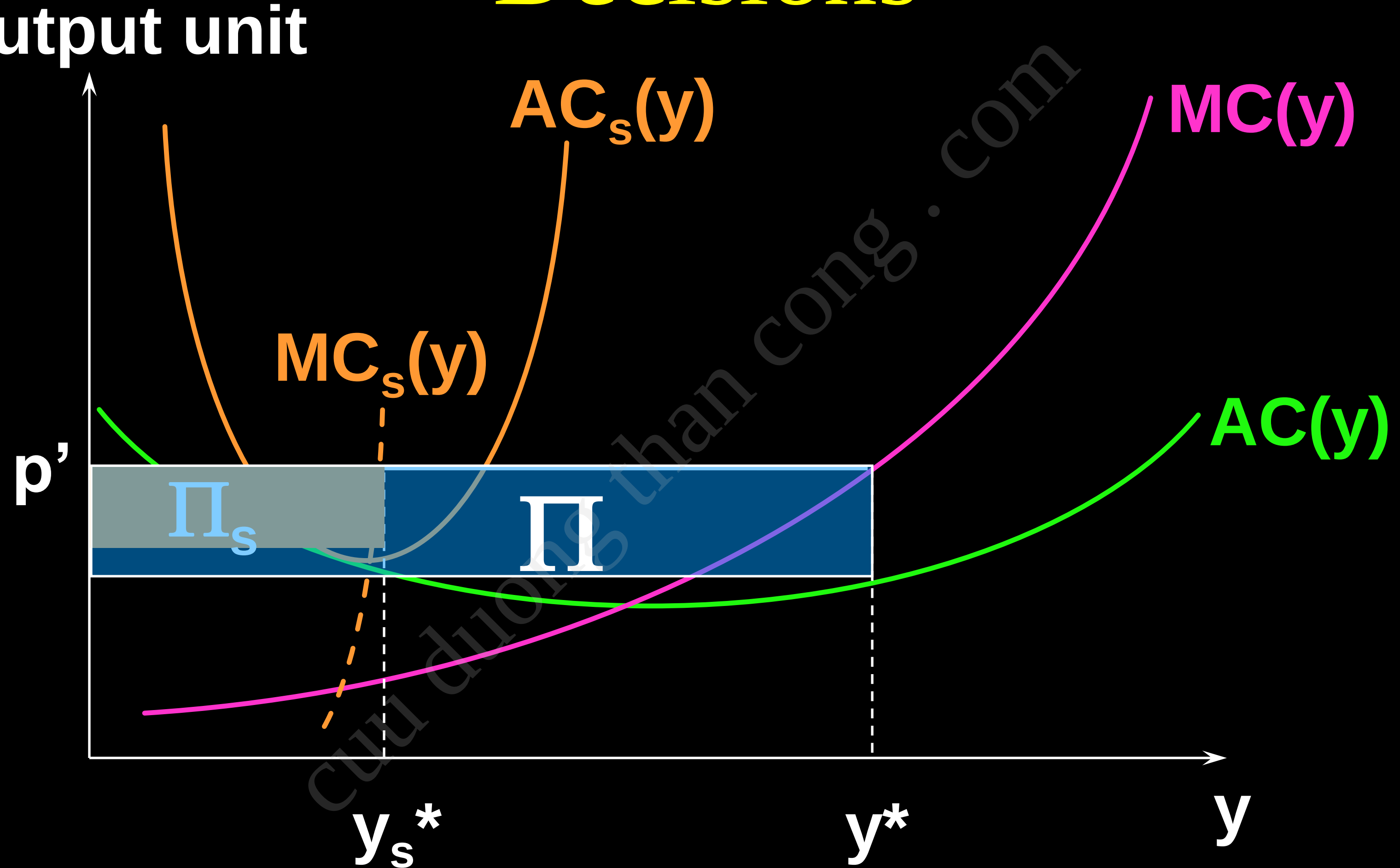
- **How is the firm's long-run supply curve related to all of its short-run supply curves?**

The Firm's Long & Short-Run Supply Decisions



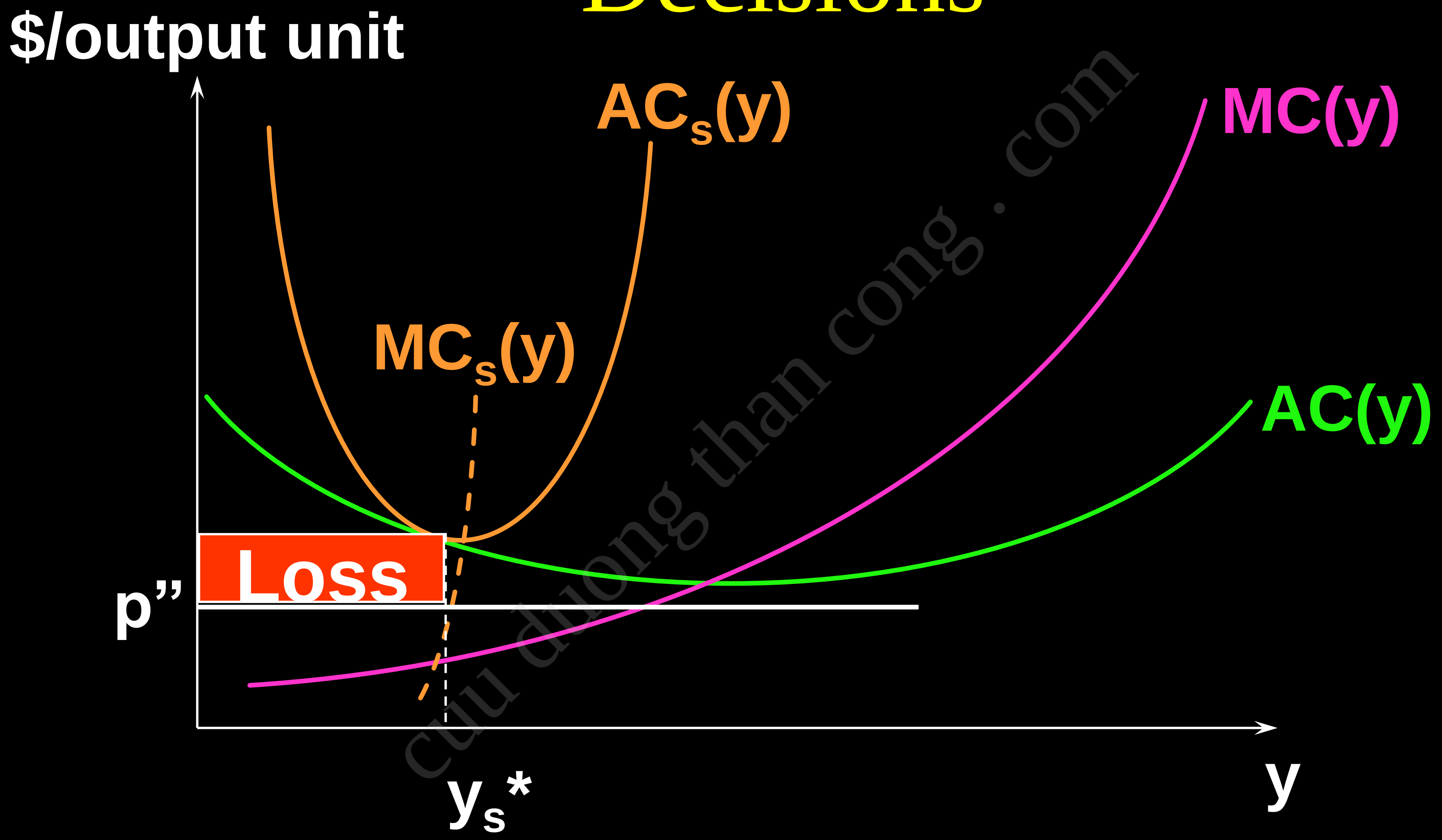
y_s* is profit-maximizing in this short-run.

The Firm's Long & Short-Run Supply Decisions



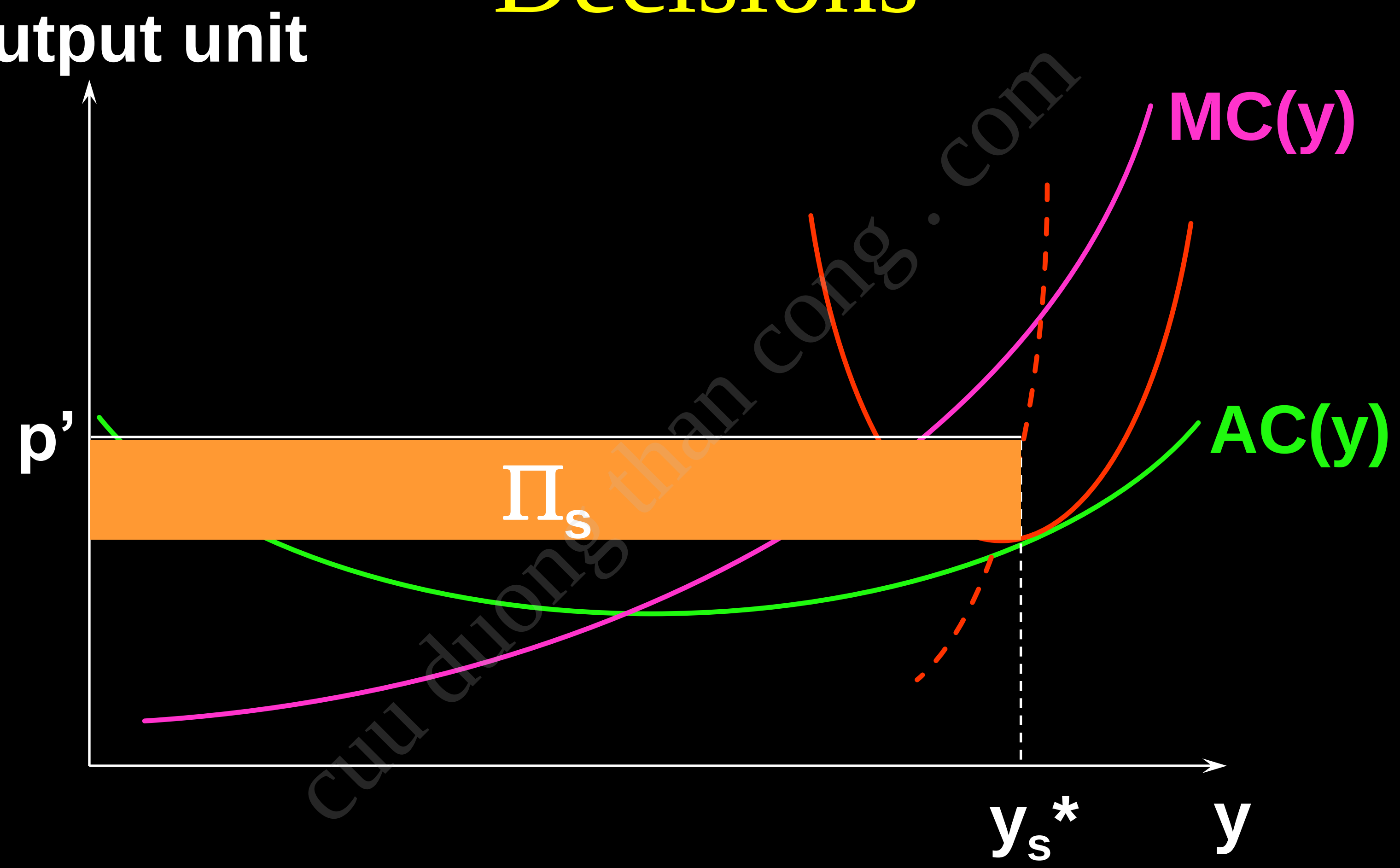
The firm can increase profit by increasing x_2 and producing y* output units.

The Firm's Long & Short-Run Supply Decisions



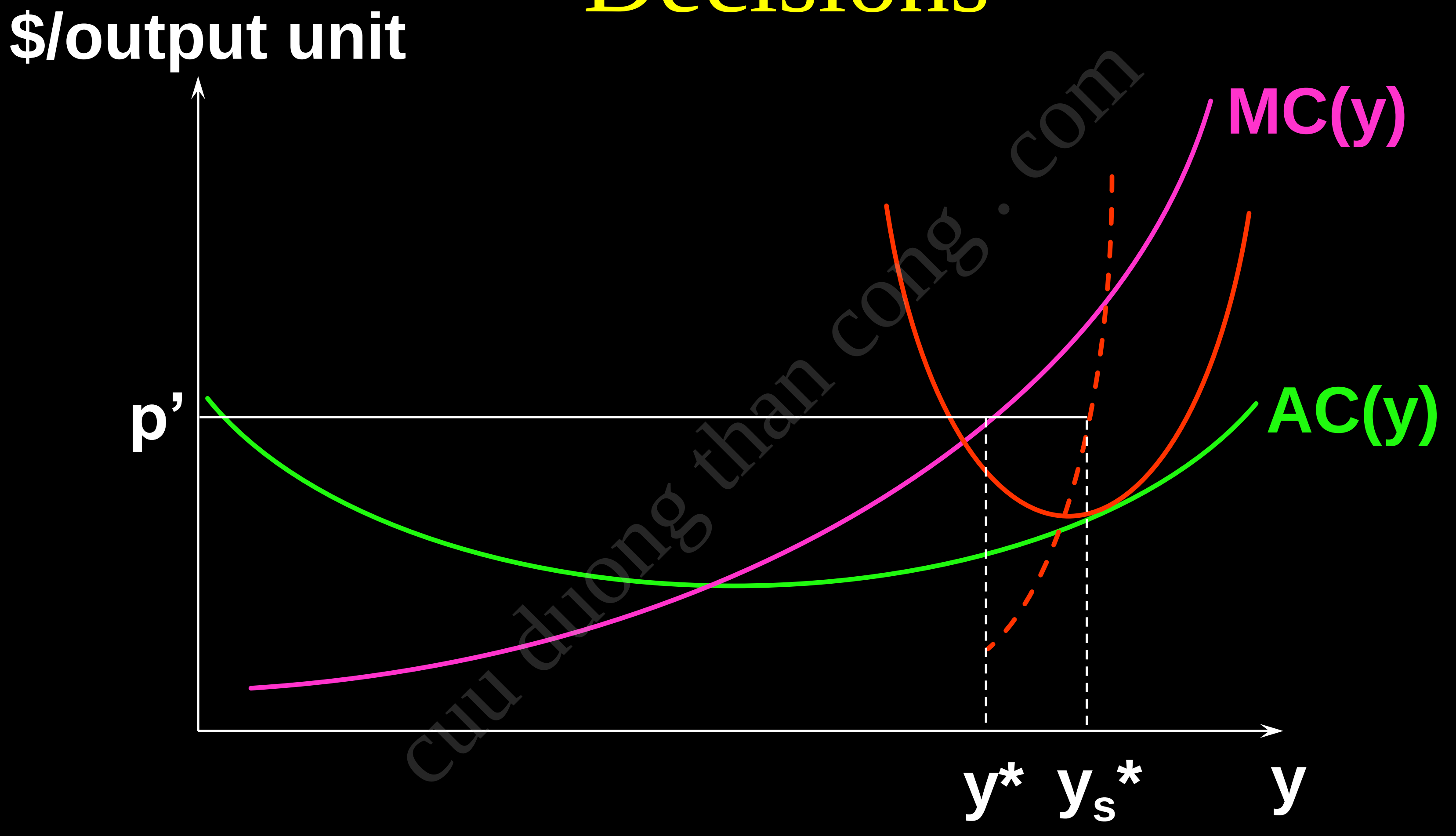
This loss can be eliminated in the long-run by the firm exiting the industry.

The Firm's Long & Short-Run Supply Decisions



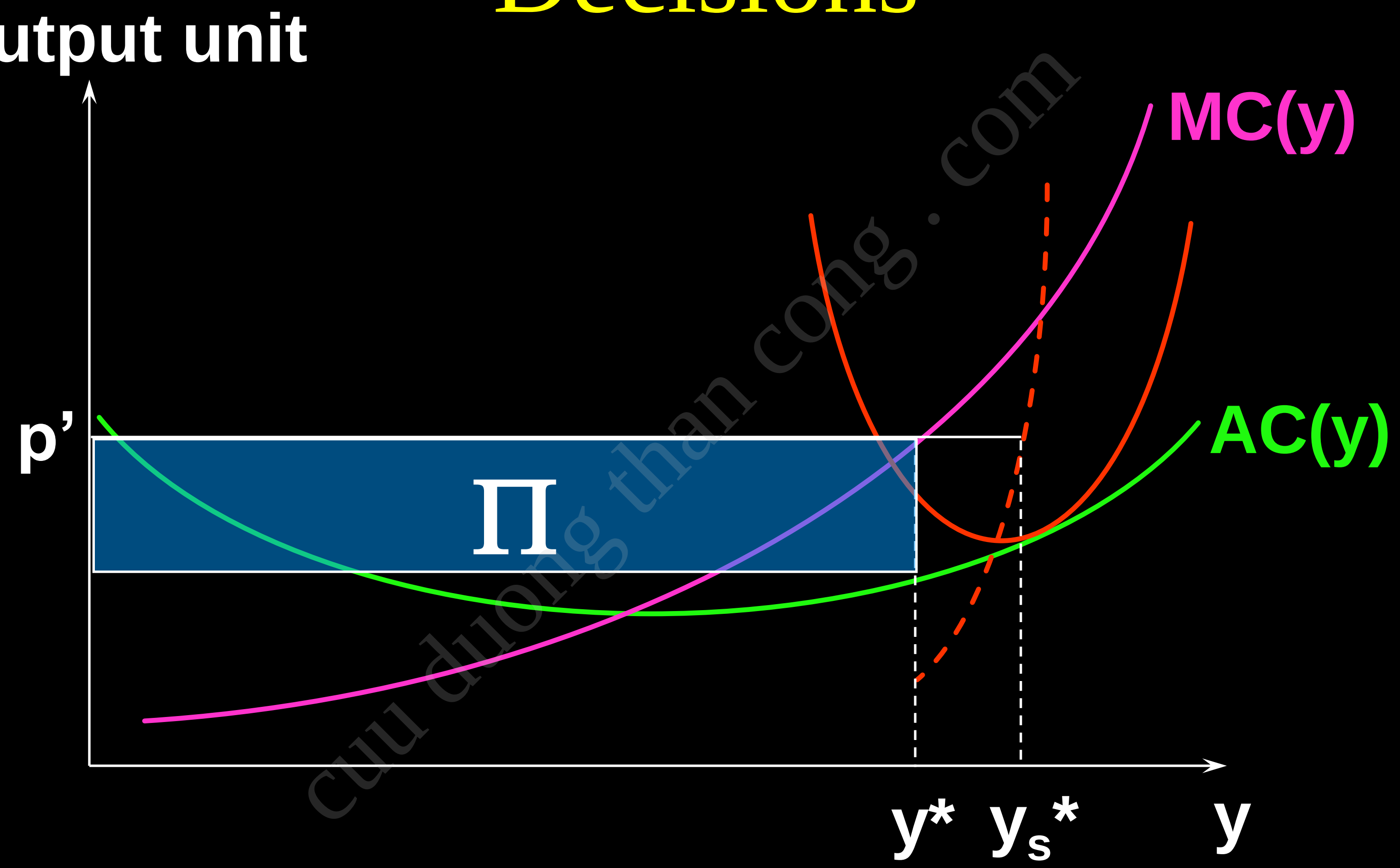
y_s* is profit-maximizing in this short-run.

The Firm's Long & Short-Run Supply Decisions



y_s* is profit-maximizing in this short-run.
y* is profit-maximizing in the long-run.

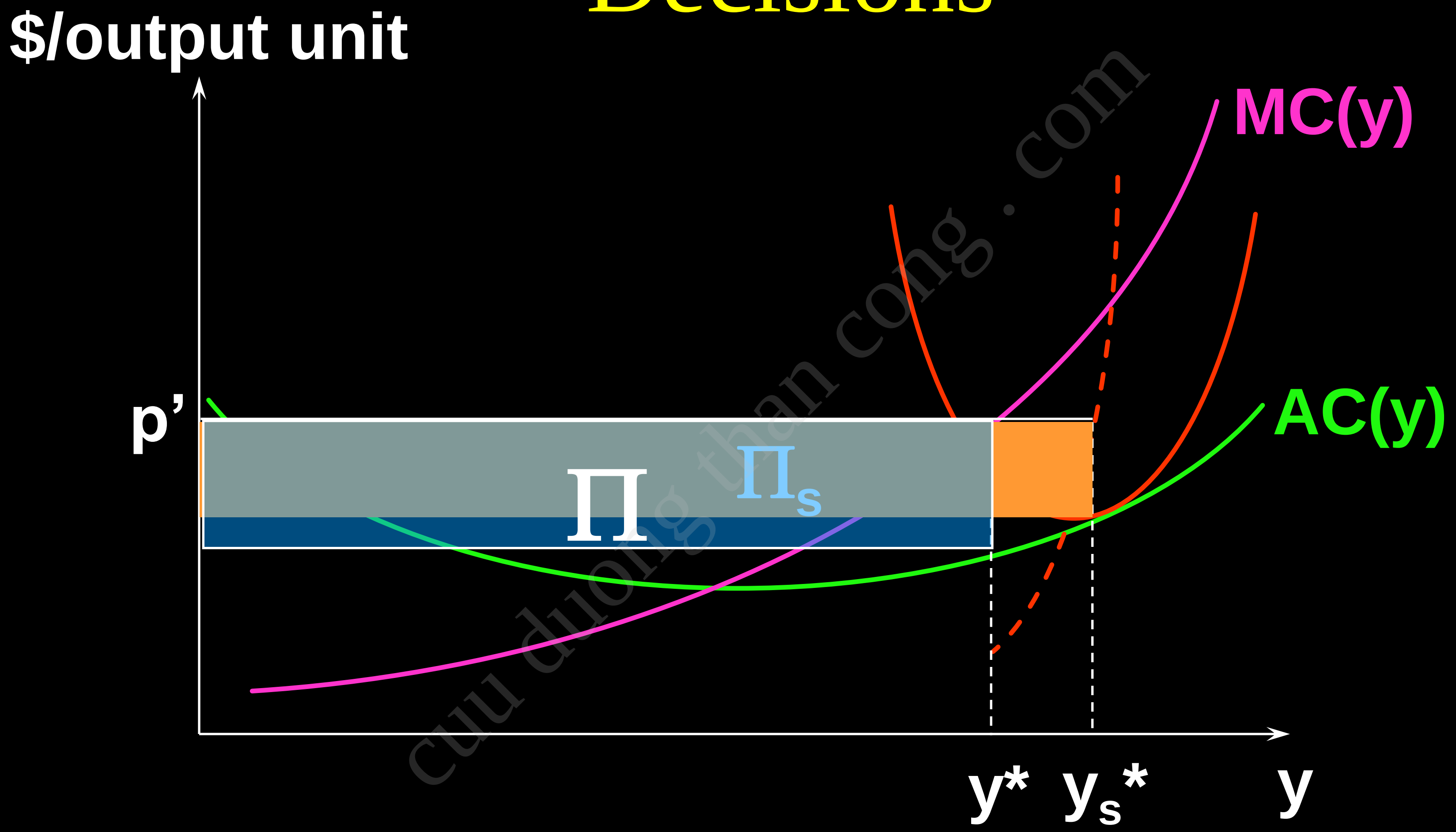
The Firm's Long & Short-Run Supply Decisions



y_s* is profit-maximizing in this short-run.

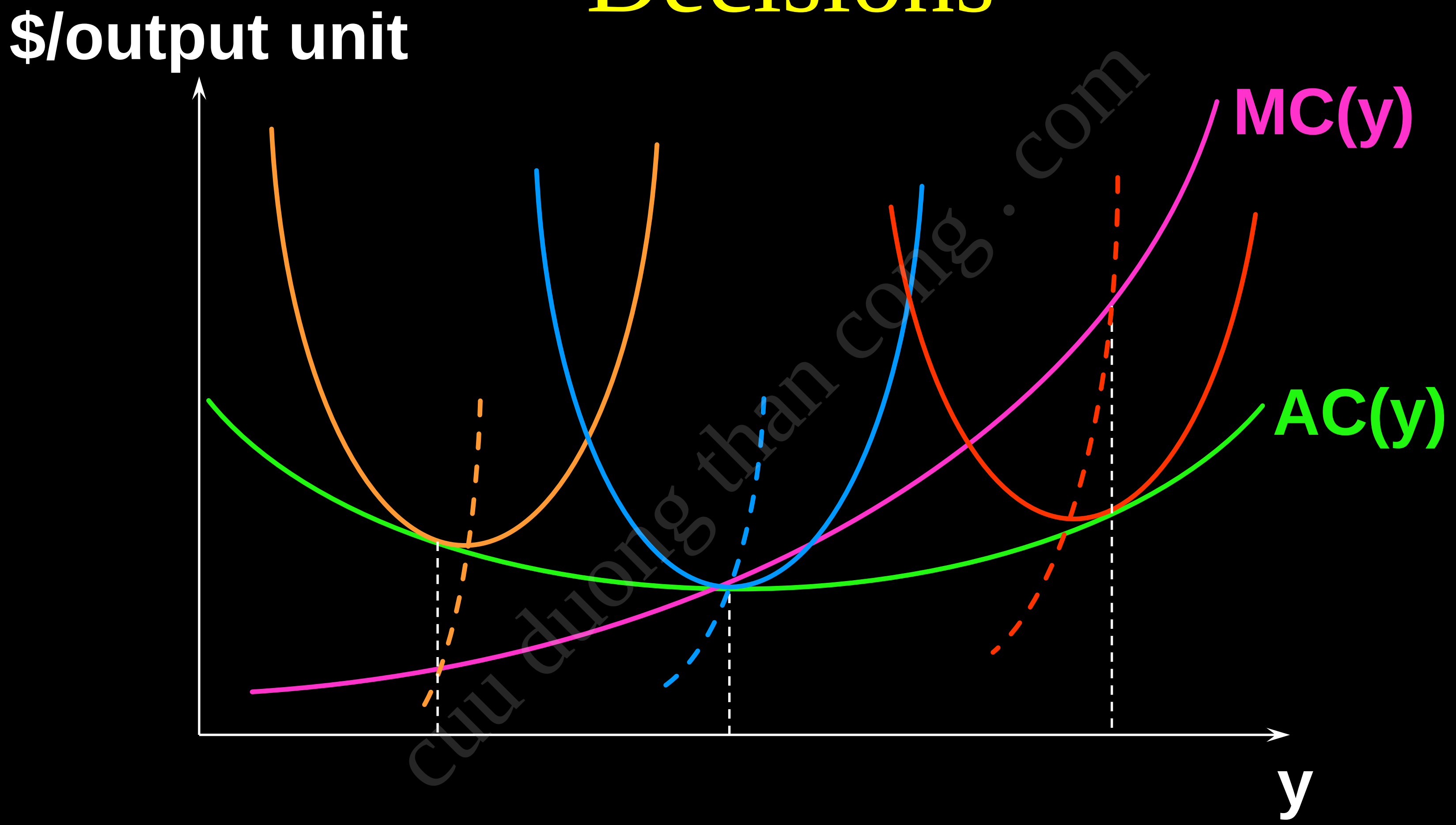
y* is profit-maximizing in the long-run.

