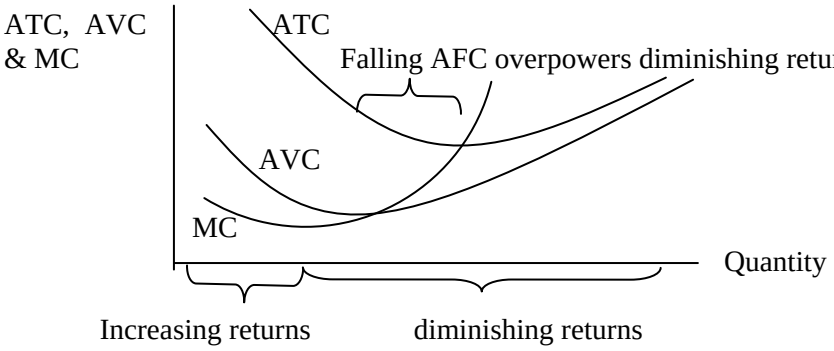
Chapter 10

COSTS

Boiling Down Chapter 10

The reason we spent so much time in the last chapter trying to identify the relationship between inputs and outputs is that inputs represent the cost of producing a given output. As in the case of production inputs, we are concerned with the capital and labor input costs rather than the raw material costs because the raw materials are not part of the value added to the product. What follows will sound like technical nonsense unless it is read slowly with a sketch pad to graph the thoughts of the paragraphs. It will make much more sense and clinch much of the material if it is read again after the material is digested and understood. The graph below shows some of the concepts discussed here.



The short-run total cost of a given output is equal to the cost of the fixed inputs plus the cost of the variable inputs. To find the cost per unit (average cost) of output, the total cost is divided by the quantity produced. The average total cost is influenced by several factors. Because increasing and then diminishing returns are part of the production function characteristics, average variable costs are pulled down initially because early additions of the variable input make the production recipe more efficient. This pulls down all the cost curves shown in the graph. However, at the point of diminishing returns this trend reverses and marginal cost begins to rise. When MC goes above AVC it pulls up the AVC and when it goes above the ATC it begins to overpower the pull down on average costs from falling AFC. At his point the ATC begins to rise indefinitely.

The key factor in understanding cost is to recognize that, as labor is added to a fixed production process, the mix between labor and the fixed capital stock varies from being too little labor in the factory to too much labor in the factory. In both cases, ATC will be higher than it is when labor and capital are in the best balance. The U shape of ATC is thus a result of increasing and then diminishing returns to production and the fact that

AFC must continuously decline. Marginal costs can be obtained by calculating the change in total cost, which means that only variable cost is relevant in the MC calculations. Fixed costs can never change total cost. In graphing all these relationships, it is important to remember that the slope of any total function is the marginal value, and the slope of a ray from the origin to the total function is the average value at that point on the total function. Try sketching graphs from total cost curves, total variable cost curves, and total fixed cost curves.

The real reason why we make all this effort to understand the way costs respond to different output levels is that we want to find the lowest cost method of producing our output goal. In the short-run this optimal combination will obviously be where average cost is the lowest possible for the level of output selected.

In the long run the choice of inputs is less constrained because there are no fixed inputs in the long run. Both capital and labor can be adjusted to find the right combination for least cost production of the desired output. The point where the isoquant is tangent to the isocost line identifies the input combination that minimizes cost for the level of output under consideration. At this point the slope of the isoquant (MP_L/MP_K) is equal to the slope of the isocost line (P_L/P_K), a relationship that could be stated as $MP_L/P_L = MP_K/P_K$.

The intuitive sense of this expression is that any factor should be used to the point where the marginal return on the last dollar spent on one input should equal exactly the return from the last dollar spent on the other input. If this were not true, the entrepreneur should substitute toward the input with the higher marginal return until the desired relationship is reached. In other words, always hire the input that gives the biggest bang for the buck.

Optimal input choice can be observed for all output levels by observing the tangency points of all possible isoquants and isocost lines. Because the isocost line represents the total cost of producing the output in question, a total cost for all output levels is determined. When plotted as a total long-run cost function, the average and marginal long-run functions also can be derived. The long-run cost curves will be either downward sloping, horizontal, or U-shaped, depending respectively upon whether economies of scale, constant returns to scale or diseconomies of scale are present in the cost relationships.

