Theory of the Firms: Costs

Econ 1101

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ECON 1101 Lecture 9.2

1. Costs

2. U shaped average costs

3. Constant returns to scale

4. Economies of scale

ECON 1101 Lecture 8.3

1. Introduction to Costs

Introducing costs in EconLand

We have kept producers very simple in EconLand

- Each could produce or not produce (only 1 unit)
  - Example S1: can make 0 or 1 widget
  - Cost to make 0 widget =0
  - Cost to make 1 widget = 1
- Each would produce if the price was higher than some associated cost
- In the real world, firms (producers) produce more than 1 unit and **costs vary with the amount produced**
  - we will meet a new producer S11 with a more complicated structure....

Meet S11

S11 is a more complicated producer, she has a very sophisticated operation that can produce more than one widget but she faces more complex costs:

1. Fixed costs: that are the same regardless the amount she produces
   - Think of (the cost to be in business)
   - Examples: salary of the CEO, Electric bill for lights, rent of a factory
2. Variable costs: costs that vary with the amount produced
   - They include labor, (inputs) materials that change with the amount produced

S11 operation (setup)

S11 produces widgets, her costs are:

- Fixed costs: \$4 - factory rent
- Variable costs:
  - She pays \$2 an hour to labor (labor requirement is: 0.5 hr to produce 1 widget, 2 hrs to produce 2 widgets, 4.5 hours to produce 3 and 8 hours to produce 4)
  - \$1 per quart of widget juice (she needs one quart to produce one widget)
- Variable cost is the sum of labor costs (wages) and material costs (juice)

Table of Variable Costs

Q	L hours	Labor Cost (wage=$2 hr)	Materials Cost ($)	Variable Cost ($)
0	0.0	0	0	0
1	.5	1	1	2 (1+1)
2	2.0	4	2	6 (4+2)
3	4.5	9	3	12 (9+3)
4	8.0	16	4	20 (16+4)

You can check that variable cost for S11 satisfies the following equation:

Variable Cost (VC) for S11 is $VC = Q + Q^2$

- Notice labor costs = Q^2, material costs= Q

Diminishing Marginal Returns

The cost structure of S11 ($VC = Q + Q^2$) exhibits diminishing marginal returns (DMR)

- DMR: means that the output I get from adding more input decreases with the amount of input
- Looking at previous table we see:
  - it only takes 0.5 hours to produce the first widget
  - but to produce the second we need 1.5 hours, to produce the 3rd 2.5...
  - we have DMR to labor: the return I get form adding labor to produce more, decreases with the amount of labor I use
    - think of the first 0.5 hours worked produce 1 good, the 2nd half an hour worked barely produces 1/3 of good
- One way to think about this is like picking low hanging fruit: do the easiest jobs first

Total and Average Costs

- Total Costs (TC) = Fixed Costs (FC) + Variable Costs (VC)
- Average Costs: are just costs per unit produced (Q) - cost/Q
  - AVC = VC/Q
  - AVF = FC/Q
  - ATC = TC/Q = TC/Q+ VC/Q

Total and Average Costs

Q	FC (Fixed Cost)	VC (Variable Cost)	TC (Total Cost)
0	4	0	4
1	4	2	6
2	4	6	10
3	4	12	16
4	4	20	24

AFC	AVC	ATC
---	---	---
4	2	6
2	3	5
1.33	4	5.33
1	5	6

Marginal Costs

- Marginal Costs (MC): change in total costs from increasing output by one unit (need to use a midpoint formula)

Q	FC (Fixed Cost)	VC (Variable Cost)	TC (Total Cost)
0	4	0	4
1	4	2	6
2	4	6	10
3	4	12	16
4	4	20	24

AFC	AVC	ATC	MC (Marginal Cost)
---	---	---	
4	2	6	
2	3	5	5
1.33	4	5.33	7
1	5	6	9

Finding MC:

- MC between 0 and 1 is $2 = 6 - 4$
- MC between 1 and 2 is $4 = 10 - 6$
- MC between 2 and 3 is $6 = 16 - 10$

What is MC at 1? (use midpoint). So MC at Q=1 is \$3 (between \$2 and \$4)
MC at Q=2 is \$5 (between \$4 and \$6)

General Cost Formulas

General Formula is easiest way to go.