The Firm's Long & Short-Run Supply Decisions

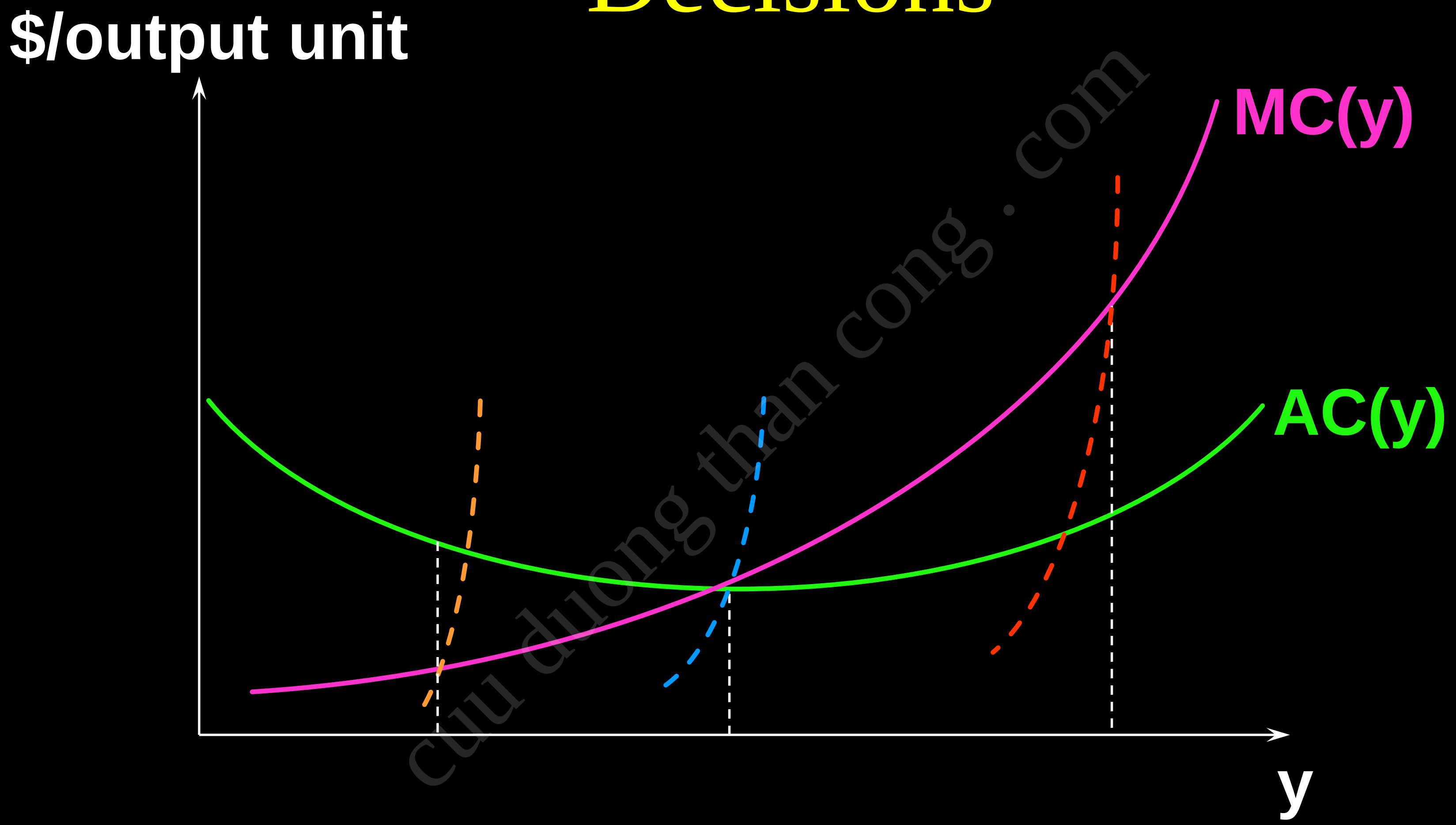


The firm can increase profit by reducing x_2 and producing y* units of output.

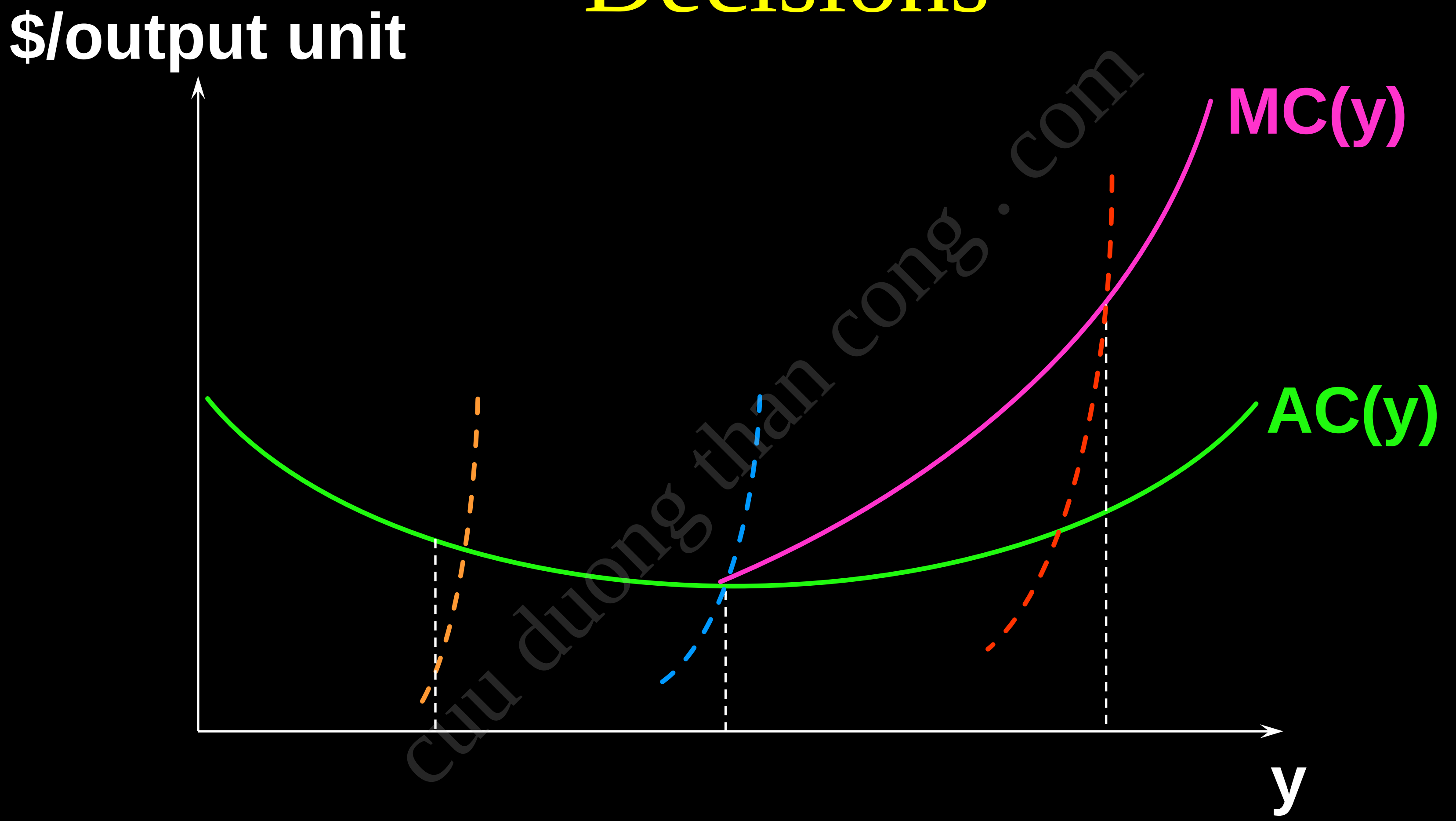
The Firm's Long & Short-Run Supply Decisions



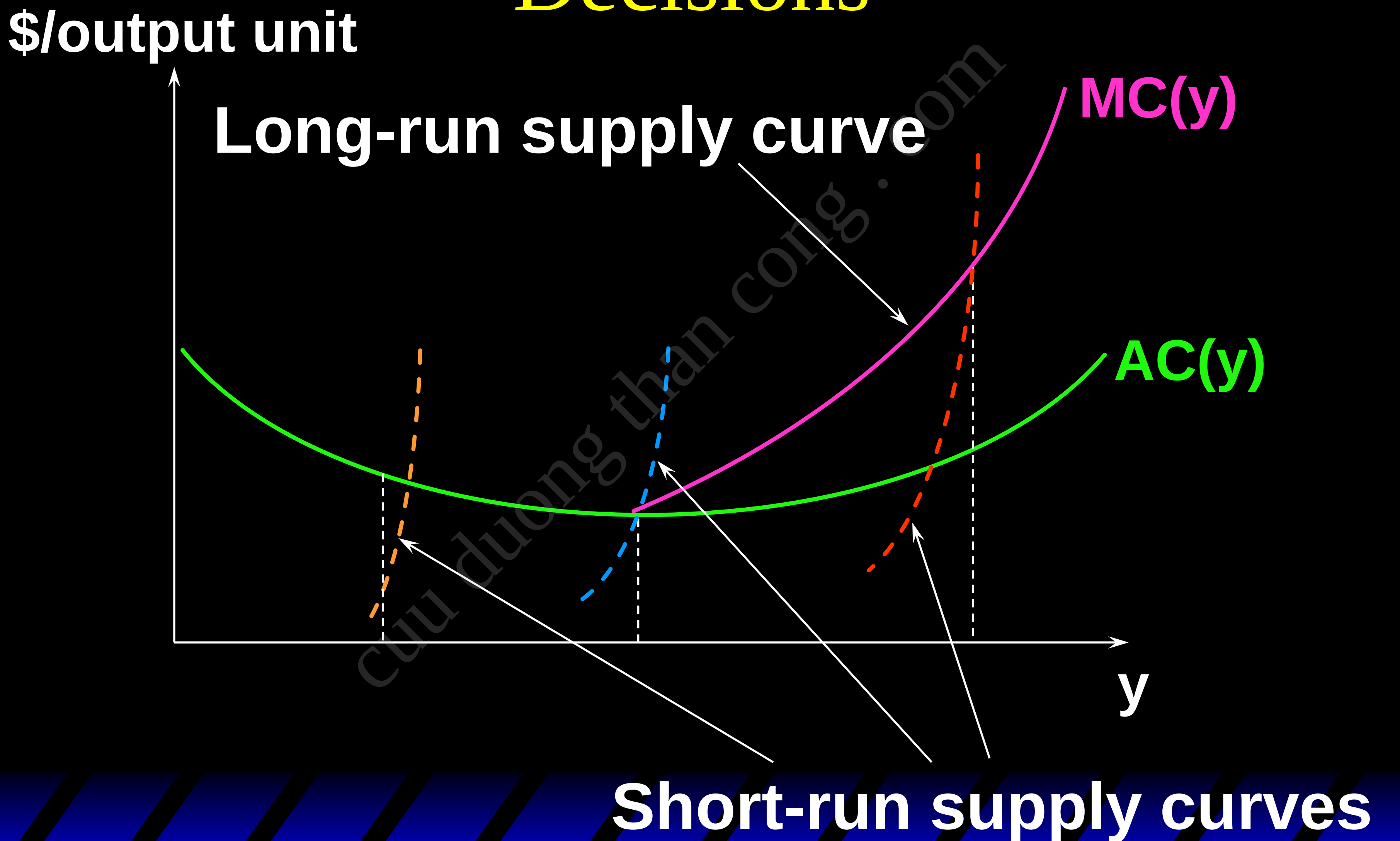
The Firm's Long & Short-Run Supply Decisions



The Firm's Long & Short-Run Supply Decisions



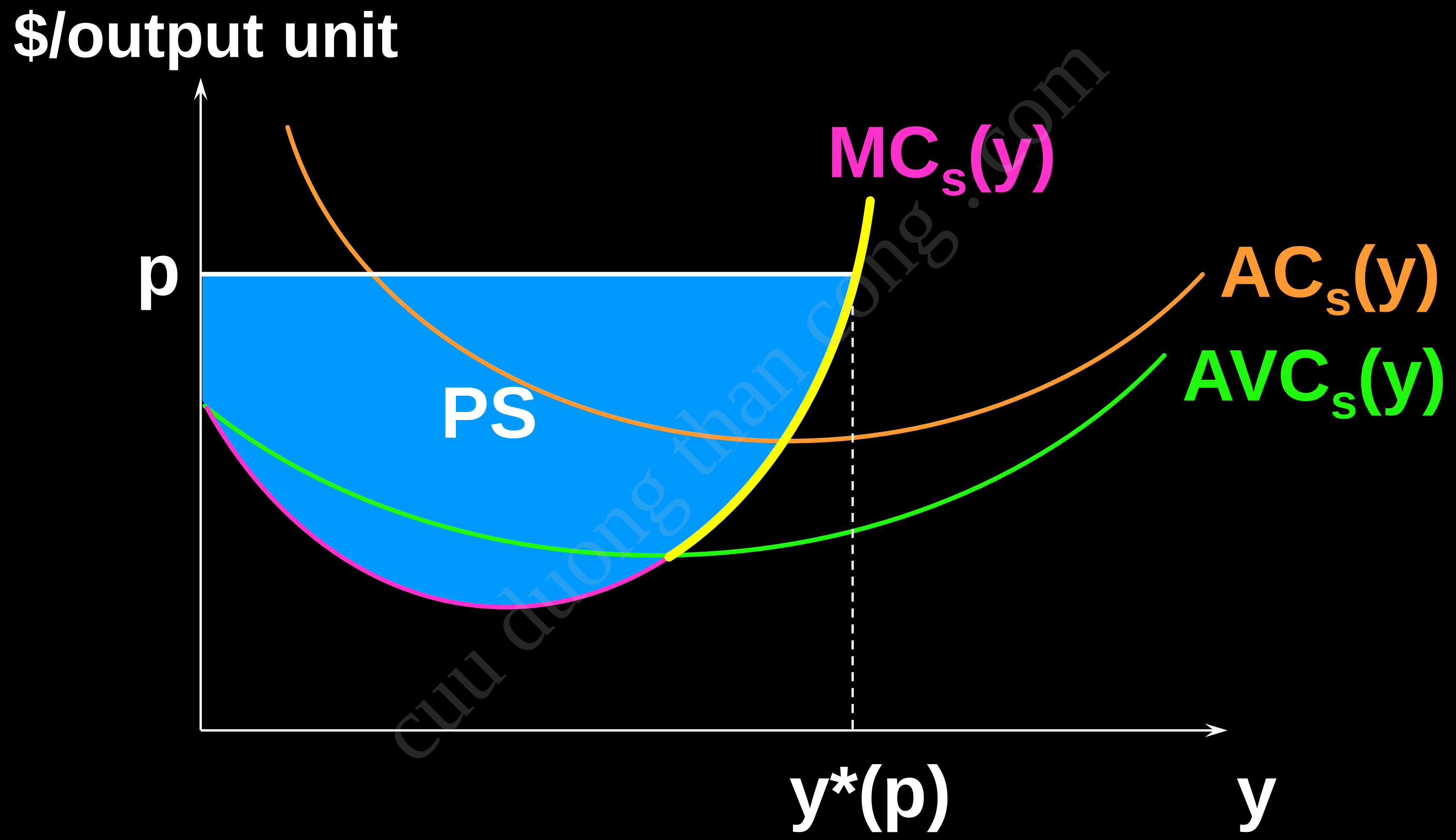
The Firm's Long & Short-Run Supply Decisions



Producer's Surplus Revisited

- The firm's producer's surplus is the accumulation, unit by extra unit of output, of extra revenue less extra production cost.
- How is producer's surplus related profit?

Producer's Surplus Revisited



Producer's Surplus Revisited

So the firm's producer's surplus is

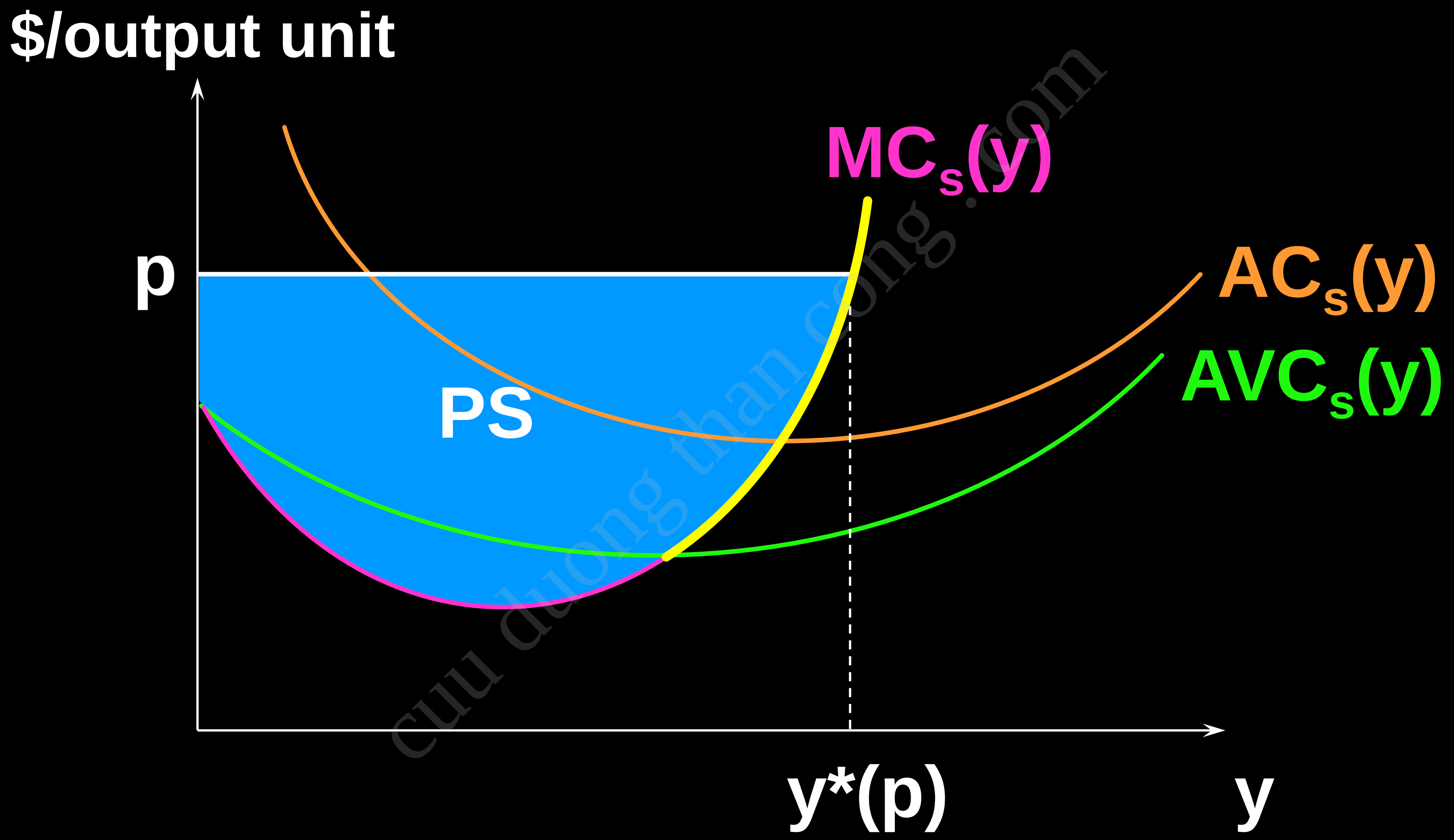
$$PS(p) = \int_0^{y^*(p)} [p - MC_s(z)]d(z)$$

$$= py^*(p) - \int_0^{y^*(p)} MC_s(z)d(z)$$

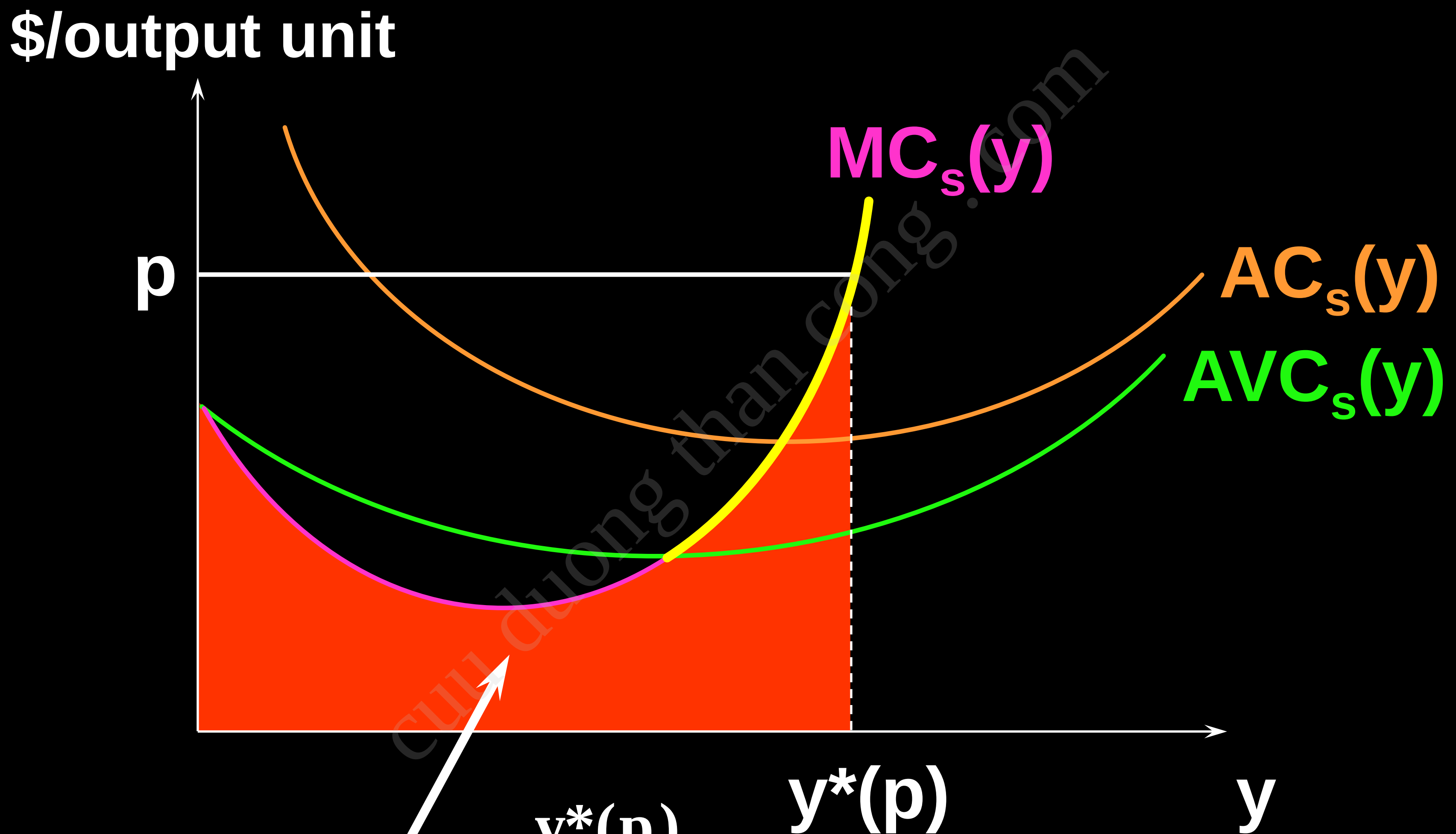
$$= py^*(p) - c_v(y^*(p)).$$

That is, PS = Revenue - Variable Cost.

