Markets

- A market is
  - *A group of sellers that trade products and services for an agreed form of remuneration (which is often money today) with the buyers*
  - *In product markets*
    - *Firms sell products*
    - *Consumers buy products*
  - *In labor markets*
    - *Workers sell labor services*
    - *Firms buy labor services*

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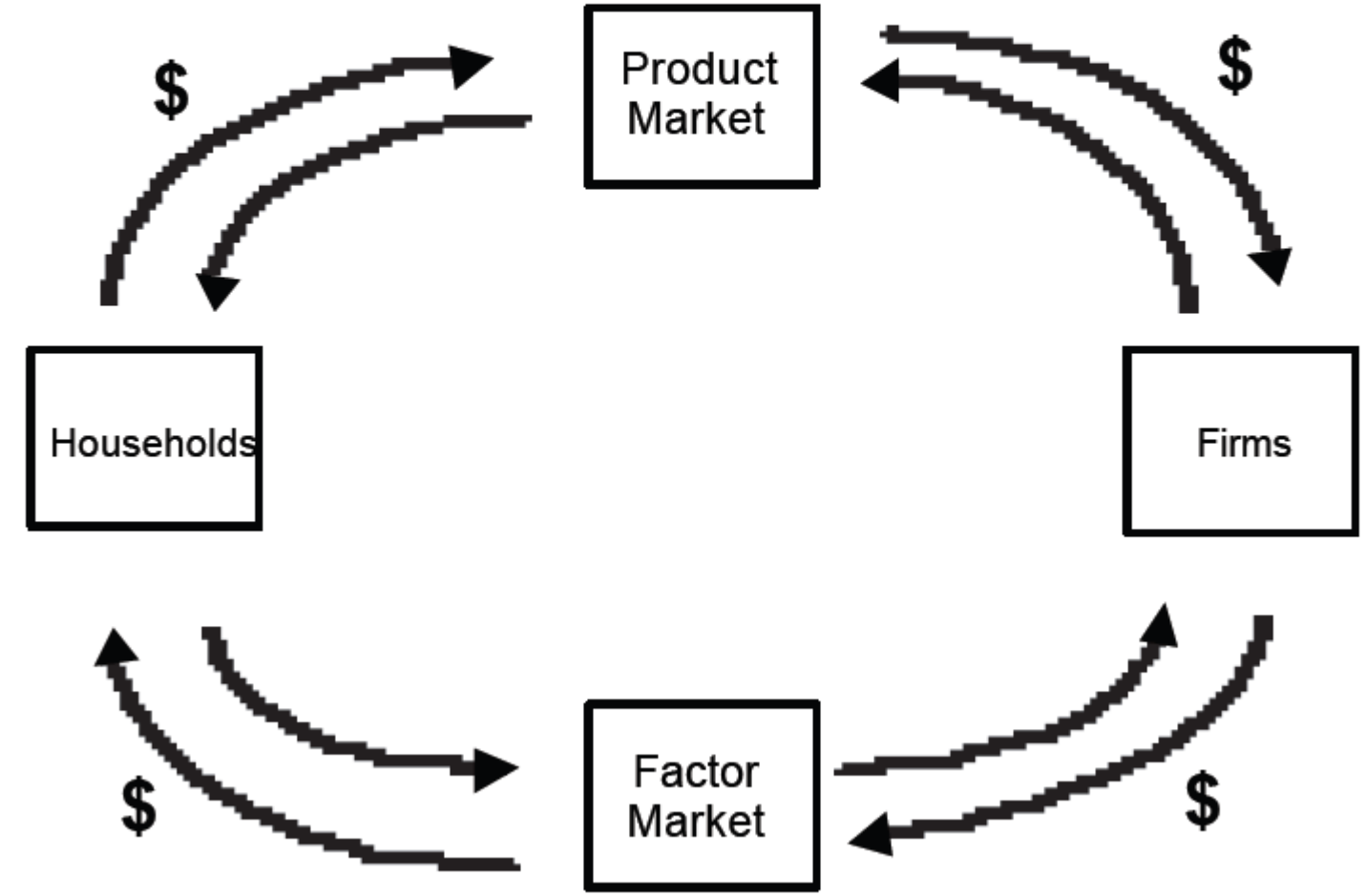
Circular Flow



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Theory of the Firm

- The theory of the firm describes how owners of firms choose inputs to produce goods and services given market prices of inputs. Topics:
  - *Production function*
    - *Returns to Scale*
  - *Optimal Choice of Inputs*
    - *Profit Maximization*
    - *Cost Minimization*
      - *Returns to Scale*
  - *Optimal Choice of Output and Prices*
    - *Types of Markets*

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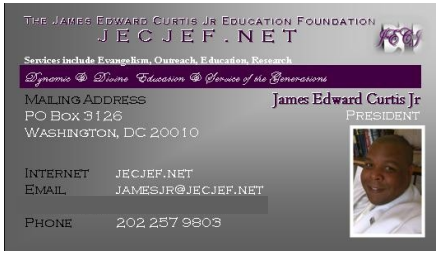
Theory of the Firm

- The theory of the firm describes how owners of firms choose inputs to produce goods and services given market prices of inputs
  - *Production function*



Production

- The production function describes how firms transform inputs into outputs
  - *Types of inputs:*
    - *Land (N), Labor (L), Capital (K), Entrepreneurship (E) and Technology (T)*
  - *Long-Run vs. Short-Run*
    - *The short-run ends when a firm can alter the amount (or the contract on) any one input. An input is fixed only in the short run.*
    - *The long-run begins at the period of time when a firm can alter the amount of (or the contract on) every input. All inputs are variable in the long run.*

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Production

- Production function notation (example):

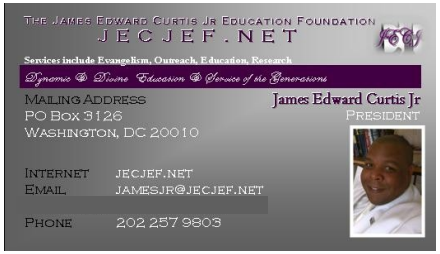
  L = *number of assembly workers*

  K = *number of robots*

  q = *the number of cars you produce from employing workers and machines*

  $\Rightarrow q = q(L,K)$ *or some function of labor and workers*

  – *The functional form of the production function depends your ability to transform workers, machines and raw materials into output*



Production

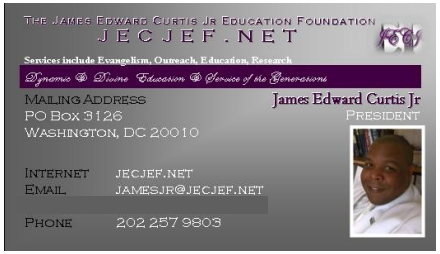
- Example 1: The perfect substitutes production function

L = *number of assembly line workers or worker hours*

K = *number of robots or robot hours*

q = *the quantity of cars you obtain from employing assembly line workers and machines*

$$q = q(L, K) = L + K$$

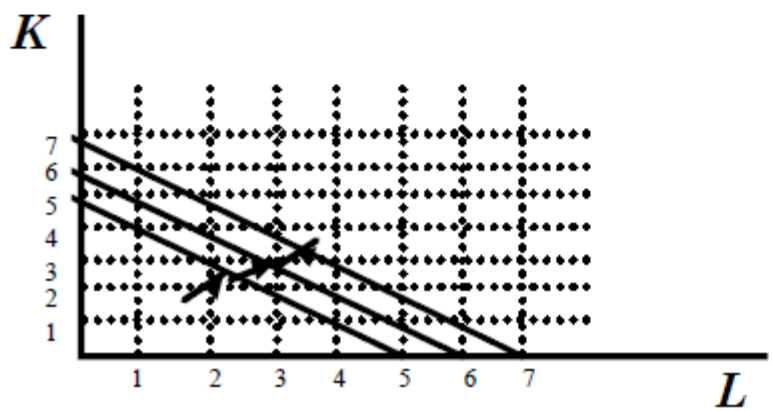


Production

- Graphing the perfect substitutes production function:
  - $q = L + K$
  - *Using robots as the y-axis, solve for K:*

$\Rightarrow K = q + (-1)L$ *such that for*

$q = 5$		$q = 6$		$q = 7$	
L	K	L	K	L	K
0	5	0	6	0	7
1	4	1	5	1	6
2	3	2	4	2	5
3	2	3	3	3	4
4	1	4	2	4	3
5	0	5	1	5	2



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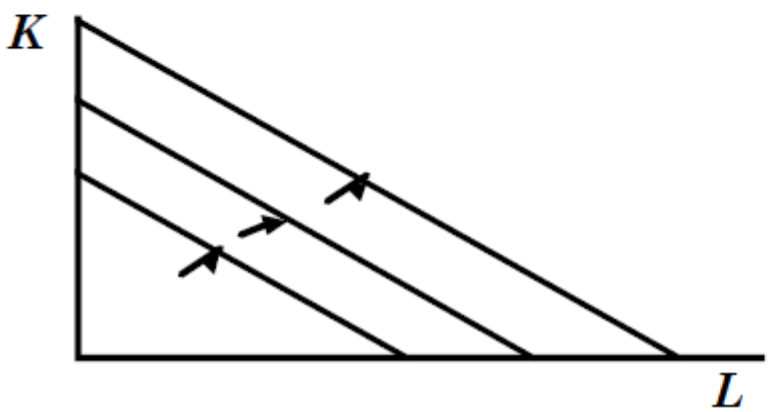
Production

- An isoquant curve is the graph of the production function and shows all combos of assembly line workers and machines that can be used to produce a car
  - *An isoquant map is a graphical summation of production relationships between two inputs and is a sample of isoquant curves that represents the complete set of the isoquant curves*



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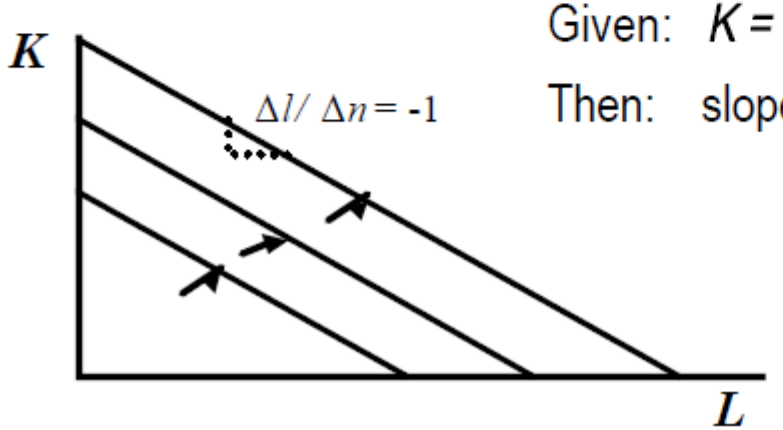
Production

- The slope of the isoquant curve equals the rate at which you are able to trade (an hour of work by) a machine for additional (hours of worker by) assembly line workers
  - *The slope of the isoquant curve is the marginal rate of technical substitution (MRTS): You are able to employ one additional (hour of work from an) assembly line worker by giving up (an hour of work by) a machine*



Given: $K = q + (-1)L$

Then: slope = rise/run = $\Delta K / \Delta L$ = MRS = -1

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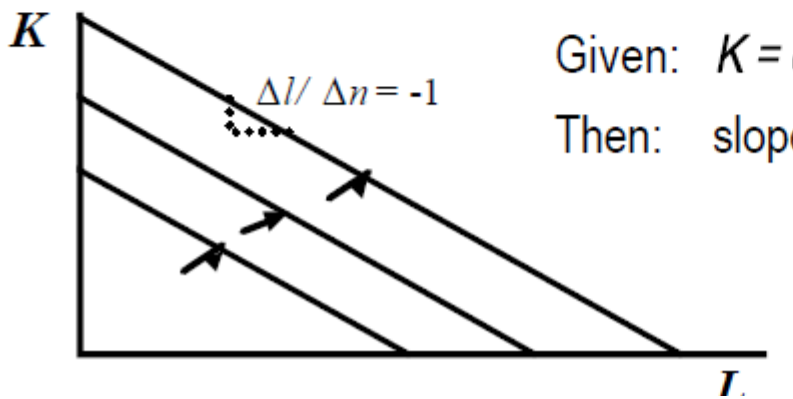
Production

- The slope of the isoquant curve, or MRTS, is also defined as the (negative) ratio of the marginal product of an hour of work by an assembly line worker to the marginal product of an hour of work by a machine
  - *Marginal product (MP) is the additional cars you obtain from employing one additional hour of a machine, or capital, (MP_K); and the additional cars you obtain from employing one additional hour of work from an assembly line worker, or labor (MP_L)*



Given: $K = q + (-1)L$

Then: slope = MRTS = $- MP_L / MP_K = -1$

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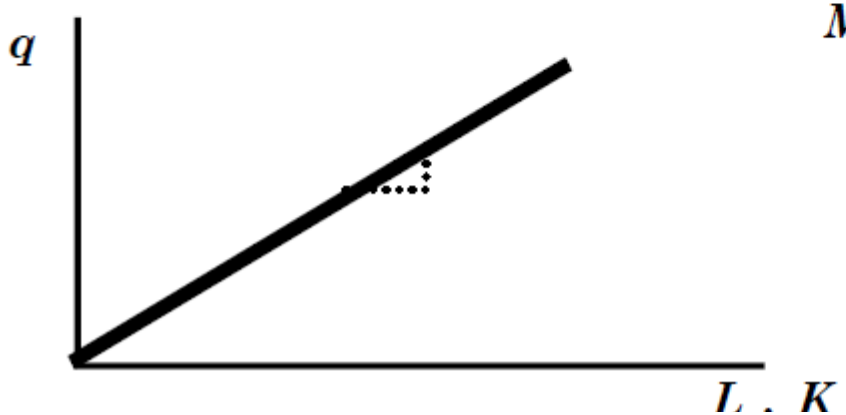
Production

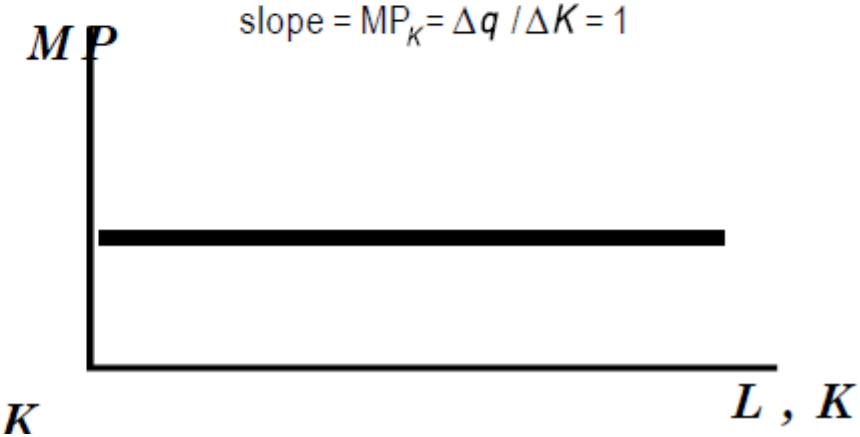
- The perfect substitutes production function (con't):
  - *Produces a constant marginal product.*
    - *It suggests that you always obtain the same additional portion of a car with each additional hour from a machine or assembly line worker*
    - *Which may be unrealistic*

Given: $q = K + L$

Then: slope = $MP_L = \Delta q / \Delta L = 1$

slope = $MP_K = \Delta q / \Delta K = 1$





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Production

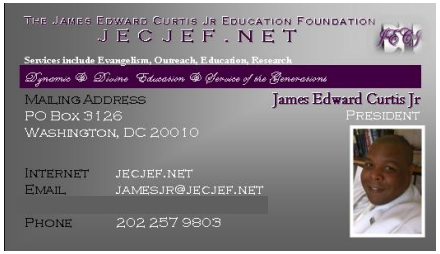
- Example 2: The perfect complements production function:

L = *number of road-pavers*

K = *number of road-paving machines*

q = *the number of streets you pave from employing road-pavers and road-paving machines*

$$q = q(L, K) = \mathrm{MIN}(L, K)$$



Production

- Graphing the perfect complements isoquant curve:
  - q = MIN(L,K)
  - *Using road-paving machines as the y-axis, solve for K:*

$\Rightarrow$ q = MIN(L,K) *such that for*

$q = 5$		$q = 6$		$q = 7$	
L	K	L	K	L	K
5	5	6	6	7	7
6	5	7	6	8	7
7	5	8	6	9	7
.	.	.	.	.	.
.	.	.	.	.	.
5	5	6	6	7	7
5	6	6	7	7	8
5	7	6	8	7	9
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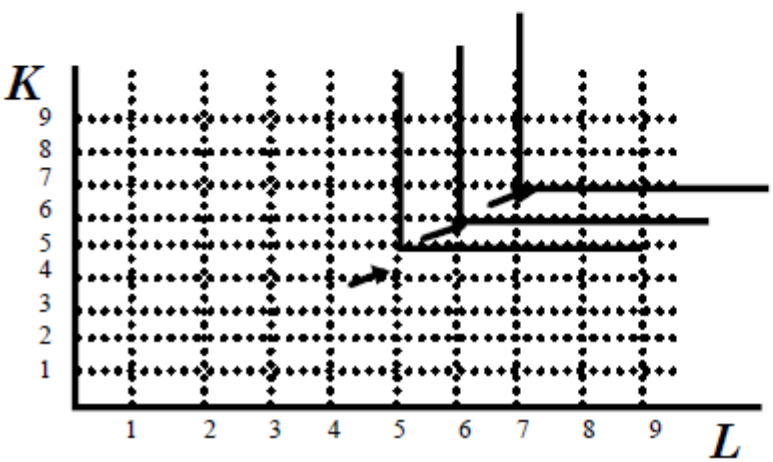
.	.	.	.	.	.



