NU Econ 101: Lecture 7

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Where are we now?

Types of cost

We have learned how to derive a cost curve.

- This told us the cost of any level of quantity.
- Note also that, in doing so, we also found optimal demand for inputs (K^*, L^*) as a function of quantity, Y.
  - I will switch Y to q now to be consistent with textbook.

So far, we have actually been focusing on **the short run**.

- And we've been focusing on **variable costs**.

Fixed costs

There are two key types of costs. The first:

Total fixed cost (TFC) (*or* overhead)

Any cost that does not depend on the firm's level of output.

- These costs are incurred even if the firm is producing nothing.
- There are no fixed costs in the long run.
  - That is, they are fixed only in the short run.
- These include construction of facilities, computers, desks, insurance, some taxes, some salaries, etc.

Average fixed costs

Often we want to talk about averages:

$$\text{Average fixed cost (AFC)} = \frac{\text{Total fixed cost}}{\text{Quantity produced}}$$

Note that the average fixed cost is decreasing in the quantity.

- A billion dollar car factory seems like a massive fixed cost.
- But the average fixed cost of each car is only 1000 if you produce a million of them.

Variable costs

Total variable cost (TVC)

A cost that depends on the level of production chosen.

- These include all sort of inputs: materials, variable labor, variable capital, etc.
  - Note that our K and L represent *variable* capital and labor.
- Average variable cost (AVC) $= \frac{\text{Total variable cost}}{\text{Quantity produced}}$.

Total cost (TC)

Total fixed cost plus total variable cost. ($TC = TFC + TVC$).

Is Uli's salary a fixed or variable cost?

Nelson Inc. employs a chief engineer, Uli.

Uli, Chief Engineer

- Uli is a salaried employee. He makes $50,000.
- If fired, he would be entitled to a severance package of $20,000.
- If fired, the firm could produce no output.

Is Uli's salary a fixed cost, a variable cost, or something else?

- $20,000 of it is fixed. $30,000 is variable.

Marginal cost (MC)

Marginal cost

The rate at which total cost increases as we increase output. Note that marginal cost is the derivative of total cost.

$$MC(q) = \frac{d}{dq}(TC) = \frac{d}{dq}(TVC)$$

Why does $\frac{d}{dq}(TC) = \frac{d}{dq}(TVC)$?

- Remember that fixed costs don't depend on q!
- So $\frac{d}{dq}(TFC) = 0$, and $\frac{d}{dq}(TC) = 0 + \frac{d}{dq}(TVC)$.

Assumption: increasing marginal cost (1)

Our key assumption in this unit is **perfect competition**.

- One consequence of this that firms are “price-takers”.
  - A price-taking firm sells its full output at the market price.
  - Its choice of quantity doesn’t affect the price.

Now, suppose (for a moment) that $MC(q)$ was decreasing in q.

- Then, if you wanted to produce one unit at a given price, you would want to produce infinitely many units!

Assumption: increasing marginal cost (2)

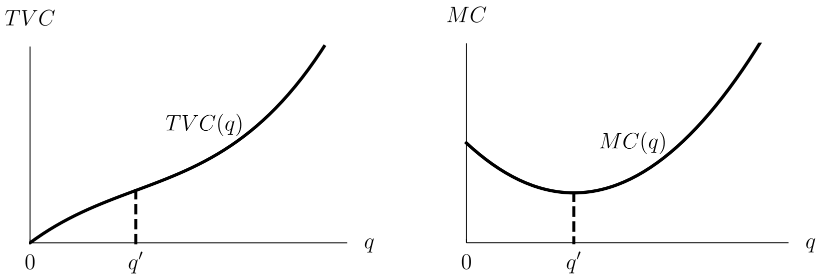
We will assume that, eventually, returns to scale are decreasing.

Or, almost equivalently, . . .

- that marginal products are eventually decreasing.
- that marginal cost is eventually increasing.

The idea: At some point, getting bigger = getting less efficient.

Assumption: increasing marginal cost (3)



Marginal cost starts decreasing (initially returns to scale are positive) but ends up increasing.

- There are often gains from specializations.

The minimum marginal cost is where the *TVC* is least steep.