A long-run cost curve is simply the envelope curve of a series of short-run average cost curves, because each short-run cost curve will have one point on it that represents a lowest possible average cost for the given output. The plant size represented by that point on the isoquant map shows which particular short-run plant is relevant for that output.

When all the technical jargon is done the basic concept is much like getting the right recipe in baking. If all inputs are in just the right balance, then the cake has the best taste. In factory life, costs are as low as possible for each level of output when all the inputs to production are combined in just the right mix.

Chapter Outline

1. Short-run costs are analyzed in relation to output produced.
    a. The full opportunity costs are broken down into fixed and variable costs.
    b. Total, average, and marginal cost characteristics are explored for variable costs while total and average characteristics are considered for fixed costs.
    c. Total variable cost for a given output is derived from the total product curve by multiplying the amount of variable input needed for that output by its price.
    d. Total cost is the vertical summation of the total variable cost and the total fixed cost.
    e. Graphs for average cost functions are derived by finding the slope of a ray from the origin to the total cost function for a given quantity.
    f. Graphs for marginal cost functions are derived by identifying the slope of the total cost functions for all outputs.
2. When production is allocated between two processes, the marginal costs in each process should be the same.
3. Average variable cost is the inverse of the average product times the price of the variable input, while marginal costs are the inverse of the marginal product times the price of the variable input.
4. Long-run costs have no fixed inputs.
    a. An isocost line shows what combinations of inputs have the same total cost, and its slope shows the relative factor prices.
    b. Output is optimized for a given expenditure when the isoquant is tangent to the isocost line.
    c. Differing slopes of the isocost line lead to differing factor combinations, as the Nepal road building example in the text illustrates.
    d. As output expands, the isocost line moves outward to identify the optimal input combinations and, therefore, the lowest cost structure.
    e. A long-run total, marginal, and average cost curve can be derived from the expansion path.
    f. Constant, increasing, or decreasing returns to scale can occur as output expands.
5. Industries with declining costs over a large range of output fit the category of natural monopolies, since meaningful competition is absent in these cases.
6. (Appendix) An isoquant map can be used to identify both long-run and short-run costs if a particular plant size is fixed for the short-run analysis.
    a. The total cost identified from the expansion path is used to derive long-run average and marginal costs.
    b. The costs identified from the short-run expansion path are used to derive short-run cost curves, which become part of the long-run envelop average cost curve.
7. (Appendix) A mathematical extension of cost uses the Lagrangian multiplier method of constrained minimization to find the tangency point of the isoquant and isocost line.

Important Terms

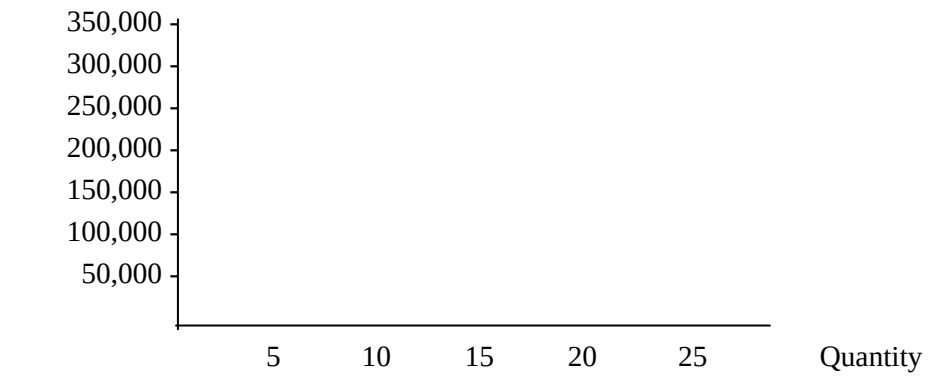
short run

isocost line

total cost
average cost
total variable cost
average variable cost
average fixed cost
marginal cost
fixed costs
overhead costs
inflection point
long run
optimal input combination
isoquant slope
isocost line slope
cost minimization
output maximization
output expansion path
total cost
average cost
marginal cost
constant returns to scale
decreasing returns to scale
increasing returns to scale
natural monopolies
envelop curves

A Case to Consider

1. Megan is seeking some information on the costs of educational computer software development. On the graph below, sketch her short-run total fixed cost and total cost from the information she has collected below. Then fill in the table below with the ATC and AVC. All cost considerations are on an annual basis for this problem.
    a. Capital rental rates are 10%/yr.
    b. Megan has $200,000 worth of capital involved in software development and a $30,000 yearly lease on her property..
    c. Her production function shows that for each additional software developer from 1 to 6 the output goes from 2 to 7 to 14 to 20 to 23 to 25 respectively.
    d. Computer programmers average $50,000 a year in salary.