Producer's Surplus Revisited

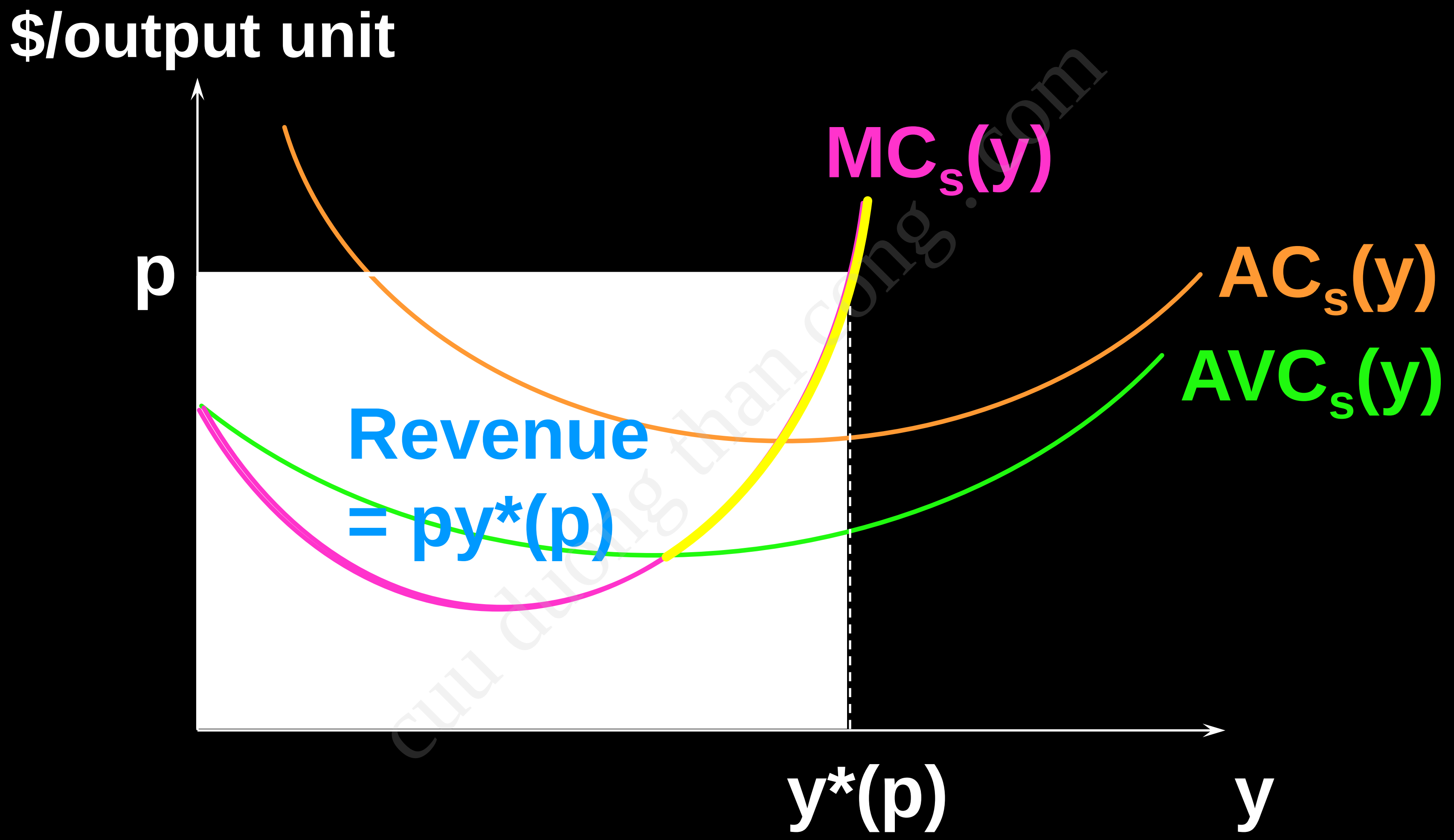


Producer's Surplus Revisited

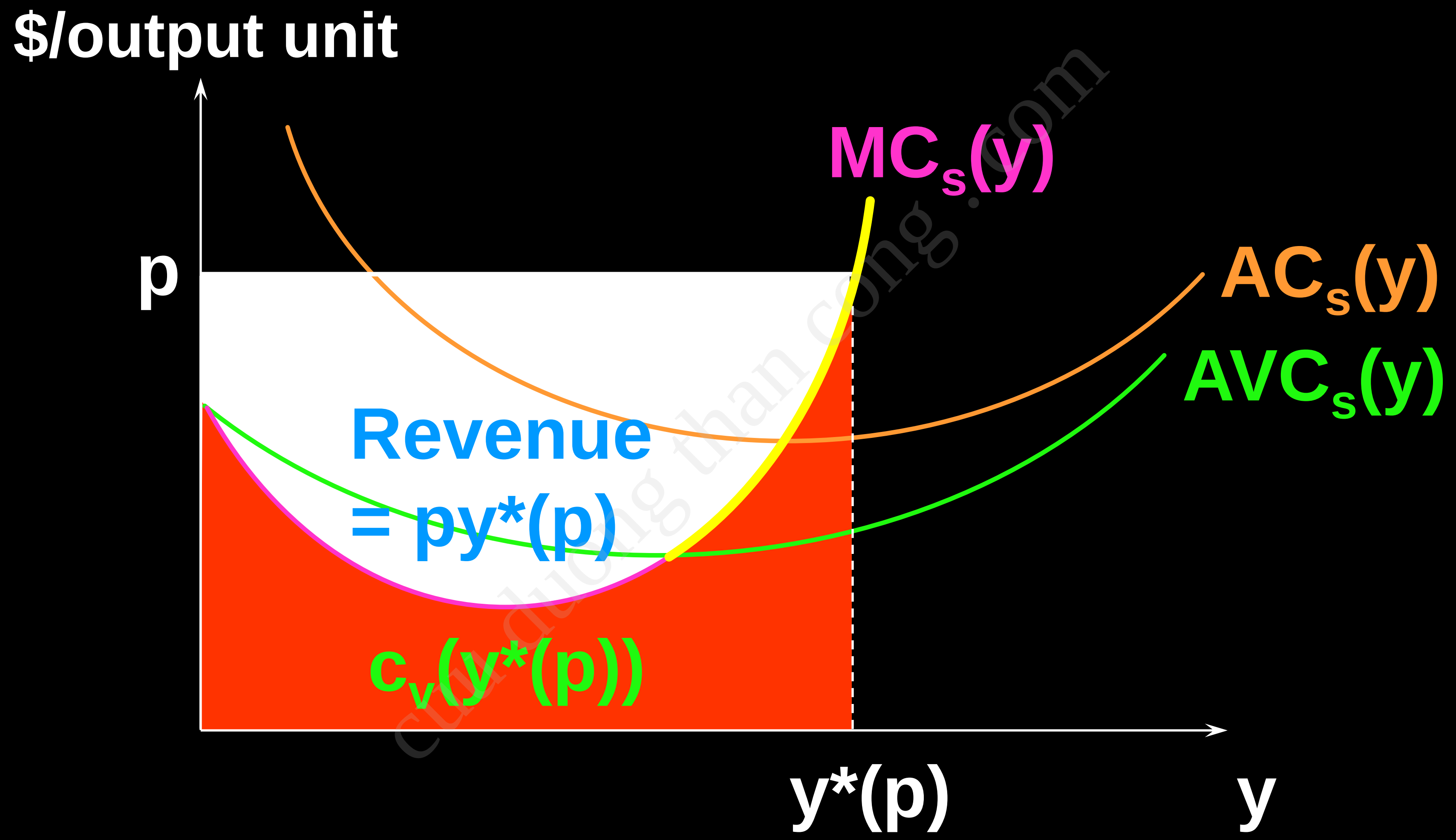


$$c_v(y^*(p)) = \int_0^{y^*(p)} MC_s(z)\,d(z)$$

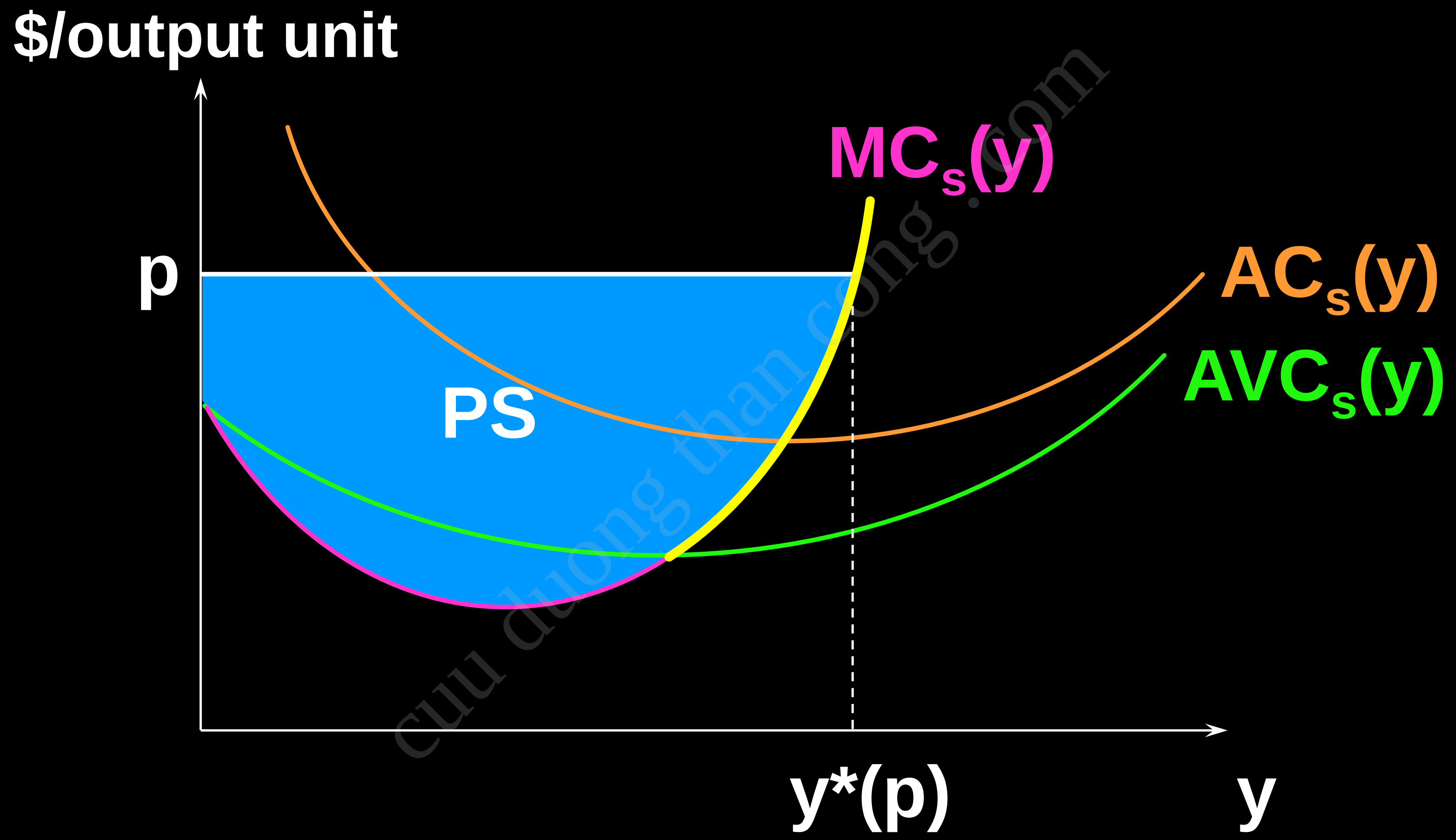
Producer's Surplus Revisited



Producer's Surplus Revisited



Producer's Surplus Revisited



Producer's Surplus Revisited

- PS = Revenue - Variable Cost.
- Profit = Revenue - Total Cost
  = Revenue - Fixed Cost
  - Variable Cost.
- So, PS = Profit + Fixed Cost.
- Only if fixed cost is zero (the long-run) are PS and profit the same.

3. Industry Supply

Supply From A Competitive Industry

- How are the supply decisions of the many individual firms in a competitive industry to be combined to discover the market supply curve for the entire industry?

Supply From A Competitive Industry

- 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.

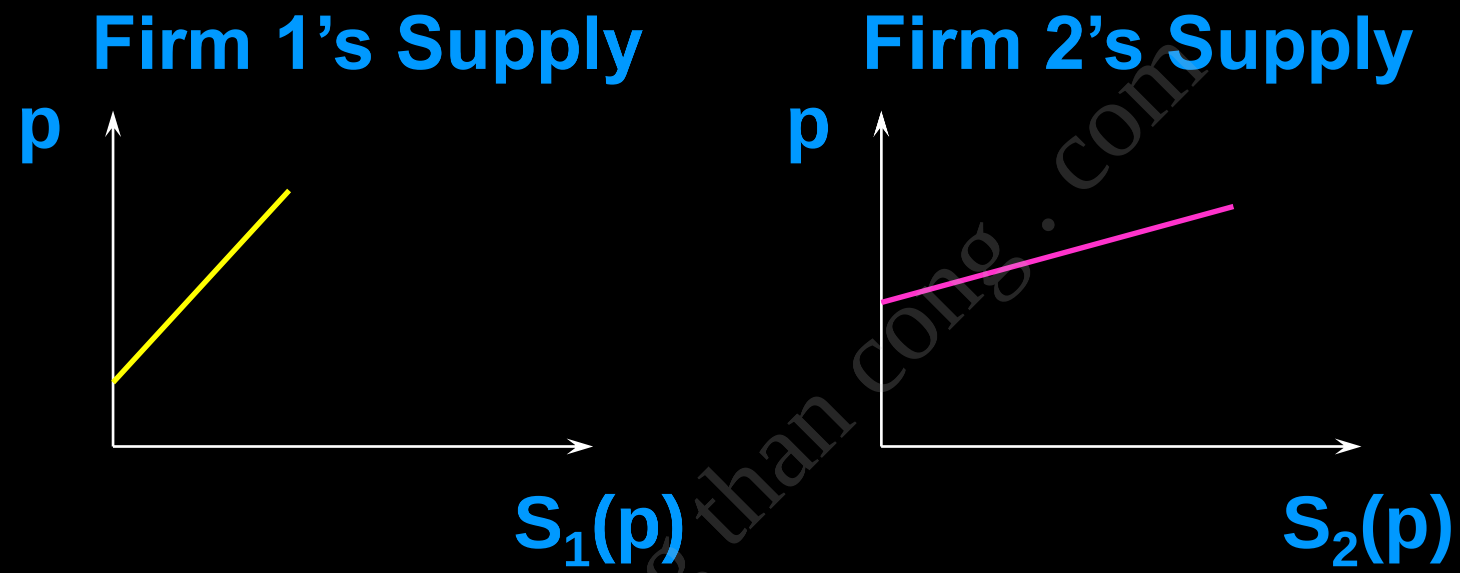
Short-Run Supply

- In a short-run the number of firms in the industry is, temporarily, fixed.
- Let n be the number of firms; i = 1, … ,n.
- $S_i(p)$ is firm i's supply function.

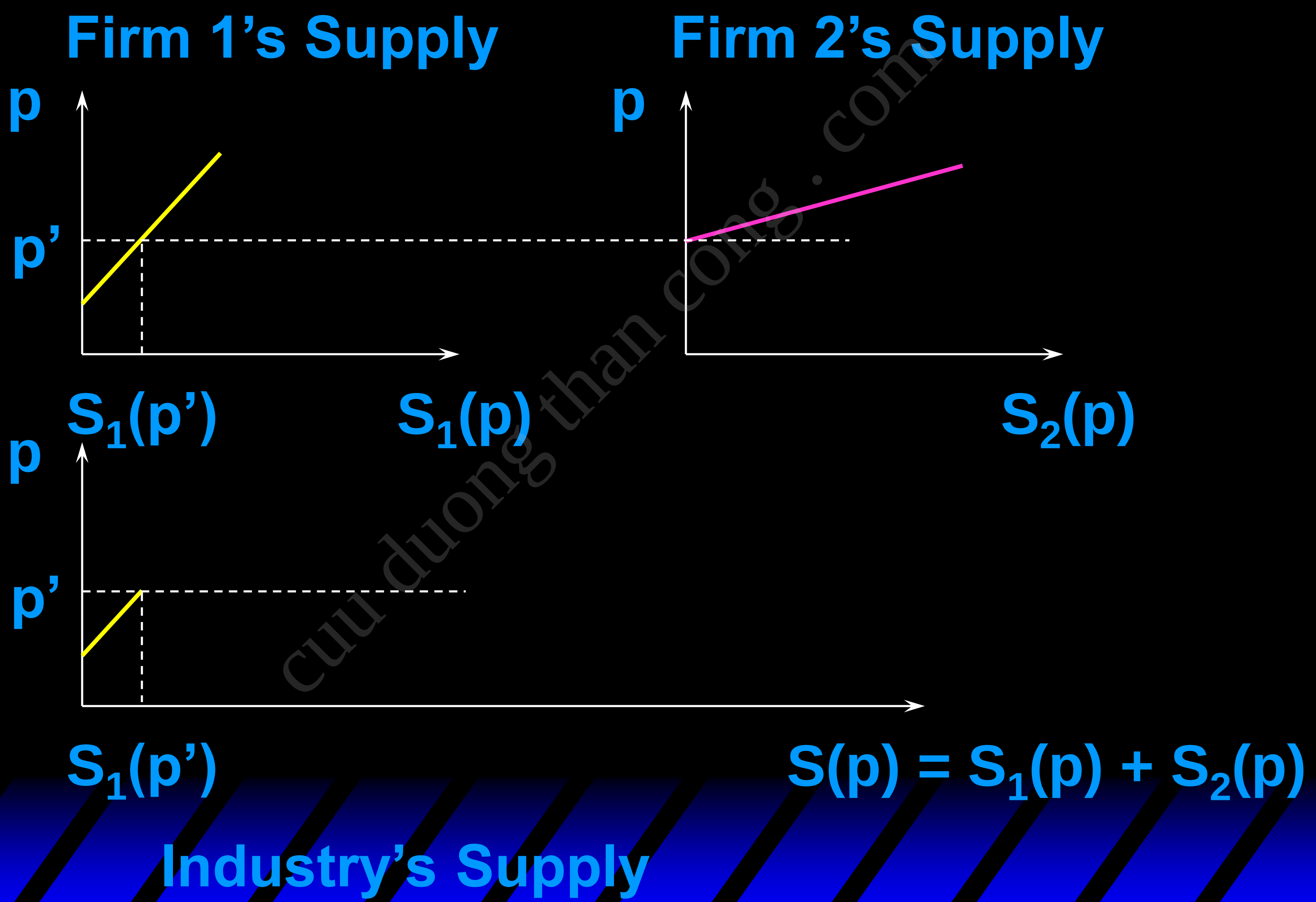
The industry's short-run supply function is

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

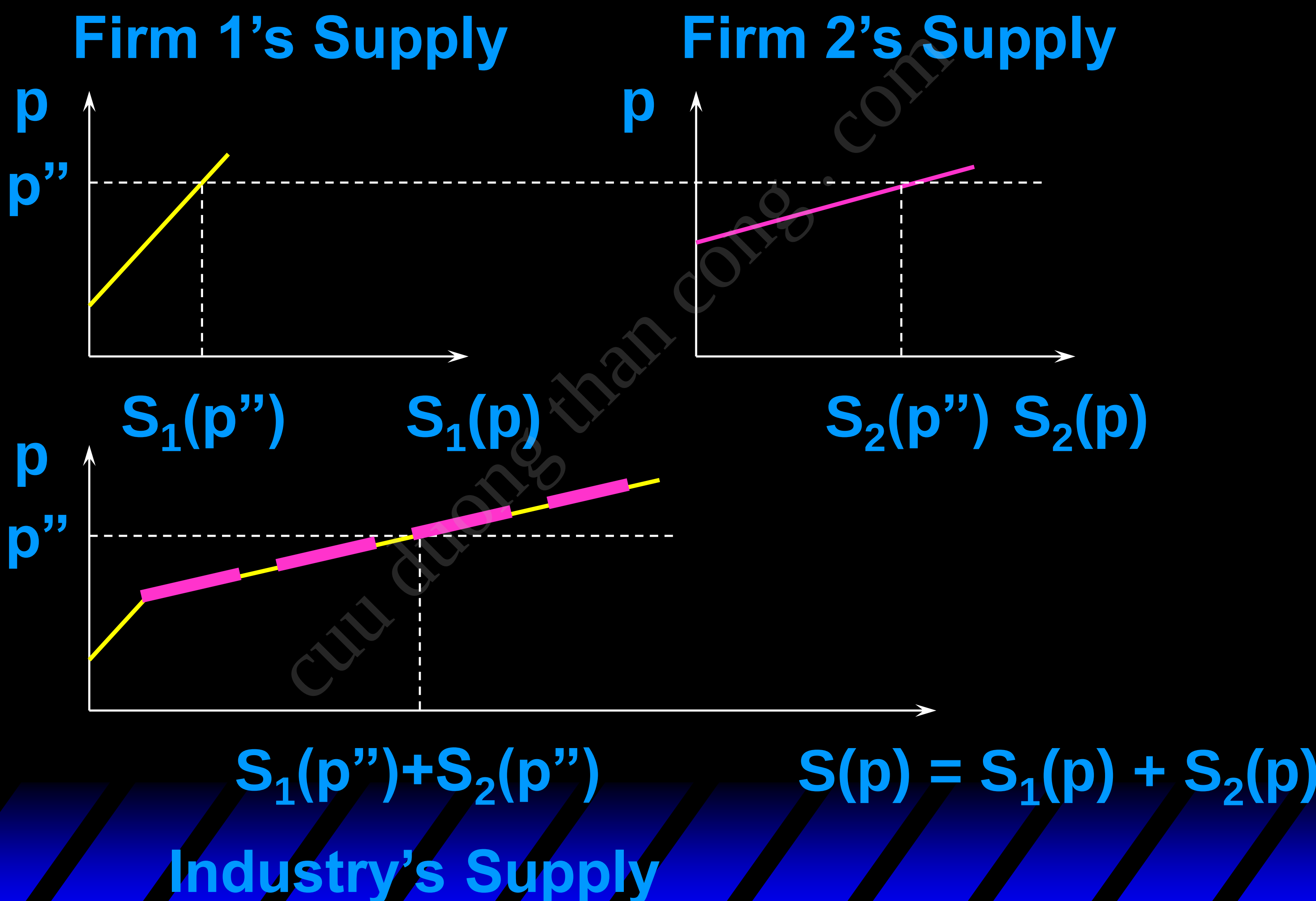
Supply From A Competitive Industry



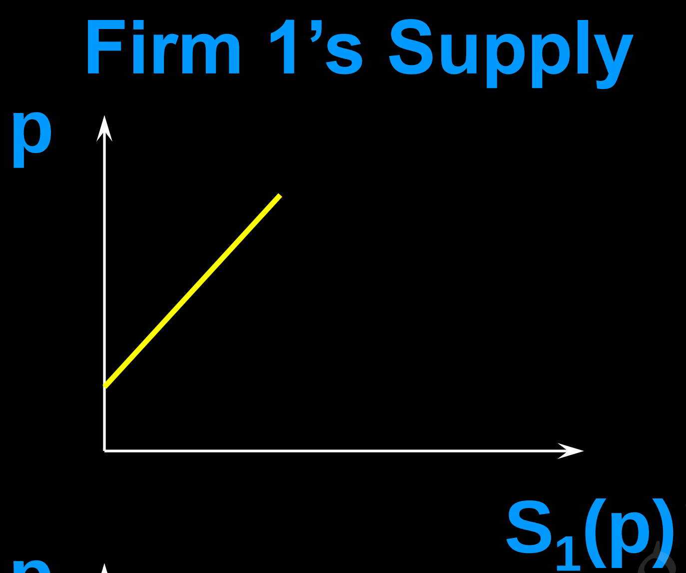
Supply From A Competitive Industry

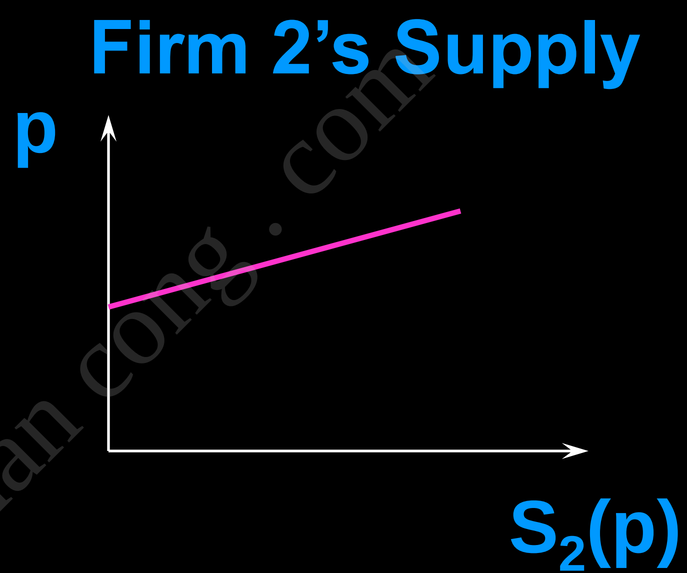


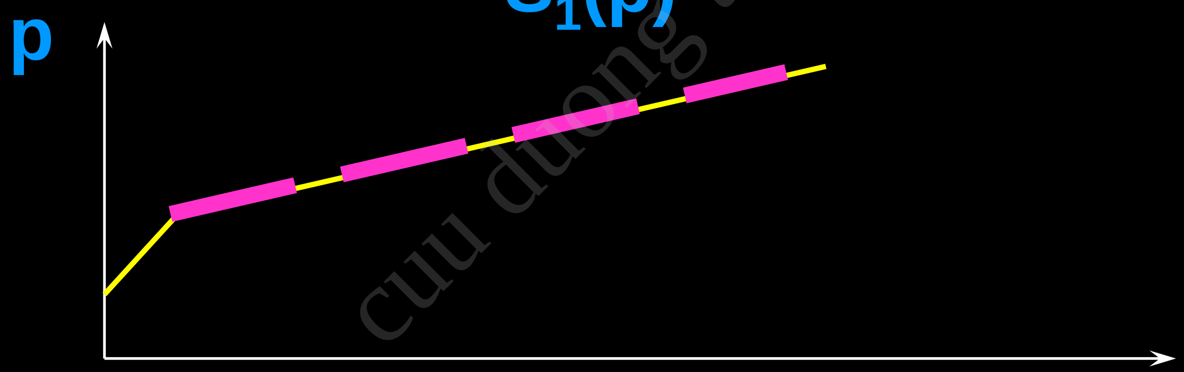
Supply From A Competitive Industry



Supply From A Competitive Industry







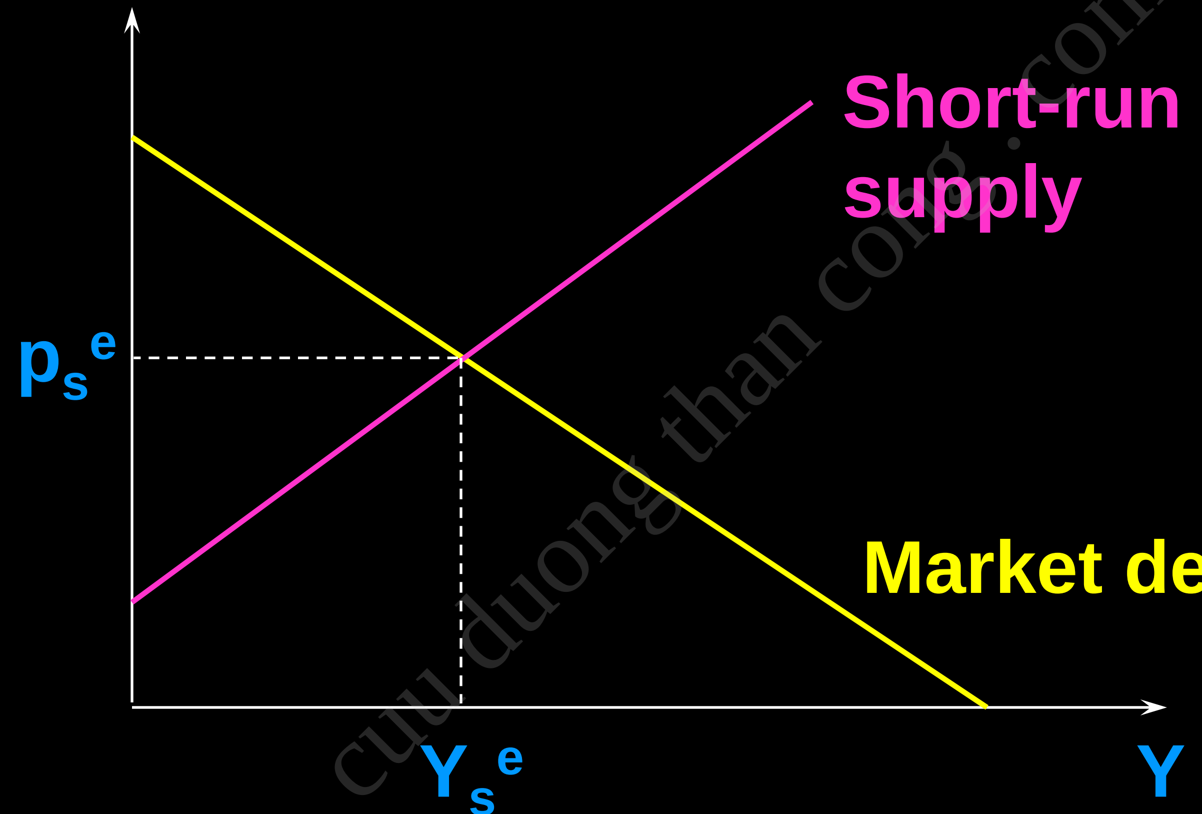
$S(p) = S_1(p) + S_2(p)$

Industry's Supply

Short-Run Industry Equilibrium

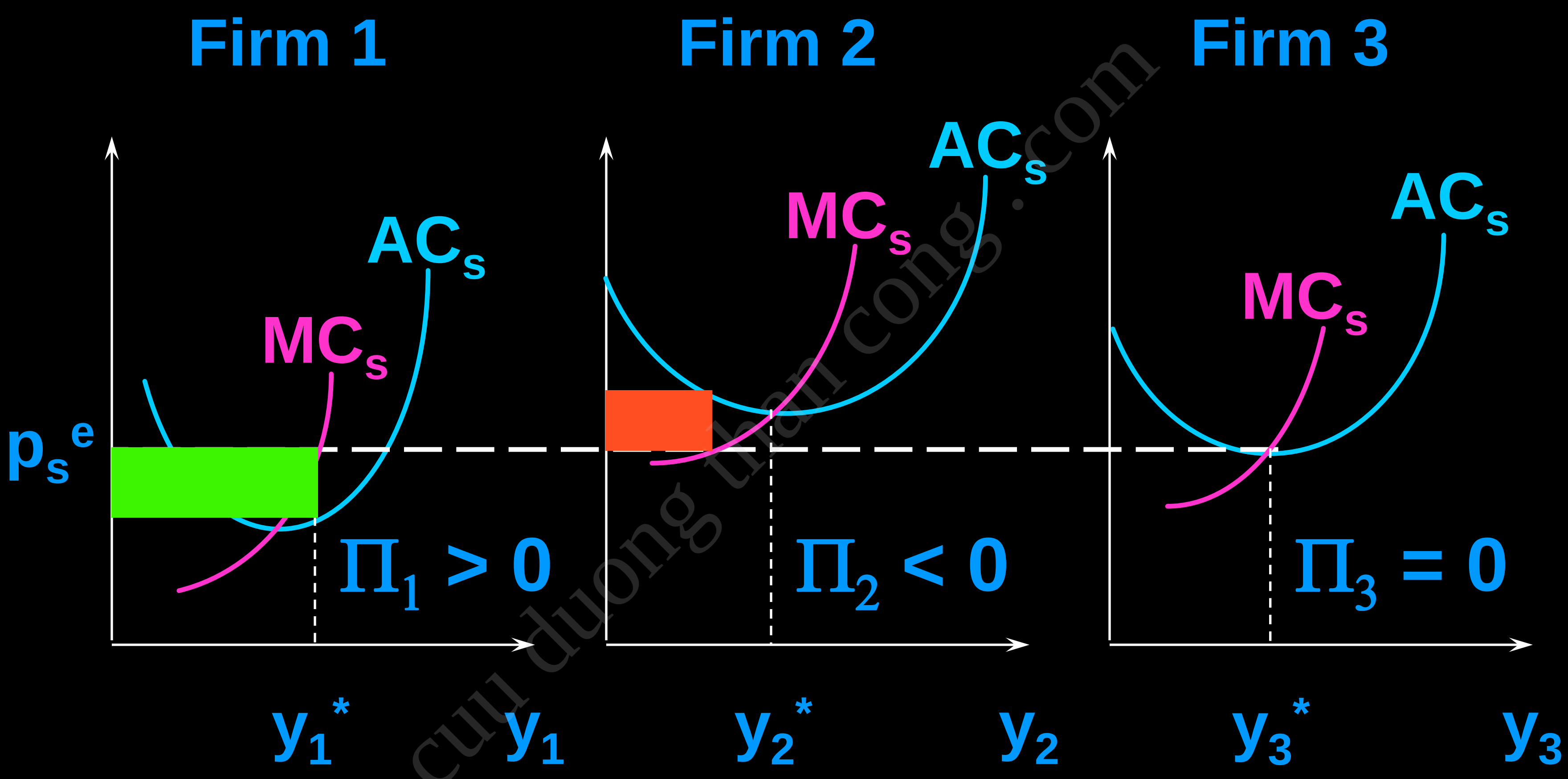
- In a short-run, neither entry nor exit can occur.
- Consequently, in a short-run equilibrium, some firms may earn positive economics profits, others may suffer economic losses, and still others may earn zero economic profit.