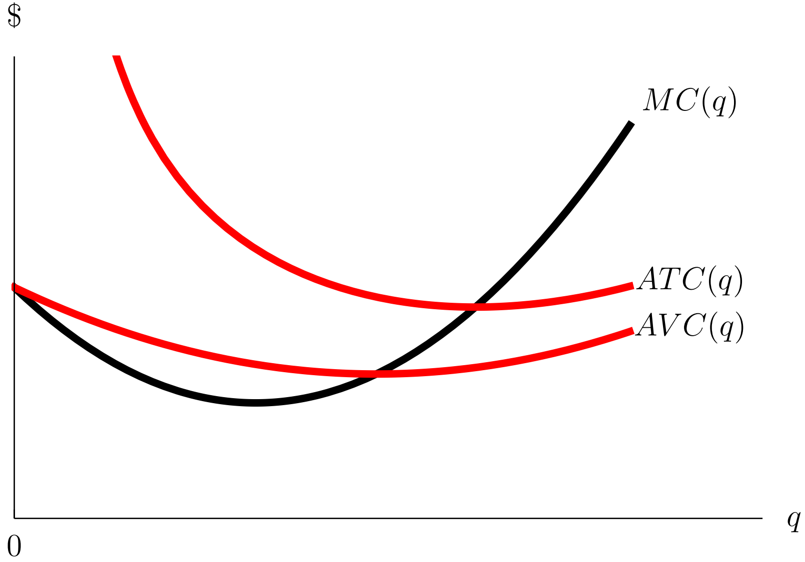
A note on marginal cost

A marginal cost is a cost per unit, as are average costs, so we can plot them together.

$MC(q)$ will cross $AVC(q)$ and $ATC(q)$ at their minimums.

- If $MC(q)$ is less than an avg., it is pulling the avg. down.
- If $MC(q)$ is greater than an avg., it is pulling the avg. up.

Plotting marginal and average costs



Review questions (1)

For each of the following statements, decide if it is true of false, and explain why:

Statement 1: $AFC(q)$ is always decreasing in q.

- This is true because fixed costs are just a constant. Average fixed costs are a constant divided by q, hence decreasing in q.

Statement 2: $MC(q)$ crosses $TC(q)$ at the minimum of $TC(q)$.

- This is false. $MC(q)$ crosses $AVC(q)$ and $ATC(q)$ at their minimums, but not $TC(q)$. $TC(q)$ is also increasing in q.

Review questions (2)

Statement 3: We assume in this class that $MC(q)$ is increasing over low q.

- This is false. $MC(q)$ can be decreasing over low q, but must be increasing for all q above some threshold, q'.

Statement 4: K denotes capital, which is a fixed cost.

- This is false. K denotes variable capital.

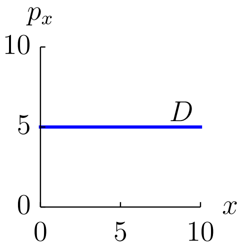
Where are we now?

Perfect competition

What is perfect competition?

Perfect competition

An industry structure in which there are many firms, each small relative to the industry, producing identical products and in which no firm is large enough to have any control over prices. Firms may enter and exit the industry freely.



- A firm in a perfectly competitive industry faces a perfectly elastic demand curve at the market price.
- They can sell as many units as they want without affecting the price.

Maximizing profits (1)

Firms want to maximize profits:

$$\max_q \ \text{Profits}(q)$$

Profits $=$ Revenues $-$ Costs. So:

$$\max_q \ \text{Revenues}(q) - \text{Costs}(q)$$

With our assumptions on costs, this is a concave function.

- Can maximize by taking a first order condition (FOC).
  - Remember taking a FOC means taking a derivative and setting it equal to zero.

Maximizing profits (2)

$$\max_q \text{ Revenues}(q) - \text{Costs}(q)$$

Note a couple of derivatives:

$$\frac{d}{dq}(\text{Revenues}(q)) = \text{Marginal revenue}(q) = MR(q)$$
$$\frac{d}{dq}(\text{Costs}(q)) = \text{Marginal cost}(q) = MC(q)$$

So the FOC for profit maximization is simply that q^* solves:

$$MR(q^*) - MC(q^*) = 0$$
$$MR(q^*) = MC(q^*)$$

Maximizing profits (3)

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

We already know about costs, but what is revenue?