2. For the outputs listed in the table below, calculate the ATC and the AVC of Megan's enterprise.

Quantity	2	7	14	20	23	25
AVC						
ATC						

3. What are the fundamental qualities of production that underlie the shape of the total cost curve and the average cost curves?

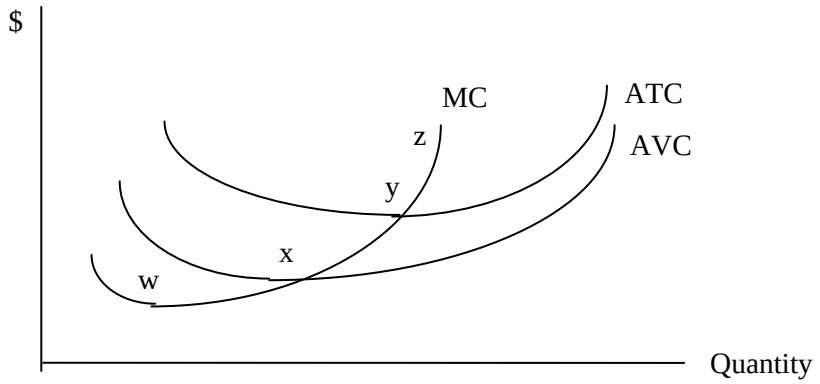
Multiple-Choice Questions

1. Average fixed cost

a. is U-shaped.
b. declines over the entire output range.
c. is a long-run concept only.
d. is influenced by diminishing returns to production.
e. is described by none of the above.

2. If average total cost is 100 for a given output and marginal cost is 70, we then know that average fixed cost is
   a. 30.
   b. 170.
   c. 70.
   d. not possible to determine with the information given.
3. If average fixed cost is 40 and average variable cost is 80 for a given output, we then know that average total cost is
   a. 40.
   b. 120.
   c. 80.
   d. not possible to determine with the information given.

Questions 4 through 6 relate to the graph below.



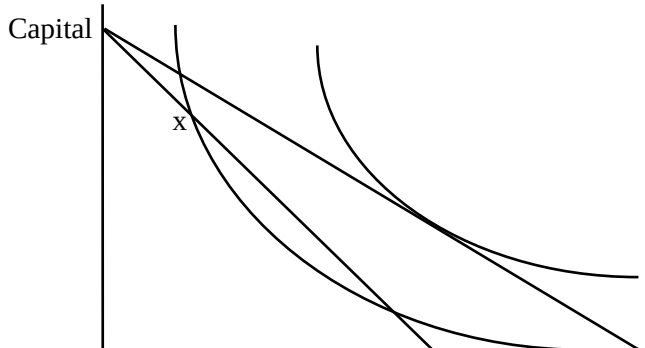
4. The point where diminishing returns to production begins as reflected in the cost relationship is located at which point?
   a. w
   b. x
   c. y
   d. z
5. Average variable cost (AVC) begins rising before average total cost (ATC) because
   a. AVC is not influenced by declining average fixed cost.
   b. AVC is not influenced by marginal cost.
   c. ATC is not influenced by rising marginal cost.
   d. AVC is not influenced by diminishing returns.

6. If the graph above were a set of long-run cost curves, which of the following would be true?
   a. There would be no AVC curve.
   b. MC would be below ATC at all points.
   c. ATC could not be U-shaped.

d. There would be no MC curve.