Short-Run Industry Equilibrium



Short-run equilibrium price clears the market and is taken as given by each firm.

Short-Run Industry Equilibrium



Firm 1 wishes to remain in the industry.

Firm 2 wishes to exit from the industry.

Firm 3 is indifferent.

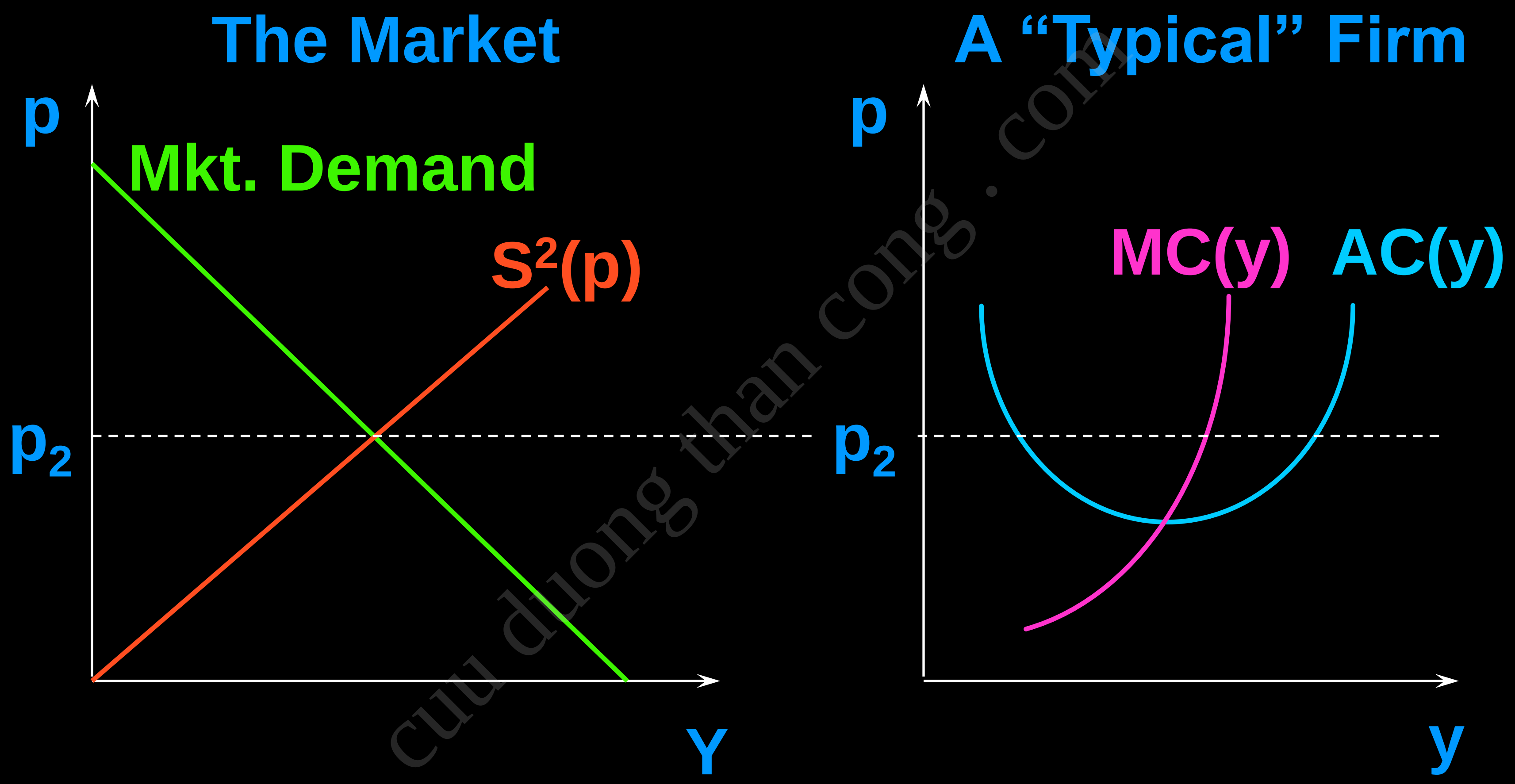
Long-Run Industry Supply

- 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.
- How is this done?

Long-Run Industry Supply

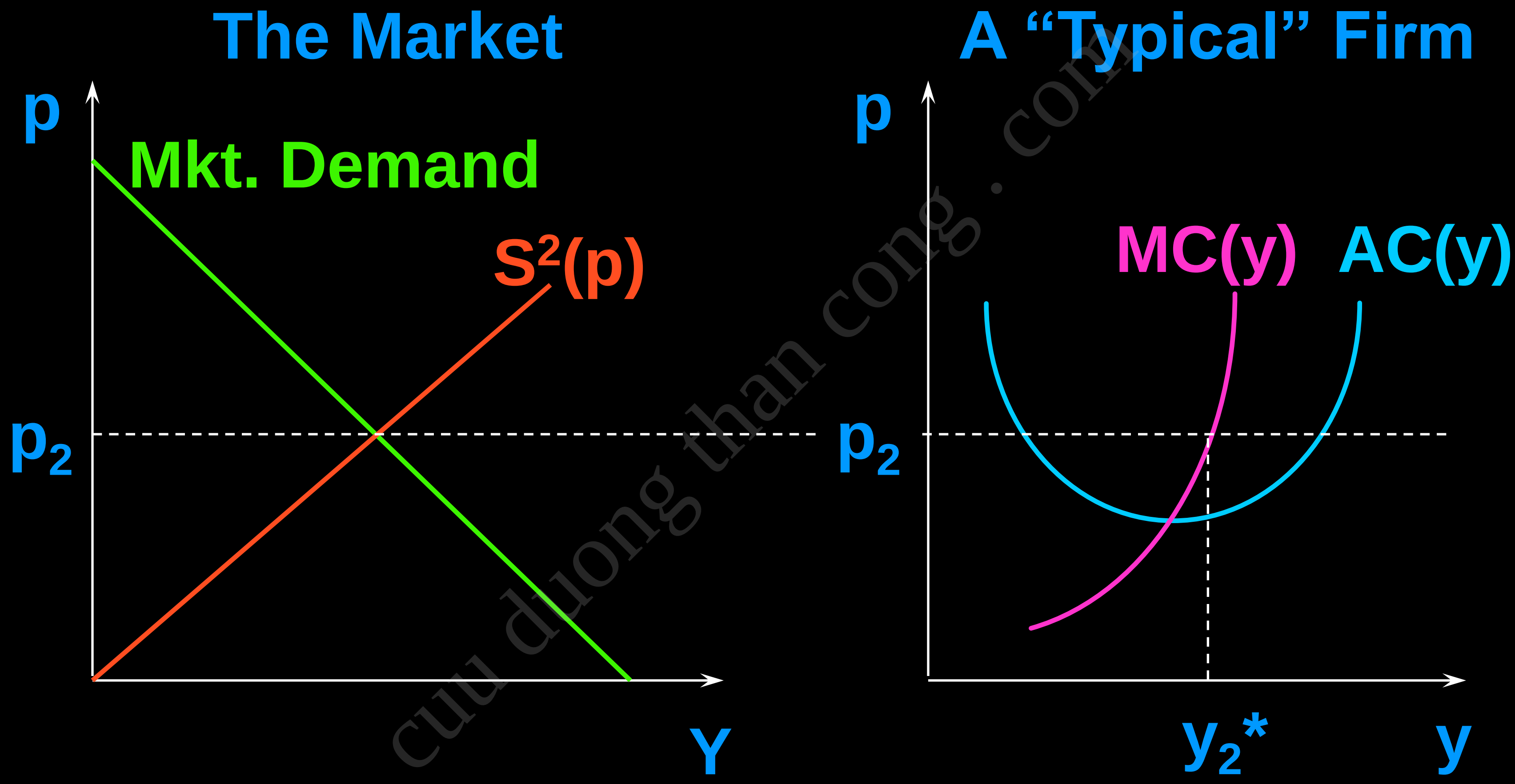
- Positive economic profit induces entry.
- Economic profit is positive when the market price p_s^e is higher than a firm's minimum av. total cost;
  $p_s^e > \min AC(y)$.
- Entry increases industry supply, causing p_s^e to fall.
- When does entry cease?

Long-Run Industry Supply



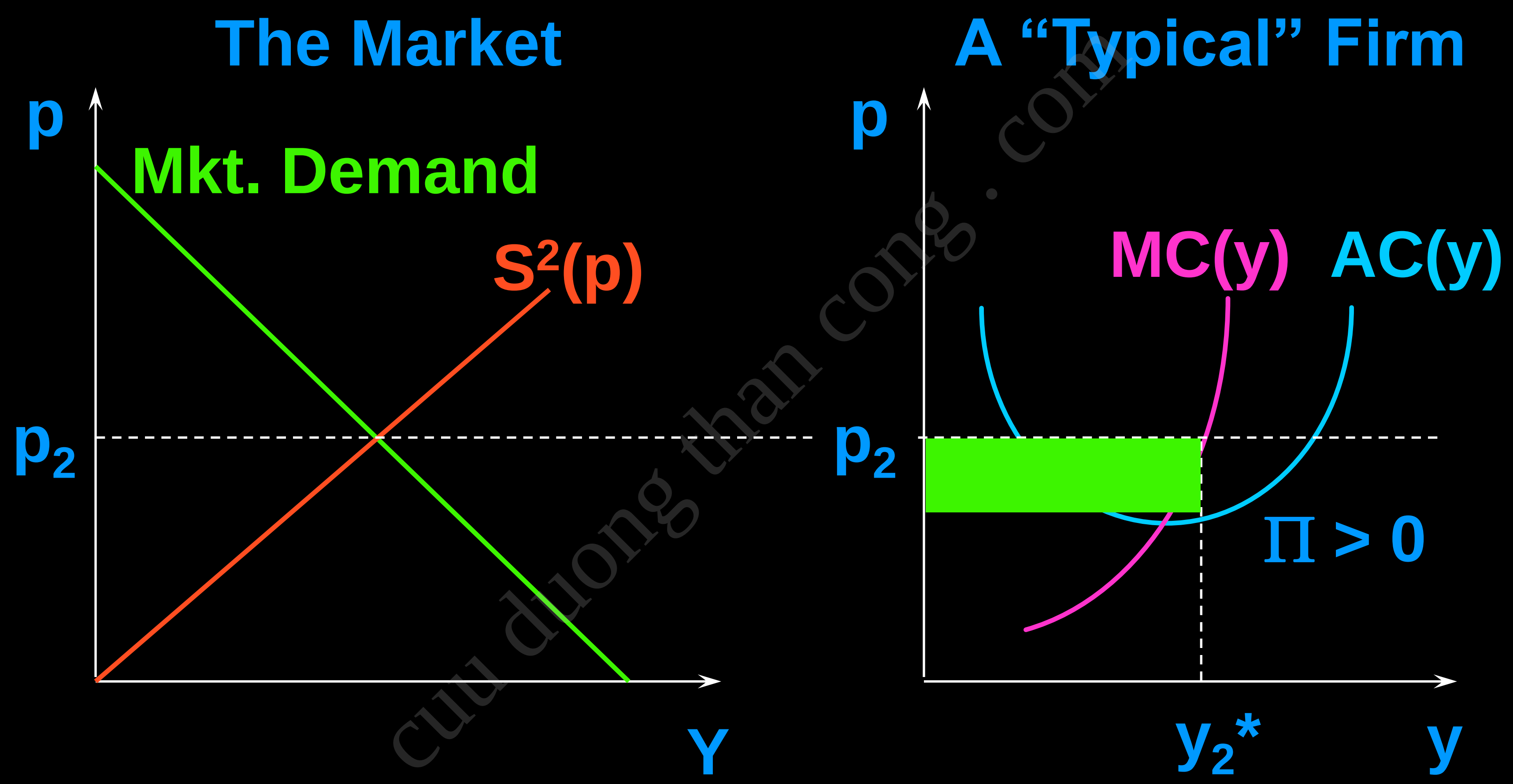
Then the market-clearing price is p_2.

Long-Run Industry Supply



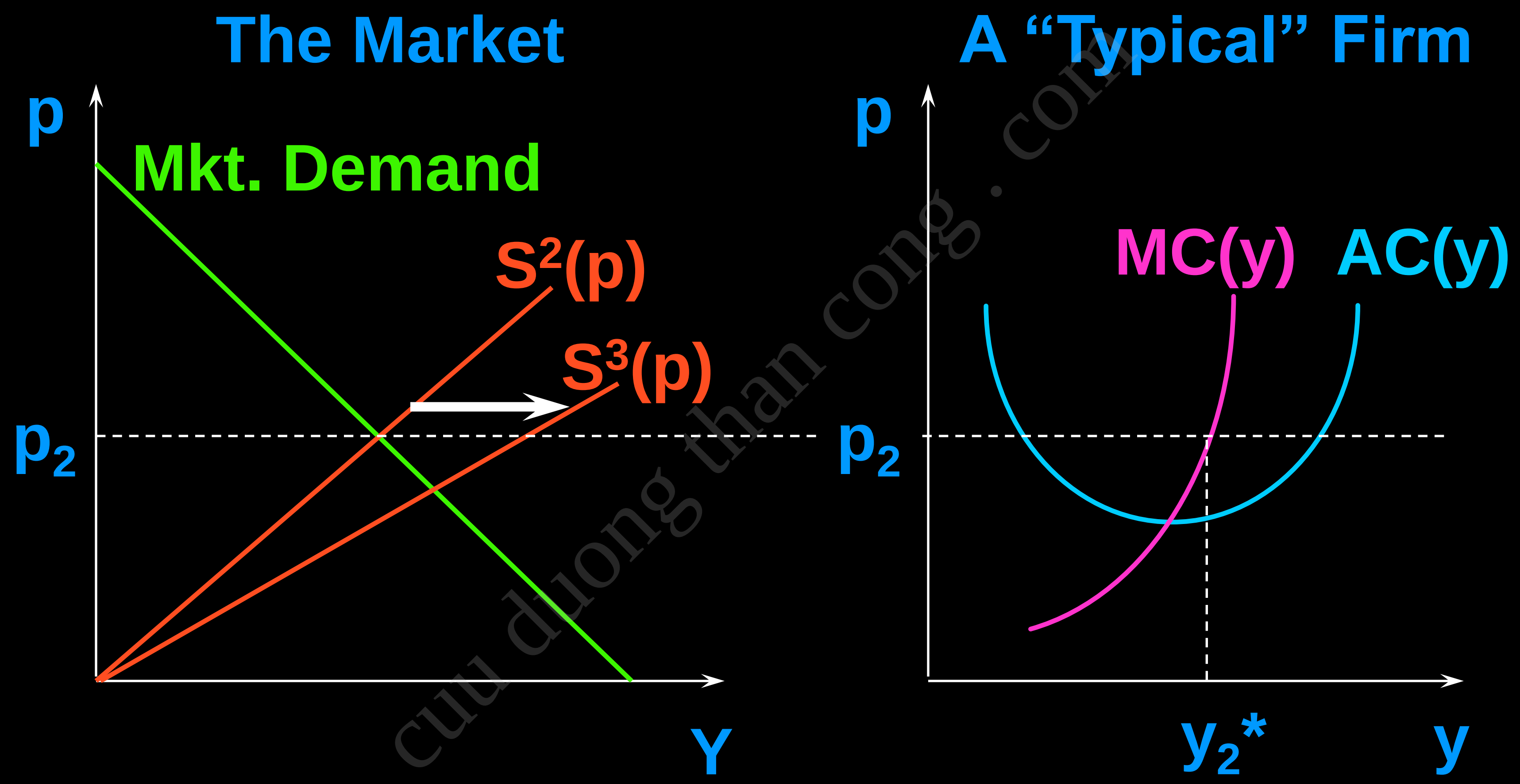
Then the market-clearing price is p_2.
Each firm produces y_2* units of output.

Long-Run Industry Supply



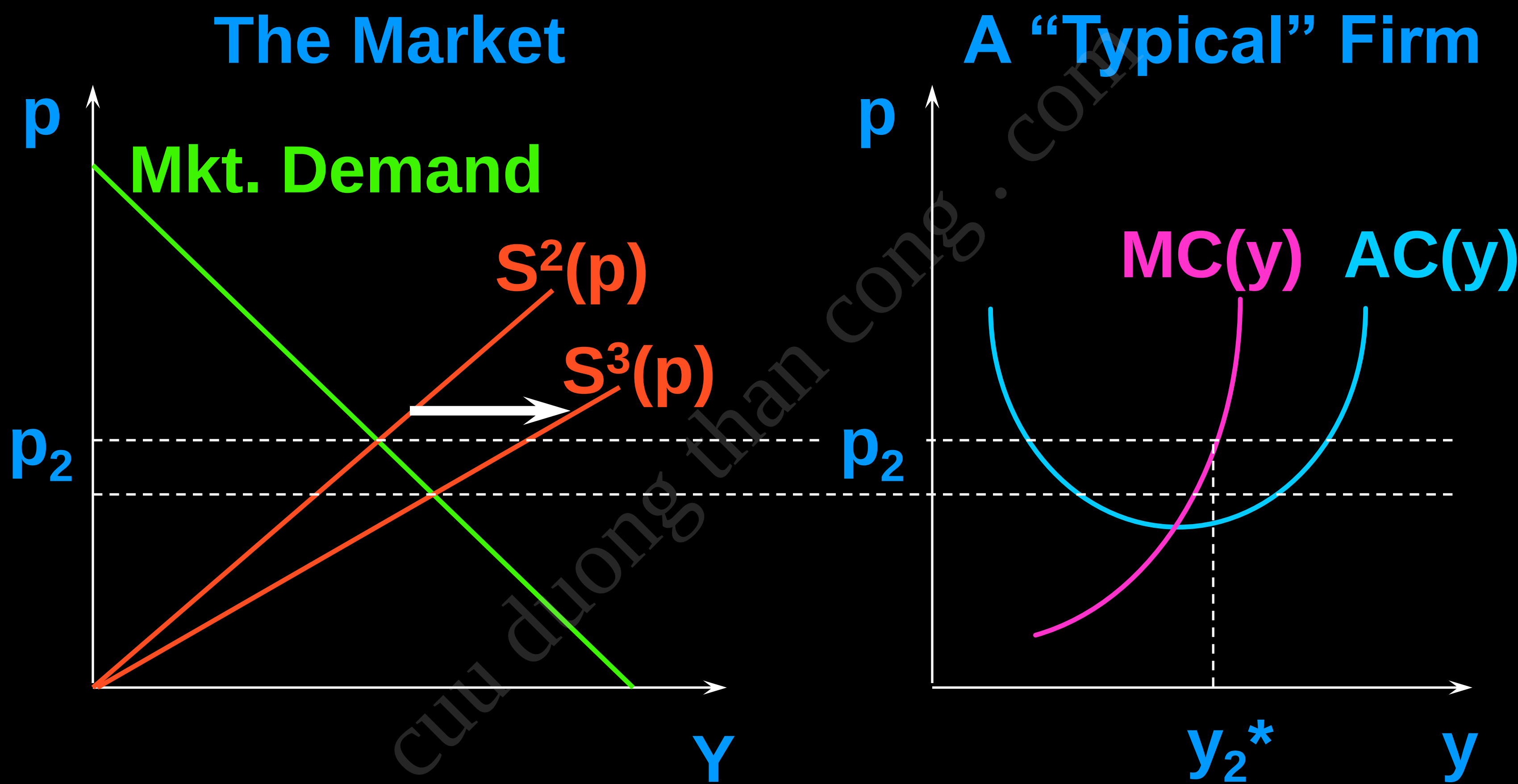
Each firm makes a positive economic profit, inducing entry by another firm.

Long-Run Industry Supply



Market supply shifts outwards.

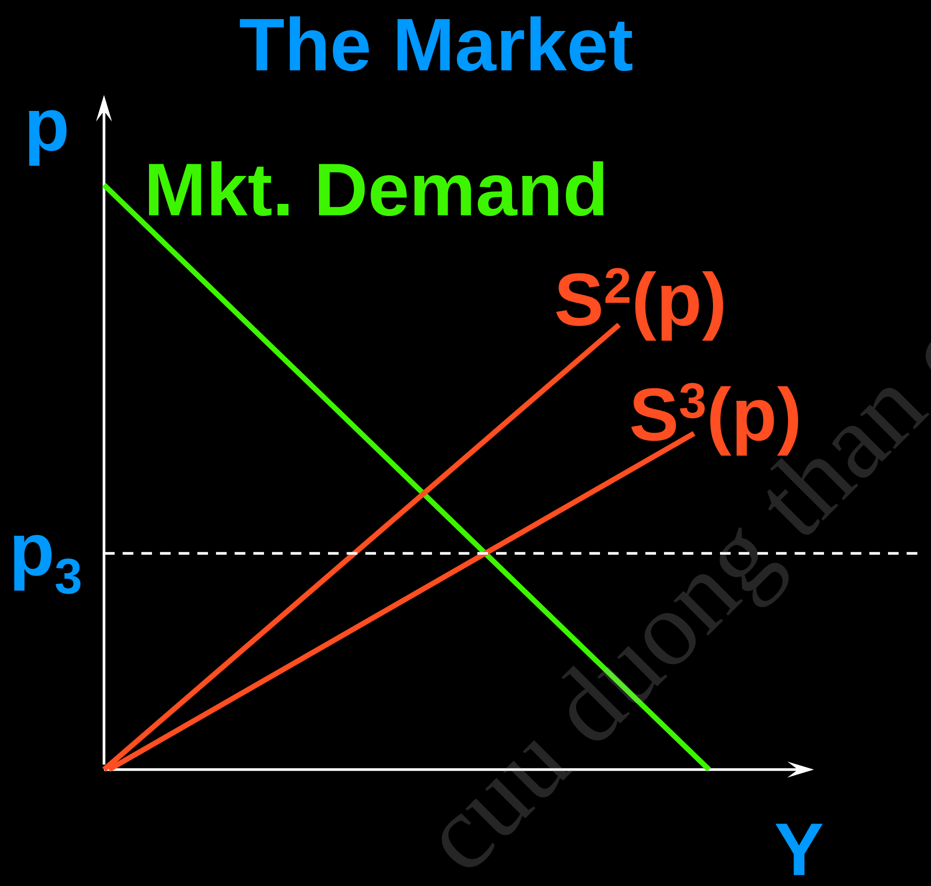
Long-Run Industry Supply

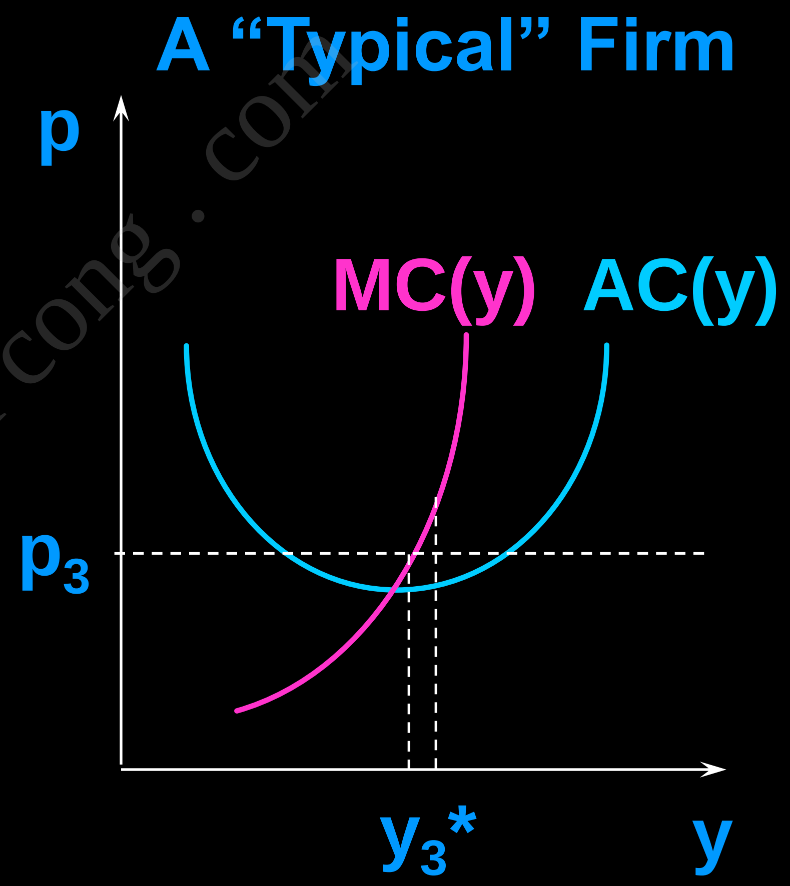


Market supply shifts outwards.

Market price falls.