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Production

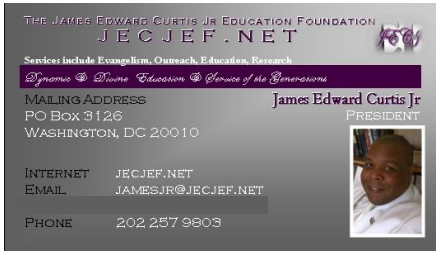
- Example 3: The strictly convex production function:

L = *number of workers*

K = *number of machines*

q = *the units of output you obtain from employing workers and machines*

$q = q(L, K) = L^{1/2}K^{1/2}$ *(also known as Cobb-Douglas)*



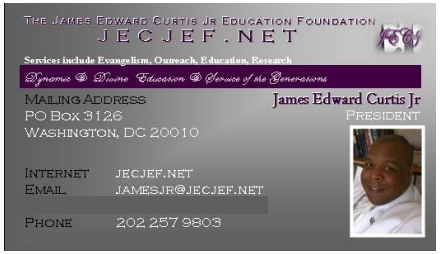
Production

- Graphing the strictly convex isoquant curve:
  - $q = L^{1/2}K^{1/2}$
  - *Using number of machines as the y-axis, solve for K:*

$\Rightarrow K^{1/2} = q / L^{1/2}$

$K = q^2 / L$ *such that for* $q = 1$ $q = 2$

L	K	L	K
0.25	4.00	0.25	16.00
0.50	2.00	0.50	8.00
1.00	1.00	1.00	4.00
2.00	0.50	2.00	2.00
4.00	0.25	4.00	1.00
8.00	0.13	8.00	0.50



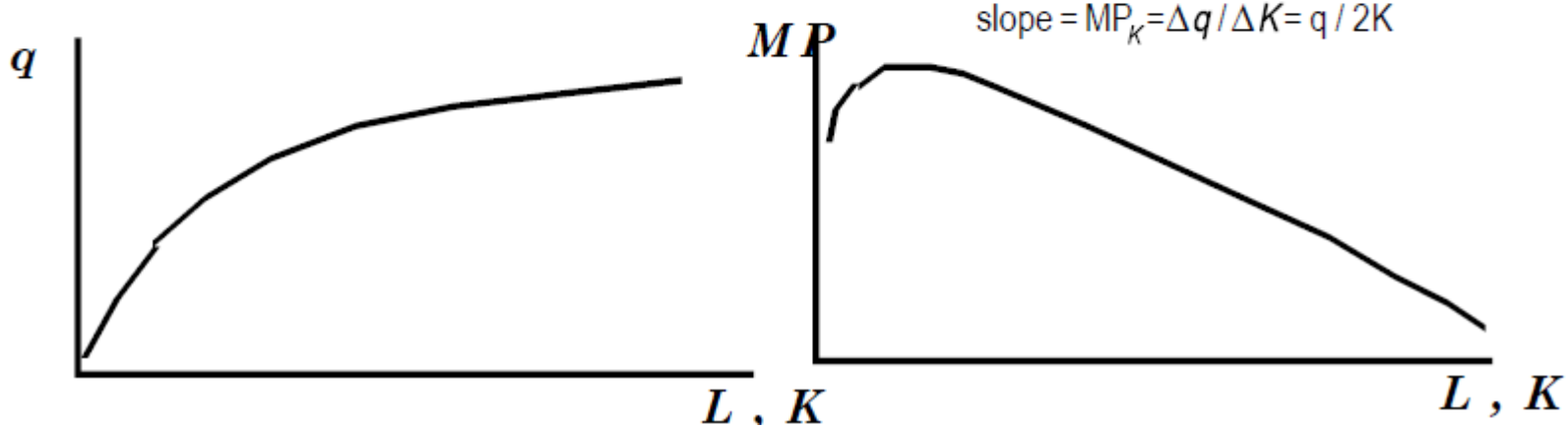
Production

- The strictly convex production function (con't):
  - *Preserves the law of diminishing marginal product*
    - *The Law of Diminishing Returns says that output grows at a decreasing rate as firms increase the amount of labor or capital employed in production*
    - *Which may be more realistic than constant marginal product*

Given: $q = L^{1/2}K^{1/2}$

Then: slope = $MP_L = \Delta q / \Delta L = q / 2L$

slope = $MP_K = \Delta q / \Delta K = q / 2K$



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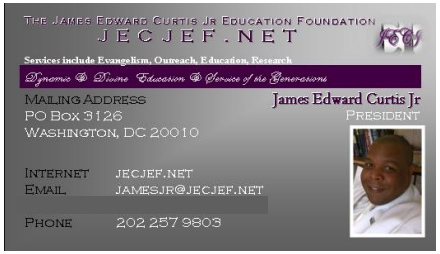
Theory of the Firm

- The theory of the firm describes how owners of firms choose inputs to produce goods and services given market prices of inputs
  - *Production function*
    - *Returns to Scale*



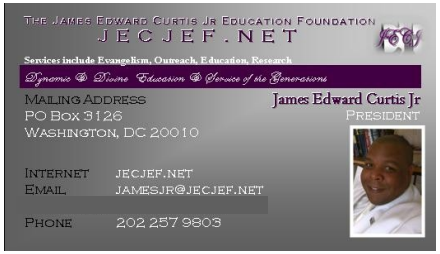
Production

- Analyzing returns to scale means answering:
  - *What happens to output when inputs double?*
    - *Output more than doubles (IRS)*
    - *Output less than doubles (DRS)*
    - *Output exactly doubles (CRS)*

  What amount of inputs are for output to double?

  less than double inputs (IRS)
  More than double inputs (DRS)
  Exactly double inputs (CRS)

  - *Firms must consider the impact of scaling (changing inputs proportionally) on outputs, profits and costs*



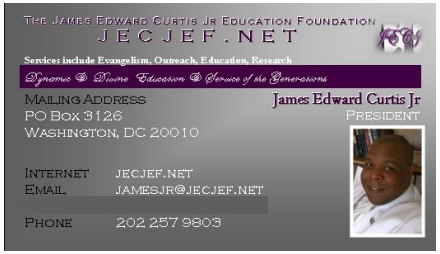
Production

- Decreasing Returns to Scale (DRS)
  - *Example 1:*
    - *Tripling your labor (3L) and tripling your capital (3K) doubles your output, which is obviously less than triple your output (3q)*
    - *i.e.* $q(3L,3K) = 2q < 3q$.
  - *Example 2:*
    - *In order double your output (2q), you must more than double your labor by tripling your labor (3L) and more than double capital by tripling your capital (3K)*
    - *i.e.* $2q = q(3L, 3K)$.
  - *Cobb-Douglass production function (example):*

$$\text{If} \quad q = q(L, K) = a L^{1/2} K^{1/4},$$

$$\text{Then} \quad q(2L, 2K) = a(2L)^{1/2}(2K)^{1/4} = a\, 2^{1/2} L^{1/2}\, 2^{1/4} K^{1/4} = (2^{1/2+1/4})(aL^{1/2}K^{1/4})$$

$$= 2^{3/4} q = 1.68q < 2q$$



Production

- Increasing Returns to Scale (IRS)
  - *Example 1:*
    - *Doubling your labor (2L) and doubling your capital (2K) triples your output (3q), which is more than doubles your output (2q)*
    - *i.e.* $q(2L,2K) = 3q > 2q$.
  - *Example 2:*
    - *In order triple your output (3q), you must less than triple your labor by doubling your labor (2L) and less than triple your capital by doubling your capital (2K)*
    - *i.e.* $q(2L, 2K) = 3q$.
  - *Cobb-Douglass production function (example):*

    If $q = q(L, K) = a L^{1/2} K^{3/4}$,

    Then $q(2L, 2K) = a(2L)^{1/2}(2K)^{3/4} = a2^{1/2}L^{1/2}2^{3/4}K^{3/4} = (2^{1/2+3/4})(aL^{1/2}K^{3/4})$

    $= 2^{1\frac{1}{4}}q = 2.38q > 2q$

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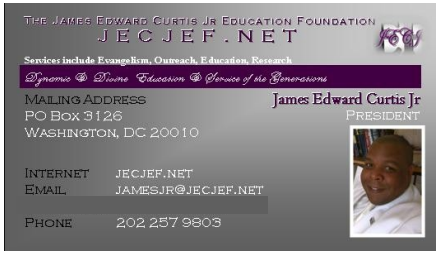
Production

- Constant Returns to Scale (CRS)
  - *Example 1:*
    - *Doubling your labor (2L) and doubling your capital (2K) equals double your output (2q)*
    - *i.e.* $q(2L,2K) = 2q$.
  - *Example 2:*
    - *In order double your output (2q), you must exactly double your labor (2L) and exactly double capital (2K)*
    - *i.e.* $q(2L, 2K) = 2q$.
  - *Cobb-Douglass production function (example):*

If $q = q(L, K) = a L^{1/2} K^{1/2}$,

Then $q(2L, 2K) = a(2L)^{1/2}(2K)^{1/2} = a2^{1/2}L^{1/2}2^{1/2}K^{1/2} = (2^{1/2+1/2})(aL^{1/2}K^{1/2})$

$= 2^1 q = 2q$

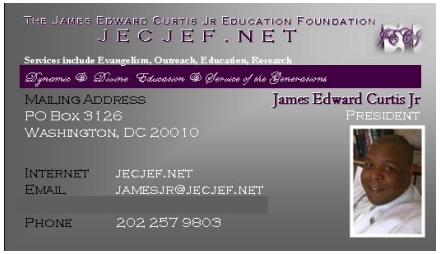


Production

- Summary of returns to scale and Cobb-Douglas production function

$$Given: q = q(L, K) = aL^c K^d ,$$

- *If* $c + d > 1$, *then IRS*
- *If* $c + d = 1$, *then CRS*
- *If* $c + d < 1$, *then DRS*



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  - *Production function*
    - *Returns to Scale*
  - *Optimal Choice of Inputs*
    - *Profit Maximization*

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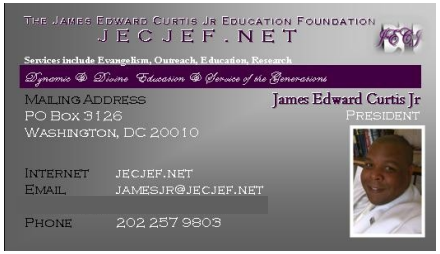
Profit Maximization

- Firms that make textbooks, for example, seek to maximize short-run profits subject to their ability to labor and machine work into textbooks
  - *Profits equals revenue from producing textbooks minus the costs of producing textbooks*
  - *Short run implies that one input is fixed*
  - *Assume perfectly competitive markets where firms sell their output at the market price (price takers)*



Profit Maximization

- Optimization problem notation (example)
  - *Strictly convex production function:*

    b = *number of economics textbooks produced (* optimal)*

    l = *units of labor hours employed to make textbooks (* optimal)*

    k_o = *number of machines employed to make textbooks (fixed at 5)*

    p_b = *market price of economics textbooks (\$100)*

    w = *market price of workers (\$50)*

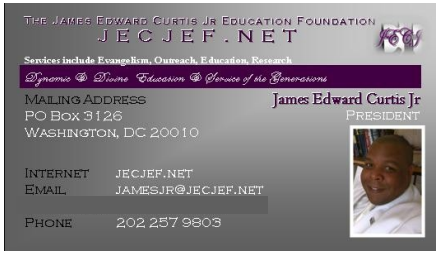
    r = *market price of machines (\$40)*

    π = *the profit you obtain from producing textbooks*

  - *Choose* l^* *and* b^* *to*

    Maximize $\pi = p_b b - (wl + rk_o)$

    Subject to $b = l^{1/2} k_o^{1/2}$

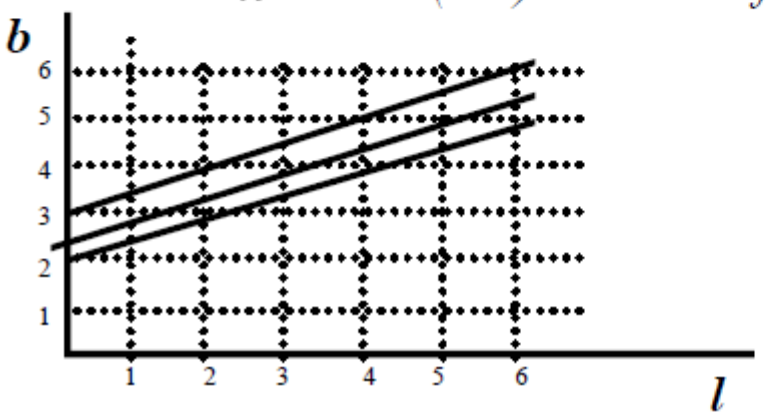


Profit Maximization

- Graphing the optimization problem (profit):
  - $\pi = p_b b - (wl + rk_o)$
  - *Using textbooks as the y-axis, solve for b:*
  - $p_b b = \pi + wl + rk_o$
  - $b = \pi/p_b + (w/p_b)l + (r/p_b)k_o$
  - *Plugging in* $p_b = 100$, $w=50$, $r=40$, *and* $k=5$

$\Rightarrow b = \pi/100 + (50/100)l + (40/100)5$

$\Rightarrow b = 2 + \pi/100 + (1/2)l$ *such that for* $\pi = 0$ $\pi = 50$ $\pi = 100$



l	b	l	b	l	b
0	2.0	0	2.5	0	3.0
1	2.5	1	3.0	1	3.5
2	3.0	2	3.5	2	4.0
3	3.5	3	4.0	3	4.5
4	4.0	4	4.5	4	5.0
5	4.5	5	5.0	5	5.5

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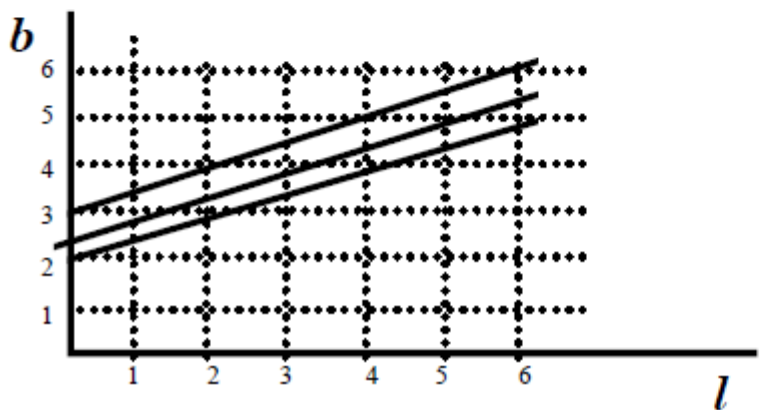
Profit Maximization

- The isoprofit curve is the graph of the profit function and shows all combinations of labor and textbooks which produces the same level of profit
  - *An isoprofit map is a graphical summation of profits at different combos of textbooks and labor, and is a sample of isoprofit curves that represents the complete set of the isoprofit curves*



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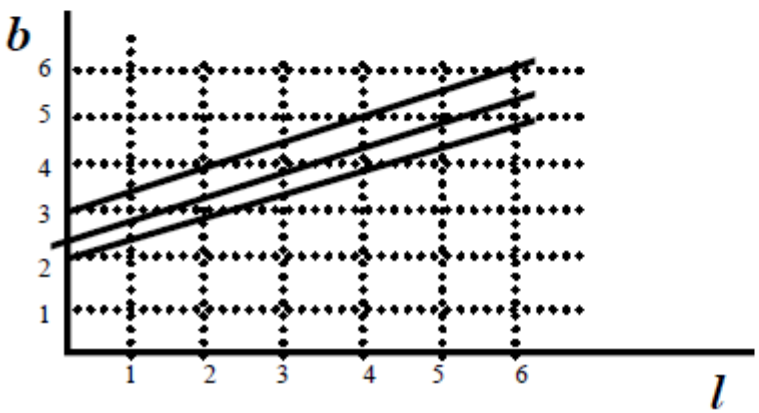
Profit Maximization

- The slope of the isoprofit curve equals w/p_b where p_b is the price of textbooks and w is the wage. The wage is the *marginal cost* or additional cost of producing a textbook with one additional unit of labor.