7. Which is not a good example of a fixed cost?
   a. Interest on long-term plant loans
   b. Property taxes
   c. Insurance payments
   d. Electricity and oil payments
8. A total cost function and a total variable cost function will
   a. always be parallel.
   b. be parallel only if total cost is a linear function of output.
   c. never be parallel.
   d. be parallel only if there are no fixed costs.
9. If the marginal cost is 50 and the average total cost is 75, we can be sure that
   a. marginal cost is rising.
   b. average total cost is rising.
   c. marginal cost is falling.
   d. average total cost is falling.
10. If there are three production processes to choose among, it is best to
    a. produce all the output with the process that has the lowest average cost for the output needed.
    b. divide up the output among the processes so that the marginal cost is the same in each process.
    c. divide up the production into thirds and have each process do one third of the output.
    d. use the process with the most fixed cost in order to use up the fixed capital.
11. The output where diminishing returns to production begin is also the output where
    a. marginal cost is at a minimum.
    b. average total cost is at a minimum.
    c. average variable cost is at a minimum.
    d. marginal and average cost intersect.
12. If an entrepreneur is minimizing cost for a given output level and the marginal product of labor is 5, the marginal product of capital is 15, and the price of capital is $300, then the price of labor
    a. must be $900.
    b. must be $400.
    c. must be $100.
    d. is not possible to determine from the information given.
13. If labor is more plentiful than capital in a country, it is likely that in that country
    a. the marginal product of capital will be less than the marginal product of labor.
    b. the price of labor will be higher than the price of capital.
    c. production will be done inefficiently.
    d. labor-intensive products will be produced at lower cost than capital intensive countries can produce them.

The graph below is used for questions 14 through 16.



z

A B Labor

14. When the isocost line moves from A to B,
    a. the absolute price of labor has fallen.
    b. the absolute price of capital has fallen.
    c. the price of labor relative to the price of capital has risen.
    d. all the above are true.
    e. none of the above are true.
15. A firm that is facing the isocost line A and has the isoquant 1 with an input combination at letter x is
    a. too labor intensive.
    b. too capital intensive.
    c. producing at the optimal input combination.
    d. producing at the lowest point on its average cost function.
16. The marginal rate of technical substitution at point z
    a. equals 1.
    b. equals 2.
    c. equals .5.
    d. is not possible to determine with the information given.
17. Which of the following statements is not true?
    a. Labor unions might support a minimum wage law even though their wages are way above the minimum.
    b. Laborers might favor higher interest rates on capital.
    c. Any firm that knows all its marginal cost points should be able to calculate its ATC from those data if it knows its fixed costs.
    d. It is inevitably inefficient to keep an old plant producing if its average costs are greater than the marginal costs of a new plant.
18. Each point on the long-run average cost curve is a
    a. minimum point on some short-run average cost curve also.
    b. level of average cost that is the lowest possible average cost for that level of output.
    c. point on the long-run marginal cost curve also, because the LAC and LMC are always identical.
    d. cost of production based on a particular input price ratio. Other points on the LAC show cost of output with alternative input prices.
19. Long-run cost functions that exhibit increasing returns to scale over the entire relevant output range lead to
    a. intensive competition among firms because low costs mean high potential profits.
    b. minimal competition and often monopoly because the market cannot support numerous large firms taking advantage of the economies of scale.

c. many small firms producing at high cost in a regulated market because of the high risk of investing heavily in one venture.
d. none of the above, since such a cost condition is a theoretical construct not observed in the real world.

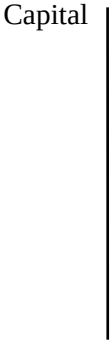
20. Which statement is true?
    a. Short-run cost assumes a fixed capital size, while long-run cost includes all possible capital levels in determining cost.
    b. Short-run total cost can never be less than long- run total cost.
    c. Long-run marginal cost never intersects long-run average cost as long as increasing returns to scale are present.
    d. All the above are true.
    e. None of the above are true.

Problems

1. If you have 5 drill presses each running eight hour days, what is the capital cost of an hour's production if the rental cost of a drill press is $5 an hour? Use your text's notation to answer this question. If drill presses were the only capital used, what would be the daily capital cost?

2. Under what conditions might a total cost curve be linear in the real world? Sketch a short run production function that would result in a linear total cost function. Explain in words why the short-run average total cost function continually declines if the total cost curve is linear.

3. Sketch an isoquant map that shows a firm producing at excessive cost levels because it has a production process that is too labor intensive.



Labor

a. Show on your graph the amount that would be saved if the firm altered its input combination to produce efficiently at the level of output selected.
b. Next, sketch on the same graph the output that could be produced if the initial cost levels were to be maintained.
c. Identify on the graph the new input combination that would be most efficient

4. Samuel has a total cost function $TC = 100 + 8Q - .12Q^2 + .004Q^3$. Show the ATC, AVC, and AFC equations.

5. Because of my heavy teaching load this term I did not have time to finish the table below, which relates output and cost. Please do it for me. The marginal cost figures refer to the marginal cost of moving from the previous unit to the unit of the row specified.