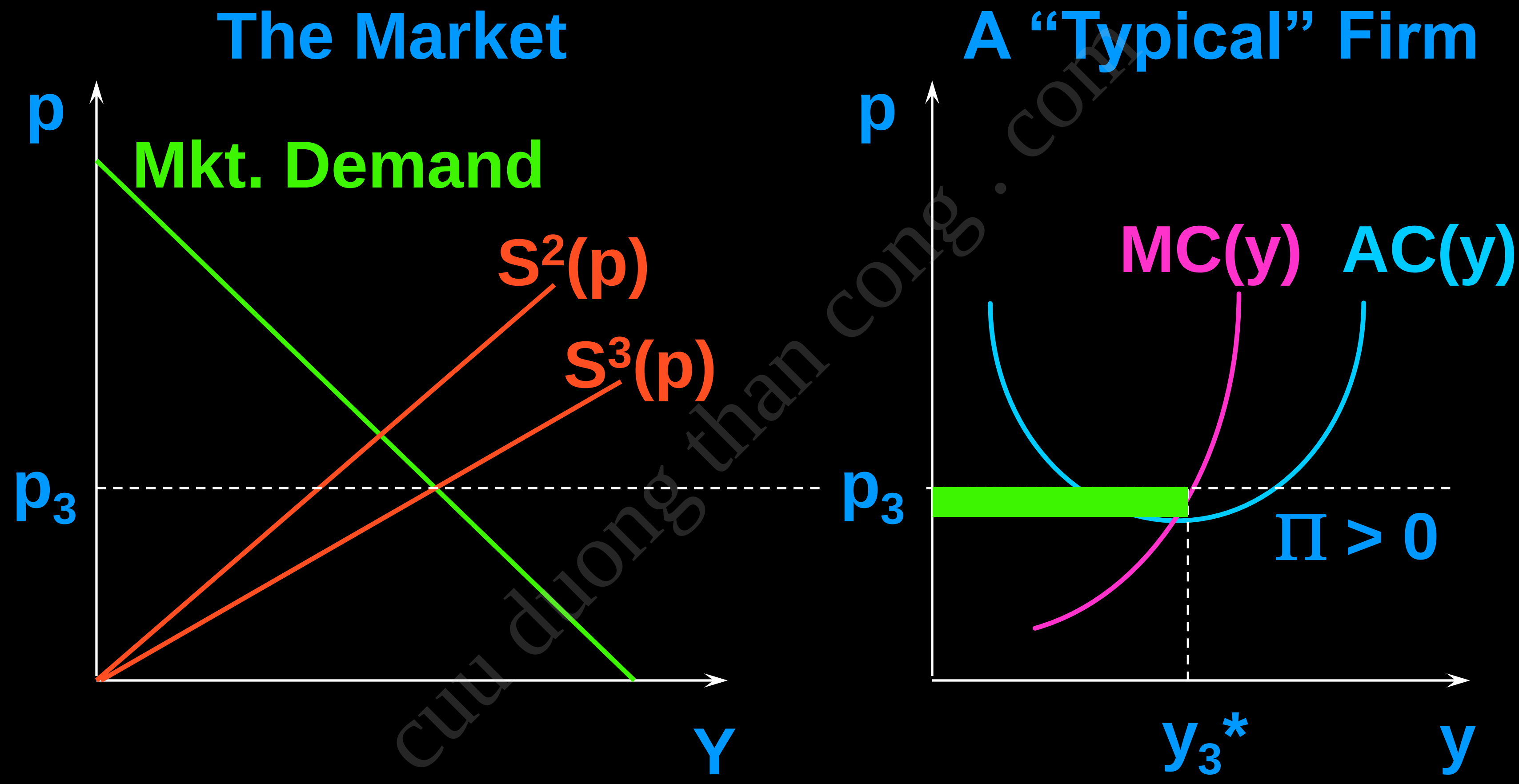
Long-Run Industry Supply





Each firm produces less.

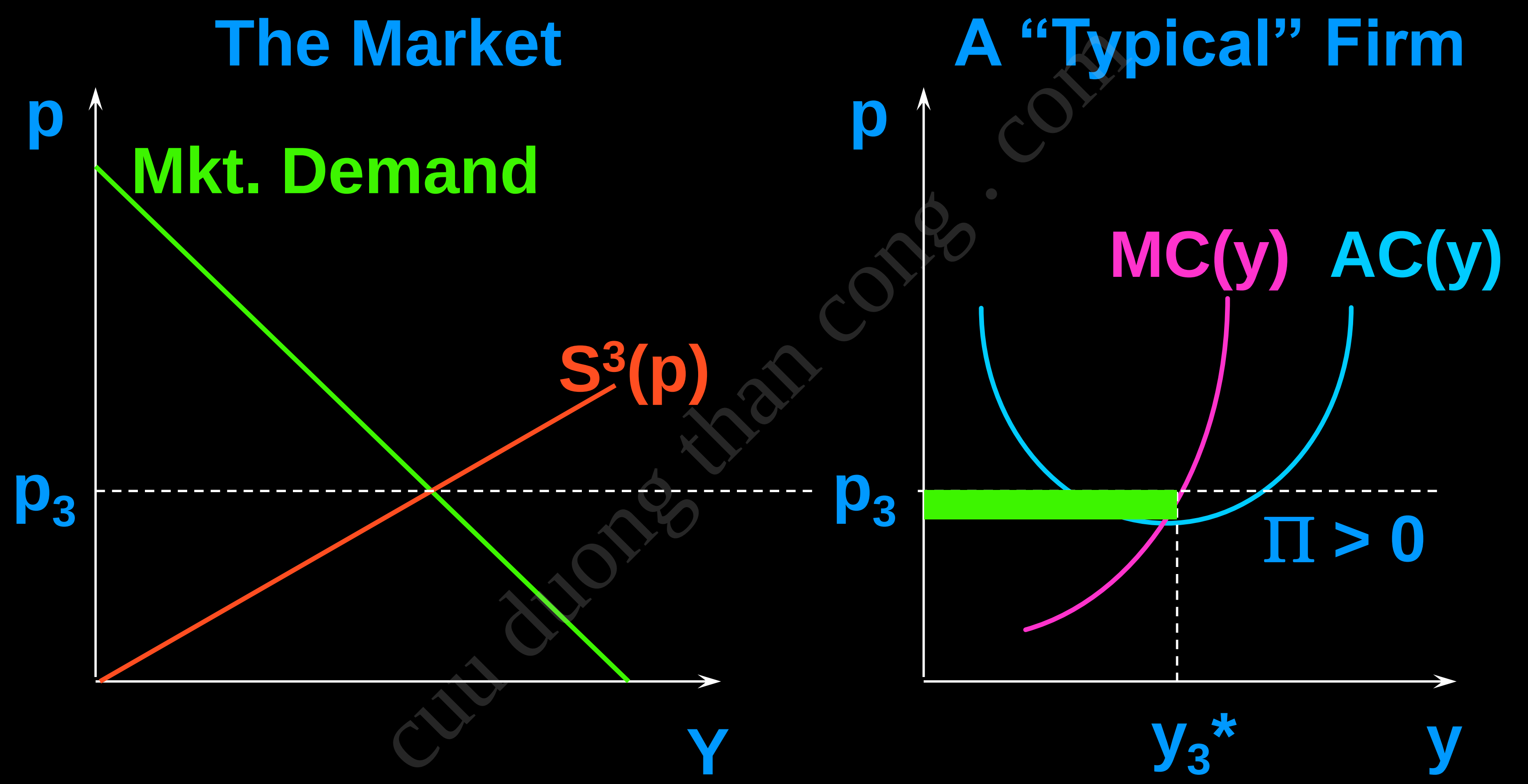
Long-Run Industry Supply



Each firm produces less.

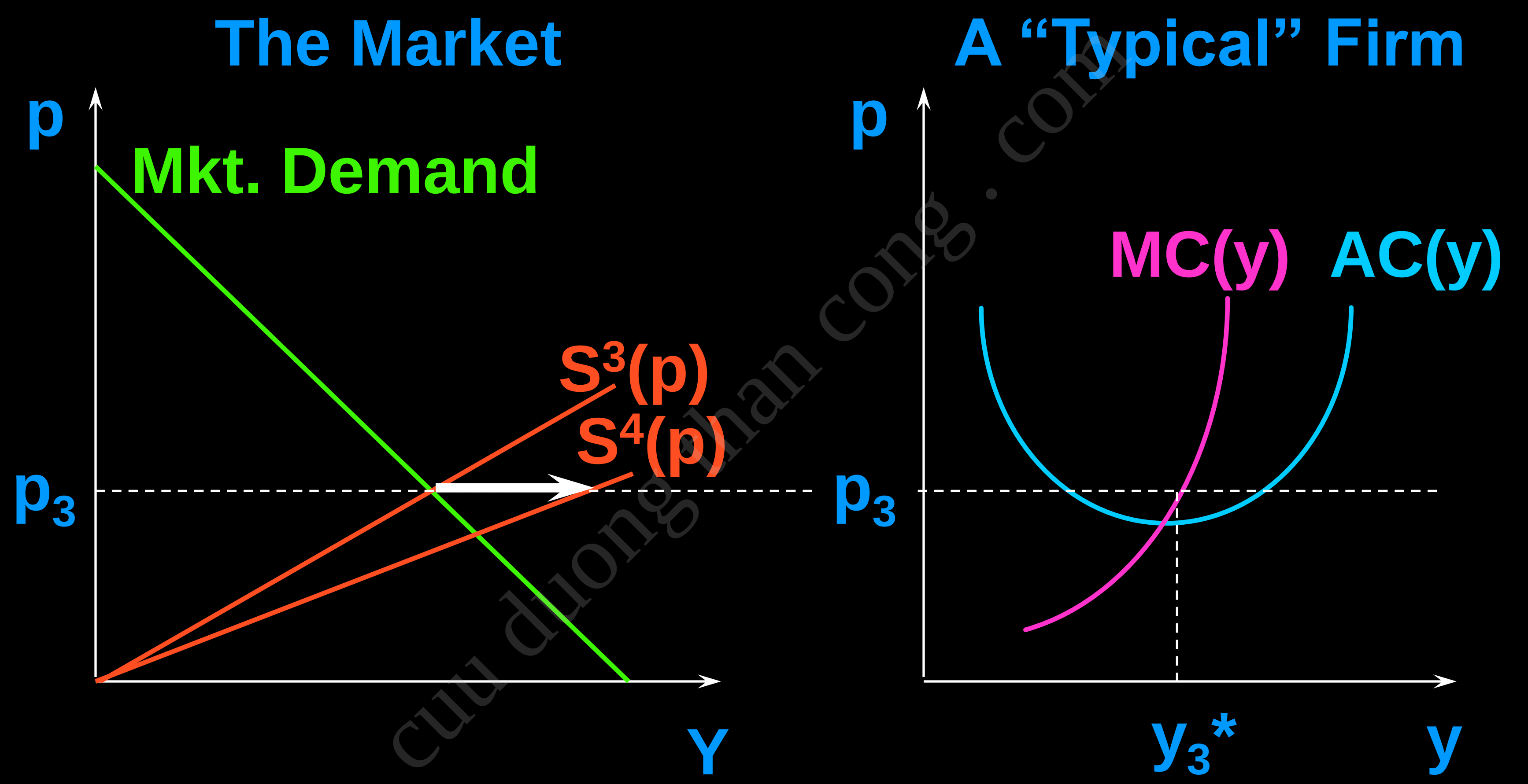
Each firm's economic profit is reduced.

Long-Run Industry Supply



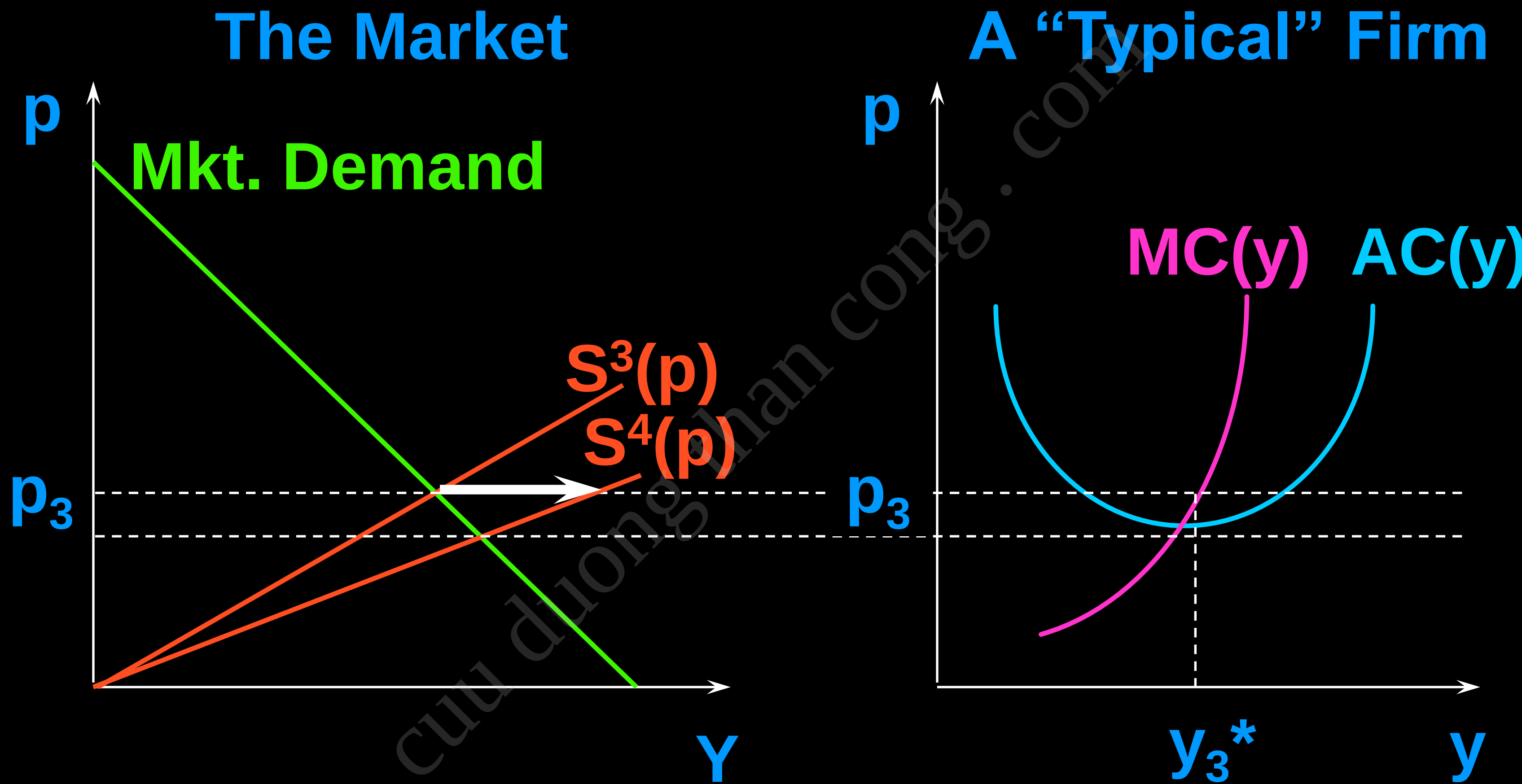
Each firm's economic profit is positive.
Will another firm enter?

Long-Run Industry Supply



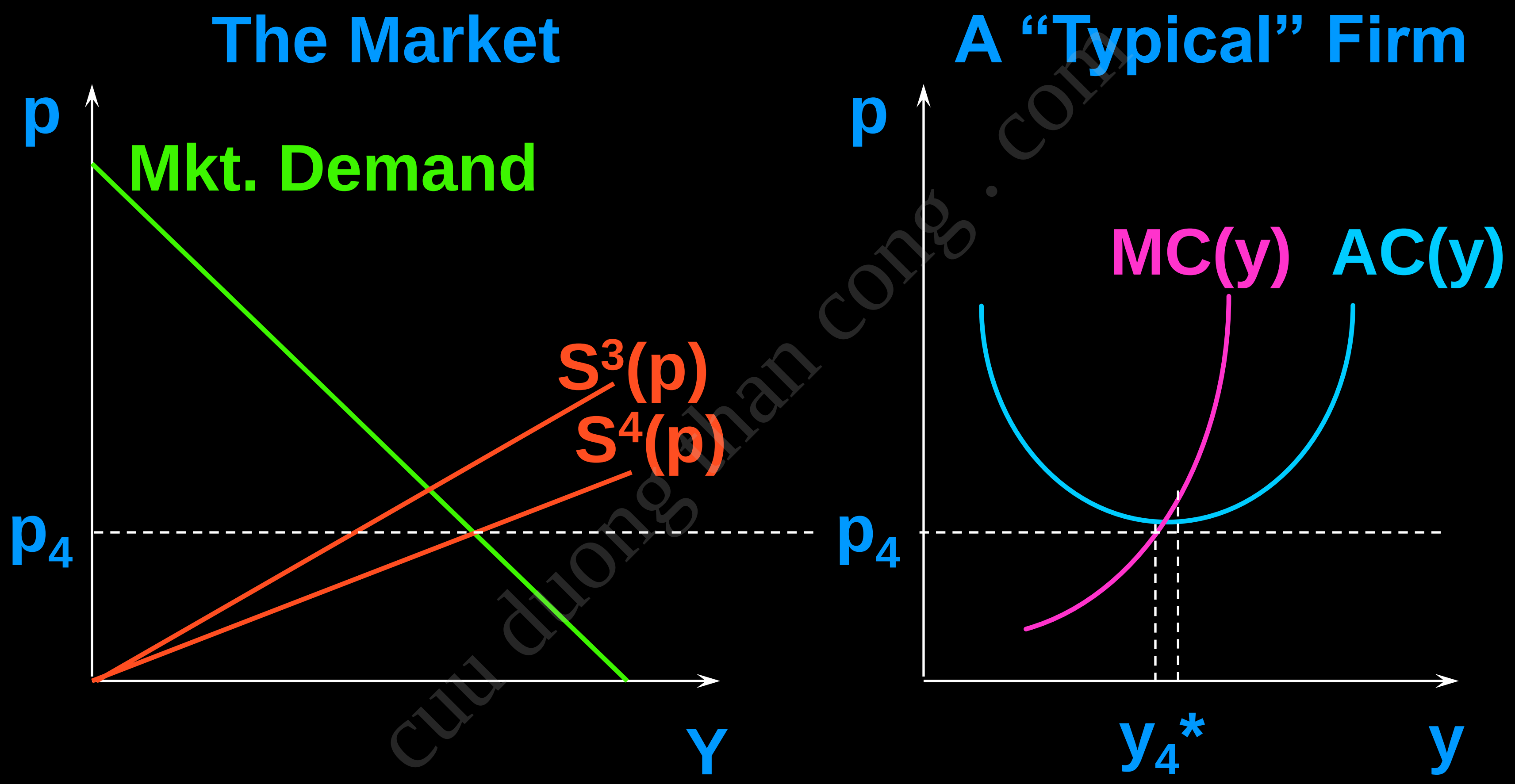
Market supply would shift outwards again.

Long-Run Industry Supply



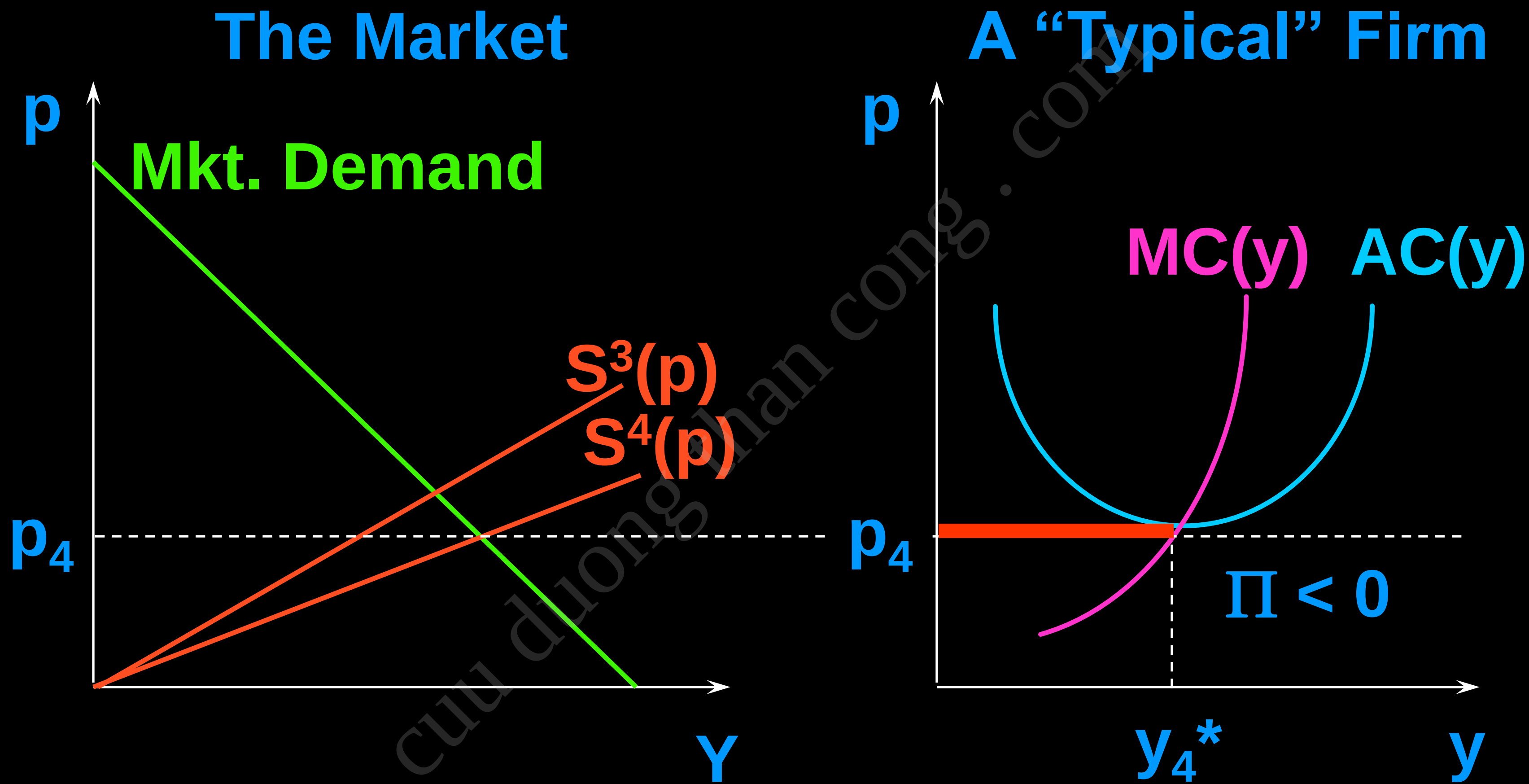
Market supply would shift outwards again.
Market price would fall again.

Long-Run Industry Supply



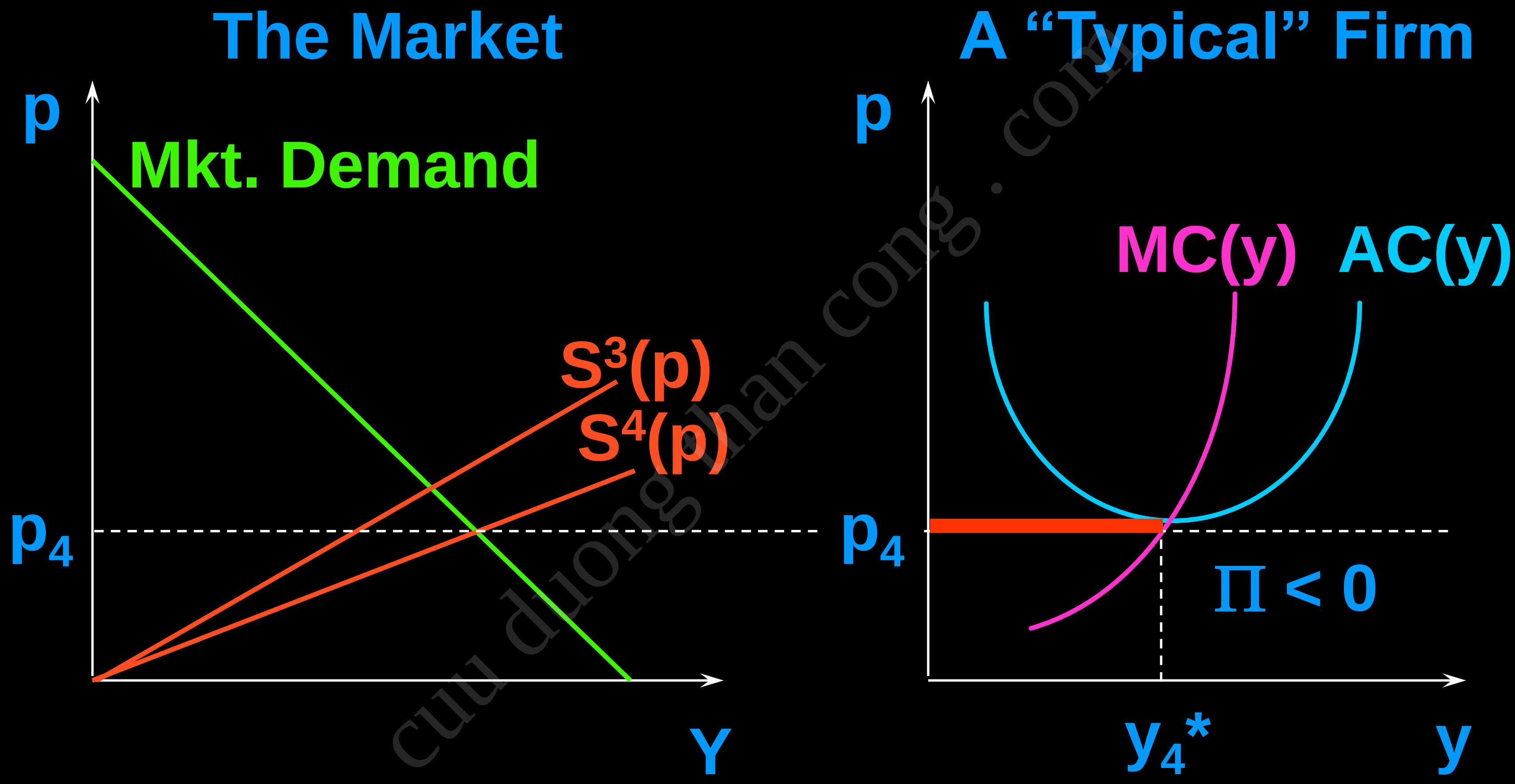
Each firm would produce less again.

Long-Run Industry Supply



Each firm would produce less again. Each firm's economic profit would be negative.

Long-Run Industry Supply



Each firm would produce less again. Each firm’s economic profit would be negative. So the fourth firm would not enter.