Given: $b = \pi/p_b + (w/p_b)l + (r/p_b)k_o$

Then: slope = rise/run = $\Delta b / \Delta l = w/p_b = 1/2$



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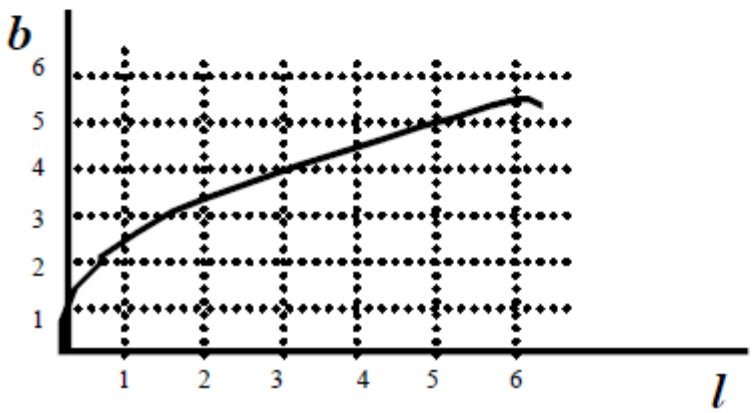
Profit Maximization

- Graphing the optimization problem (production):
  - $b = l^{½} k_o^{½}$
  - *Using number of textbooks as the y-axis, solve for b:*

$\Rightarrow b = l^{½} 5^{½}$ *such that for*

l	b
0	0.00
1	2.24
2	3.16
3	3.87
4	4.47
5	5.00



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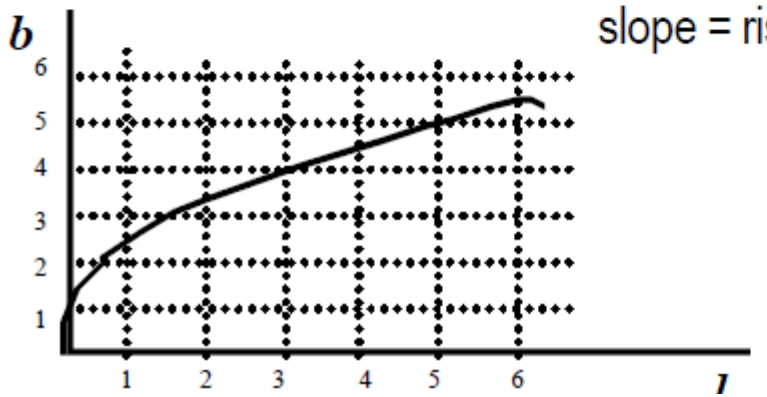
Profit Maximization

- The slope of the production function equals the marginal product of labor.
  - *The marginal product of labor (MP_l) is the additional textbooks you obtain with an additional unit of labor.*
    - *The price of textbooks (p_b) times MP_l is the marginal revenue. Marginal revenue, here, is the additional revenue you obtain from employing an additional unit of labor*



slope = rise/run = $\Delta b / \Delta l = MP_l$

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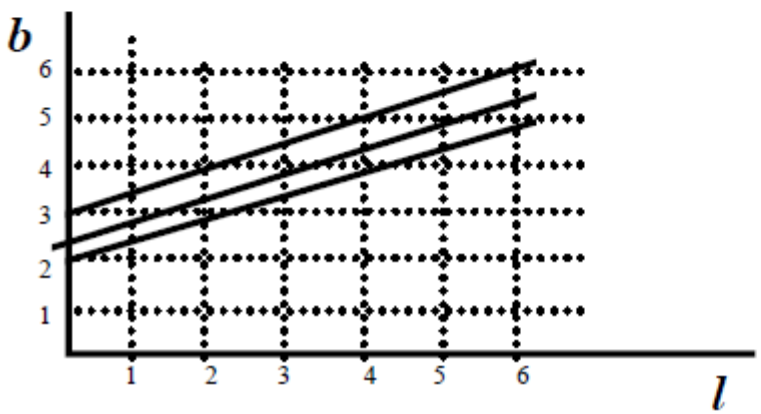
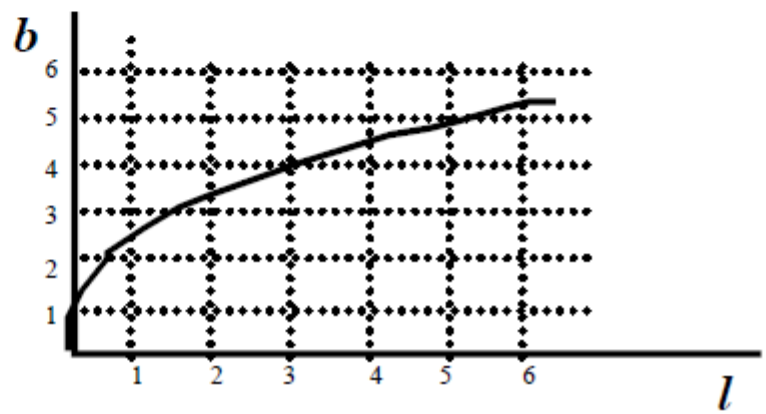
Profit Maximization

- Graphing the optimization problem *(con't)*:
  - *Combining profit function and production function to obtain the optimal choices of labor and textbooks*





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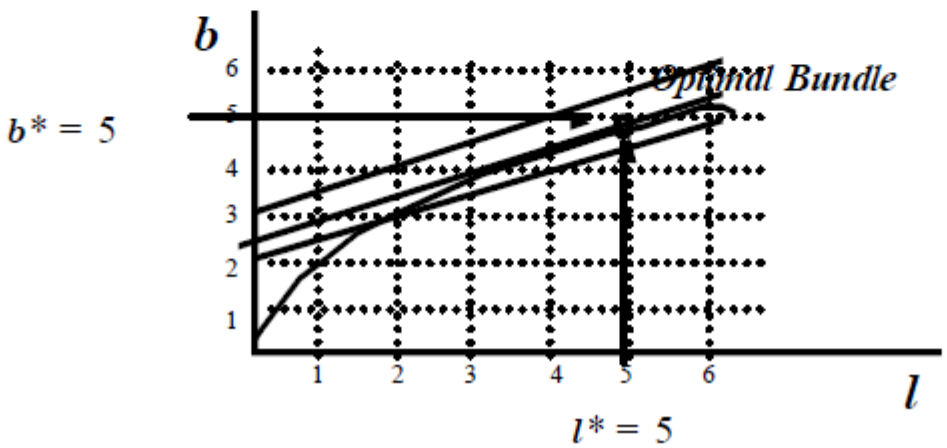
Profit Maximization

- The solution to the optimization problem:
  - *The optimal choice of textbooks and labor occurs where:*
    - *The isoprofit curve is tangent to the production function*
    - *The slopes are equal (where $MP_l = w/p_b$)*



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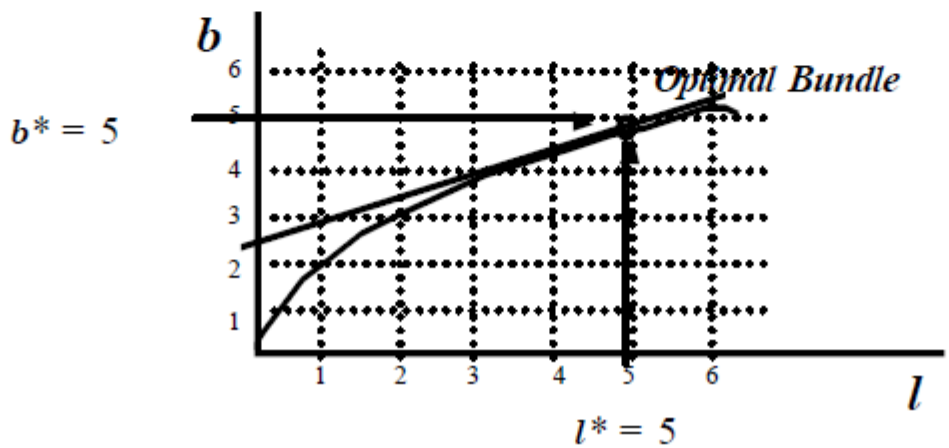
Profit Maximization

- The solution to the optimization problem *(con't)*:
  - *The optimal choice of textbooks and labor occurs where:*
    - $MP_l = w/p_b$ or $0.5 = 50 / 100$

      $p_b\, MP_l = w$ or $100\,(0.5) = 50$

      Marginal Revenue (labor) = Marginal Cost (labor)



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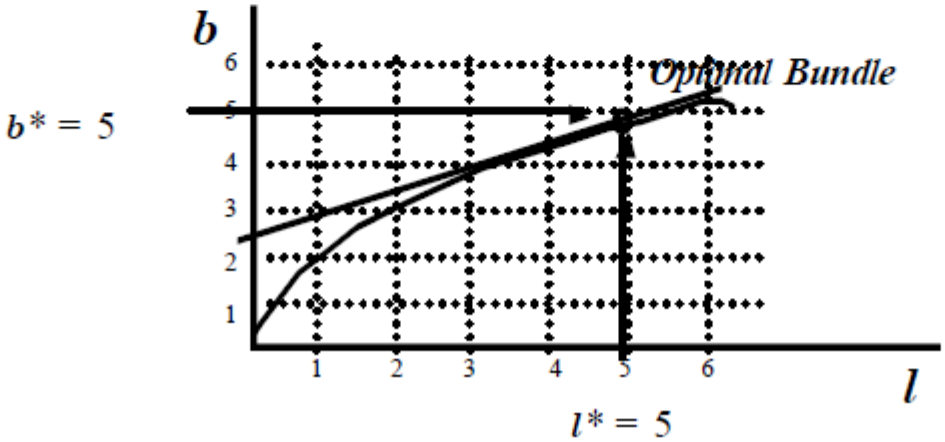
Profit Maximization

- The short-run individual labor demand curve is formed by the optimal choice of labor at different market wages, holding constant the market price of textbooks.
  - *The short-run individual labor demand curve is more technically derived using the value of the MP_l (= p_b*MP_l).*



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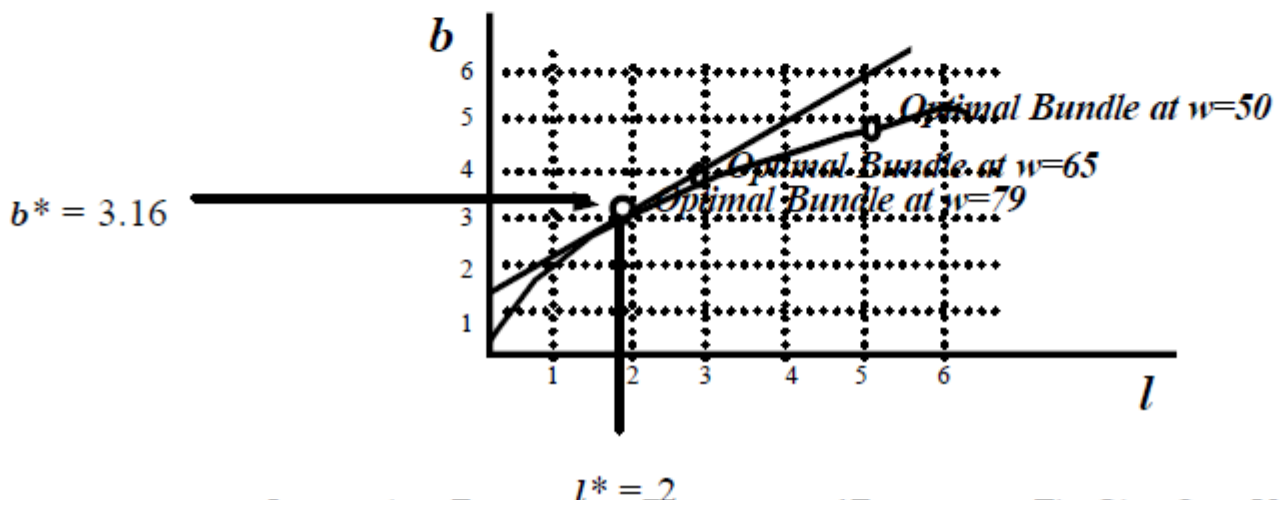
Profit Maximization

- If the wage increases
  - *From $50 to $79*
  - *The isoprofit curve becomes steeper*



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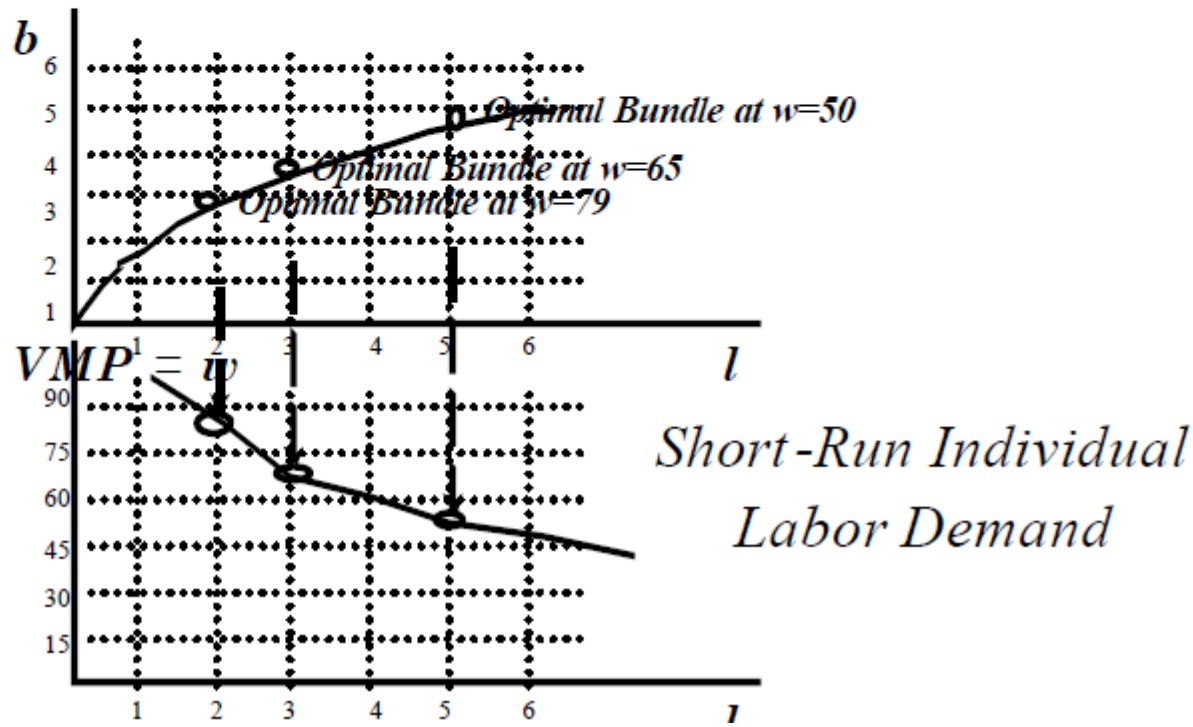
Profit Maximization

- The short-run individual labor demand curve
  - *Formed by the optimal choice of labor at different market wages holding constant the market price of textbooks*



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Theory of the Firm

- The theory of the firm describes how owners of firms choose inputs to produce goods and services given market prices of inputs. Topics:
  - *Production function*
    - *Returns to Scale*
  - *Optimal Choice of Inputs*
    - *Profit Maximization*
    - *Cost Minimization*

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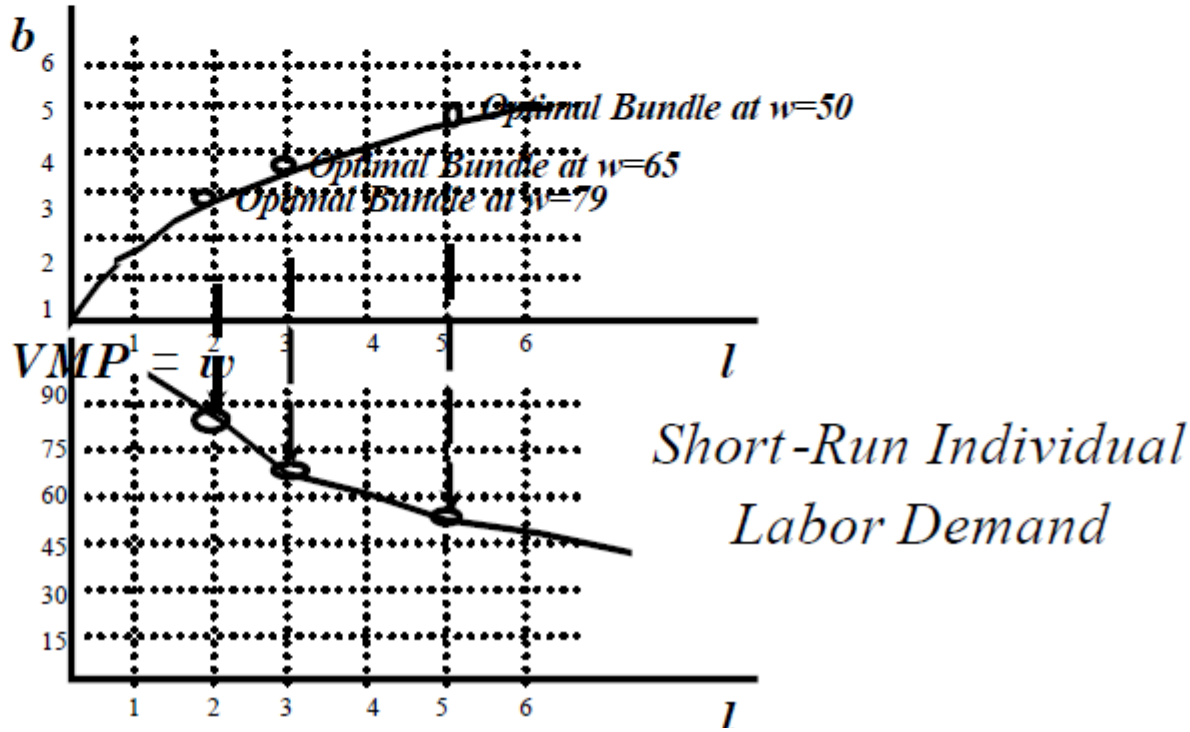
Profit Maximization

- The short-run individual labor demand curve
  - *Formed by the optimal choice of labor at different market wages holding constant the market price of textbooks*



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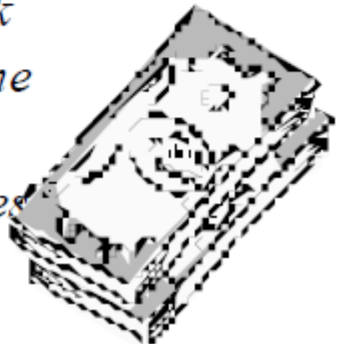
Cost Minimization

- Firms that produce textbooks, for example, seek to minimize long-run costs based on their ability to transform paper, labor and machines into textbooks
  - *Cost minimization equals profit maximization in perfectly competitive markets (p_b is given)*
  - *Cost minimization implies minimizing economic costs by choosing inputs based on their marginal costs*
    - *Accounting Costs are actual costs (C) , such as labor (l) and capital (k) costs of producing textbooks: C=wl+rk*
    - *Economic Costs are opportunity costs or foregone profit from other production opportunities*
    - *Sunk Costs are unrecoverable (previous) expenses*
    - *Marginal Costs are additional (future) expenses*



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Cost Minimization

- Optimization problem notation (example)
  - *Strictly convex production function:*

    b = *number of economics textbooks produced (fixed at 3.16)*

    l = *units of labor hours employed to make textbooks (* optimal)*

    k = *number of machines employed to make textbooks (* optimal)*

    w = *market price of workers (\$50)*

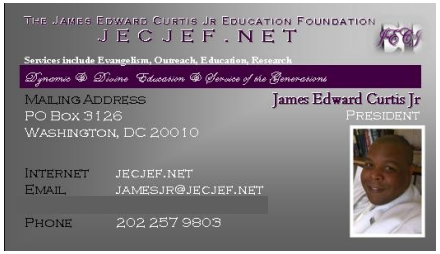
    r = *market price of machines (\$40)*