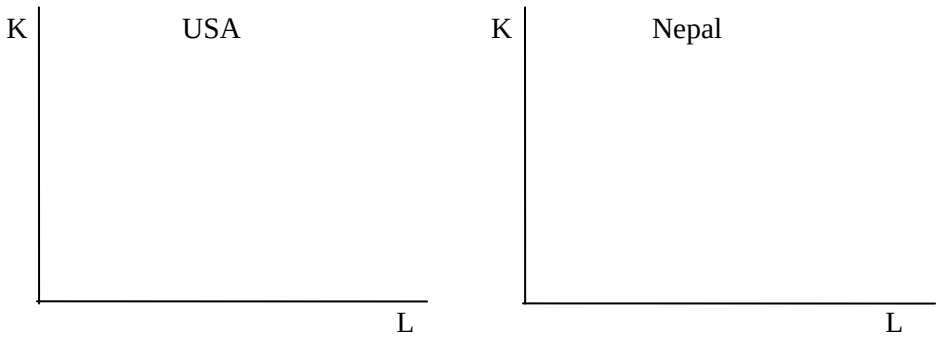
Q	STC	TFC	TVC	SAC	AFC	AVC	SMC
0							
1							25
2							20
3							24
4							30
5							38
6					30		48

6. Tell a real world story about costs of a specific McDonalds fast food restaurant in the short run. Describe what happens inside the restaurant as hamburger sales go from 1 to 100, 100 to 500, etc. and as the number of employees expands. What actually causes total cost to rise at a decreasing and then an increasing rate? Answer in terms of activity in the restaurant rather than technical economic jargon.

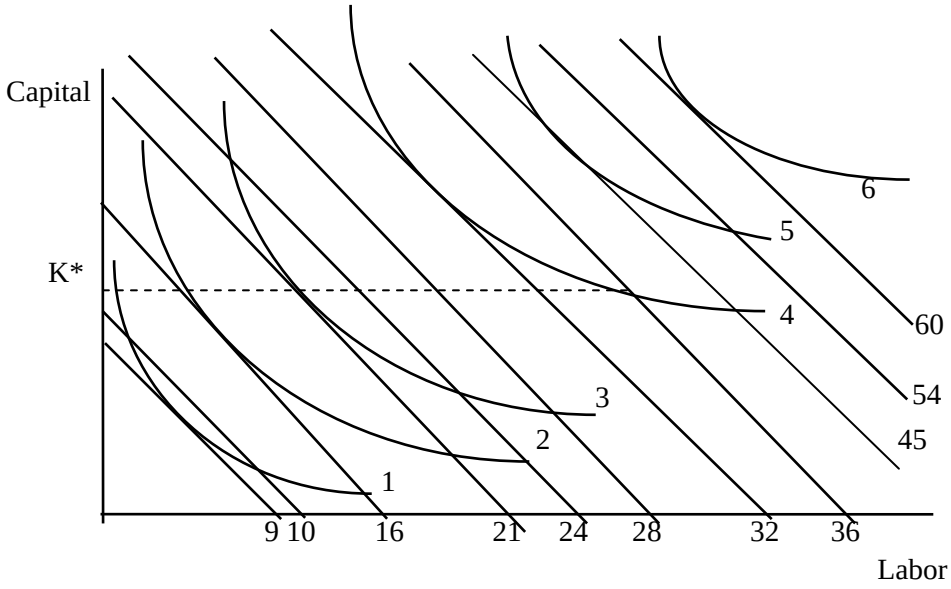
7. (True or False) Because controlling costs is so important in making profits, firms seek efficiency by first identifying the cost level they can afford and second, maximizing output subject to that cost constraint. Explain.

8. In the first part of this chapter in the text, Robert Frank tells the story of the road making process in Nepal. Use two graphs of isoquants and isocost functions to show

that both the US and Nepal may be efficient even though they have radically different approaches to the production process.



9. Identify six points on the long run average total cost curve from the graph below. If plant size K* produces four units of output how much waste will there be? The price of labor is $1.



ANSWERS TO QUESTIONS FOR CHAPTER 10

Case Questions

1. a. Fixed costs will be a horizontal line at $50,000 because capital costs will be $20,000 for the year and the lease of $30,000 is fixed for the year.
2. Total cost coordinates are (100,000: 2), (150,000: 7), (200,000: 14), (250,000: 20), (300,000: 23), (350,000: 25). The upper cells in the table which show AVC are 25,000: 14286: 10,714: 10,000: 10,870: 12,000. The lower row of ATC figures are 50,000: 21,429: 14,286: 12,500: 13,043: 14,000.