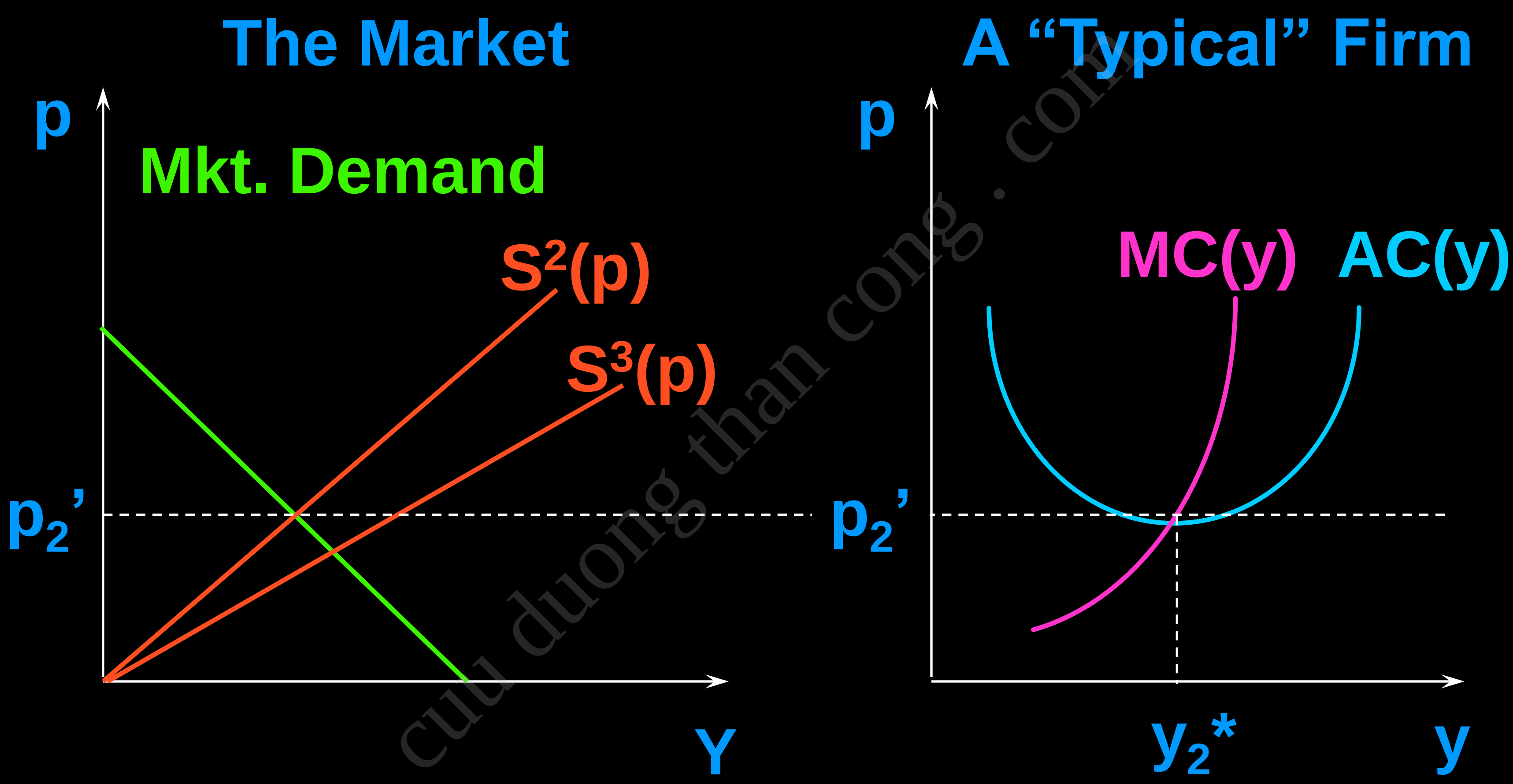
Long-Run Industry Supply

- 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).
- Now we can construct the industry's long-run supply curve.

Long-Run Industry Supply

- **Suppose that market demand is large enough to sustain only two firms in the industry.**

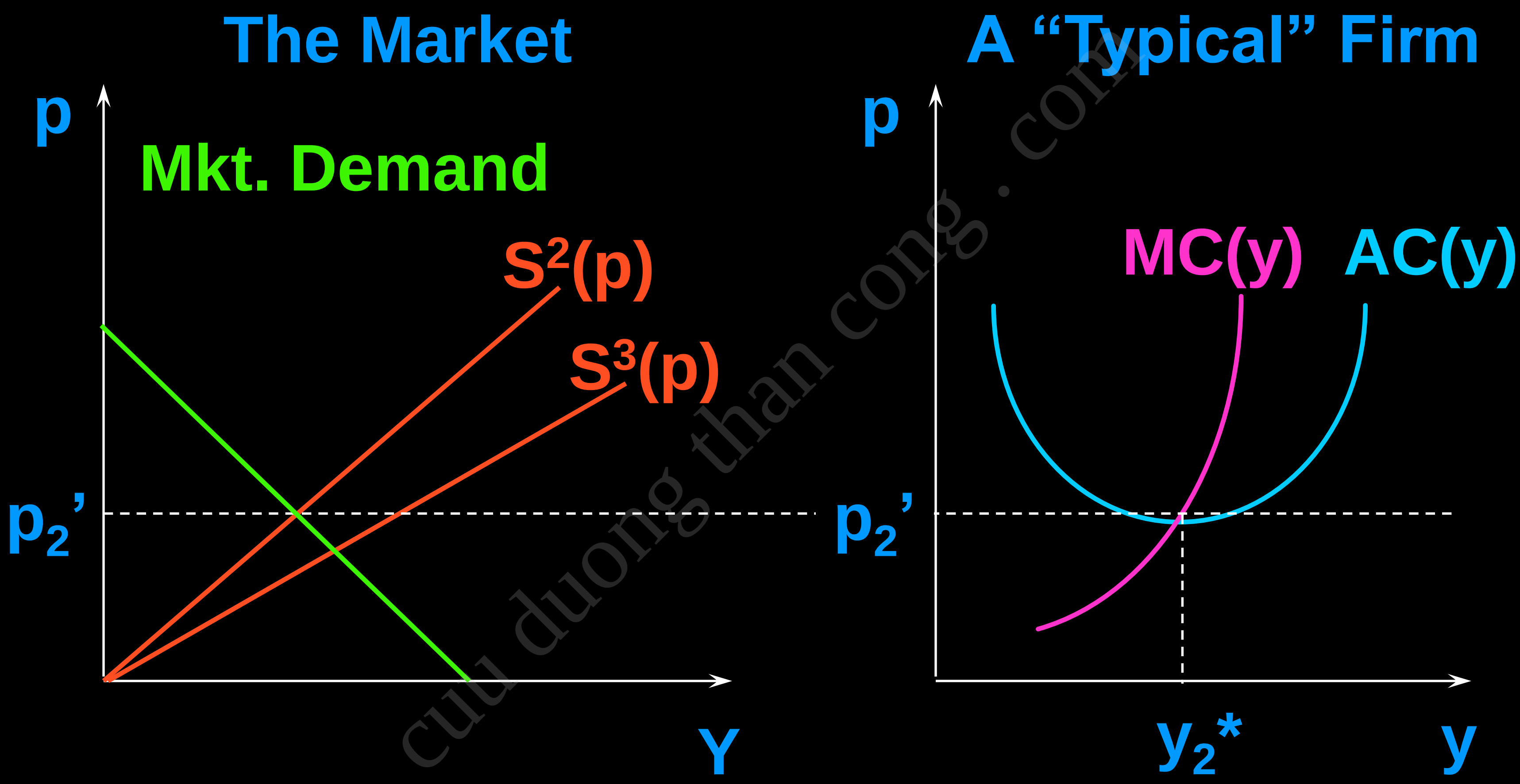
Long-Run Industry Supply



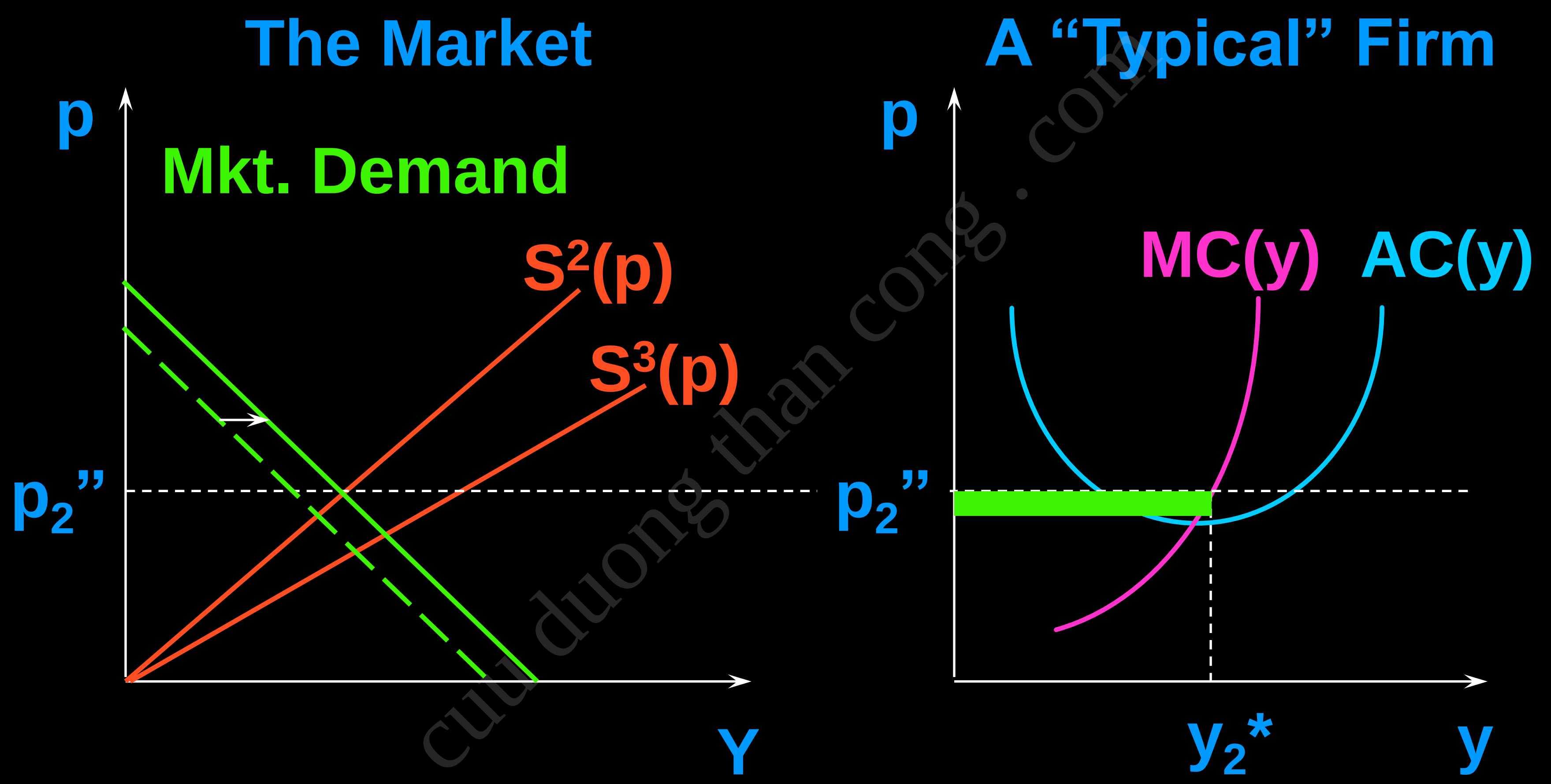
Long-Run Industry Supply

- Suppose that market demand is large enough to sustain only two firms in the industry.
- Then market demand increases, the market price rises, each firm produces more, and earns a higher economic profit.

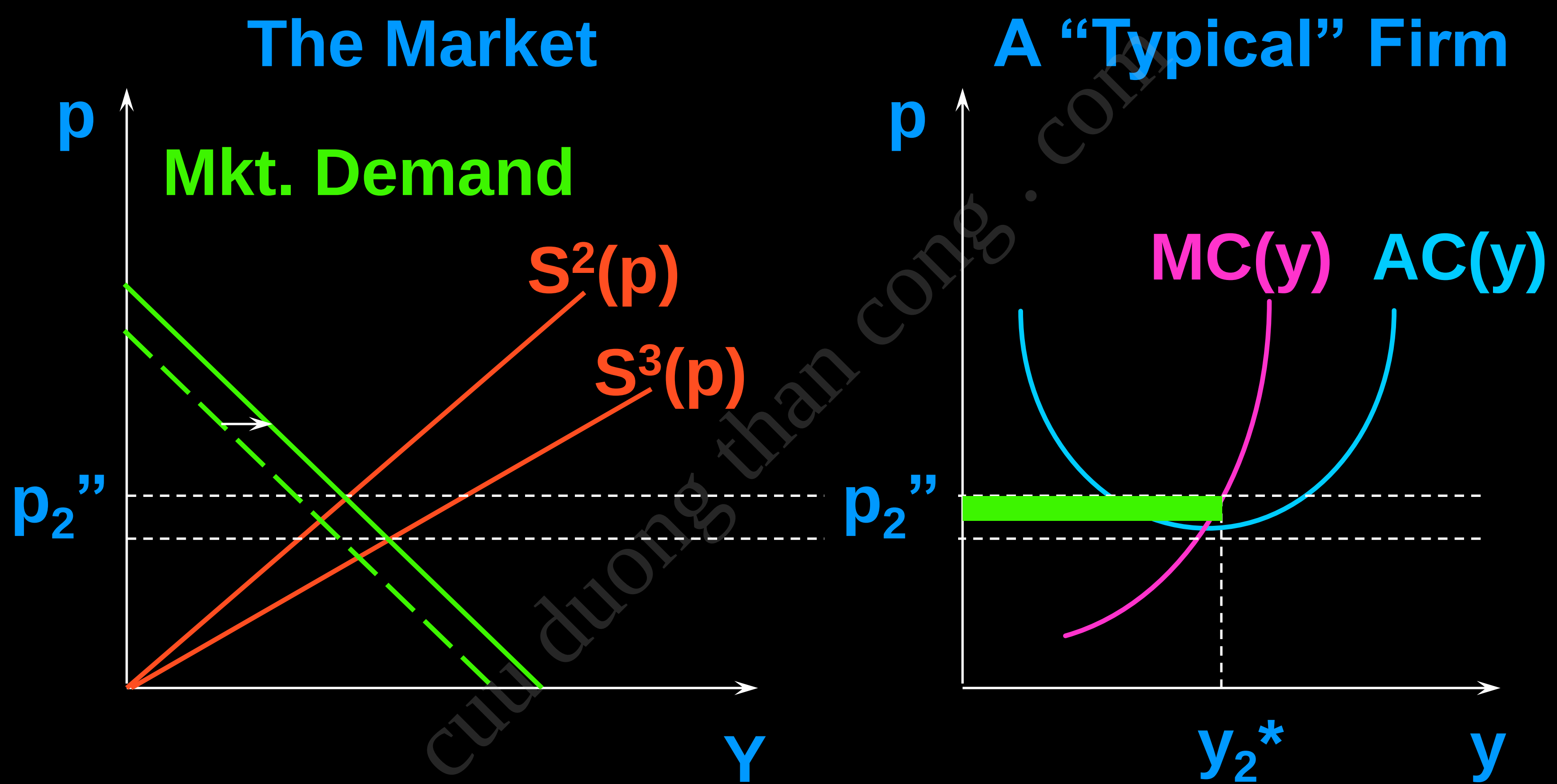
Long-Run Industry Supply



Long-Run Industry Supply



Long-Run Industry Supply

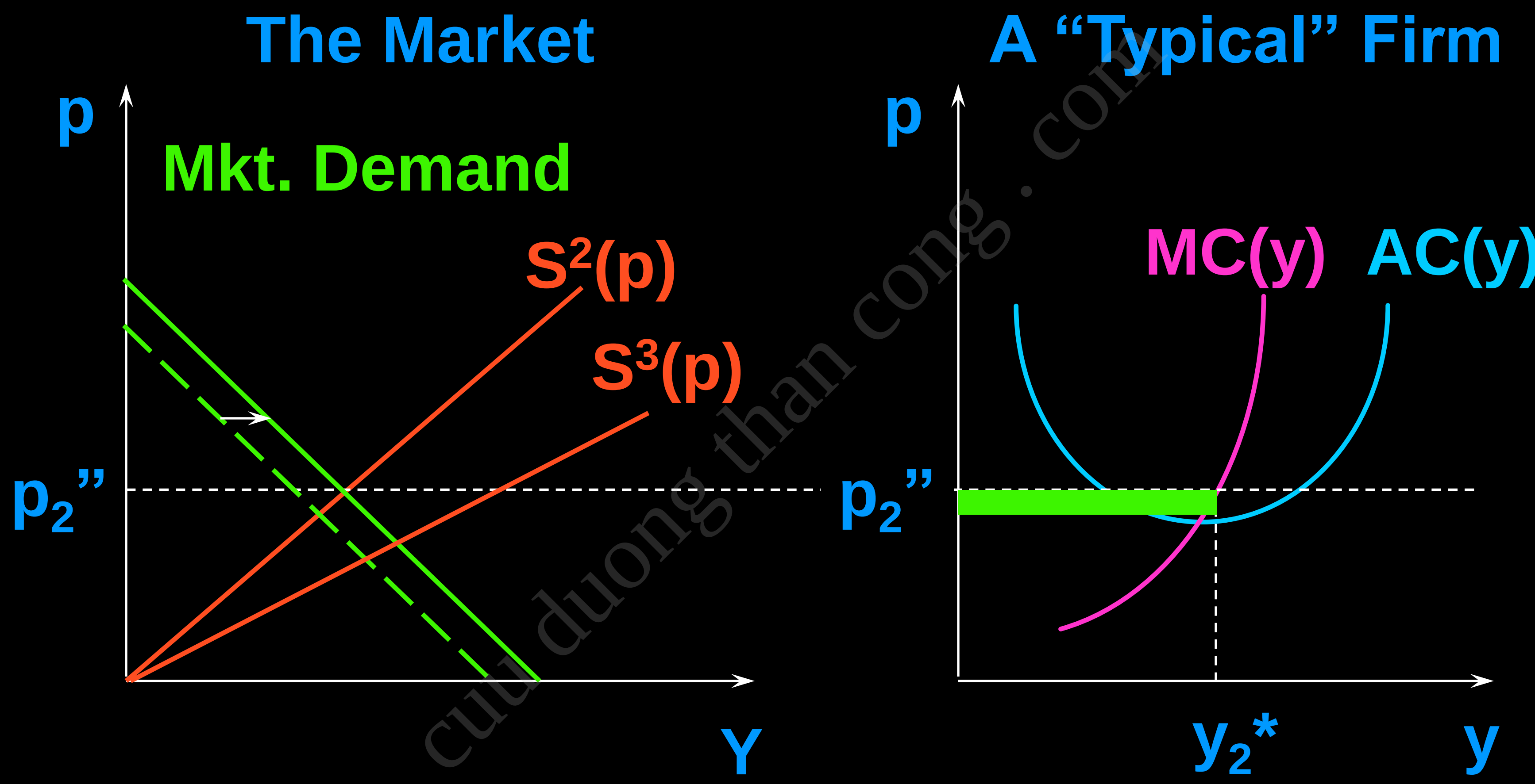


Notice that a 3rd firm will not enter since it would earn negative economic profits.

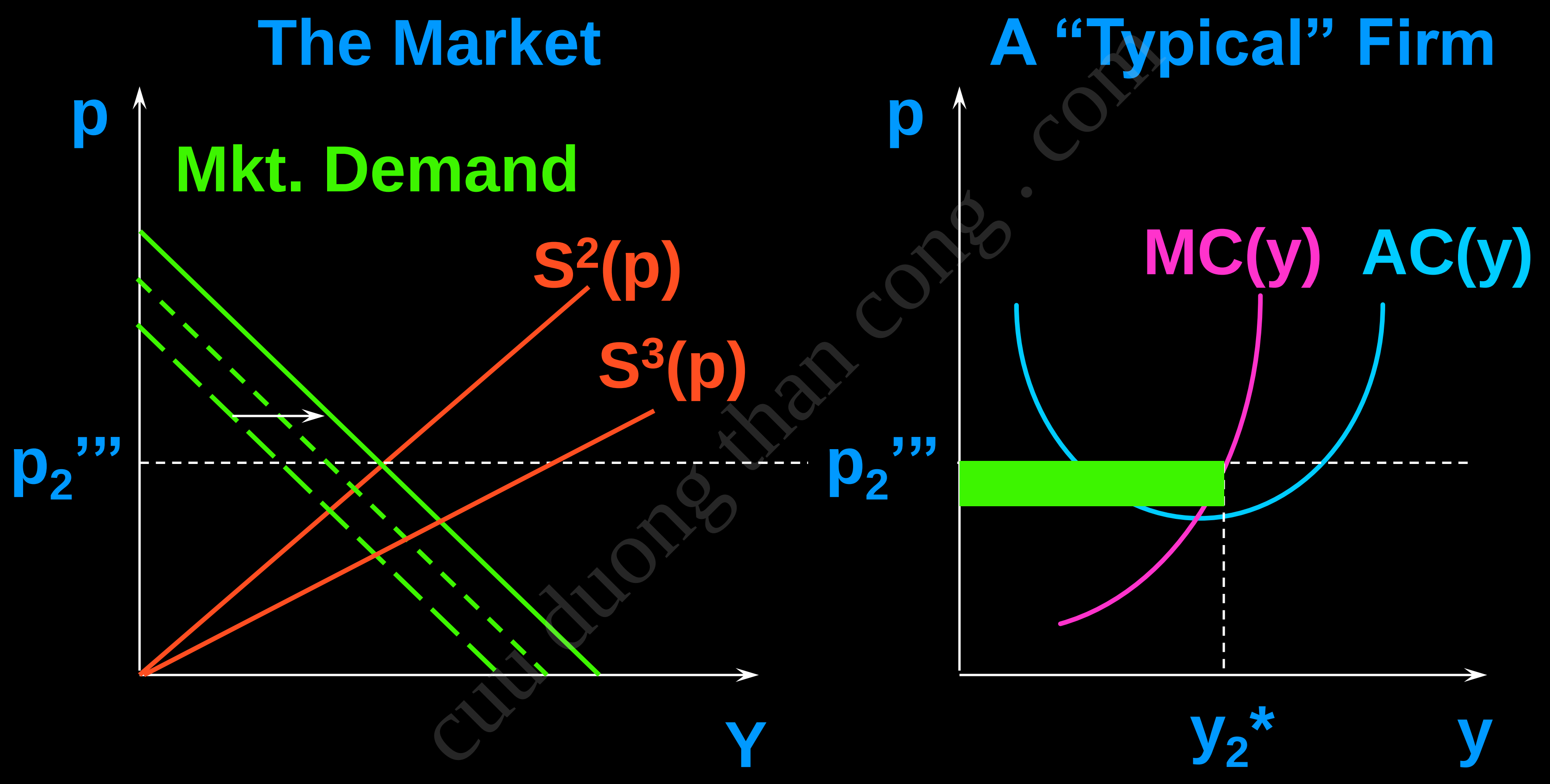
Long-Run Industry Supply

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

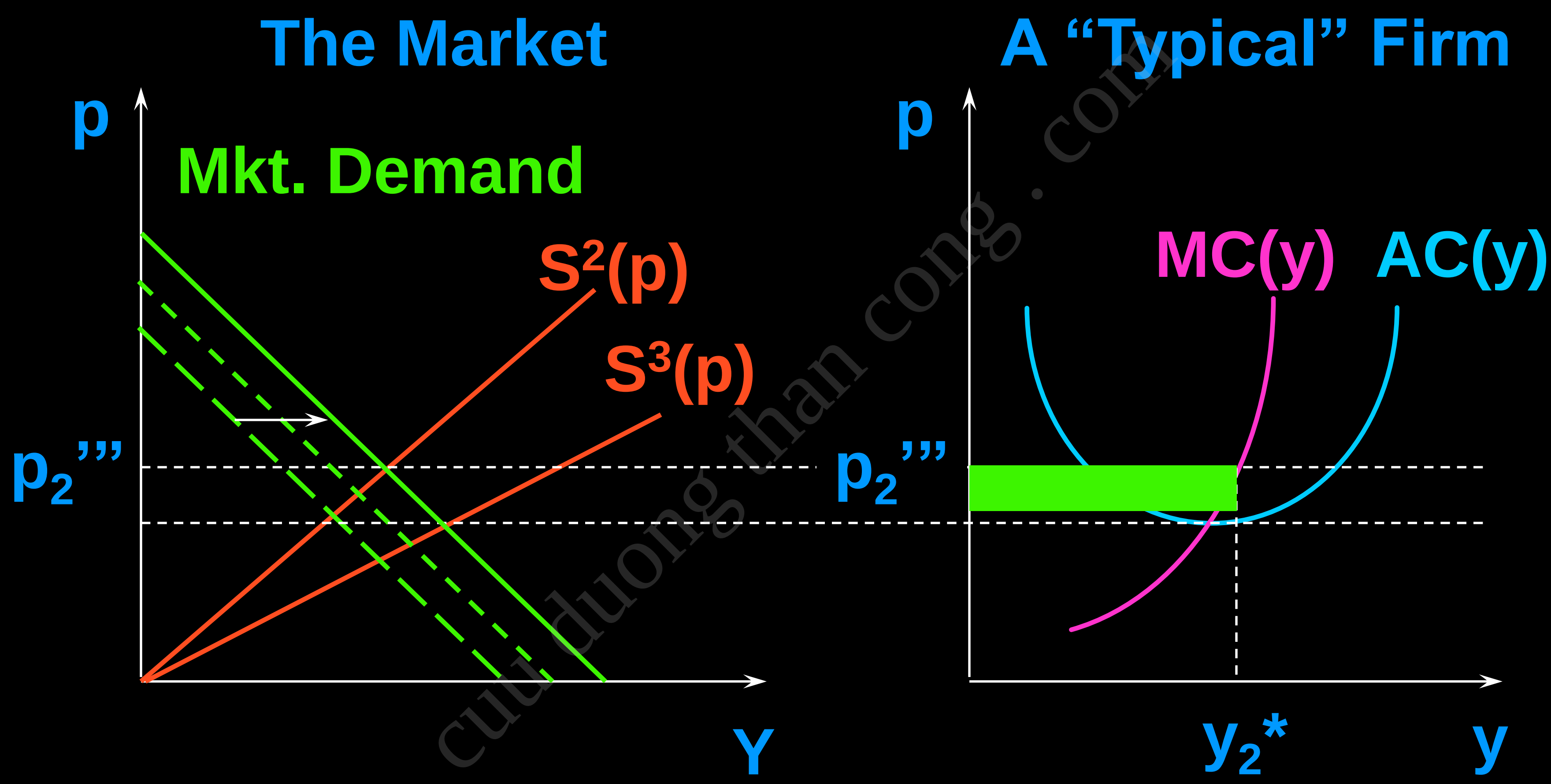
Long-Run Industry Supply



Long-Run Industry Supply



Long-Run Industry Supply

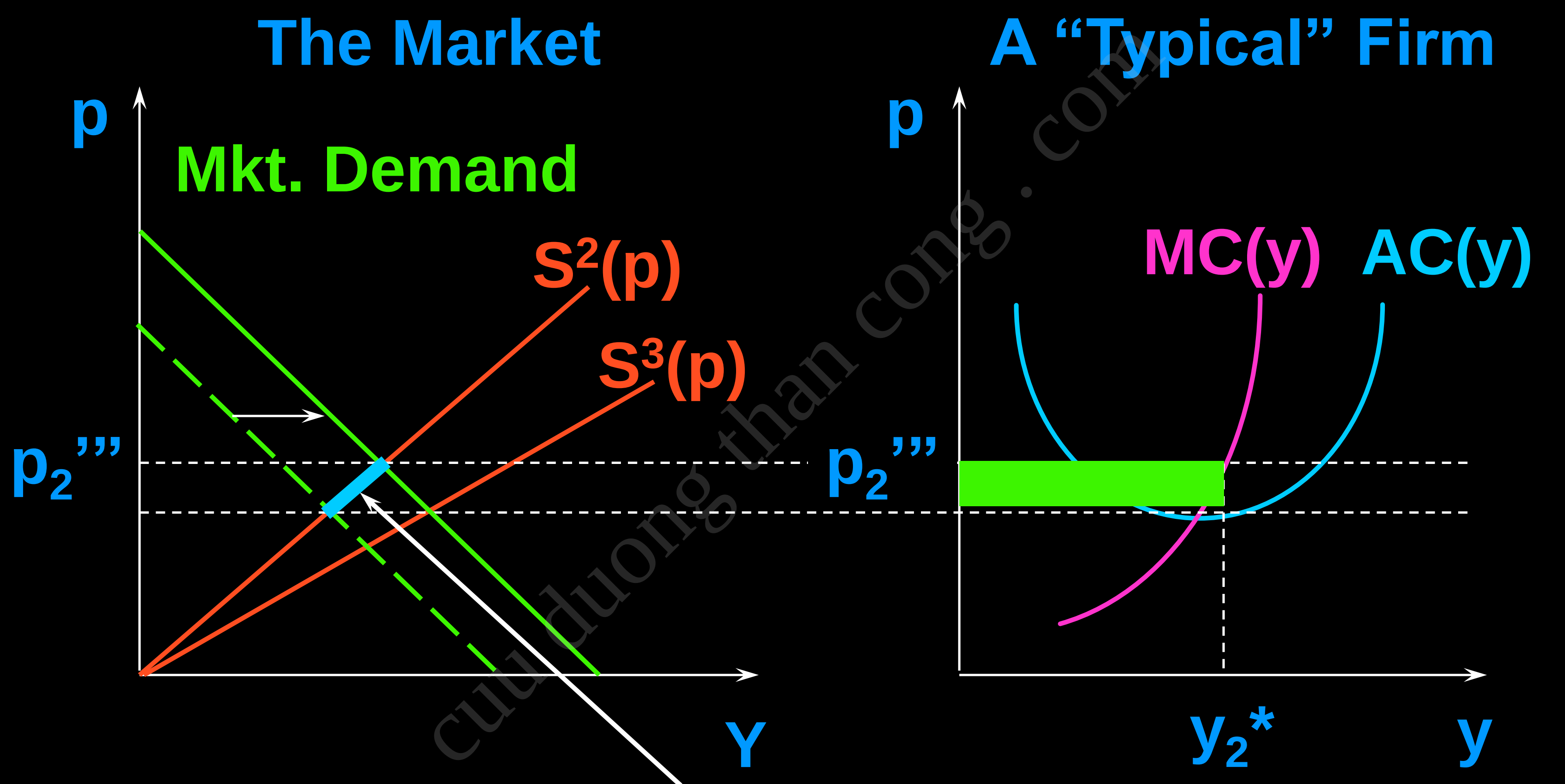


A third firm can now enter, causing all firms to earn zero economic profits.