Total Cost: $TC = aQ^2 + bQ + c$

Marginal Cost: $MC = 2aQ + b$

- (when TC look as above, MC look like this: should be clear to those with calculus backgrounds, other wise can just memorize the formula)

- a, b, c, are the parameters of the cost function. This general form has many cases. Different firms will have different values of a, b, c

General Cost Formulas

- In our case: $VC = Q^2 + Q$ and $FC = 4$ so $TC = Q^2 + Q + 4$
- This fits in our general formula with a=1, b=1, c=4

- What is the marginal cost here?
  - recall general formula $MC = 2aQ + b$
  - so here $MC = 2Q + 1$

Parameters of general formula

Parameters in our general formula ($TC = aQ^2 + bQ + c$) have an interpretation:

- **c** is a fixed cost (notice it doesn't grow with quantity)
  - for Airbus researching planes this is huge $16 billion, for widgets here, the fixed costs are probably smaller
- **b** is a variable cost (notice it grows proportional to quantity)
- **a** does not have a natural interpretation and in most cases will be 0
  - If a>0, marginal costs are increasing with Q (this is equivalent to saying there are diminishing marginal returns)
  - low hanging fruit story

Graphing Cost Structure

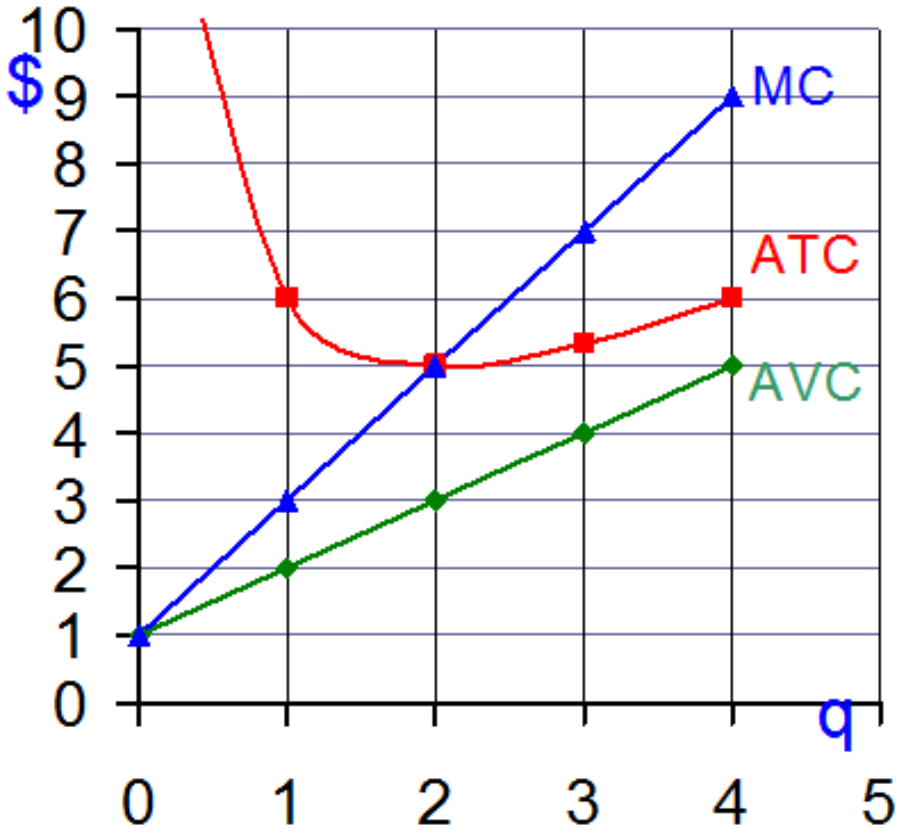
Back to S11. Let's gather up what we know:

S11's Cost Table (Example of U-Shaped ATC)

Q	AFC	AVC	ATC	MC
0	-	0	-	**1.00**
1	4.00	2.00	6.00	**3.00**
2	2.00	3.00	5.00	**5.00**
3	1.33	4.00	5.33	**7.00**
4	**1.00**	**5.00**	**6.00**	**9.00**

Graphing Cost Structure

Q	AFC	AVC	ATC	MC
0	-	0	-	**1.00**
1	4.00	2.00	6.00	**3.00**
2	2.00	3.00	5.00	**5.00**
3	1.33	4.00	5.33	**7.00**
4	**1.00**	**5.00**	**6.00**	**9.00**