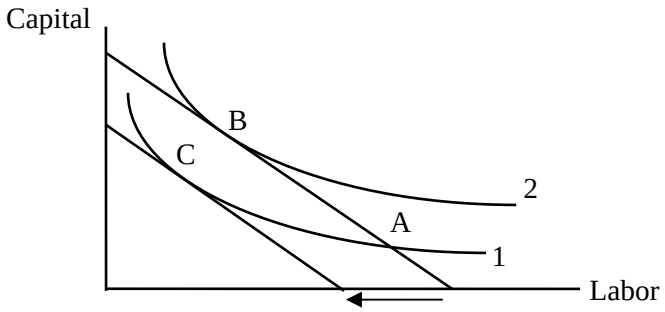
3. The fundamental reason that the average cost curves fall and then rise again is that there are increasing and then diminishing returns to production that first reduce average costs and then cause average costs to rise again.

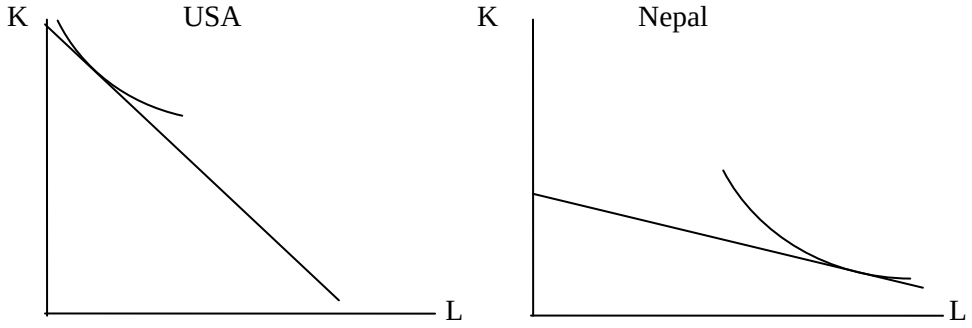
Multiple-Choice Questions

1. b, The numerator stays constant and the denominator keeps increasing.
2. d, We would need to know what the average variable cost is before we can know AFC.
3. b, AFC + AVC = ATC
4. a, When marginal product starts to fall, marginal costs begin to rise.
5. a, The ATC is pulled down by diminishing returns and falling AFC. AVC is not pulled down by the falling AFC, so the effect of diminishing returns is obvious sooner.
6. a, In the long run all costs are variable, so the ATC and AVC are the same.
7. d, One can always freeze in the dark or at least move in that direction.
8. a, The distance between them is TFC, which will not vary.
9. d, The marginal cost always pulls the average down if it is below the average cost.
10. b, If the MCs are not the same it will always be better to shift resources to the lowest MC operation until they equalize.
11. a, This was illustrated in the graph on page 137 and question number 4 above.
12. c, The ratio of the prices should equal the ratio of the marginal products, which is 1/3.
13. d, Labor will be cheap and profit-maximizing entrepreneurs will produce things that require labor rather than capital.
14. a, The absolute price is shown by the intercept and the relative price by the slope.
15. b, The slope of the isoquant shows that the $MP_K < P_K$.
16. d, The slope of the isoquant cannot be known without numbers.
17. d, If the marginal cost of an old plant is less than the marginal cost of a new plant the old plant should be used. This could happen if short run production requirements push a new plant toward too high a capacity.
18. b, All points on the LAC are the lowest cost points possible for that output even though they may not be low points on the short-run cost curve of the plant in use.
19. b, We call these natural monopolies, as we will see in Chapter 12.
20. d, Long-run costs are always the lowest cost that the best-sized short-run plant for each output can produce.