    C = *the labor and capital costs you pay to produce textbooks*

  - *Choose* l^* *and* k^* *to*

    Minimize $C = wl + rk$

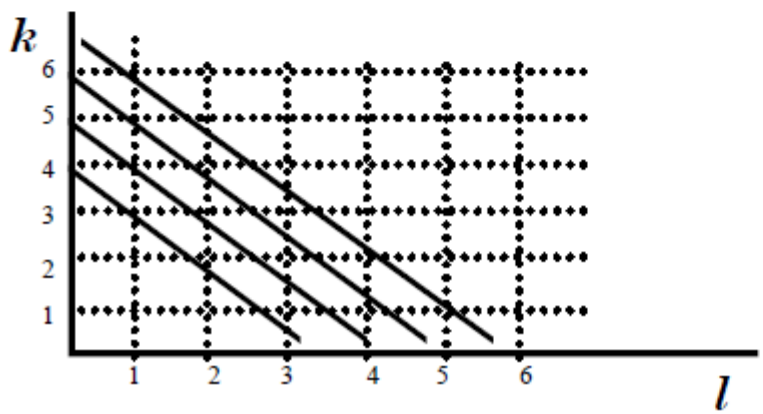
    Subject to $b = l^{1/2} k^{1/2}$



Cost Minimization

- Graphing the optimization problem (costs):
  - $C = wl + rk$
  - *Using capital as the y-axis, solve for k:*
  - $rk = C - wl$
  - $k = C/r - (w/r)l$
  - *Plugging in w=50 and r=40*

$\Rightarrow$ $k = C/40 - (50/40)l$ *such that for* **C = 160** **C = 200** **C = 240**



l	k	l	k	l	k
0	4.00	0	5.00	0	6.00
1	2.75	1	3.75	1	4.75
2	1.50	2	2.50	2	3.50
3	0.25	3	1.25	3	2.25
		4	0.00	4	1.00

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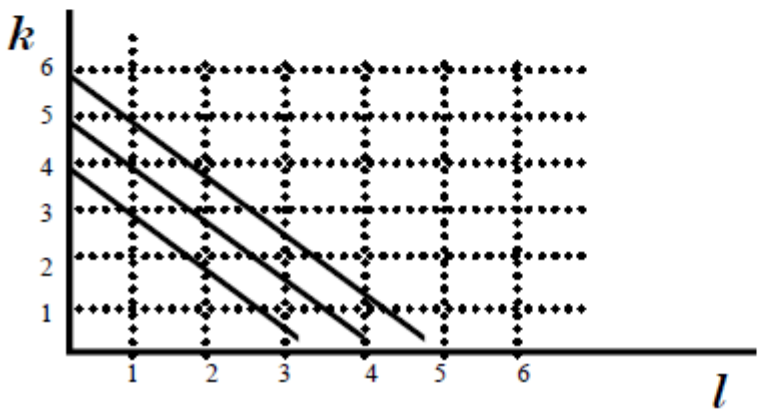
Cost Minimization

- The isocost curve is the graph of the cost function and shows all combinations of labor and capital which have the same total cost
  - *An isocost map is a graphical summation of costs at different combos of capital and labor, and is a sample of isocost curves that represents the complete set of the isocost curves*



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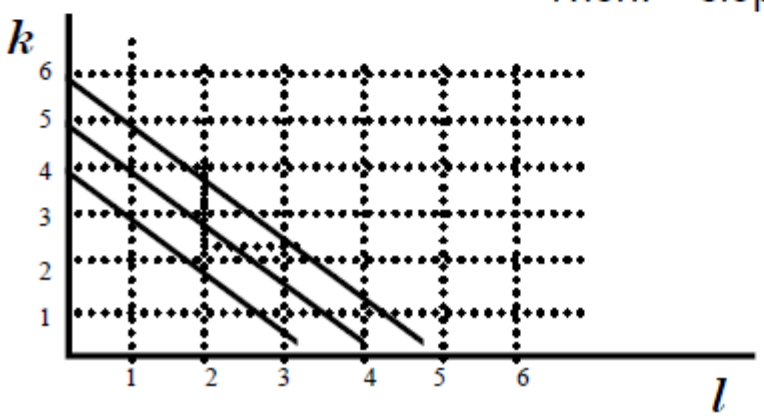
Cost Minimization

- The slope of the isocost curve is the factor price ratio
  - *The factor price ratio measures the amount of capital you must give up to obtain an additional unit of labor*
    - *You must give up one and one-fourth units of capital to obtain an additional unit of labor*

Given: $k = C/40 - 1.25l$

Then: slope = rise / run = $\Delta k / \Delta l = -w/r = -1.25$



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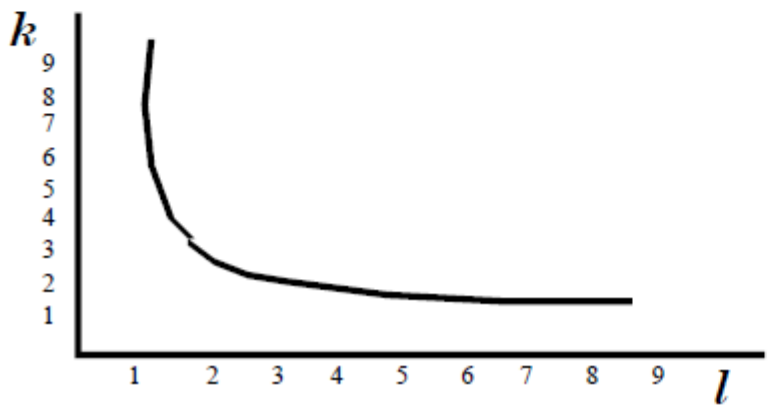
Cost Minimization

- Graphing the optimization problem (isoquant):
  - $b = l^{1/2} k^{1/2}$
  - *Using number of machines as the y-axis, solve for K:*

$\Rightarrow k^{1/2} = b / l^{1/2}$

  - *Plugging in b =3.16:*
  - $k = 3.16^2 / l$ *such that for* $\underline{b = 3.16}$



L	K
0.50	19.97
1.00	9.99
2.00	4.99
3.00	3.33
4.00	2.50
8.00	1.25

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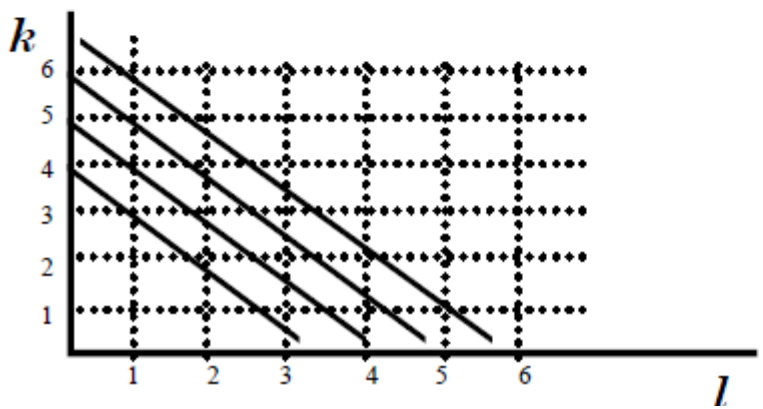
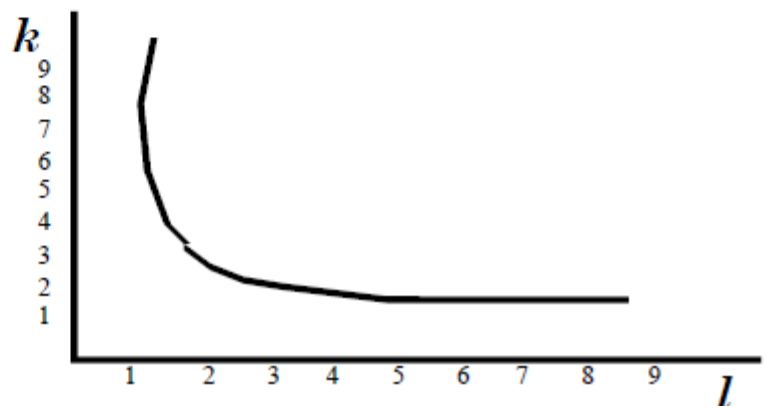
Cost Minimization

- Graphing the optimization problem (*con't*):
  - *Combining cost function and production function to obtain the optimal choices of labor and capital*





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Cost Minimization

- The solution to the optimization problem:
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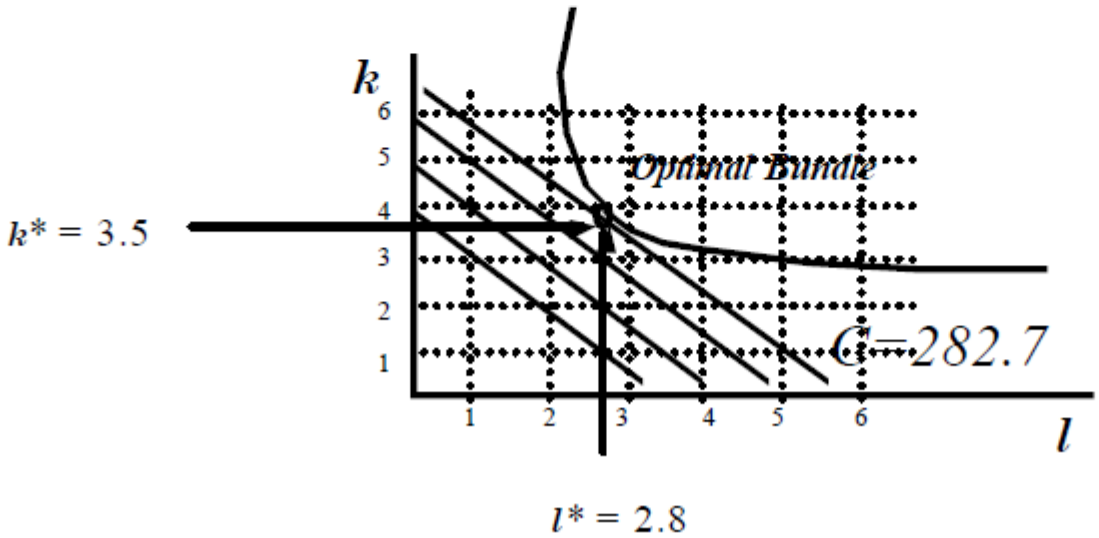
    - *The slopes are equal (where MRTS = w/r)*



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Cost Minimization

- The solution to the optimization problem (*con't*)
  - *Slope analysis at 2.8 units of labor & 3.5 units of capital*
    - *MRTS = factor price ratio (or relative factor prices) = -1.25:*
    - *Your technology (production ability) allows you to give up one and one-fourth of units of capital to obtain one unit of labor (MRTS)*
    - *Because of market prices, it costs you one and one-fourth units of capital to obtain one unit of labor (factor price ratio)*
    - *Interior Solution*

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Cost Minimization

- The solution to the optimization problem (*con't*)
  - *Dollar-spent analysis at 2.8 units of labor & 3.5 units of capital*
    - *Rearranging MRTS = relative factor price ratio (1.25):*

$$MP_l / MP_k = w / r$$

$$MP_l = MP_k (w / r)$$

$$MP_l / w = MP_k / r$$

  - *The additional textbooks obtained from a dollar spent on labor equals the additional textbooks obtained from a dollar spent on capital*
    - *If not, re-adjust production to obtain same marginal product of a dollar spent*

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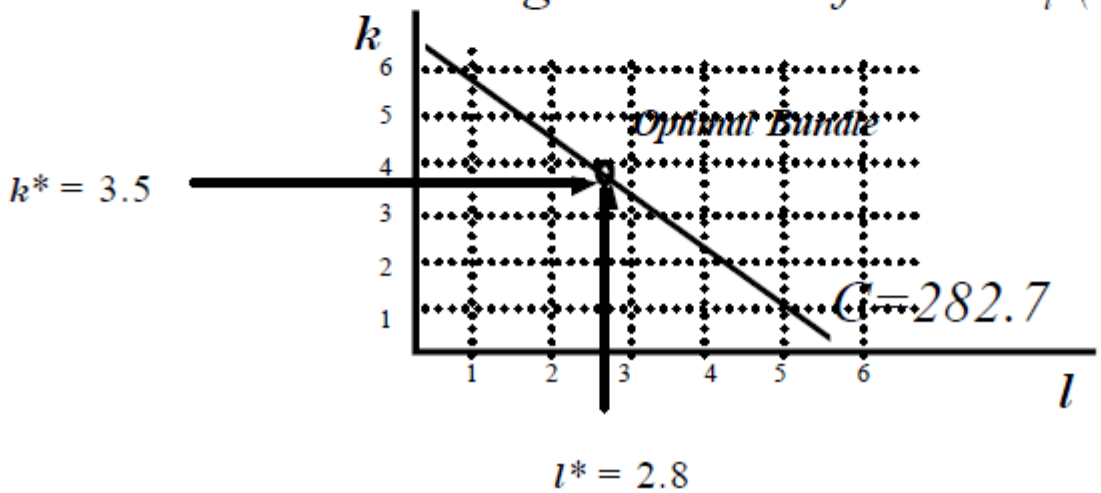
Cost Minimization

- The long-run individual labor demand curve is formed by the optimal choice of labor at different market wages, holding constant the choice and market price of capital.
  - *More technically, the long-run individual labor demand curve is derived using the value of the MP_l ($= p_b * MP_l$).*



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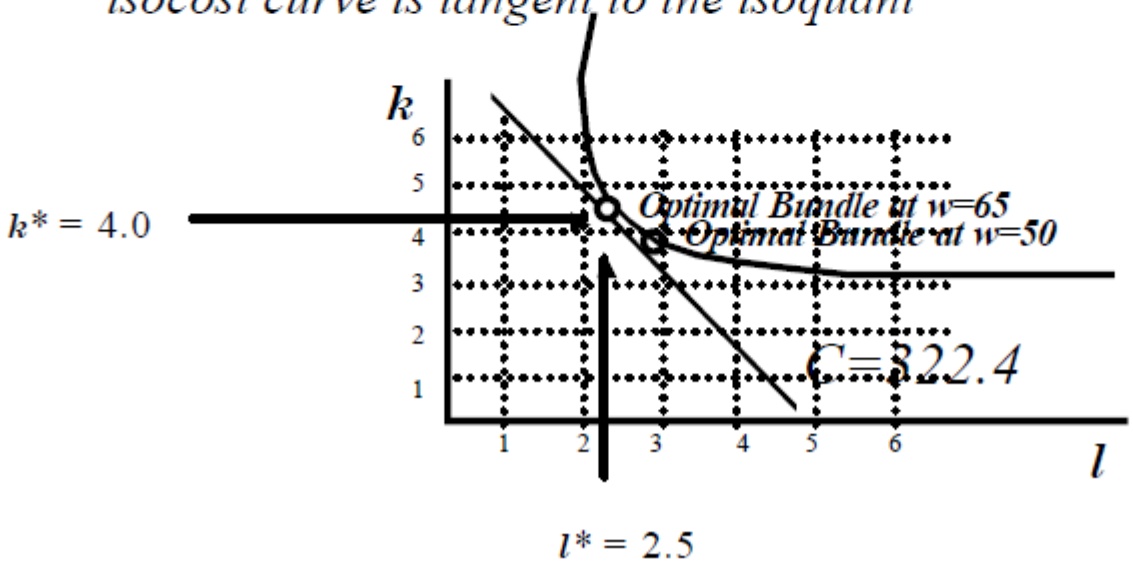
Cost Minimization

- If the wage increases:
  - *from $50 to $65,*
    - *The isocost curve pivots inward (around the fixed isoquant)*
    - *The optimal choice of labor and capital occurs where the isocost curve is tangent to the isoquant*



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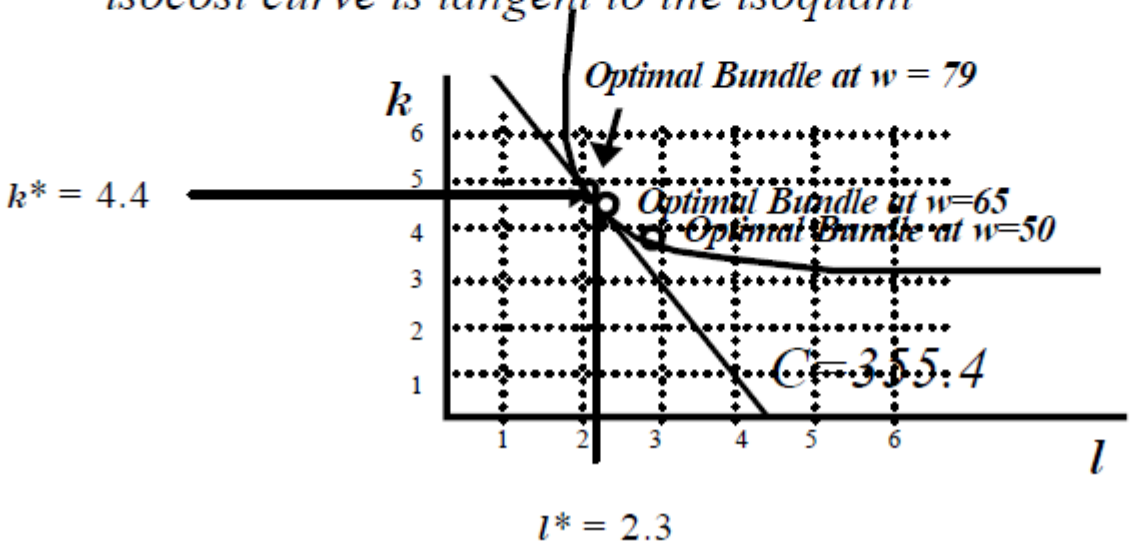
Cost Minimization

- If the wage increases:
  - *from \$50 to \$79,*
    - *The isocost curve pivots inward (around the fixed isoquant)*
    - *The optimal choice of labor and capital occurs where the isocost curve is tangent to the isoquant*