Revenue is just how much output we sell multiplied by the price we sell it at. Since price might depend on how much we sell:

$$\text{Revenues} = p(q) \cdot q.$$

But with perfect competition, q doesn't affect price:

$$\text{Revenues under perfect competition} = p \cdot q.$$

Then $MR(q) = \frac{d}{dq}(p \cdot q) = p$. So, q^* solves

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

Golden rule of profit maximization

General case:

Profit is maximized when q^* is chosen to solve:

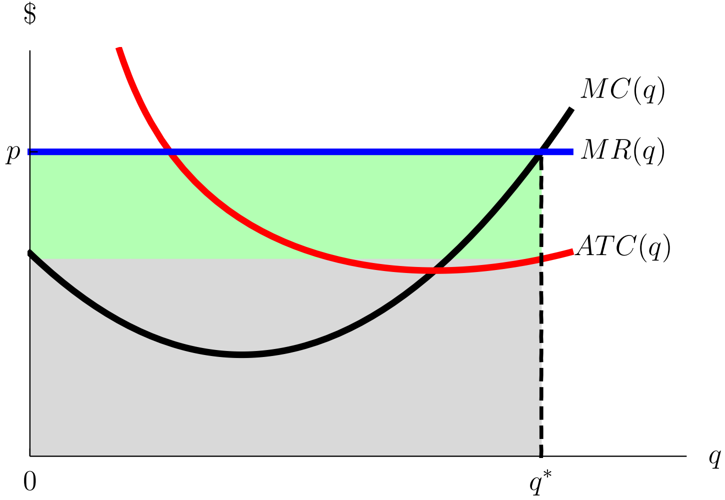
$$MR(q^*) = MC(q^*)$$

Under perfect competition:

$MR(q) = p$ for all q, hence q^* is chosen to solve:

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

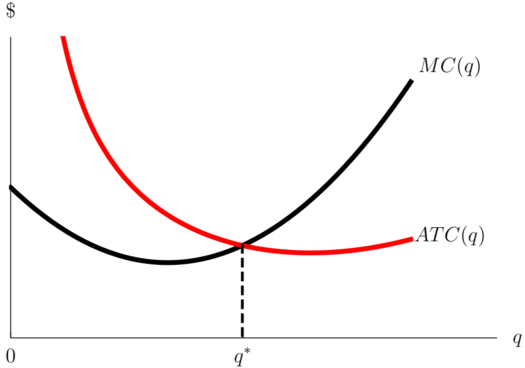
Profit maximization, graphically



Revenues = Profits (Green area) + Costs (Grey area)

Review question

Question: What's wrong (two things) with this picture?



- MC(q) should pass through minimum of $ATC(q)$
- q^* solves $MR(q^*) = MC(q^*)$, not $ATC(q^*) = MC(q^*)$.

Where are we now?

Profits with perfect competition

We just saw a firm making profits in perfect competition.

- Possible in the short run.
- Not in the long run.
  - If a firm is making profits, other firms will enter, increasing supply and lowering market price.

Can firms lose money?

- In the short run: Yes!

Minimizing losses (1)

Why might a firm lose money in the short run?

Because of the fixed costs! If $p < ATC(q^*)$, the firm loses money.

At what point would a firm shutdown in the short run?

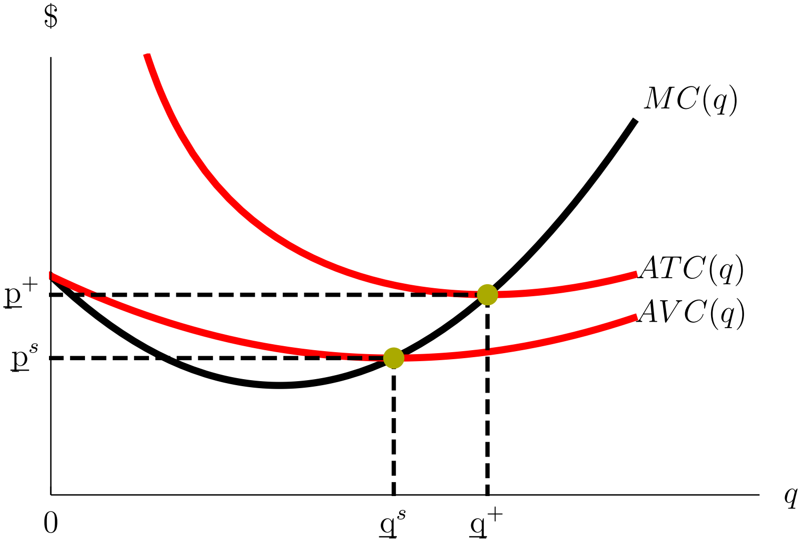
If $p < AVC(q^*)$, then firm would be better off producing zero.