Problems

1. ($5/drill press hr.)(5 drill press hr./hr.) = $25/hr.. If the presses run all day the calculations will be ($5/drill press hr.)(5 drill press hr./hr.)(8 hr. day) = $200.
2. In the day to day operations where additions or subtractions from the variable inputs are relatively small the returns may be nearly constant. It is as though one takes a small piece of the normal total cost function and expands it until the curvature is irrelevant. Many daily, weekly or monthly production variations are likely to fit this kind of analysis. The production function that produces a linear cost function will be linear as well. If the TC is linear, there is no diminishing returns to production and so no upward pressure on cost exists. At the same time, TFC are being spread further and pulling ATC down. Thus the ATC curve continues to fall.
3. If the isoquant is flatter than the isocost line at the relevant production input combination, (point A) it means that the input on the horizontal axis has a lower marginal product than its cost and the other input has a higher marginal product than its cost. On the graph below, the producer could move up the isocost line to point B and produce the higher output 2 for the same cost as output 1. Alternatively, the producer could move to point C and produce output 1 for less cost as shown by the arrow.



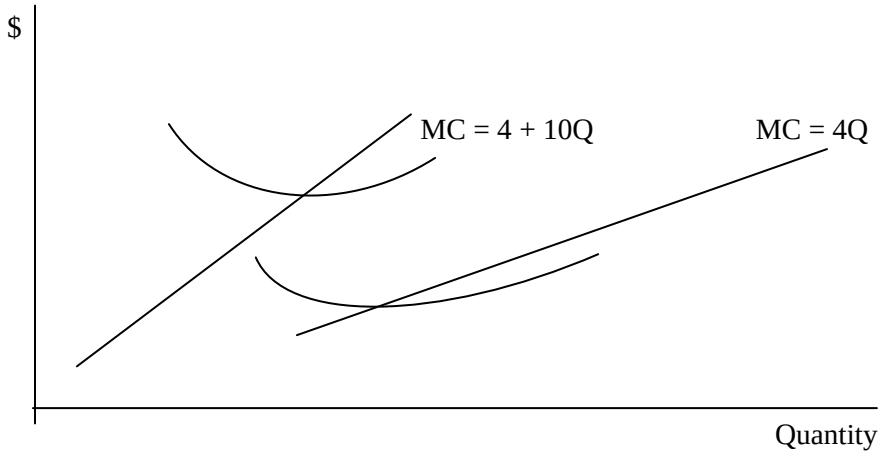
4. ATC = 100/Q + 8 -.12Q +.004Q^2 and AVC = 8 - .12Q + .004Q^2 and AFC = 100/Q
5. The STC column is 180, 205, 225, 249, 279, 317, 365. The TFC column is 180 in each space. The TVC column is 25, 45, 69, 99,137, 185. The SAC column is 205, 112.5, 83, 69.8, 63.4, 60.8. The AFC column is 180, 90, 60, 45, 36, 30. The AVC column is 25, 22.5, 23, 24.8, 27.4, 30.8.
6. At first, because workers special in a task, productivity rises and hamburgers per worker go up. However, eventually if workers are continually added, they will get in each other's way and have to wait on each other to do their work. That will reduce the hamburgers per worker and illustrate diminishing returns to production.
7. False. Firms should find the profit maximizing output that would result from an efficient operation and then they should produce that output with the least cost input combination to achieve the maximum profit possible.
8. 

9. The six points are (9,1), (8,2), (7,3), (8,4), (9,5), (10,6). If K* capital is used to produce isoquant 4, then the total cost will be 36 and average cost will be 9. By increasing the plant size and moving up the isocost line 32, output 4 could be produced for 32 and average cost would fall to 8. Thus 4 is lost by using the smaller facility.

HOMEWORK ASSIGNMENT **NAME: _____**

1. On the graph below sketch a set of short run cost curves that exhibit increasing and then diminishing returns. Include ATC, AVC, MC, and AFC. Label all axis and functions. Make sure the intersections are carefully located and the curves relate to each other in the appropriate manner. Do not use numbers. A sketch graph is sufficient if the relationships are all correct.

2. On the graph below the MC and ATC of two plants are shown. Both produce the same product and the MC equations for each are shown. Forty three units of output are to be produced. How many should be produced by each plant? Show on the graph why your answer is correct.



3. If both plants are used, explain why you would use one that has average costs so much higher than the other one. If your answer above included only one plant, explain why you would use only one plant when the marginal cost of the other would have lower marginal costs at low output levels.

4. The academic world has seen an enormous improvement in communications technology. Internet access, distance learning, virtual classrooms are part of the discussion and many schools are moving toward higher tech learning. Along with all of this has come a decline in the price of electronic information. By using isoquants and isocost lines, tell a story about what you might expect to happen to faculty salaries. List your assumptions because your answer could vary considerably depending on what you assume about the isoquants and isocost lines. Use the graph below as your starting point.