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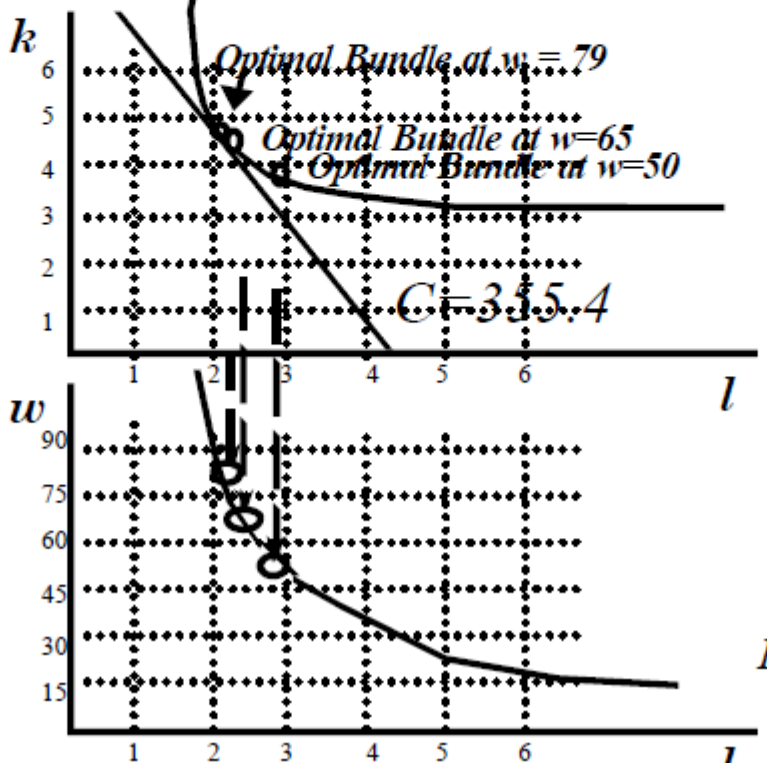
Cost Minimization

- Long-Run Individual Labor Demand Curves:
  - *Your individual demand curve for labor is formed by your demand, or optimal choice, of labor at different market wages:*



Long-Run Individual Labor Demand Curve (at 3.16 textbooks)

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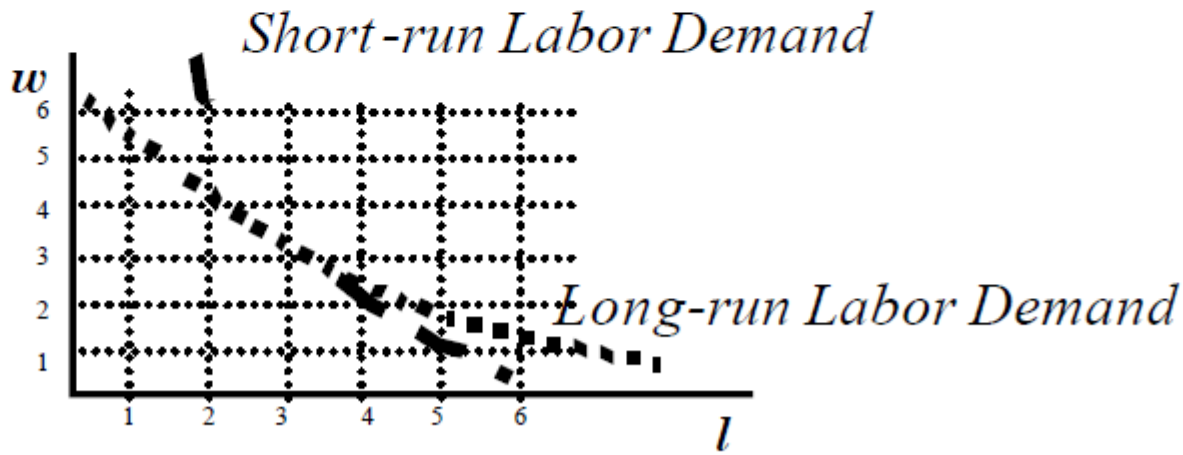
Cost Minimization

- The long-run individual labor demand curve is more elastic (flatter) than the short-run labor demand curve
  - *Firms respond to changes in wages more in the long run than in the short run due fixed amounts of capital in the short run*



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Theory of the Firm

- The theory of the firm describes how owners of firms choose inputs to produce goods and services given market prices of inputs.
  Topics:
  - *Production function*
    - *Returns to Scale*
  - *Optimal Choice of Inputs*
    - *Profit Maximization*
    - *Cost Minimization*
      - *Returns to Scale*

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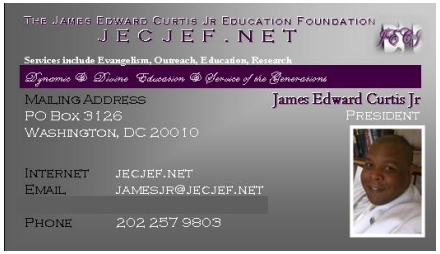
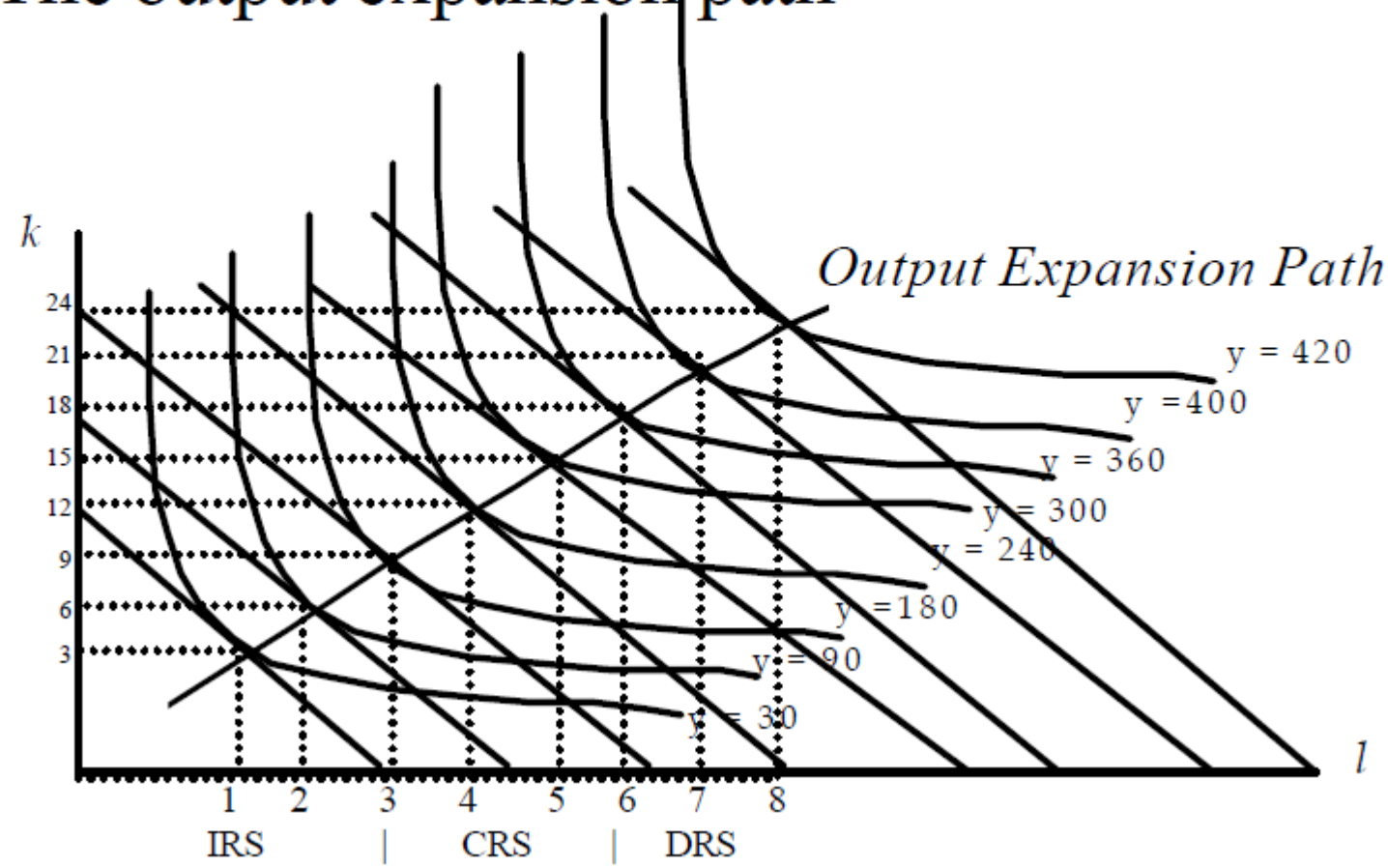
Cost Minimization

- The Output Expansion Path shows the lowest long-run total cost of employing labor and capital to produce each level of output given the price of inputs and production function
  - *The output expansion path is used to observe:*
    - *Output returns to scaling inputs*
    - *Long-run total cost curve*
    - *Long-run average total cost curve*
      - *Which is also linked to output returns to scaling inputs*



Cost Minimization

- The output expansion path



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Theory of the Firm

- Case study: The Ohio State University
  1. *Use the graph of the output expansion path to determine the long-run total cost curve where wages are $50 and the rental rate of capital is $40.*
  2. *Use the long-run total cost curve to graph the average cost curve where average costs = total costs / output*
  3. *Link the returns of scale ranges from the output expansion path to the average cost curve*
  4. *Why due these ranges of returns to scale correlate with a particular portion of the average cost curve*

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Cost Minimization

- Using an example of a(n):
  - DRS technology
  - IRS technology, and
  - CRS technology
    - *The following will analyze the long and short run:*
      - *Output expansion path*
      - *Total cost curve (TC)*
      - *Average total cost curve (ATC)*
      - *Marginal Cost curve (MC) and changes in TAC when scaling inputs*

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Cost Minimization

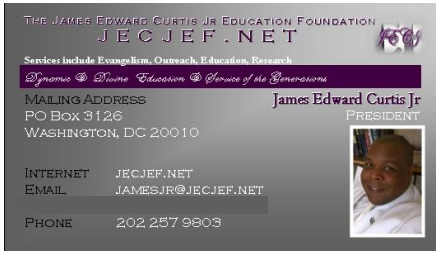
- Example 1 (LR-DRS): Long-Run (LR) Decreasing Returns to Scale (DRS) Technology
  - *Strictly convex production function:*

q	= *quantity of output produced (fixed)*
L	= *units of labor hours employed (* optimal)*
K	= *number of machines employed (* optimal)*
w	= *market price of workers ($5)*
r	= *market price of machines ($5)*
C	= *the labor and capital costs you pay to produce output*

Choose L^* and K^* to

Minimize $C = 5L + 5K$

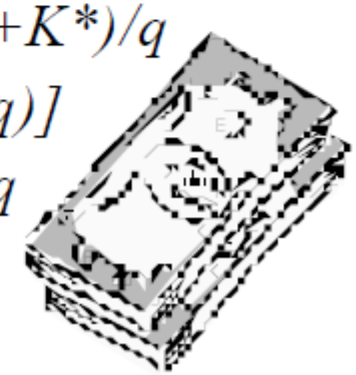
Subject to $q = L^{1/2}K^{1/4}$



Cost Minimization

- Example of LR-DRS (continued)
  - *To solve for the long-run labor demand, capital demand, TC, ATC, and MC, use the following equations:*

  - $L^* = (a/b)^{b/(a+b)}\, w^{-b/(a+b)}\, r^{b/(a+b)}\, q^{1/(a+b)}$
  - $K^* = (a/b)^{-a/(a+b)}\, w^{a/(a+b)}\, r^{-a/(a+b)}\, q^{1/(a+b)}$
  - $TC = TVC = wl + rk = 5(L^* + K^*)$
  - $ATC = AVC = (wl + rk)/q = 5(L^* + K^*)/q$
  - $MC = \partial TC/\partial q = 5[(\partial L^*/\partial q) + (\partial K^*/\partial q)]$
    $= 5[1/(a+b)](L^*+K^*)/q$



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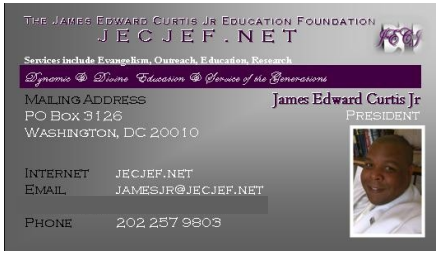
Cost Minimization

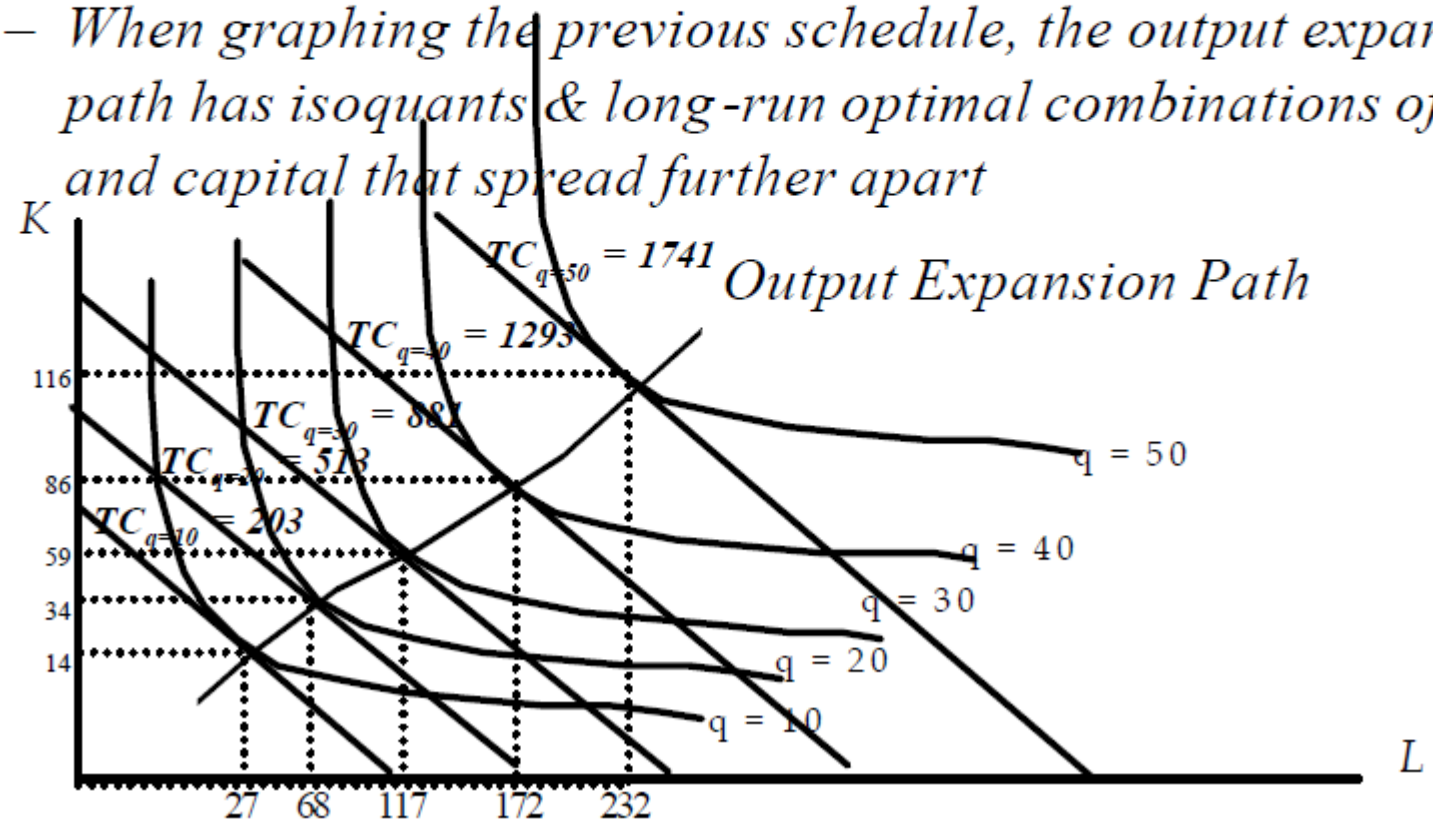
- Example of LR-DRS (continued)
  - *To derive the schedules for the long-run labor demand, capital demand, TC, ATC, and MC, use the previous equations and factor prices (w=r=5) :*

q_{fixed}	L^*	K^*	TC	ATC	MC
10	27	14	203	20	27
20	68	34	513	26	34
30	117	59	881	29	39
40	172	86	1293	32	43
50	232	116	1741	35	46



Cost Minimization

- Example of LR-DRS (continued)
  - *When graphing the previous schedule, the output expansion path has isoquants & long-run optimal combinations of labor and capital that spread further apart*