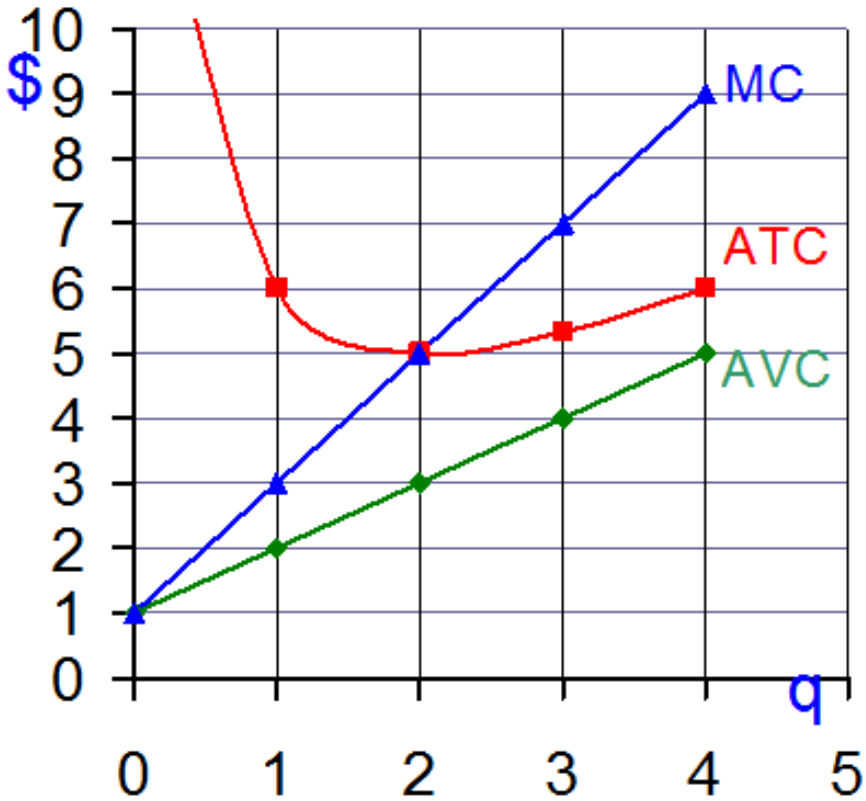


Average Costs

Interpretation of Average Costs

- It will turn out that average and marginal costs are most important
- Later we will talk about their impact on supply
- As we saw, S11 has u-shaped ATC, lets discuss this

U-Shaped ATC (S11)



Points of interest.

1. For Q<2, ATC falling
Region of Increasing returns to Scale
(also called economies of scale)

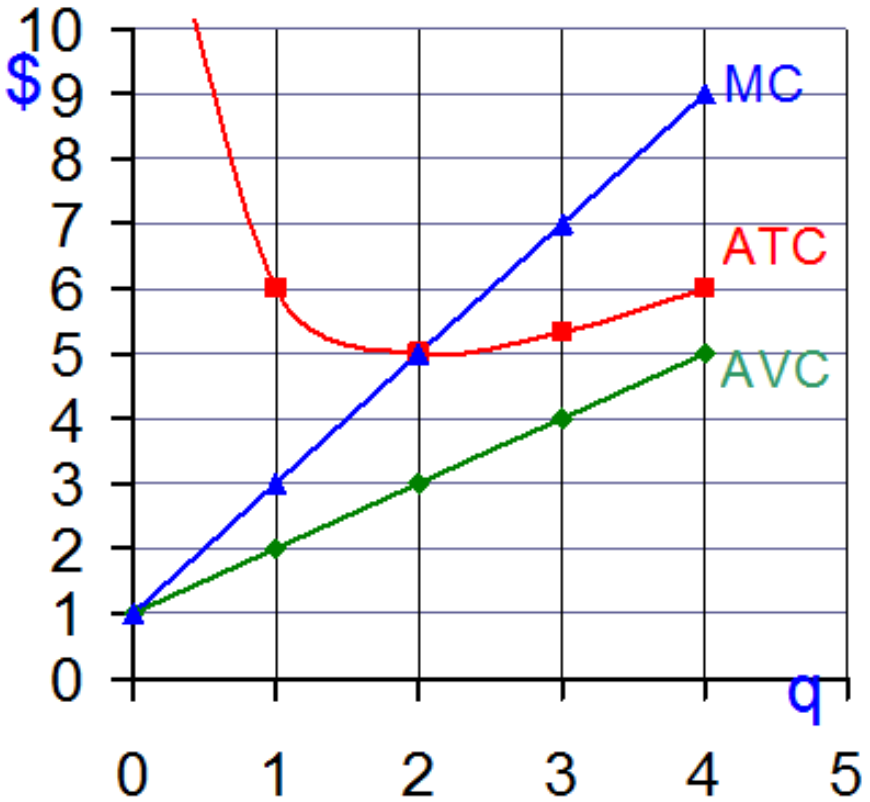
2. For Q>2, ATC rising
Region of Decreasing returns to scale
(also called diseconomies of scale.)