Long-Run Industry Supply

- So any further increase in market demand will cause the number of firms in the industry to rise to three.

Long-Run Industry Supply

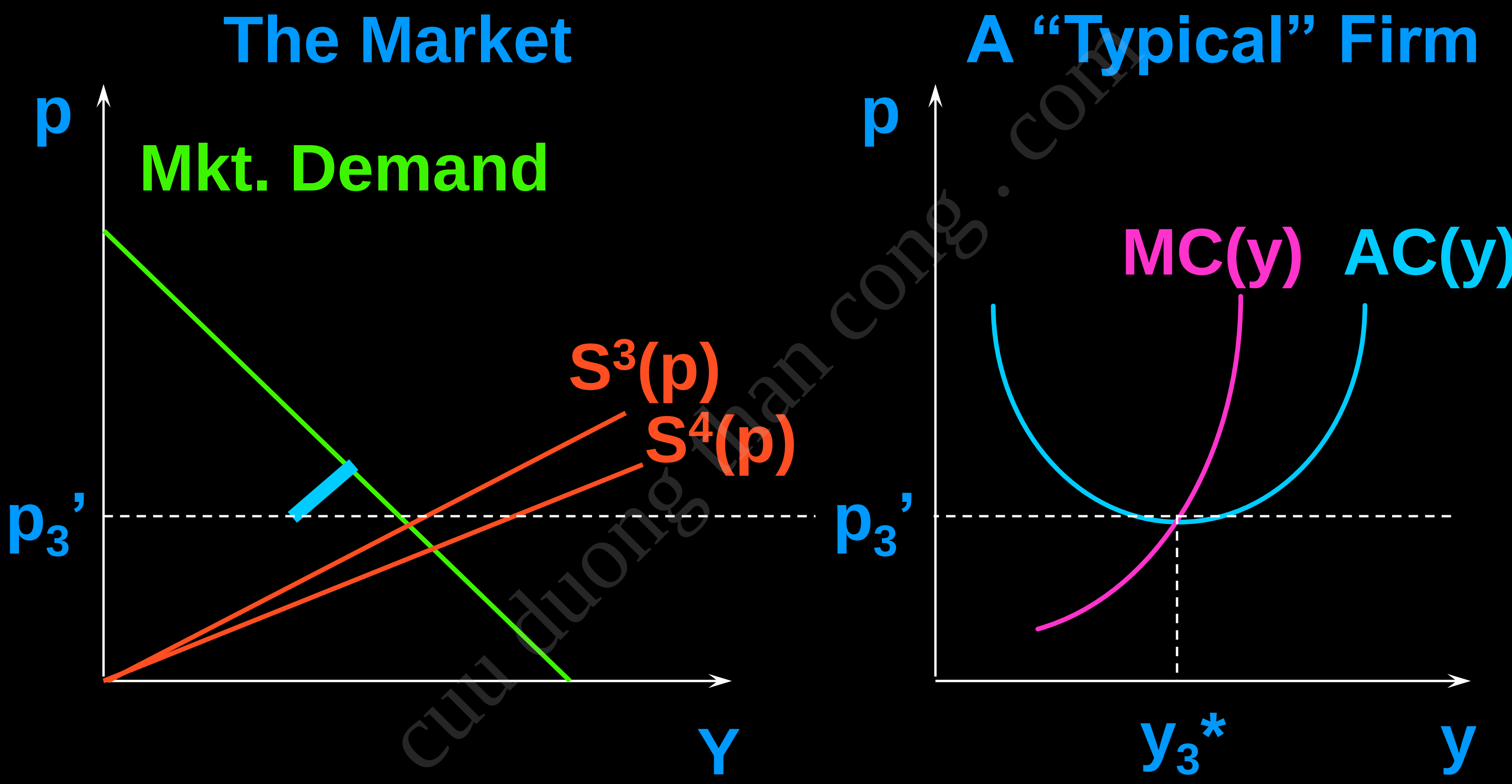


The only relevant part of the short-run supply curve for n = 2 firms in the industry.

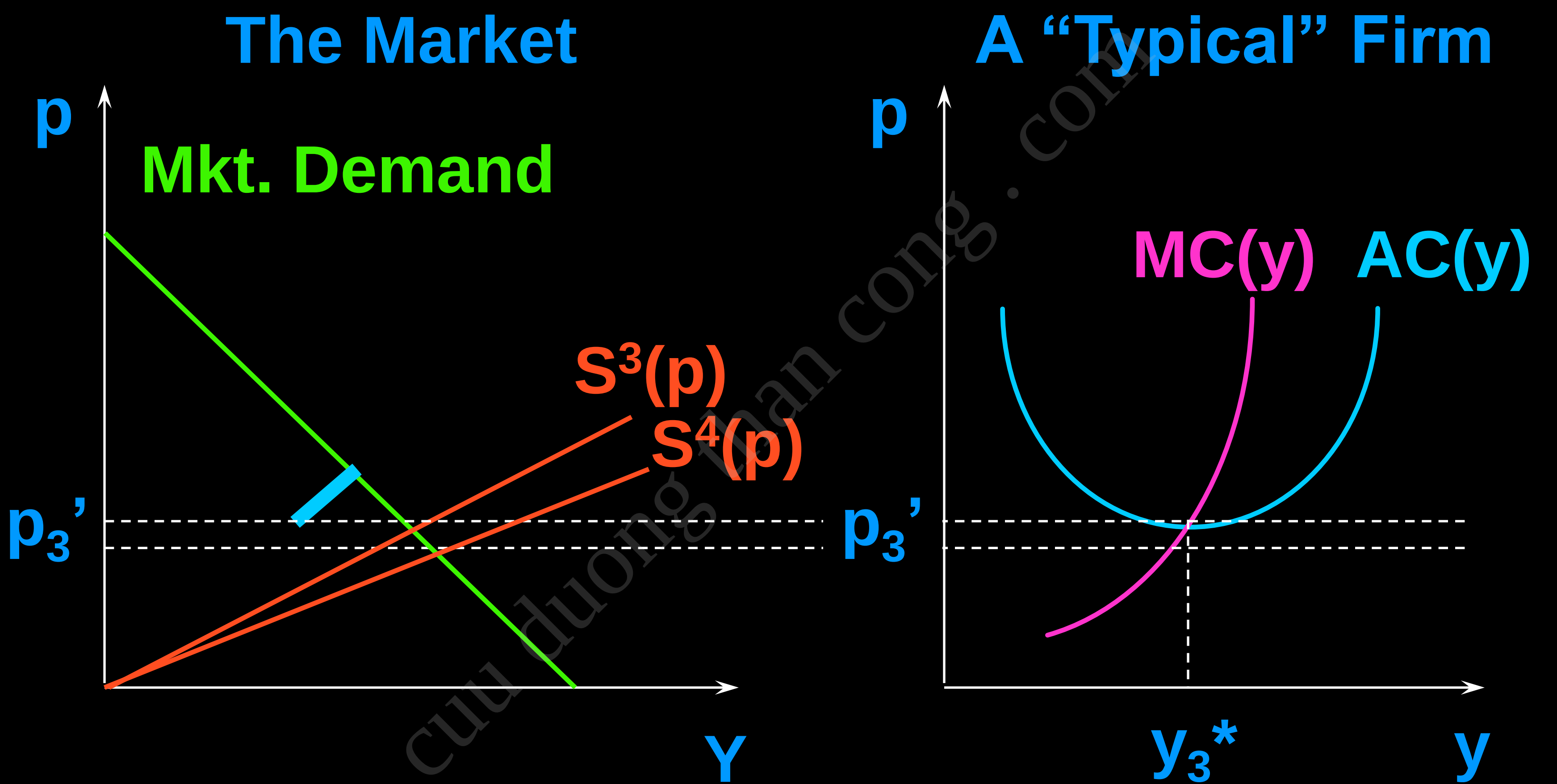
Long-Run Industry Supply

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

Long-Run Industry Supply

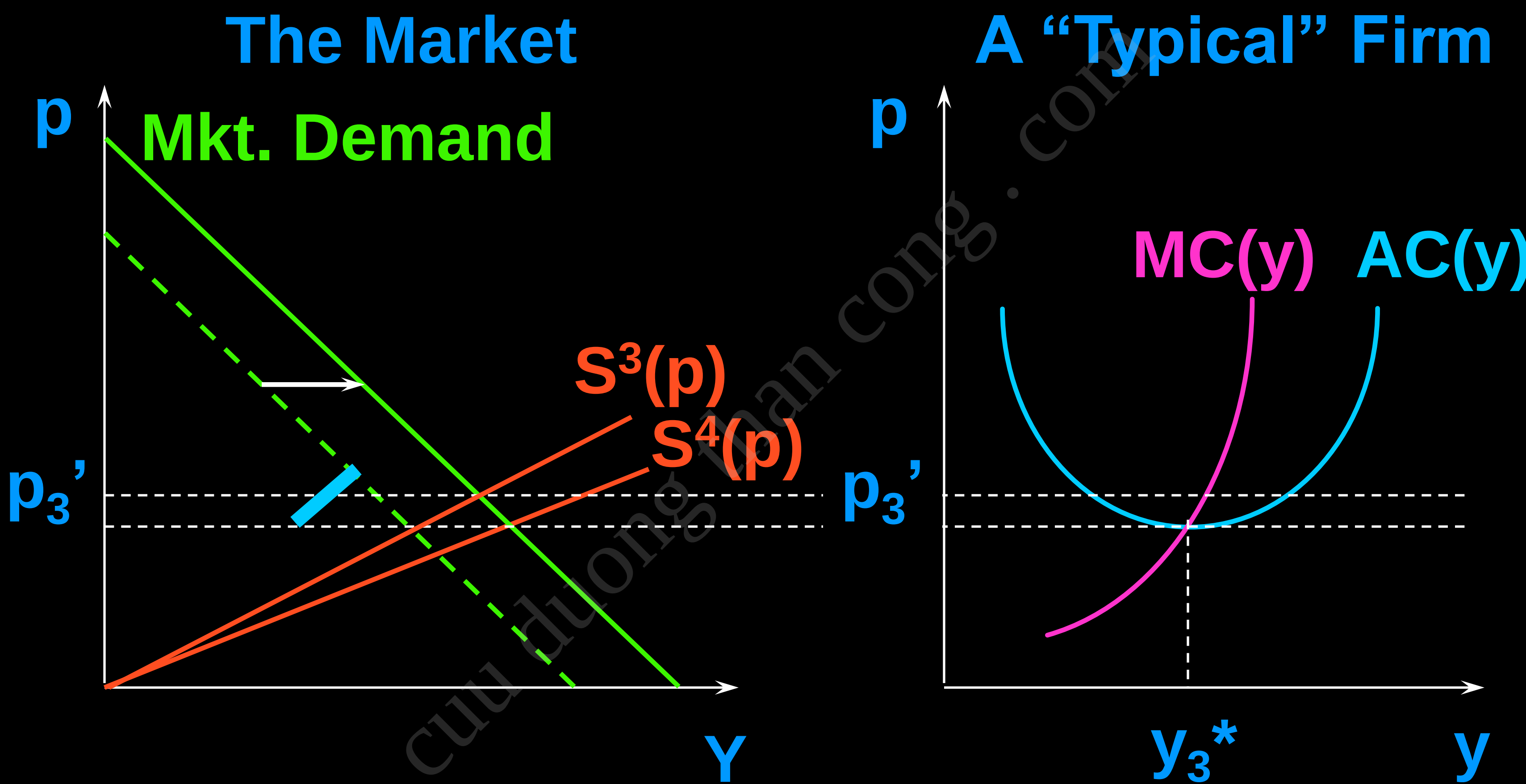


Long-Run Industry Supply



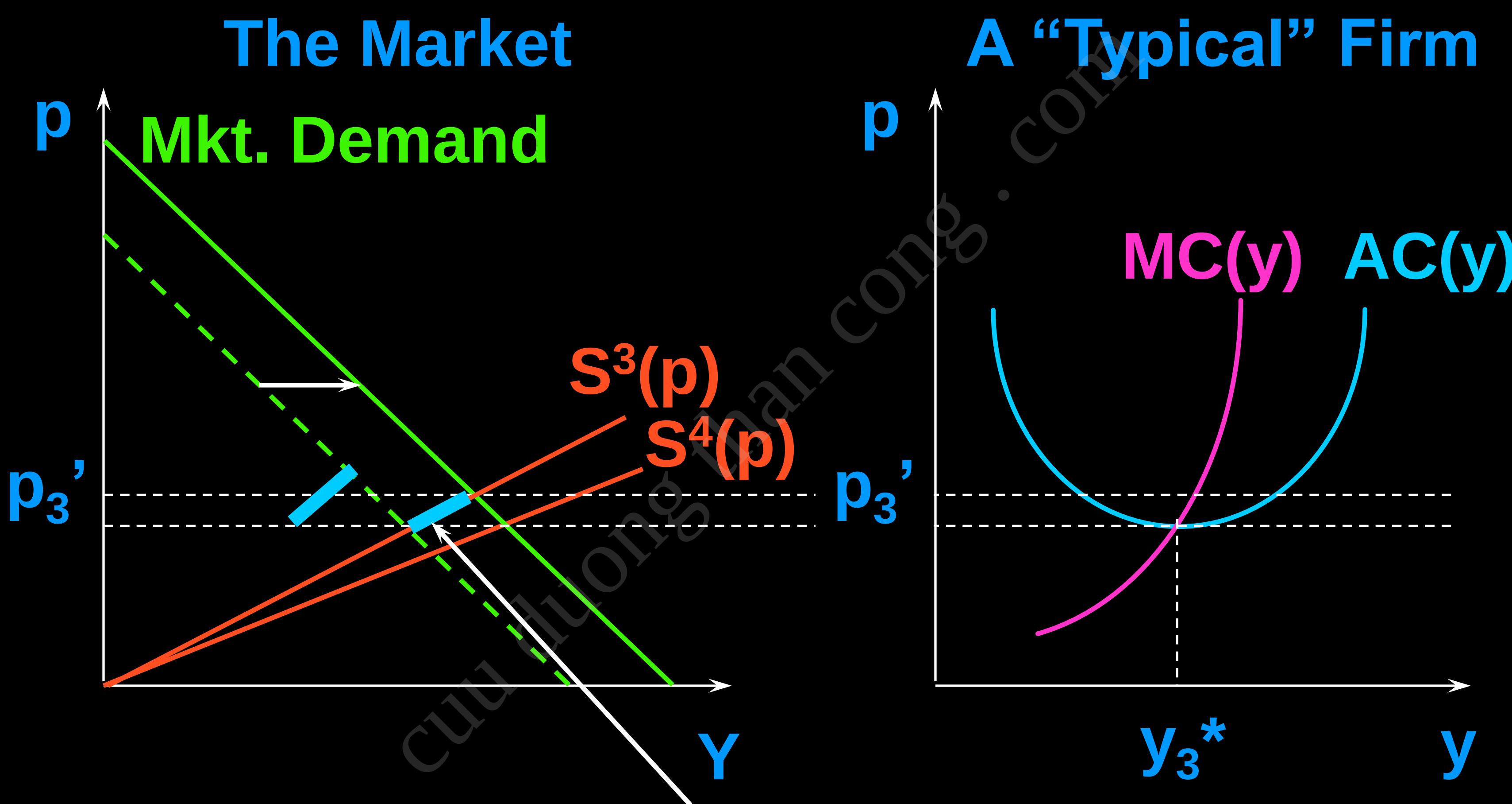
A 4th firm would now earn negative economic profits if it entered the industry.

Long-Run Industry Supply



But now a 4th firm would earn zero economic profit if it entered the industry.

Long-Run Industry Supply

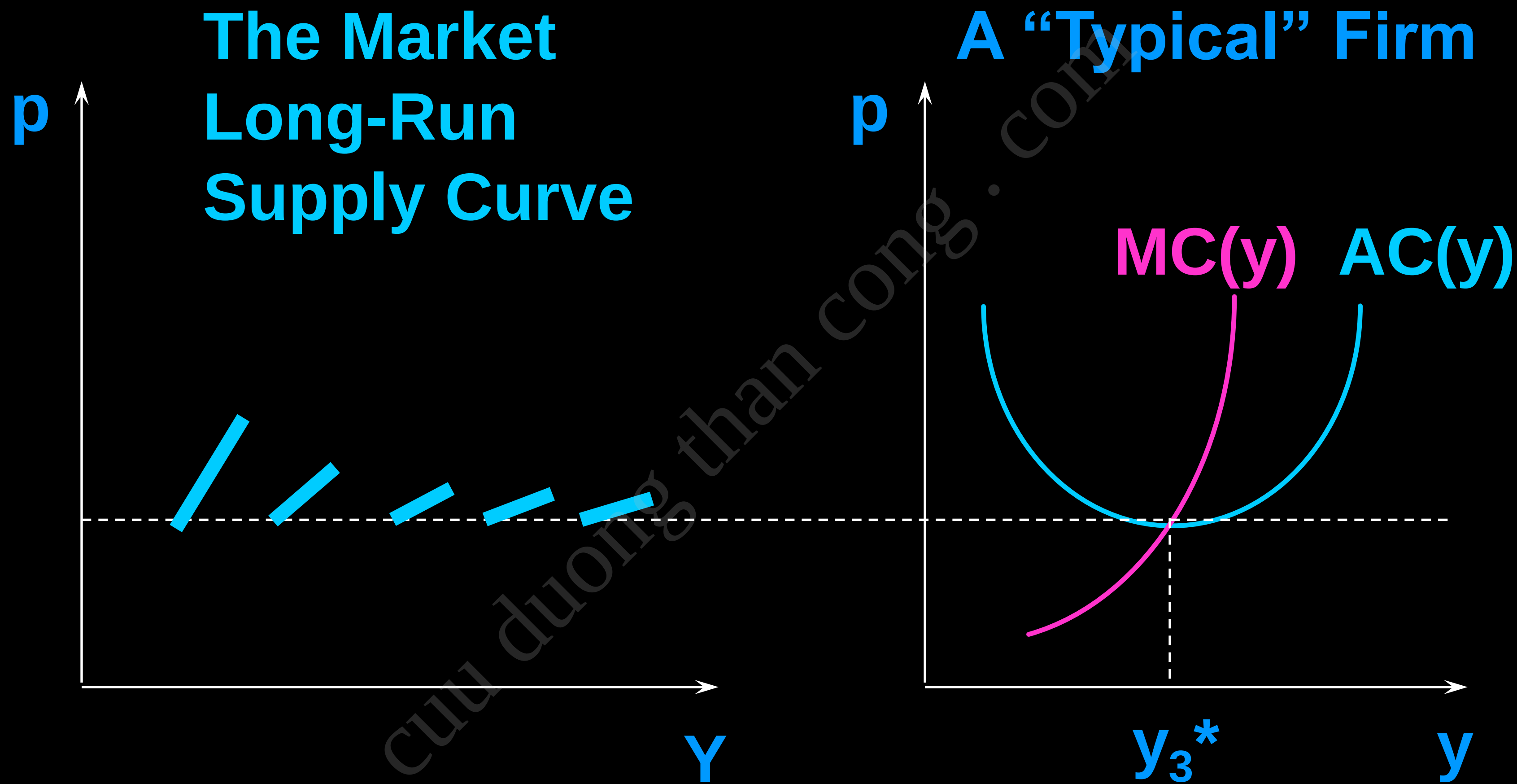


The only relevant part of the short-run supply curve for n = 3 firms in the industry.

Long-Run Industry Supply

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

Long-Run Industry Supply

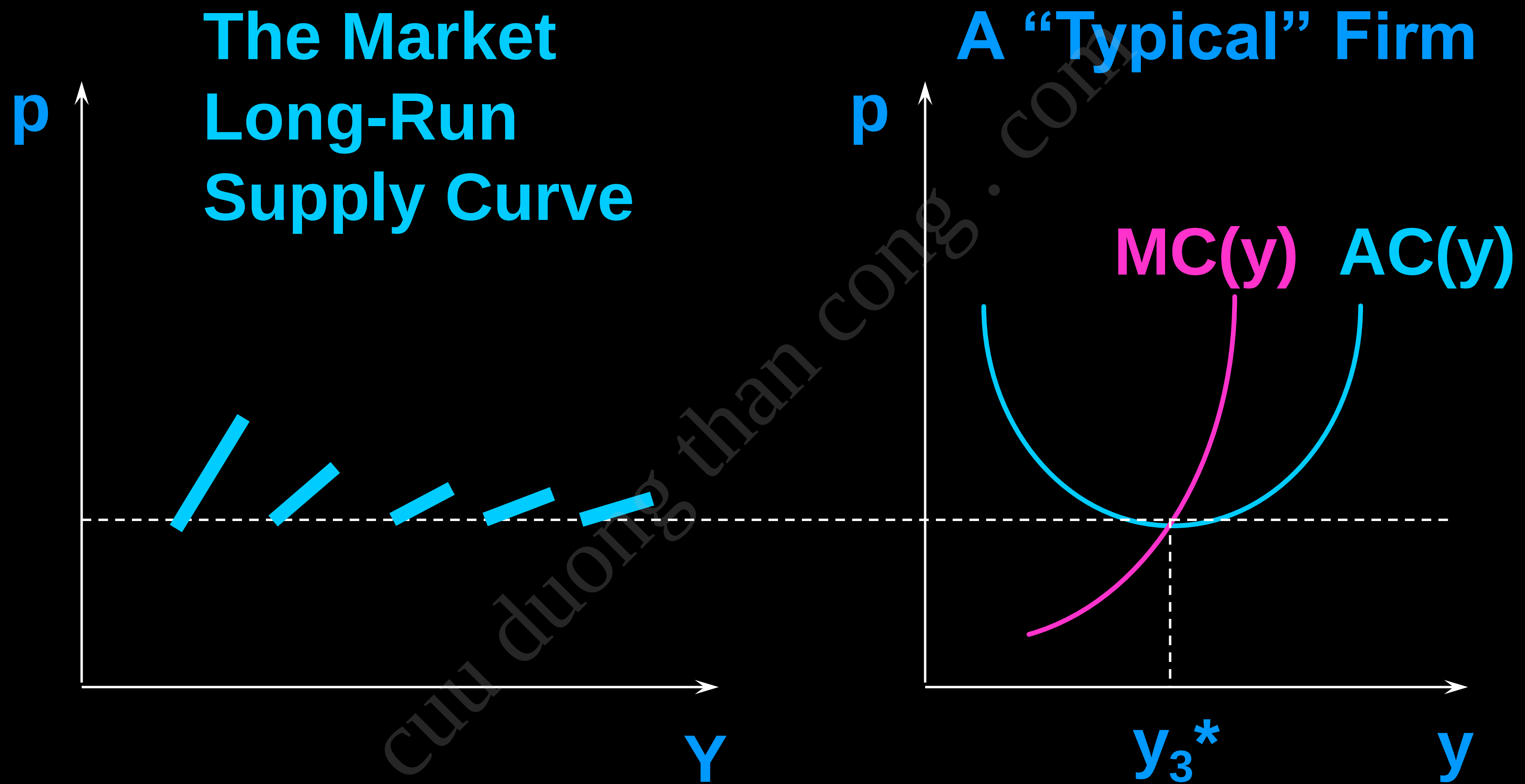


Notice that the bottom of each segment of the supply curve is min AC(y).