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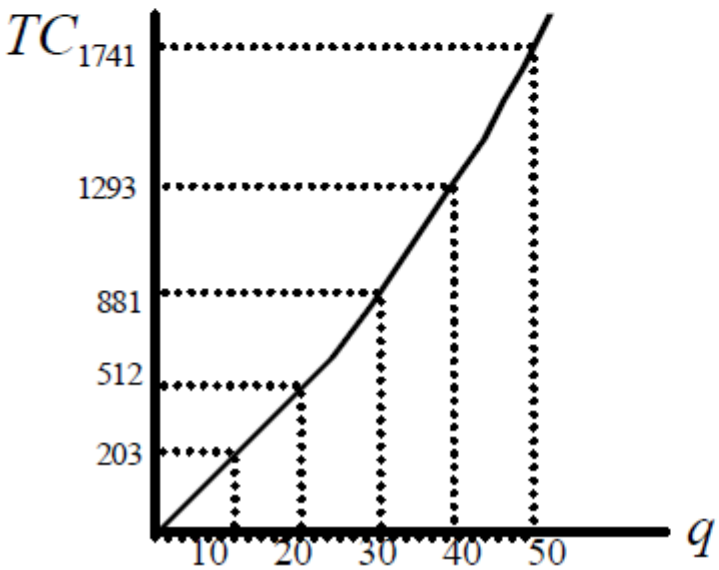
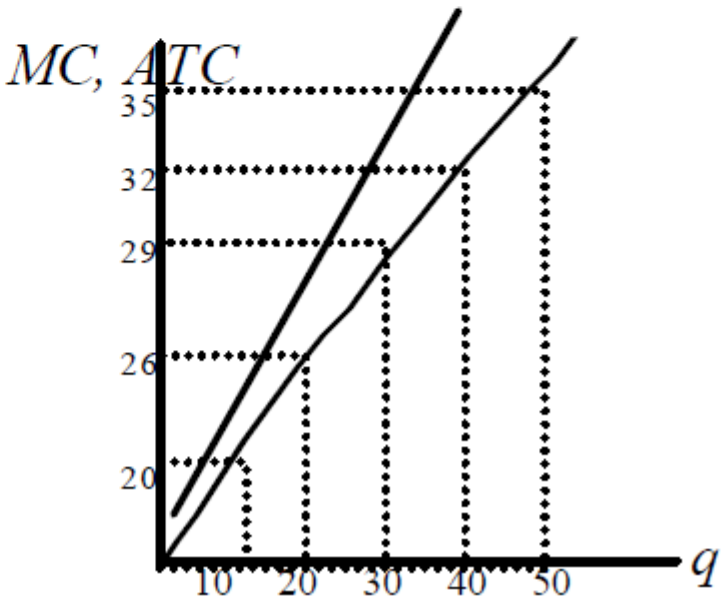
Cost Minimization

- Example of LR-DRS (continued)
  - *The long-run TC grows increasingly with higher output (due to larger growth in inputs relative to output)*
  - *Increasing MC and ATC with higher output*
  - *MC Curve is above the ATC Curve*





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Cost Minimization

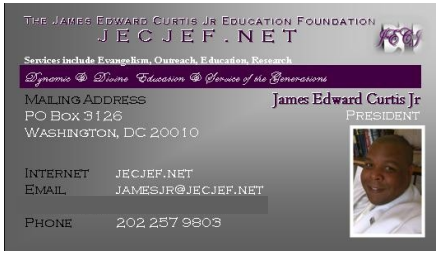
- Example 1 (SR- DRS) Short-Run (SR) Decreasing Returns to Scale (DRS) Technology
  - *Strictly convex production function:*

q	= *quantity of output produced (fixed)*
l	= *units of labor hours employed (* optimal)*
k_{fixed}	= *number of machines employed (fixed)*
w	= *market price of workers (\$5)*
r	= *market price of machines (\$5)*
C	= *the labor and capital costs you pay to produce output*

Choose l^* *to*

Minimize $C = 5l + 5\,k_{fixed}$

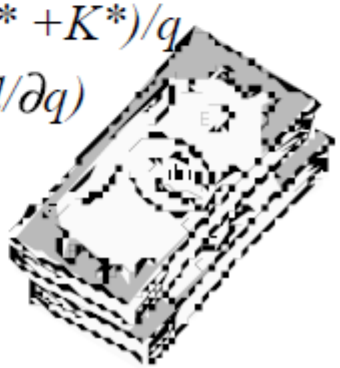
Subject to $q = l^{1/2}\,k_{fixed}^{1/4}$

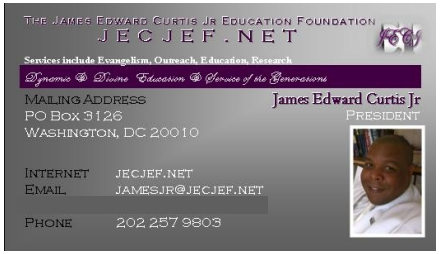


Cost Minimization

- Example of SR-DRS (continued)
  - *To solve for short-run labor demand, TC, ATC, and MC*
    - *Consider a short-run contract that derives* $k_{fixed} = 59$ *units*
      - *Terms of the contract are based firm's calculation of the optimal capital demand (K*) in the long-run at the firm's output capacity, i.e. q = 30*
  - $l^* = [q_f/(k_{fixed})^{1/4}]^2$
  - $TC = TVC + TFC = wl + rk_{fixed} = 5(L^* + K^*)$
  - $ATC = AVC + AFC = wl/q + rk_{fixed}/q = 5(L^* + K^*)/q$
  - $MC = \partial TC/\partial q = w(\partial l/\partial q) = 5(\partial l/\partial q)$

    $= 5\{2[q/(k_{fixed})^{1/4}]\}$

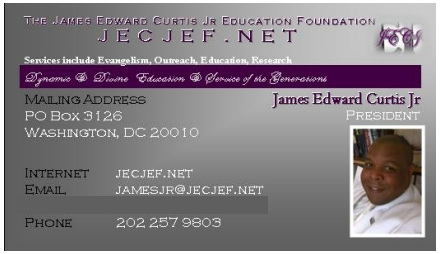




Cost Minimization

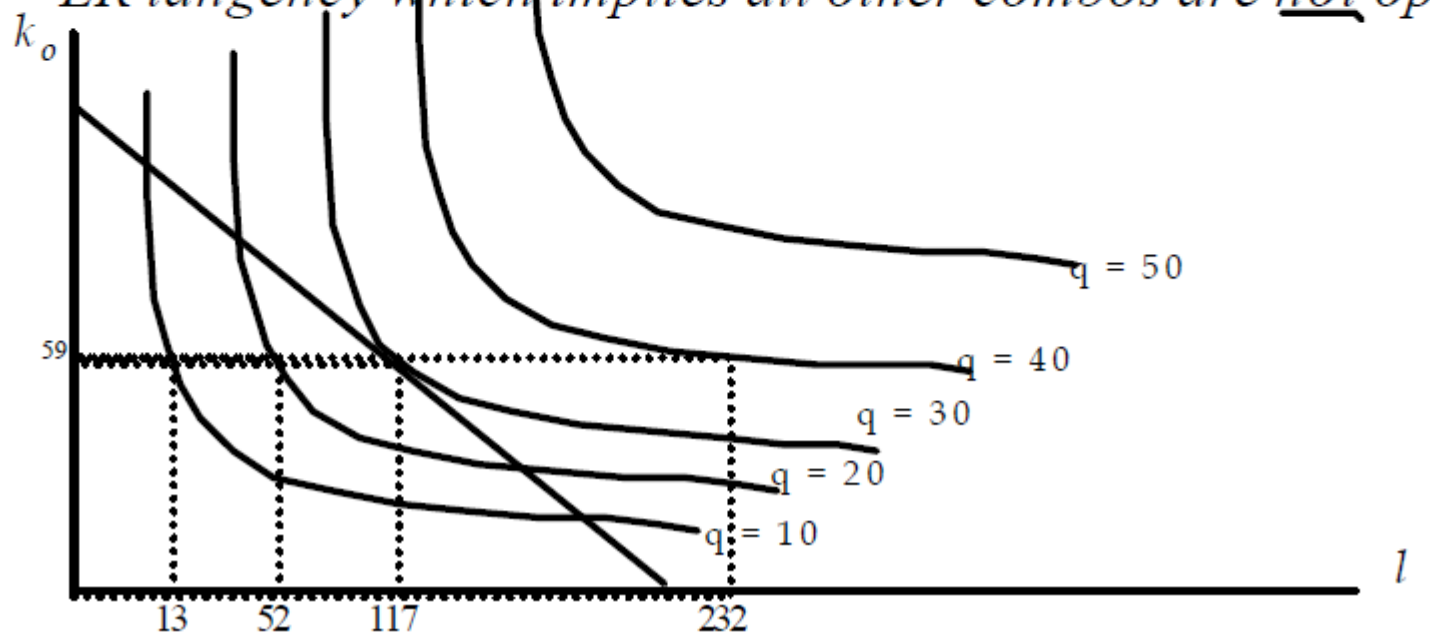
- Example of SR-DRS (continued)
  - *To derive the schedules for the long-run labor demand, TC, ATC, and MC, use the previous equations and factor prices (w=r=5):*

q	l^*	k_o^*	TC	ATC	MC
10	13	59	359	36	48
20	52	59	555	28	37
30	117	59	881	29	39
40	209	59	1338	33	45
50	326	59	1925	39	51



Cost Minimization

- Example of SR-DRS (continued)
  - *When graphing the previous schedule, the output expansion path shows only one combo of capital and labor produces a LR tangency which implies all other combos are not optimal*



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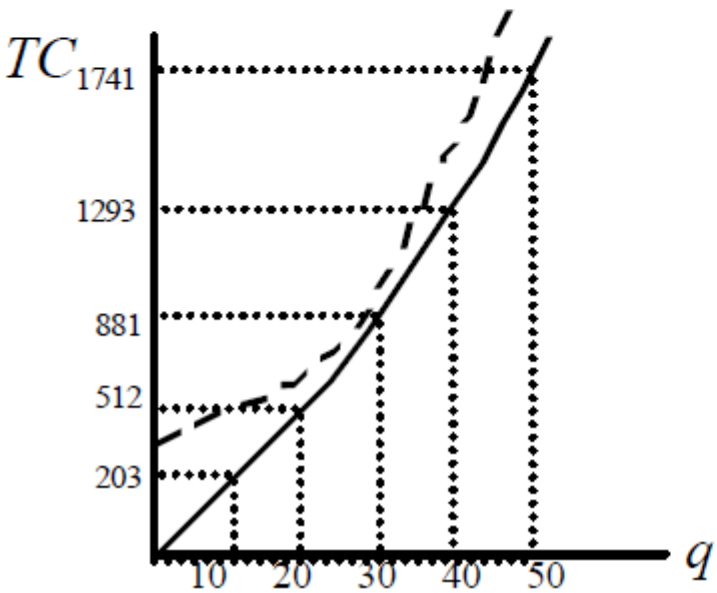
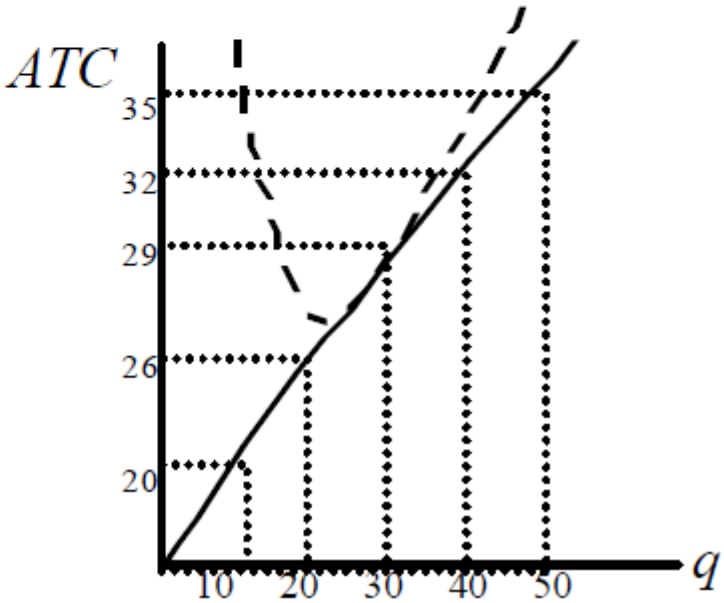
Cost Minimization

- Example of SR/LR-DRS (continued)
  - *The long-run TC curve is the envelope of short-run TC curves for the DRS technology*
  - *Increasing short run TC curve*
  - *Long-run ATC is envelope of short-run ATC curves for the DRS technology*
  - *"U" shaped short run ATC curve*





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Cost Minimization

- Summary of Costs and DRS technology
  - *With Cobb-Douglas technology, Sum of elasticities < 1*
  - *Isoquants spread further apart*
  - *Since inputs must grow faster with growing output,*
    - *Total cost of inputs grow exponentially*
    - *Average costs of inputs are increasing*
  - *Expanding long-run production (by employing more labor and capital) reduces long-run profits because:*
    - *Holding output and input prices constant, inputs are increasing faster than outputs*
    - *Thus, costs increase faster than revenue*

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Cost Minimization

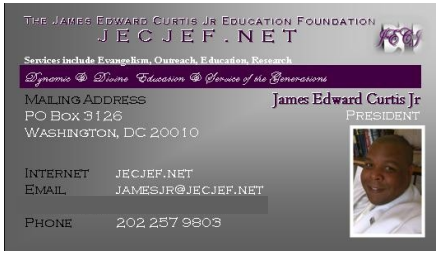
- Example 2 (LR-IRS): Long-Run (LR) Increasing Returns to Scale (IRS) Technology
  - *Strictly convex production function:*

q	= *quantity of output produced (fixed)*
L	= *units of labor hours employed (* optimal)*
K	= *number of machines employed (* optimal)*
w	= *market price of workers (\$5)*
r	= *market price of machines (\$5)*
C	= *the labor and capital costs you pay to produce output*

Choose L^* and K^* to

Minimize $C = 5L + 5K$

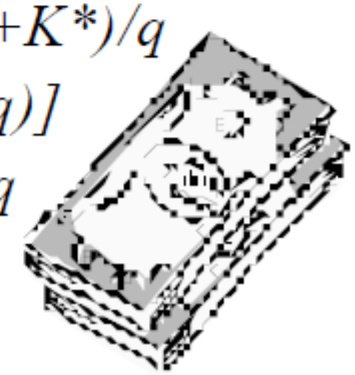
Subject to $q = L^{1/2}K^{3/4}$

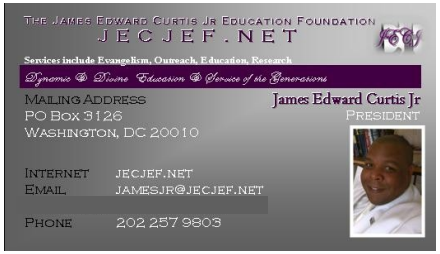


Cost Minimization

- Example of LR-IRS (continued)
  - *To solve for the long-run labor demand, capital demand, TC, ATC, and MC, use the following equations:*

  - $L^* = (a/b)^{b/(a+b)}\, w^{-b/(a+b)}\, r^{b/(a+b)}\, q^{1/(a+b)}$
  - $K^* = (a/b)^{-a/(a+b)}\, w^{a/(a+b)}\, r^{-a/(a+b)}\, q^{1/(a+b)}$
  - $TC = TVC = wl + rk = 5(L^* + K^*)$
  - $ATC = AVC = (wl + rk)/q = 5(L^* + K^*)/q$
  - $MC = \partial TC/\partial q = 5[(\partial L^*/\partial q) + (\partial K^*/\partial q)]$
    $= 5[1/(a+b)](L^*+K^*)/q$

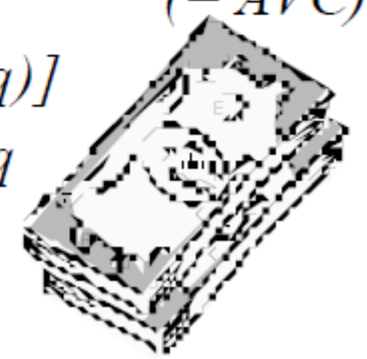




Cost Minimization

- Example of LR-IRS (continued)
  - *To solve for the long-run labor demand, capital demand, TC, ATC, and MC, use the following equations:*

  - $L^* = (a/b)^{b/(a+b)}\, w^{-b/(a+b)}\, r^{b/(a+b)}\, q^{1/(a+b)}$
  - $K^* = (a/b)^{-a/(a+b)}\, w^{a/(a+b)}\, r^{-a/(a+b)}\, q^{1/(a+b)}$
  - $TC = C = 5(L^* + K^*)$ $(= TVC)$
  - $ATC = TC/q = 5(L^* + K^*)/q$ $(= AVC)$
  - $MC = \partial TC/\partial q = 5[(\partial L^*/\partial q) + (\partial K^*/\partial q)]$
    $= 5[1/(a+b)](L^*+K^*)/q$



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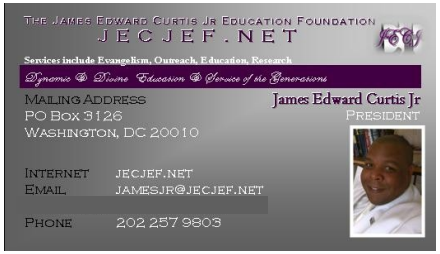
Cost Minimization