3. Q = 2, Minimum Average Cost

Facts:

- Q<2, MC<ATC and ATC falling
- Q>2, MC>ATC and ATC rising
- Q = 2, MC=ATC and at ATC min.

U-Shaped ATC and MC curve



What about MC?

- The MC curve seems to cross at the
- point of change in direction of ATC

1. For Q>2, MC<ATC and ATC falling

2. For Q>2, MC>ATC and ATC rising

3. Q = 2, MC=ATC and ATC is at its minimum

Constant Returns to Scale

- For S11, we saw that for certain quantities he enjoyed increasing returns to scale at others decreasing returns to scale
- Some producers have Constant Returns to Scale (CRS) over the entire range of Q
- If a firm has costs that are constant returns to scale, then as they increase production, all inputs of production will scale up in the same proportion, so costs increase proportionately.
- Example: House painting: suppose S12 paints houses in her free time, she has the following cost structure

Q	TC	ATC
0	0	-
1	5	5
2	10	5
3	15	5
4	20	5

TC = 5Q (a=0, b=5, c=0)

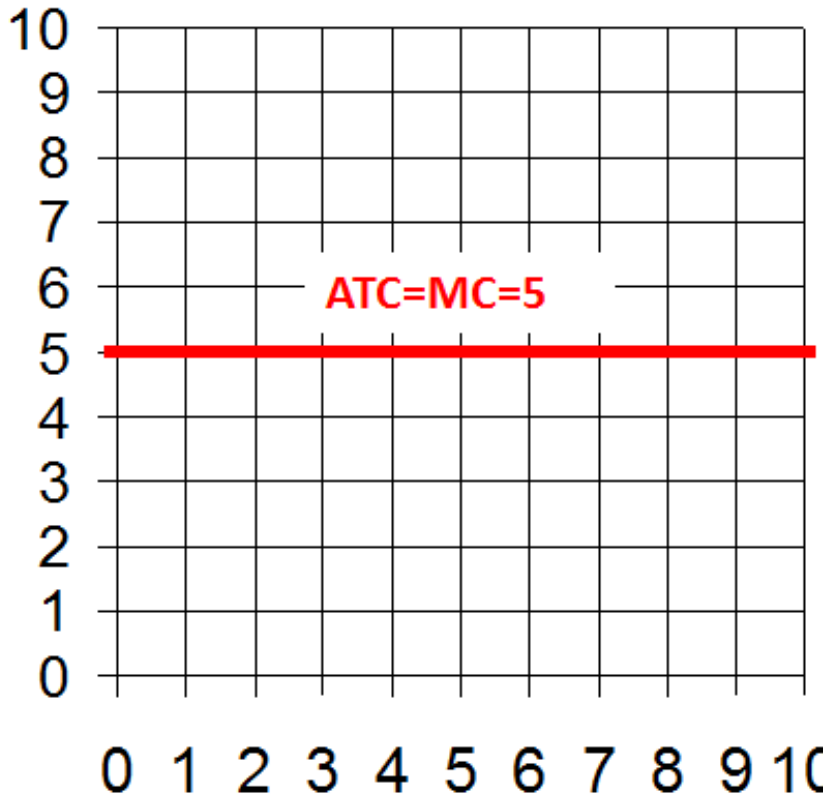
Constant Returns to Scale

Note a=0, b=5 c=0 , so $MC = 2aQ + b = 5$

- MC=ATC=5

Q	TC	ATC
0	0	-
1	5	**5**
2	10	**5**
3	15	**5**
4	**20**	**5**

TC = 5Q (a=0, b=5, c=0)