- Producing q^* does not even cover the variable costs.

Define:

- $\underline{p}^+$ = the minimum price at which a firm can break even.
  - We'll call this the **break-even price**.
- $\underline{p}^s$ = the minimum price at which the firm produces output.
  - We'll call this the **shutdown price**.

Minimizing losses (2)



Minimizing losses (3)

We will call $(\underline{q}^s, \underline{p}^s)$ the **shutdown point**.

For $p \in [\underline{p}^s, \underline{p}^+]$, setting q^* to solve $p = MC(q^*)$ minimizes losses rather than maximizing profits.

If $p < \underline{p}^s$, the firm optimally chooses $q^* = 0$.

Where are we now?

Supply (1)

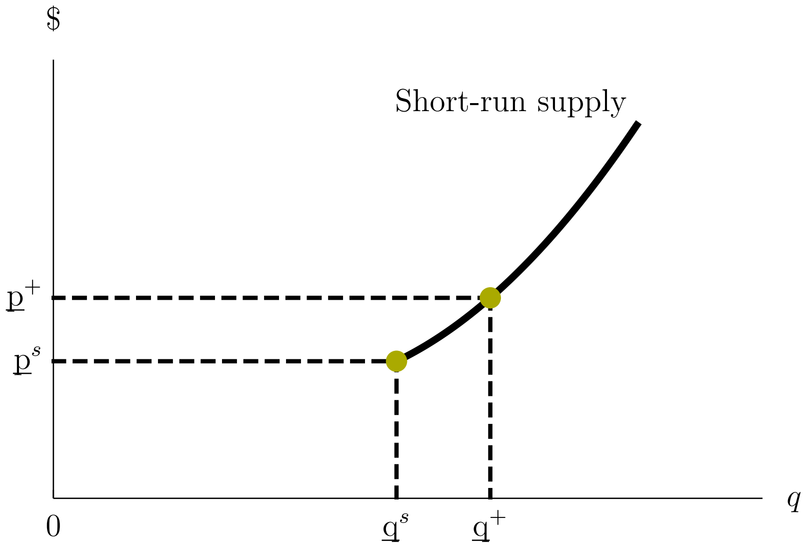
We have actually already worked out the inverse supply:

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

Of course, this is only valid for $p > \underline{p}^s$. Otherwise $q^* = 0$.

We can plot the inverse short-run supply curve . . .

Supply (2)



A call from the boss

We get a call from the CEO!

Nelson says: "Our variable costs are $TVC(q) = q^2 + 16$. What is our shutdown price? I need to see a plot of our short-run supply curve!"

Nelson forgot to tell us the fixed costs! Does it matter?

- **No!** The fixed costs are irrelevant for decision-making in the short-run. They are incurred no matter what!

Finding the shutdown price (1)

Is our variable cost valid?

- It might look like it isn't as the 16 appears fixed. But we will say the 16 is incurred only for production of one or more units, hence it is not actually fixed.

How do we solve for the shutdown price?

- Go back and look at the plot of it . . .
- We find that it is where $AVC(q) = MC(q)$.
- So we need to find $AVC(q)$ and $MC(q)$.

Finding the shutdown price (1)

$AVC(q)$ is the average variable cost, hence:

$$AVC(q) = \frac{TVC(q)}{q} = \frac{q^2 + 16}{q} = q + \frac{16}{q}$$

$MC(q)$ is the derivative of $TVC(q)$ with respect to q:

$$MC(q) = \frac{d}{dq}\left(TVC(q)\right) = \frac{d}{dq}\left(q^2 + 16\right) = 2q$$

Finding the shutdown price (2)

$$AVC(q) = q + \frac{16}{q} \ , \ \ MC(q) = 2q$$

Equating average variable and marginal cost:

$$2q = q + 16/q$$
$$q^2 = 16$$
$$\underline{q}^s = 4$$

Plugging back into either (for $\underline{p}^s$):

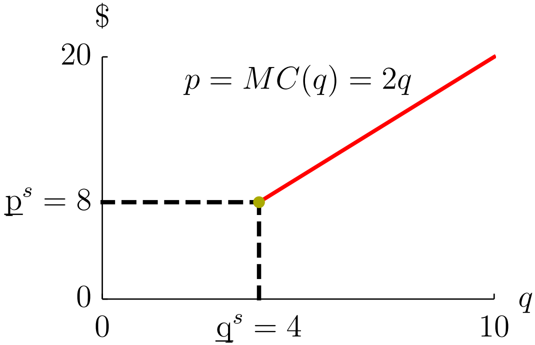
$$\underline{p}^s = 2\underline{q}^s = 8$$

Finding the supply curve

The inverse supply curve (which we plot) is:

$$p = MC(q) = 2q$$

So the supply curve is:



A call from the boss

We get a call from the CEO!