Long-Run Industry Supply

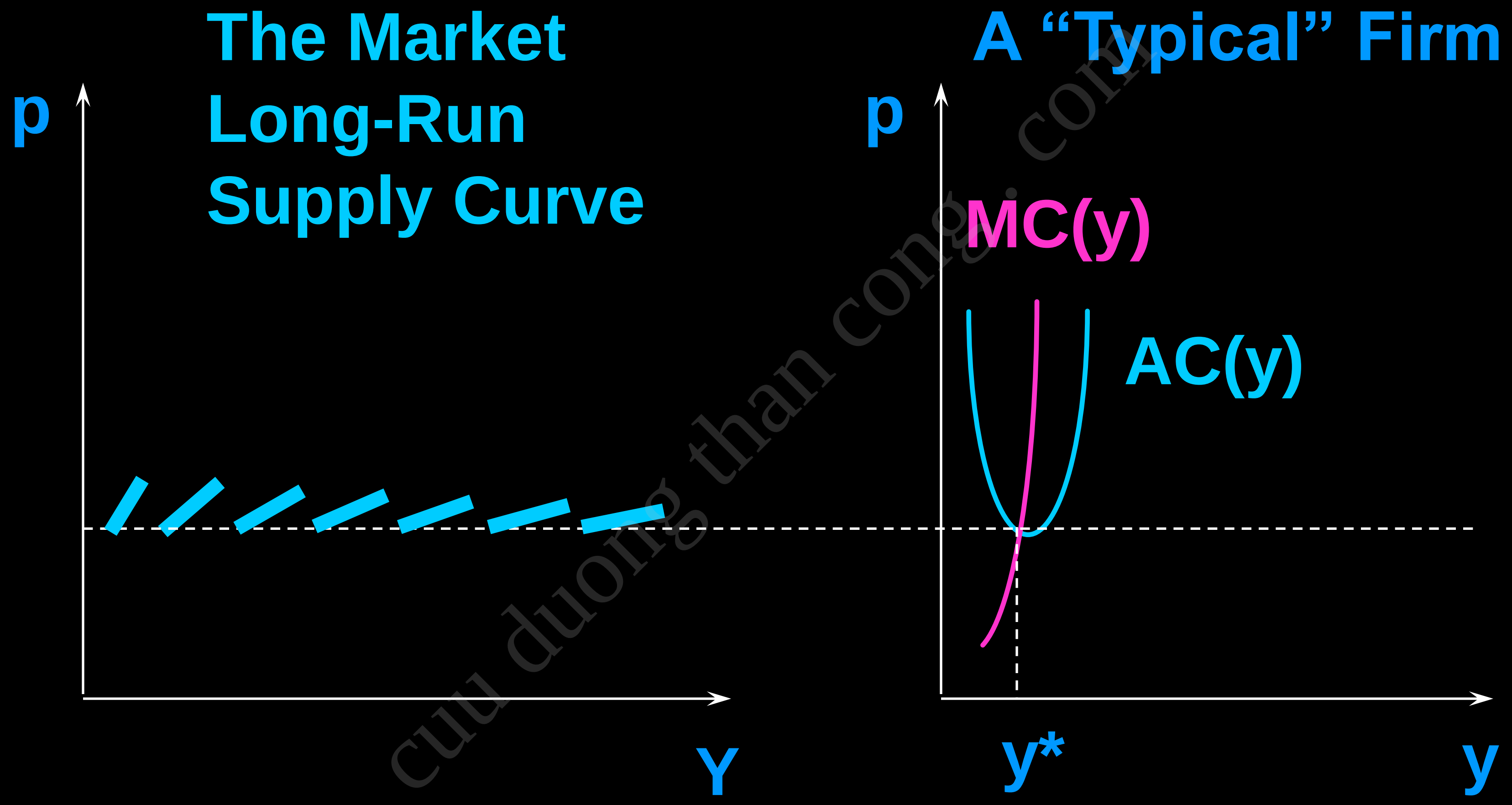
- **As each firm gets "smaller" relative to the industry, the long-run industry supply curve approaches a horizontal line at the height of min AC(y).**

Long-Run Industry Supply



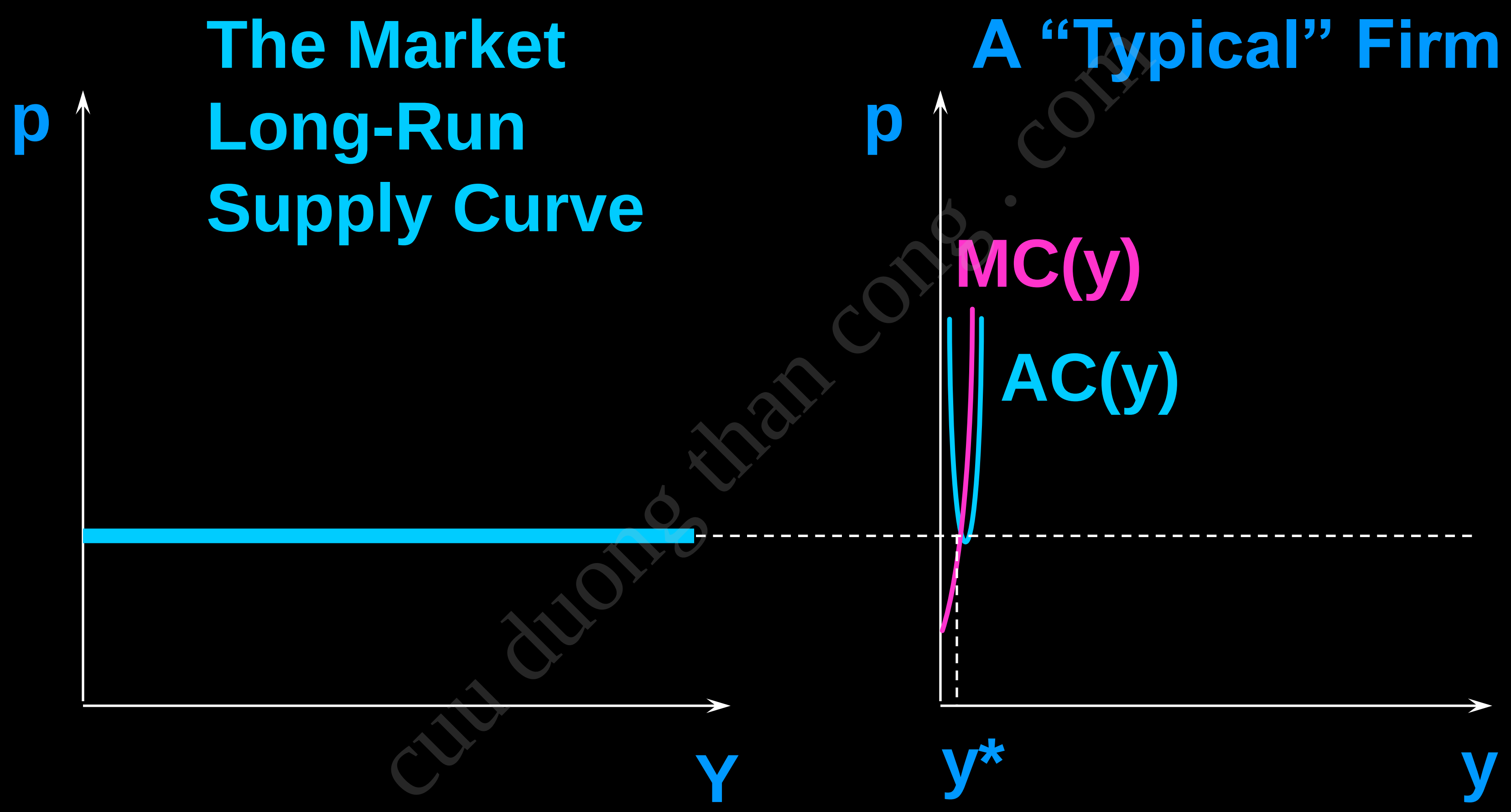
Notice that the bottom of each segment of the supply curve is min AC(y).

Long-Run Industry Supply



The bottom of each segment of the supply curve is min AC(y). As firms get "smaller" the segments get shorter.

Long-Run Industry Supply



In the limit, as firms become infinitesimally small, the industry's long-run supply curve is horizontal at min AC(y)

Long-Run Market Equilibrium Price

- **In the long-run market equilibrium, the market price is determined solely by the long-run minimum average production cost.**

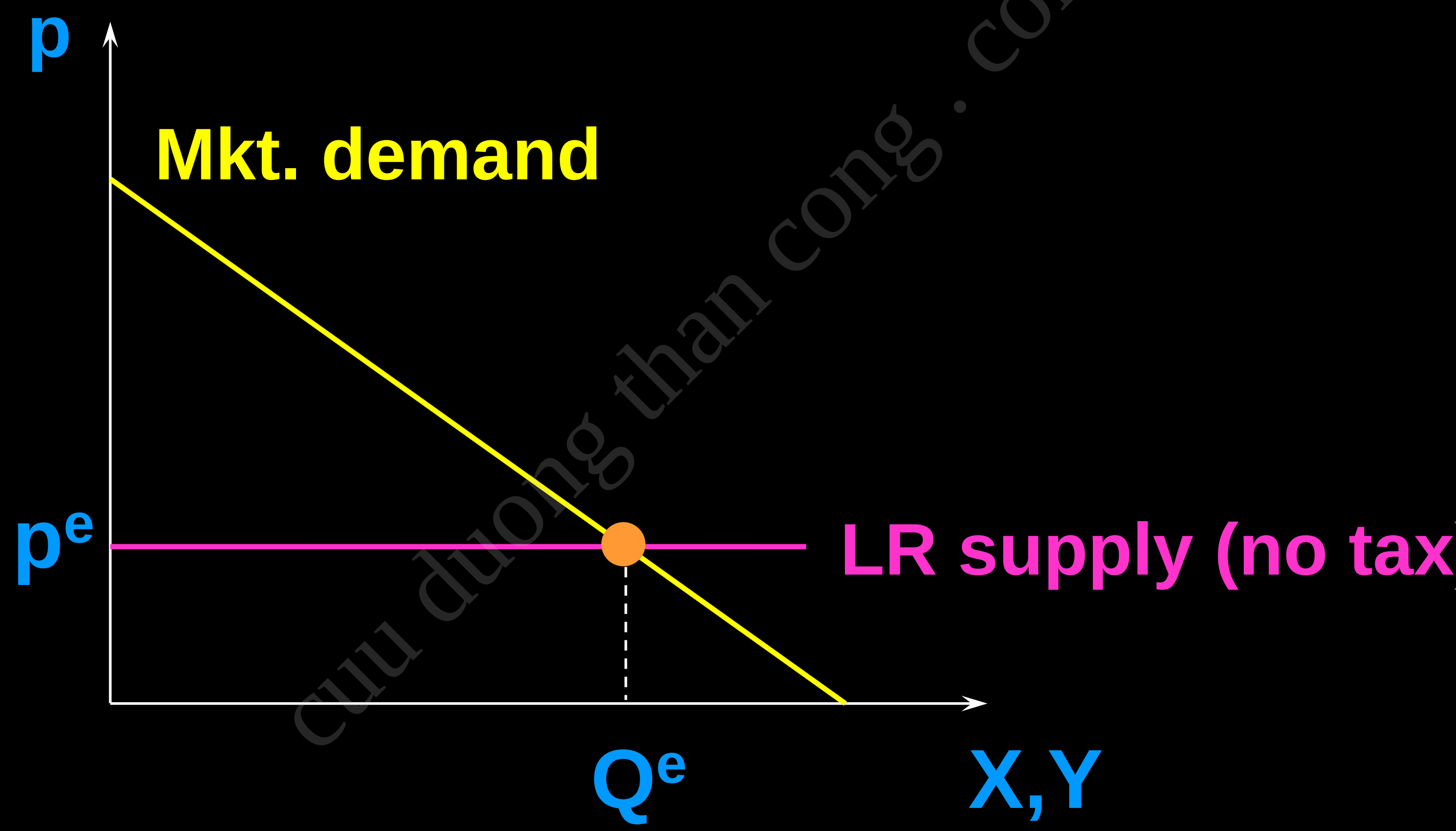
Long-run market price is

$$p^e = \min_{y>0} AC(y).$$

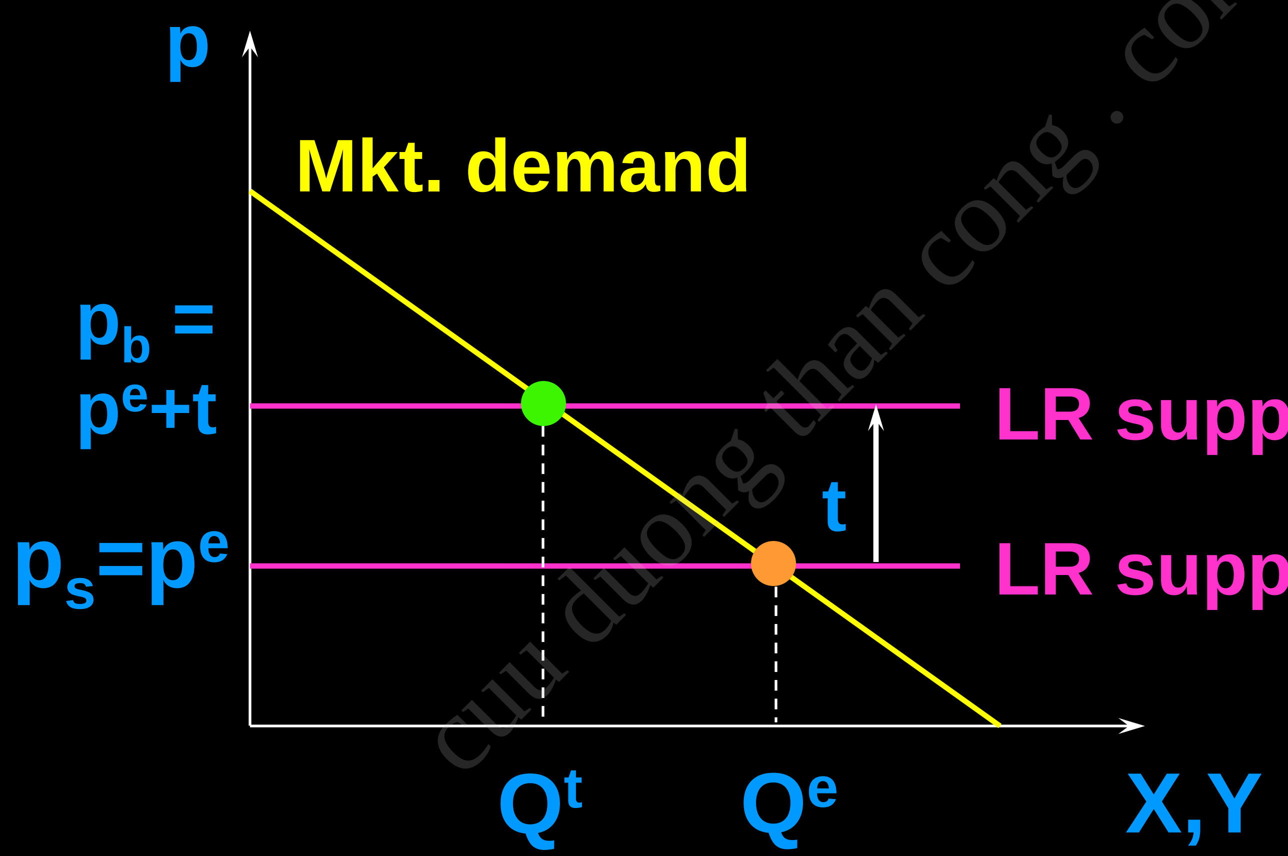
Long-Run Implications for Taxation

- In a short-run equilibrium, the burden of a sales or an excise tax is typically shared by both buyers and sellers, tax incidence of the tax depending upon the own-price elasticities of demand and supply.
- Q: Is this true in a long-run market equilibrium?

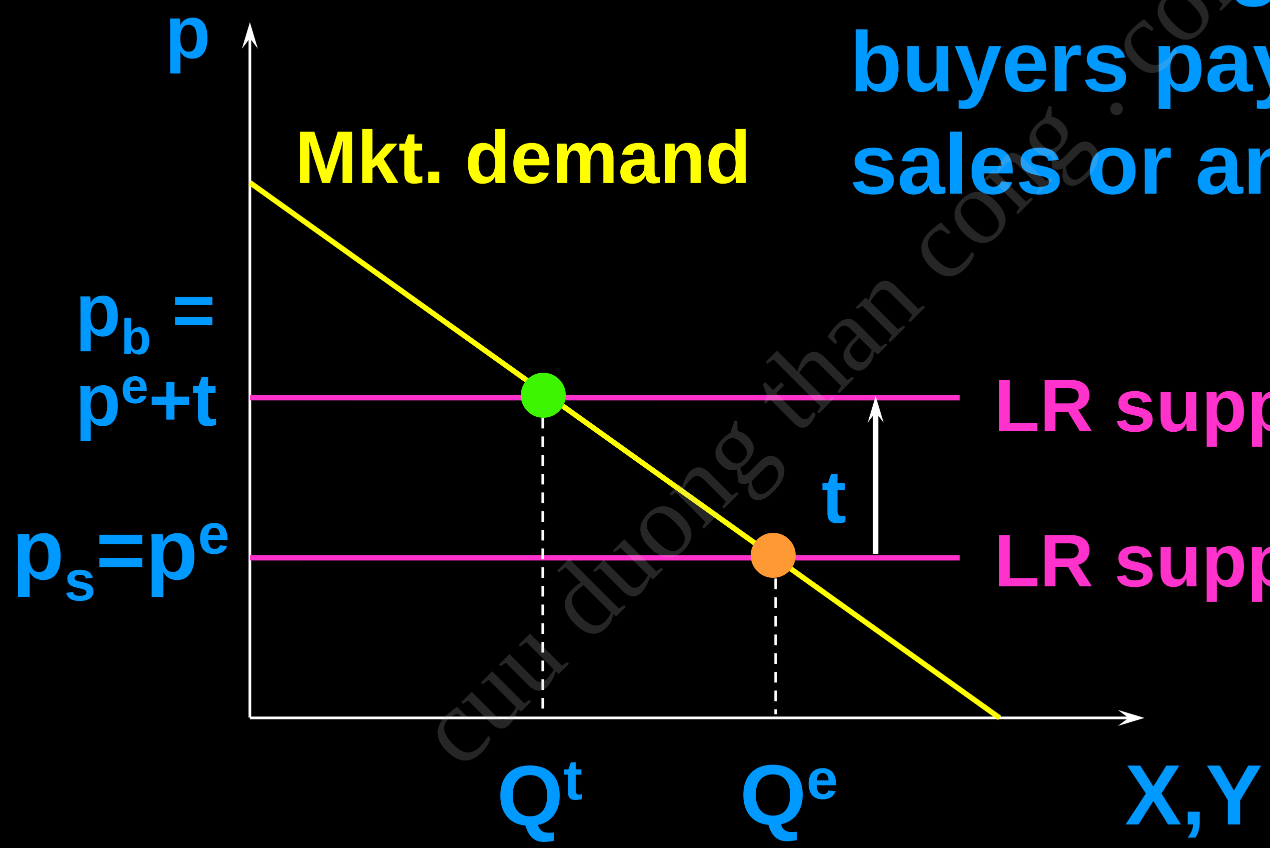
Long-Run Implications for Taxation



Long-Run Implications for Taxation



Long-Run Implications for Taxation



In the long-run the buyers pay all of a sales or an excise tax.

Fixed Inputs and Economic Rent

- What if there is a barriers to entry or exit?
- E.g., the taxi-cab industry has a barrier to entry even though there are lots of cabs competing with each other.
- Liquor licensing is a barrier to entry into a competitive industry.

Fixed Inputs and Economic Rent

- **Q: When there is a barrier to entry, will not the firms already in the industry make positive economic profits?**

Fixed Inputs and Economic Rent

- Q: When there is a barrier to entry, will not the firms already in the industry make positive economic profits?
- A: No. Each firm in the industry makes a zero economic profit. Why?

Fixed Inputs and Economic Rent

- An input (e.g. an operating license) that is fixed in the long-run causes a long-run fixed cost, F.
- Long-run total cost, $c(y) = F + c_v(y)$.
- And long-run average total cost,
  $$AC(y) = AFC(y) + AVC(y).$$
- In the long-run equilibrium, what will be the value of F?

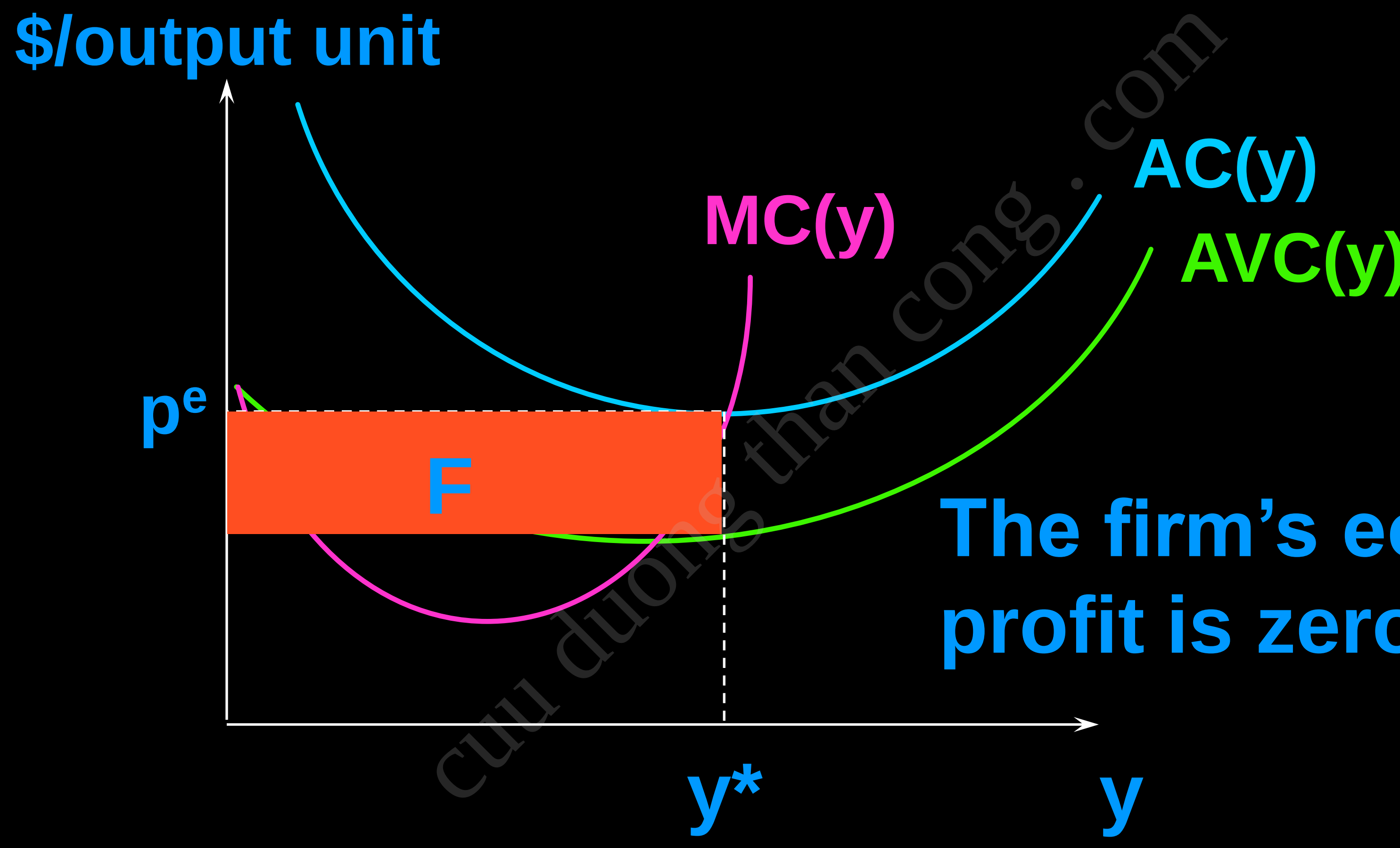
Fixed Inputs and Economic Rent

- Think of a firm that needs an operating license -- the license is a fixed input that is rented but not owned by the firm.
- If the firm makes a positive economic profit then another firm can offer the license owner a higher price for it. In this way, all firms' economic profits are competed away, to zero.

Fixed Inputs and Economic Rent

- **So in the long-run equilibrium, each firm makes a zero economic profit and each firm's fixed cost is its payment for its operating license.**

Fixed Inputs and Economic Rent



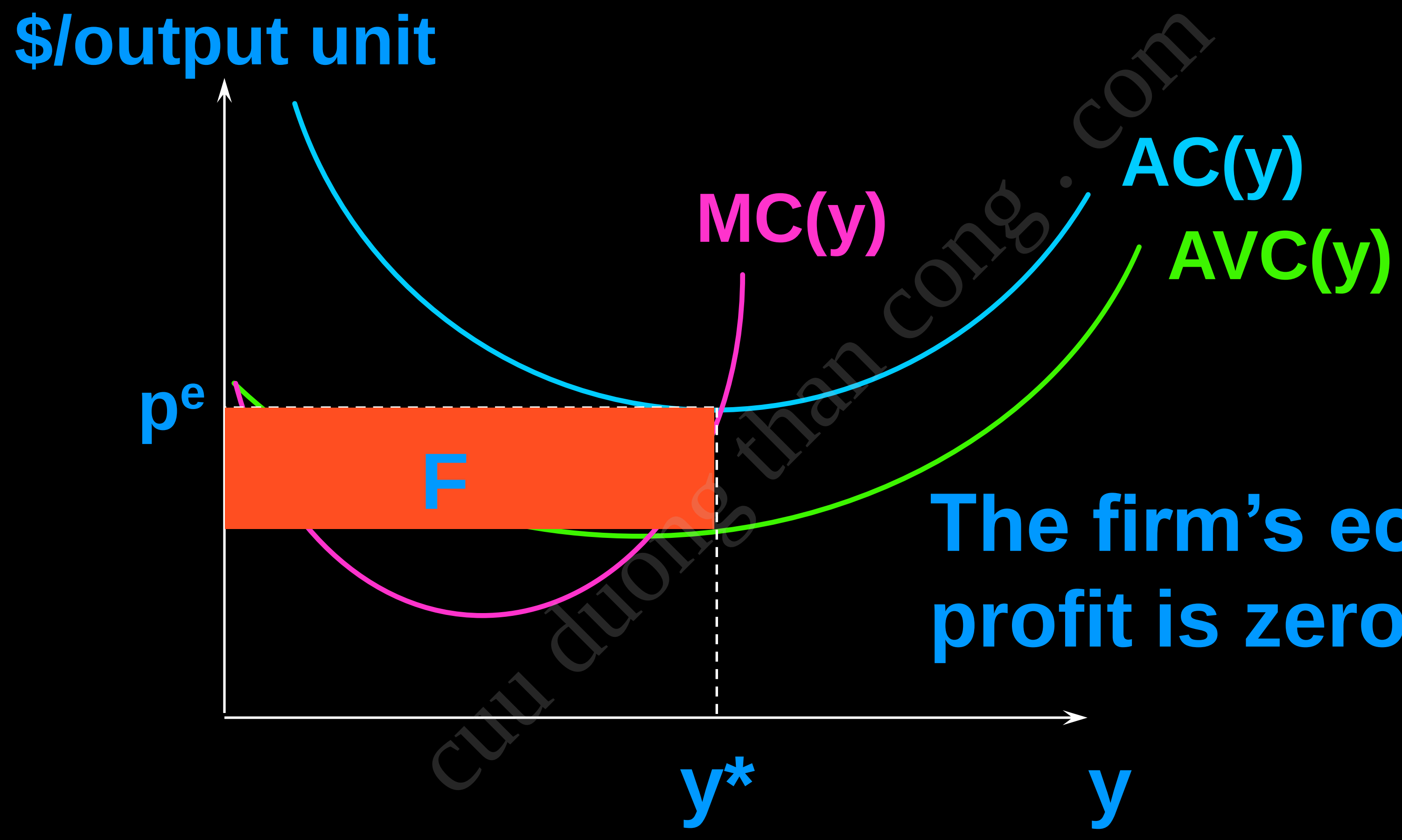
The firm's economic profit is zero.

F is the payment to the owner of the fixed input (the license).

Fixed Inputs and Economic Rent

- **Economic rent** is the payment for an input that is in excess of the minimum payment required to have that input supplied.
- Each license essentially costs zero to supply, so the long-run economic rent paid to the license owner is the firm's long-run fixed cost.

Fixed Inputs and Economic Rent



The firm's economic profit is zero.

F is the payment to the owner of the fixed input (the license); F = economic rent.