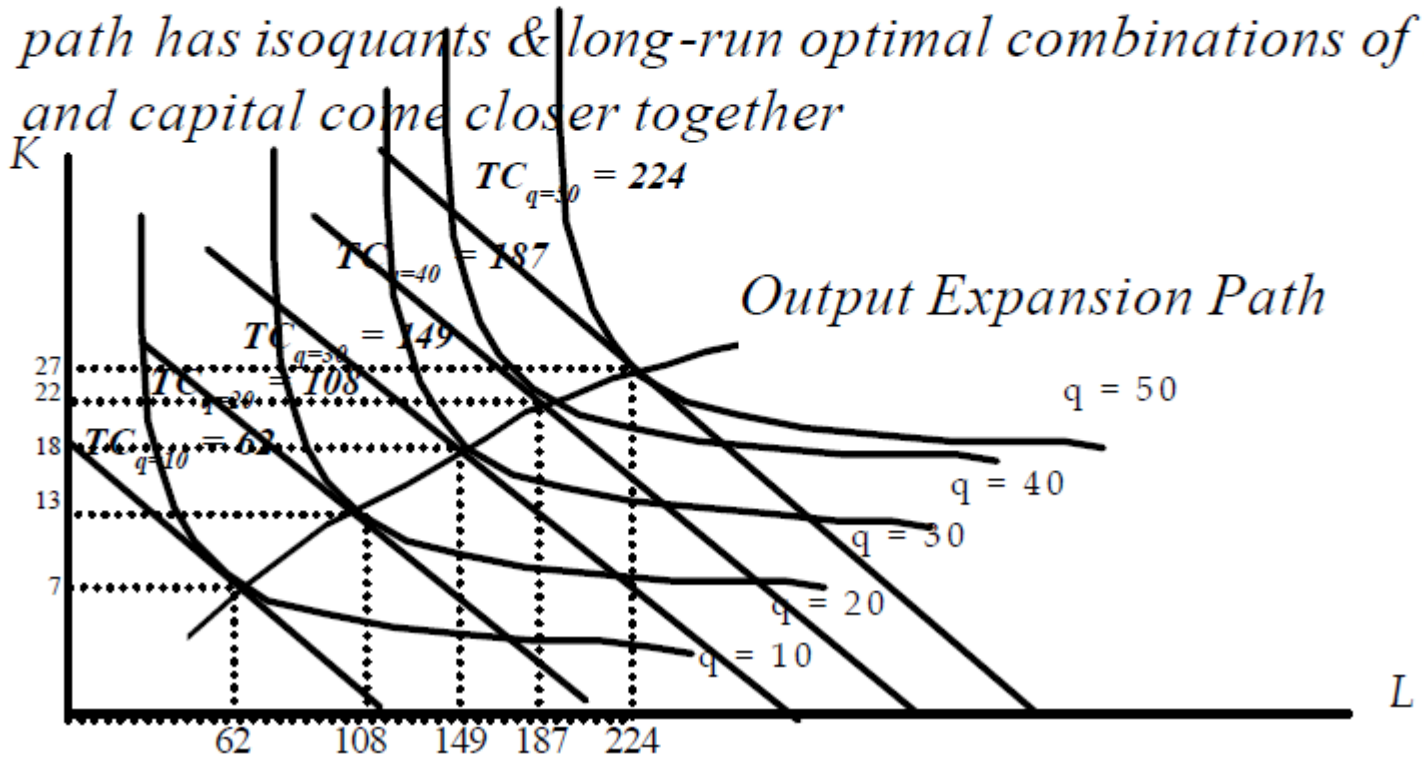
- Example of LR-IRS (continued)
  - *To derive the schedules for the long-run labor demand, capital demand, TC, ATC, and MC, use the previous equations and factor prices (w=r=5) :*

q_{fixed}	L^*	K^*	TC	ATC	MC
10	5	7	62	6.2	8.2
20	9	13	108	5.4	7.2
30	12	18	149	5.0	6.6
40	15	22	187	4.7	6.2
50	18	27	224	4.5	6.0



Cost Minimization

- Example of LR-IRS (continued)
  - *When graphing the previous schedule, the output expansion path has isoquants & long-run optimal combinations of labor and capital come closer together*



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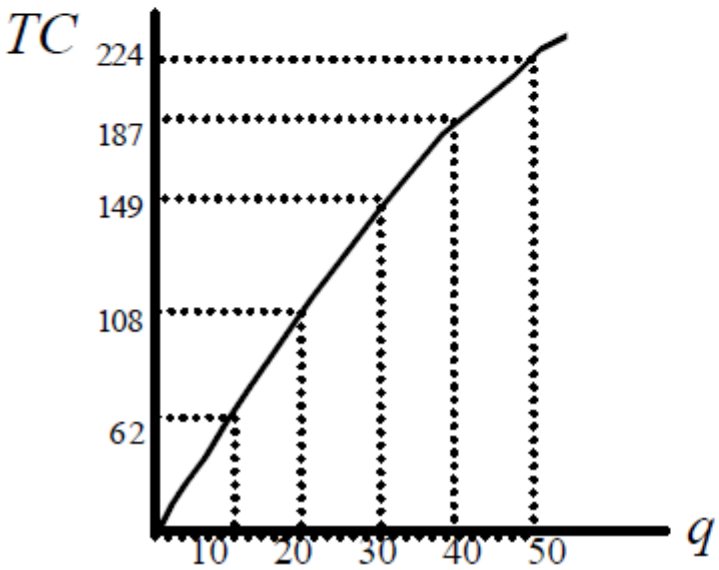
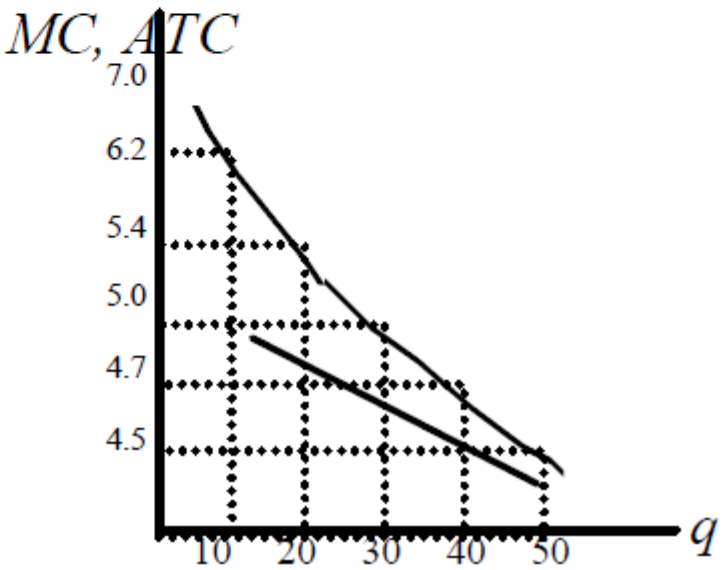
Cost Minimization

- Example of LR-IRS (continued)
  - *The long-run TC grows at a diminishing rate with higher output (due to smaller growth in inputs relative to output)*
  - *Decreasing MC and ATC with higher output*
  - *MC Curve is below the ATC Curve*





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Cost Minimization

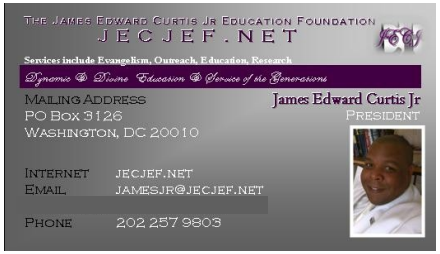
- Example 2 (SR-IRS): Short-Run (SR) Increasing Returns to Scale (IRS) Technology
  - *Strictly convex production function:*

q	= *quantity of output produced (fixed)*
l	= *units of labor hours employed (* optimal)*
k_{fixed}	= *number of machines employed (fixed)*
w	= *market price of workers (\$5)*
r	= *market price of machines (\$5)*
C	= *the labor and capital costs you pay to produce output*

Choose l^* *to*

Minimize $C = 5l + 5\,k_{fixed}$

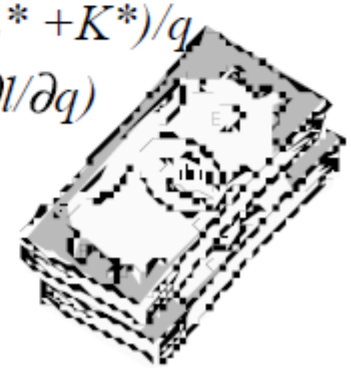
Subject to $q = l^{1/2}\,k_{fixed}^{\,3/4}$



Cost Minimization

- Example of SR-IRS (continued)
  - *To solve for short-run labor demand, TC, ATC, and MC*
    - *Consider a short-run contract that derives* k_{fixed} *= 18 units*
      - *Terms of the contract are based firm's calculation of the optimal capital demand (K*) in the long-run at the firm's output capacity, i.e. q = 30*
  - $l^* = [q_f/(k_{fixed})^{1/4}]^2$
  - $TC = TVC + TFC = wl + rk_{fixed} = 5(L^* + K^*)$
  - $ATC = AVC + AFC = wl/q + rk_{fixed}/q = 5(L^* + K^*)/q$
  - $MC = \partial TC/\partial q = w(\partial l/\partial q) = 5(\partial l/\partial q)$

    $= 5\{2[q/(k_{fixed})^{1/4}]\}$



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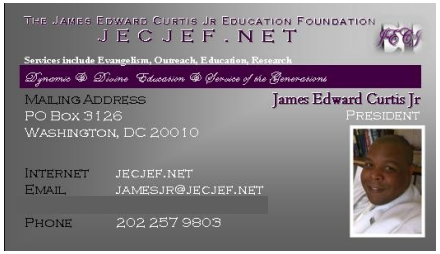
Cost Minimization

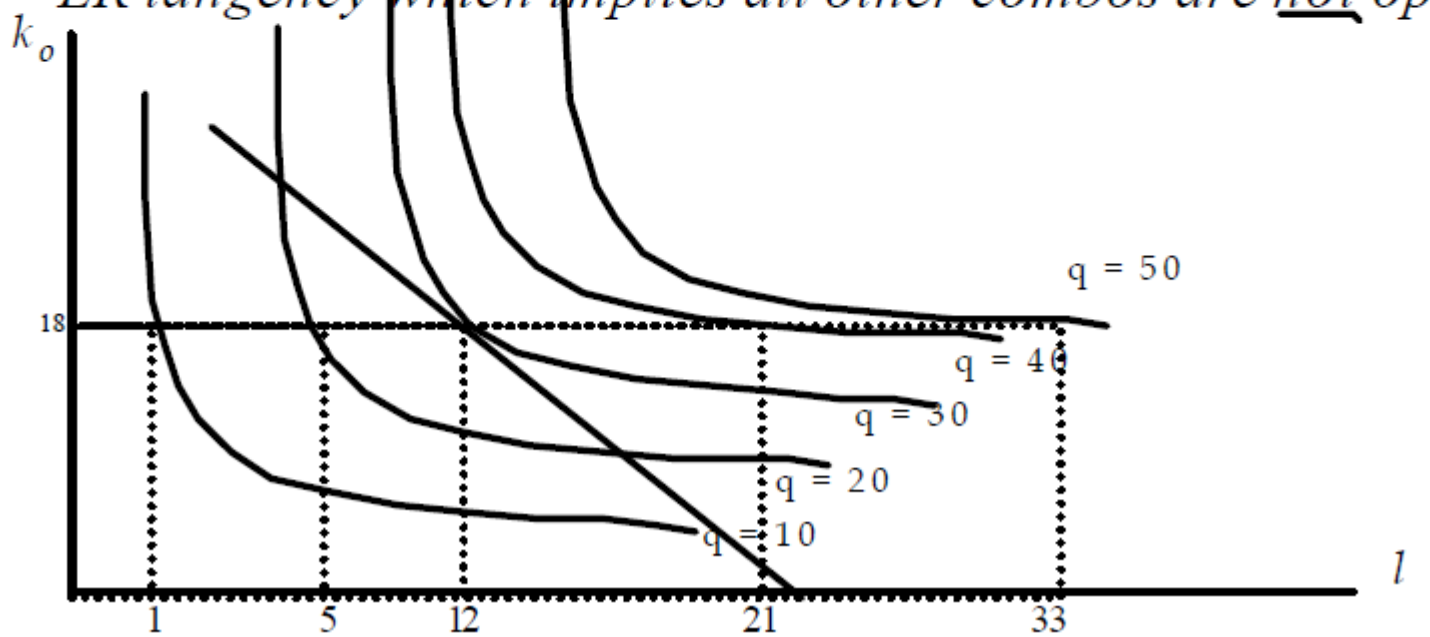
- Example of SR-IRS (continued)
  - *To derive the schedules for the long-run labor demand, TC, ATC, and MC, use the previous equations and factor prices (w=r=5):*

q_{fixed}	l^*	k_o^*	TC	ATC	MC
10	1	18	96	9.6	0.9
20	5	18	116	5.8	1.8
30	12	18	149	5.0	2.6
40	21	18	195	4.9	3.5
50	33	18	255	5.1	4.4



Cost Minimization

- Example of SR-IRS (continued)
  - *When graphing the previous schedule, the output expansion path shows only one combo of capital and labor produces a LR tangency which implies all other combos are not optimal*



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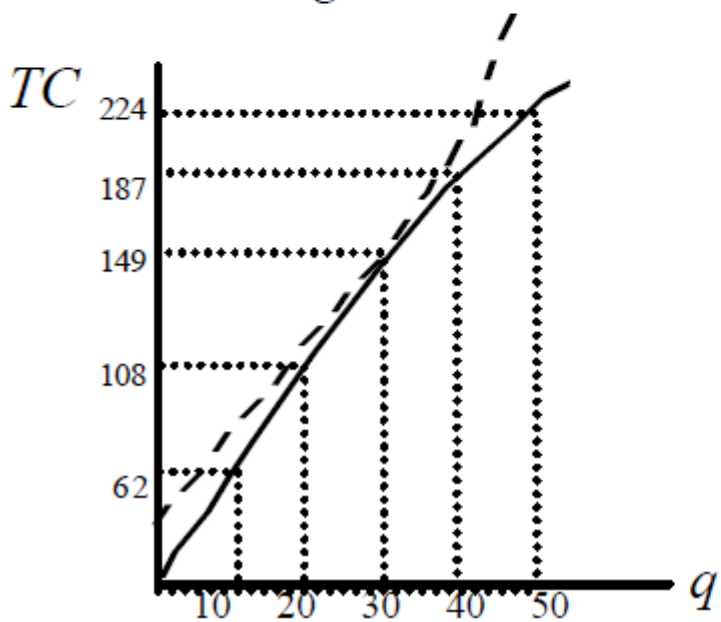
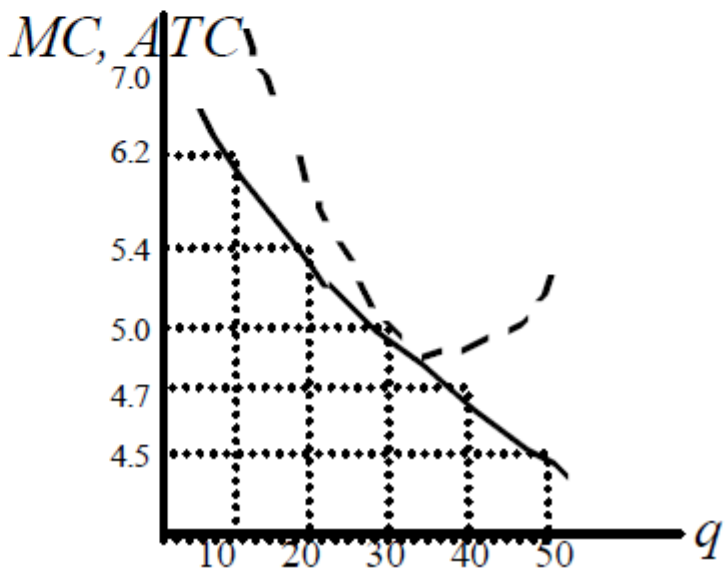
Cost Minimization

- Example of SR/LR-IRS (continued)
  - *The long-run TC curve is the envelope of short-run TC curves for the DRS technology*
  - *Increasing short run TC curve*
  - *Long-run ATC is envelope of short-run ATC curves for the DRS technology*
  - *"U" shaped short run ATC curve*





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Cost Minimization

- Summary of Costs and IRS technology
  - *With Cobb-Douglas technology, sum of elasticities > 1*
  - *Isoquants move closer together*
  - *Since inputs do <u>not</u> grow as fast as output,*
    - *LR total cost of inputs grow at a diminishing rate with more output*
    - *LR average costs of inputs are decreasing with more output*
  - *Expanding long-run production (by employing more labor and capital) <u>increases</u> long-run profits because:*
    - *Holding output and input prices constant, outputs are increasing faster than inputs*
    - *Thus, revenue increase faster than costs*

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Cost Minimization

- Example 3: Constant Returns to Scale
  - *In the Short-run:*
    - *Choose* l^* *to Minimize* $C = 5l + 5k_{fixed}$

      Subject to $q_{fixed} = l^{1/2}(k_{fixed})^{1/2}$
  - *In the Long-run:*
    - *Choose* L^* *and* K^* *to Minimize* $C = 5L + 5K$

      Subject to $q_{fixed} = L^{1/2}K^{1/2}$

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Cost Minimization

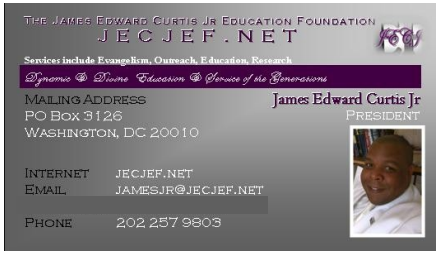
- Example 3 (LR-CRS): Long-Run (LR) Constant Returns to Scale (CRS) Technology
  - *Strictly convex production function:*

q	= *quantity of output produced (fixed)*
L	= *units of labor hours employed (* optimal)*
K	= *number of machines employed (* optimal)*
w	= *market price of workers (\$5)*
r	= *market price of machines (\$5)*
C	= *the labor and capital costs you pay to produce output*

Choose L^* and K^* to

Minimize $C = 5L + 5K$

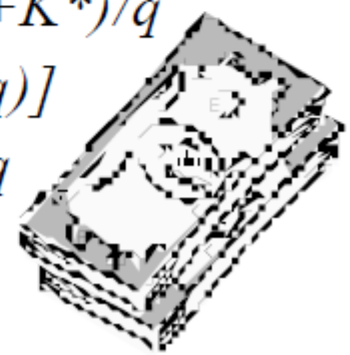
Subject to $q = L^{1/2}K^{1/2}$



Cost Minimization

- Example of LR-CRS (continued)
  - *To solve for the long-run labor demand, capital demand, TC, ATC, and MC, use the following equations:*

  - $L^* = (a/b)^{b/(a+b)}\, w^{-b/(a+b)}\, r^{b/(a+b)}\, q^{1/(a+b)}$
  - $K^* = (a/b)^{-a/(a+b)}\, w^{a/(a+b)}\, r^{-a/(a+b)}\, q^{1/(a+b)}$
  - $TC = TVC = wl + rk = 5(L^* + K^*)$
  - $ATC = AVC = (wl + rk)/q = 5(L^* + K^*)/q$
  - $MC = \partial TC/\partial q = 5[(\partial L^*/\partial q) + (\partial K^*/\partial q)]$
    $= 5[1/(a+b)](L^*+K^*)/q$



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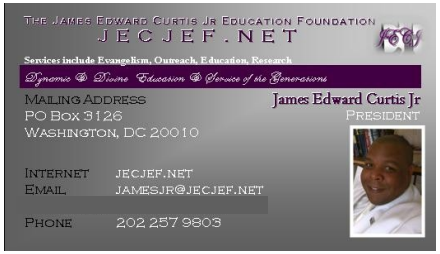
Cost Minimization