Nelson says: "It turns out our fixed costs are 20. What is our break-even price? Show it to me on the supply curve!"

Nelson adds: "I could get our fixed costs down to 9 next year by not renewing Uli's contract? What would our break-even be?

Solving for the break-even (1)

The break-even is where $ATC(q) = MC(q)$.

Total cost is:

$$TC(q) = TVC(q) + TFC = q^2 + 16 + 20 = q^2 + 36$$

So average total cost is:

$$ATC(q) = \frac{TC(q)}{q} = \frac{q^2 + 36}{q} = q + \frac{36}{q}$$

Recall that marginal cost is unaffected by fixed costs:

$$MC(q) = \frac{d}{dq}\left(TVC(q)\right) = \frac{d}{dq}\left(q^2 + 16\right) = 2q$$

Solving for the break-even (2)

Equating average total and marginal cost:

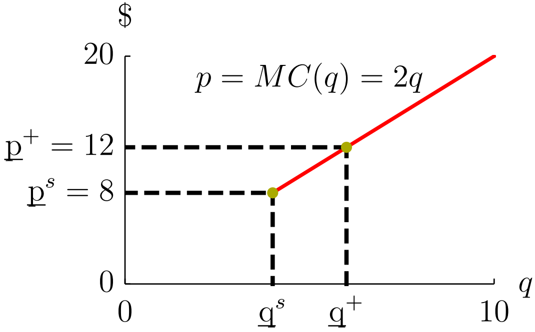
$$ATC(q) = MC(q)$$
$$q + \frac{36}{q} = 2q$$
$$\underline{q}^+ = 6$$

Plugging that into $MC(q)$ gives $\underline{p}^+ = 12$.

An exercise: Do the same with fixed costs down at 9 to find that $\underline{q}^+ = 5$ and $\underline{p}^+ = 10$.

Plotting the supply curve

Finally, we plot the point on the supply curve:



Where are we now?

Scale (1)

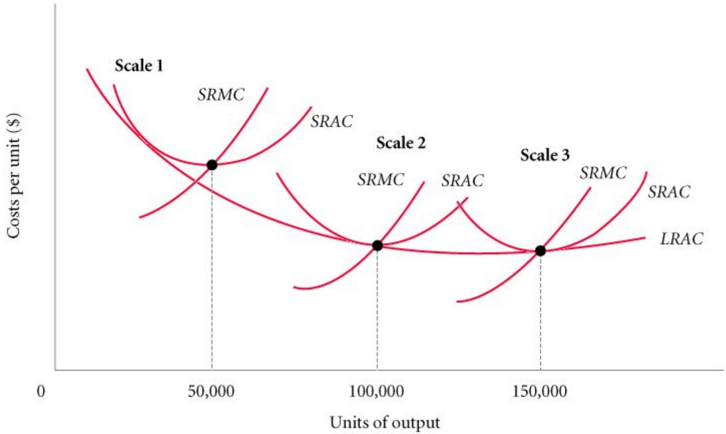
In the long-run, the firm chooses everything.

- It chooses what size factory to operate.
- It thereby chooses its scale.
- Different scales might have different minimal average costs.

Long-run average cost (LRAC)

The “envelope” of a series of short-run cost curves.

Scale (2)



There's a mistake in this textbook graphic. Can you spot it?

- The LRAC must go through the min. of the SRAC at 50,000.

Scale (3)

Finally, we define a notion of the optimal scale:

Minimum efficient scale (MES)

The smallest size at which long-run average cost curve is at its minimum.

Where are we now?

Useful problems in textbook

The following problems from the textbook are worth a look:

- Chapter 8: 1, 3, 7, 9, 15, 16
- Chapter 9: 5, 6, 7, 8, 9