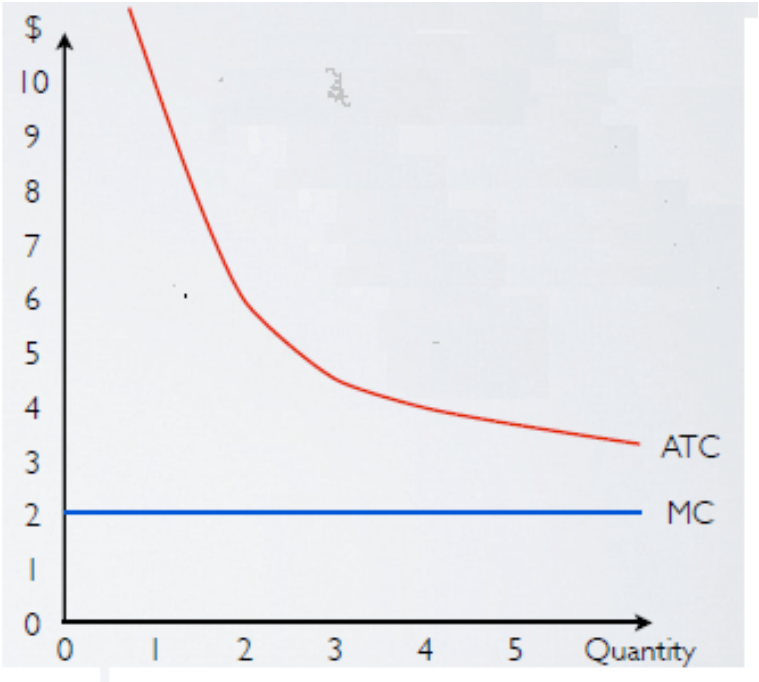
Economies of Scale

- Recall: S11 had different returns to scale (Q), S12 (house painting) had constant returns to scale (CRS)
- Finally S13 will enjoy increasing returns to scale or economies of scale in the whole range of Q
- Suppose S13 has FC=8 and **constant marginal cost = 2**
  - Recall $MC = 2aQ + b$ hence $a = 0, \quad b = 2$
  - so $TC = 2Q + 8$
  - and $AC = 2 + 8/Q$

Q	TC	ATC
0	8	-
1	10	10
2	12	6
3	14	4.7
4	16	4
...	...	...
8	24	3

Economies of Scale

Q	TC	ATC
0	8	-
1	10	10
2	12	6
3	14	4.7
4	16	4
...	...	...
8	24	3



- Here ATC is always falling, never turns back up. So decreasing over entire range of Q

Economies of Scale: Discussion

Example industries where scale economies are important

Pharmaceuticals

- Fixed cost for research
- Marginal cost of making pills small compared to AFC

Software: MC quite low relative to AFC. MC when distribute on internet = 0!

Jumbojet passenger planes with more than 500 people.

- (Airbus 380), $16 billion in development costs before they flew first plane.

Economies of Scale: Discussion

- Discount Retailing: By maintaining large scale, Wal-Mart has keep average total costs from its logistics low
- For example, there are fixed cost to set up a distribution center. By putting many stores close to distribution centers, Wal-Mart enjoys economies of scale (and can keep inventories low and replenish empty shelves quickly. e.g. restocked flags on 9/11)
- Can read about strategy of packing stores close to each other to enjoy economies of density in recent Holmes paper.

  (http://www.econ.umn.edu/~holmes/papers/diffusion_walmart_holmes.pdf)
- The paper is technical, so let's just look at the a movie of how Wal-Mart rolled out its store openings.

  (http://www.econ.umn.edu/~holmes/papers/Wal1962-2004_nov_05.wmv)

Economies of Scale: Discussion

- In industries where scale economies are huge relative to the market size, there is only room for a few players.
- Discount Retailing: Wal-Mart, Target, K-Mart, plus regional players.
- Wide-Body Jets: Boeing, Airbus.
- After the midterm, we will talk about industries where individual firms are large. But first, let's figure out industries where firms are small relative to the market (so firms take price as given.)