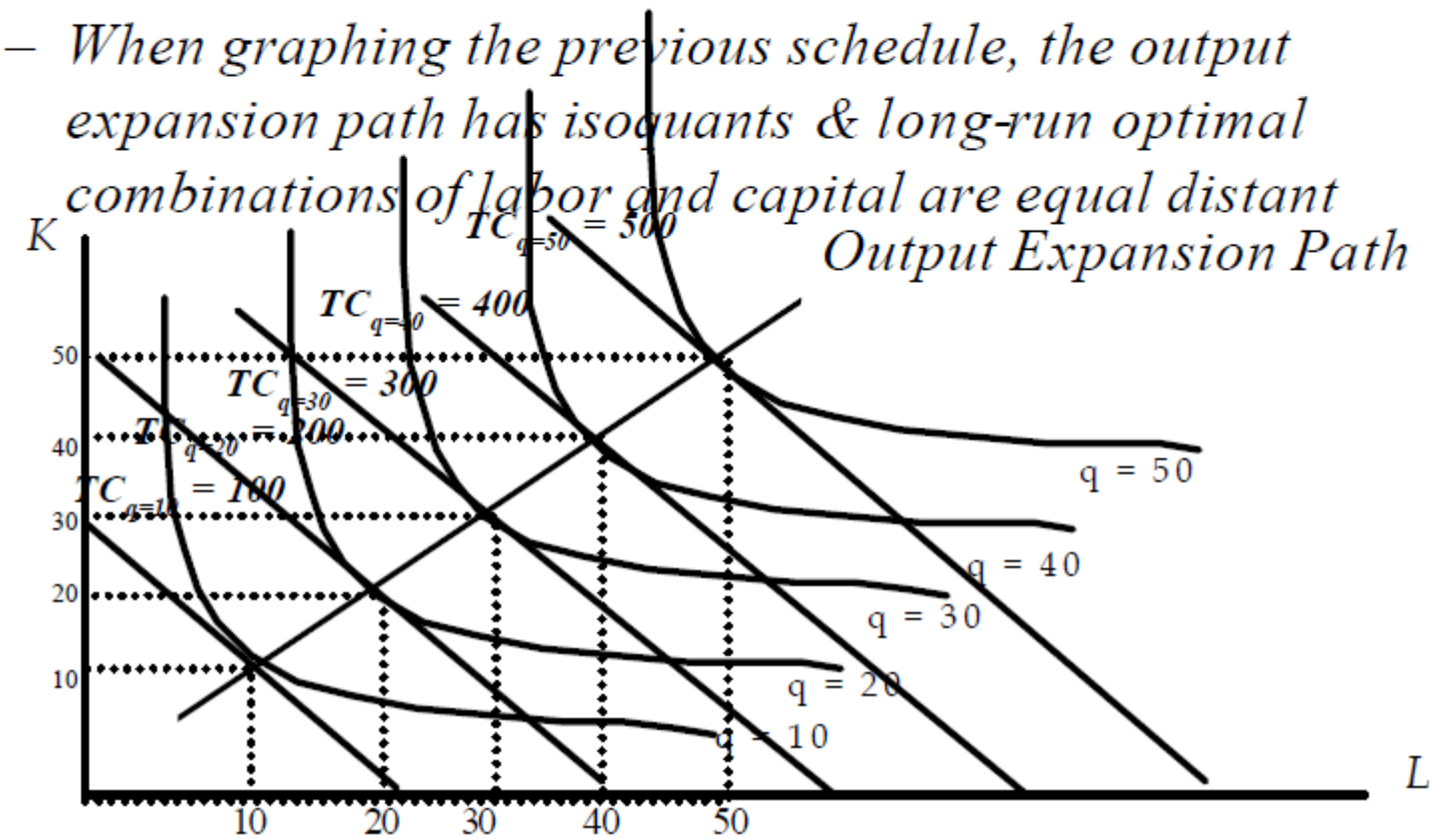
- Example of LR-CRS (continued)
  - *To derive the schedules for the long-run labor demand, capital demand, TC, ATC, and MC, use the previous equations and factor prices (w=r=5) :*

q_{fixed}	L^*	K^*	TC	ATC	MC
10	10	10	100	10	10
20	20	20	200	10	10
30	30	30	300	10	10
40	40	40	400	10	10
50	50	50	500	10	10



Cost Minimization

- Example of LR-CRS (continued)
  - *When graphing the previous schedule, the output expansion path has isoquants & long-run optimal combinations of labor and capital are equal distant*



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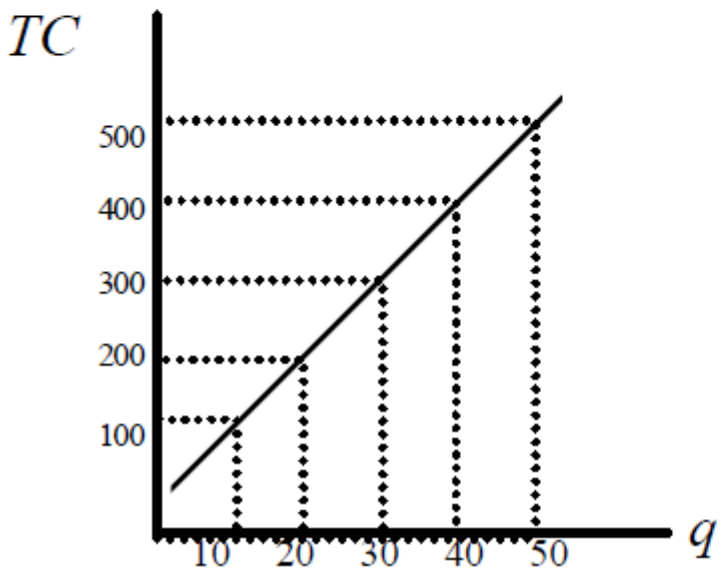
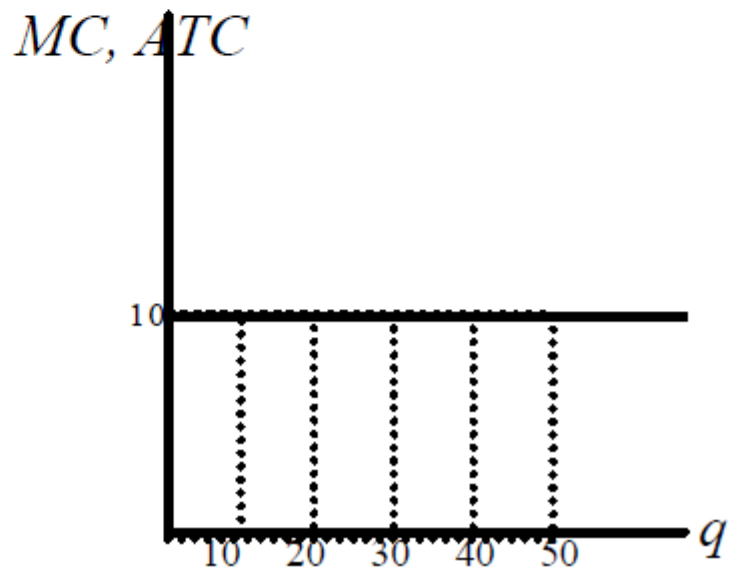
Cost Minimization

- Example of LR-CRS (continued)
  - *The long-run TC grows at a constant rate with higher output (due to constant growth in inputs relative to output)*
  - *Constant MC and ATC with higher output*
  - *MC Curve is equal to the ATC Curve*





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Cost Minimization

- Example 3 (SR-CRS): Short-Run (SR) Constant Returns to Scale (CRS) Technology
  - *Strictly convex production function:*

q	= *quantity of output produced (fixed)*
l	= *units of labor hours employed (* optimal)*
k_{fixed}	= *number of machines employed (fixed)*
w	= *market price of workers (\$5)*
r	= *market price of machines (\$5)*
C	= *the labor and capital costs you pay to produce output*

Choose l^* *to*

Minimize $C = 5l + 5\,k_{fixed}$

Subject to $q = l^{1/2}\,k_{fixed}^{\,1/2}$

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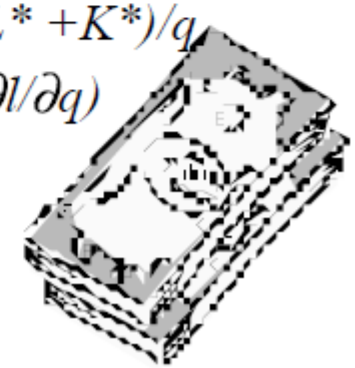
Cost Minimization

- Example of SR-CRS (continued)
  - *To solve for short-run labor demand, TC, ATC, and MC*
    - *Consider a short-run contract that derives* k_{fixed} *= 30 units*
      - *Terms of the contract are based firm's calculation of the optimal capital demand (K*) in the long-run at the firm's output capacity, i.e. q = 30*
  - $l^* = [q_f/(k_{fixed})^{1/2}]^2$
  - $TC = TVC + TFC = wl + rk_{fixed} = 5(L^* + K^*)$
  - $ATC = AVC + AFC = wl/q + rk_{fixed}/q = 5(L^* + K^*)/q$
  - $MC = \partial TC/\partial q = w(\partial l/\partial q) = 5(\partial l/\partial q)$

    $= 5\{2[q/(k_{fixed})^{1/2}]\}$



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Cost Minimization

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q_{fixed},	l^*	k_o^*	TC	ATC	MC
10	3	30	167	16.7	2.2
20	13	30	217	10.8	4.4
30	30	30	300	10.0	6.7
40	53	30	417	10.4	8.9
50	83	30	567	11.3	11.1

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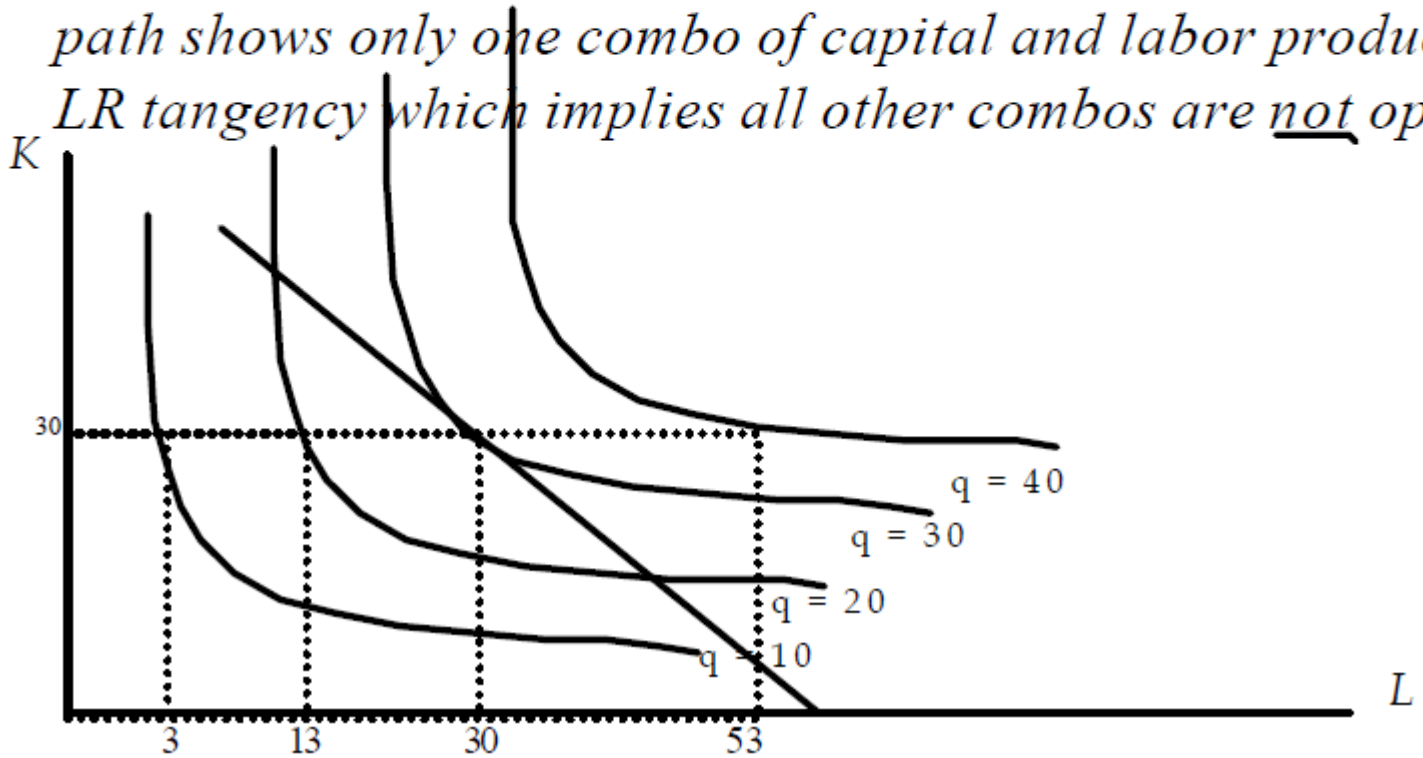

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Cost Minimization

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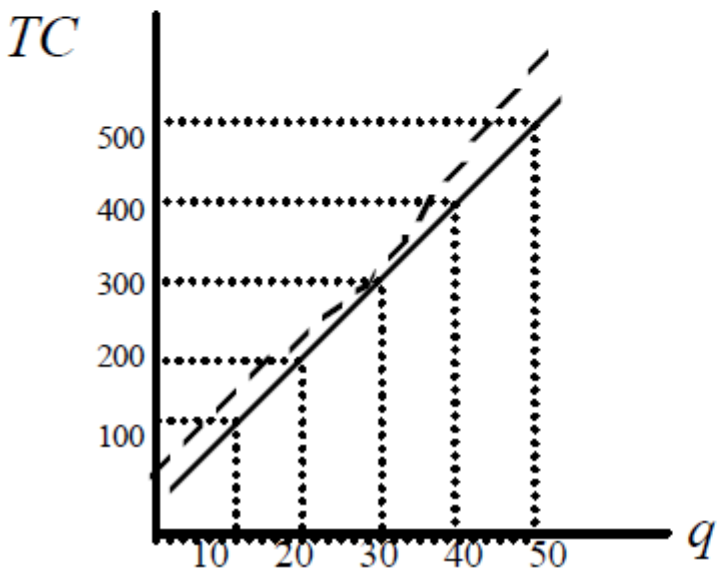
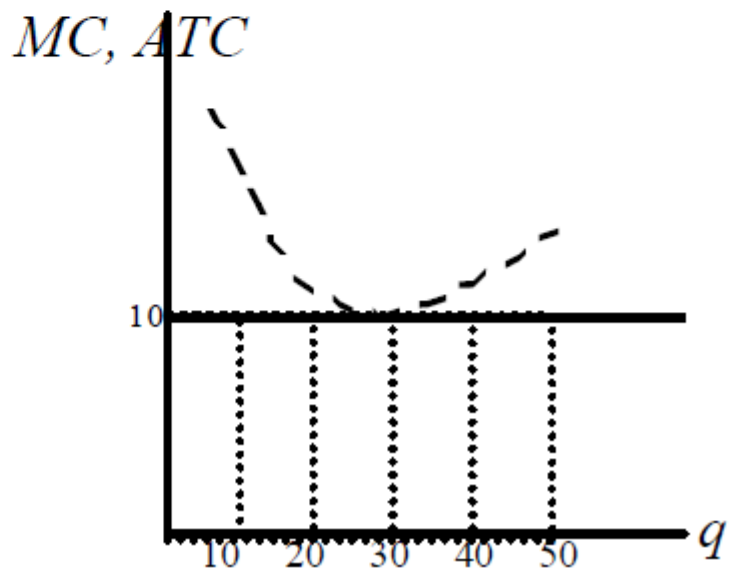
  - *Increasing short run TC curve*
  - *Long-run ATC is envelope of short-run ATC curves for the DRS technology*
  - *"U" shaped short run ATC curve*





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Cost Minimization

- Summary of Cost and CRS technology
  - *With Cobb-Douglas technology, sum of elasticities = 1*
  - *Isoquants are equidistant*
  - *Since inputs grows as fast as output,*
    - *LR total cost of inputs grow at the same rate as growth in output*
    - *LR average costs of inputs remain constant with more output*
  - *Expanding long-run production (by employing more labor and capital) does not change long-run profits because:*
    - *Holding output and input prices constant, outputs are increasing as fast as inputs*
    - *Thus, revenue increase as fast as than costs*

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Cost Minimization

- Summary of all production technologies
  - *Firms seek to maximize their short-run profits*
    - *Calculate long-run costs from optimal choice of inputs to derive terms of short-run contracts for fixed inputs*
  - *But firms are constrained by their technology*
    - *Technology constraints are limitations on the combinations of inputs and outputs.*
    - *We have just shown that technology constraints directly lead to economic constraints.*
      - *Economic constraints, in this instance, are limitations on profits due to costs.*

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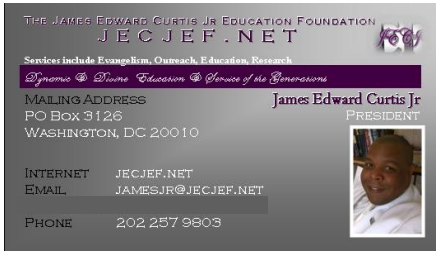
Theory of the Firm

- The theory of the firm describes how owners of firms choose inputs to produce goods and services given market prices of inputs. Topics:
  - *Production function*
    - *Returns to Scale*
  - *Optimal Choice of Inputs*
    - *Profit Maximization*
    - *Cost Minimization*
      - *Returns to Scale*
  - *Optimal Choice of Output and Prices*
    - *Types of Markets*



Markets

- A market is
  - *A group of sellers that trade products and services for an agreed form of remuneration (which is often money today) with the buyers*
  - *In product markets*
    - *Firms sell products*
    - *Consumers buy products*
  - *In labor markets*
    - *Workers sell labor services*
    - *Firms buy labor services*

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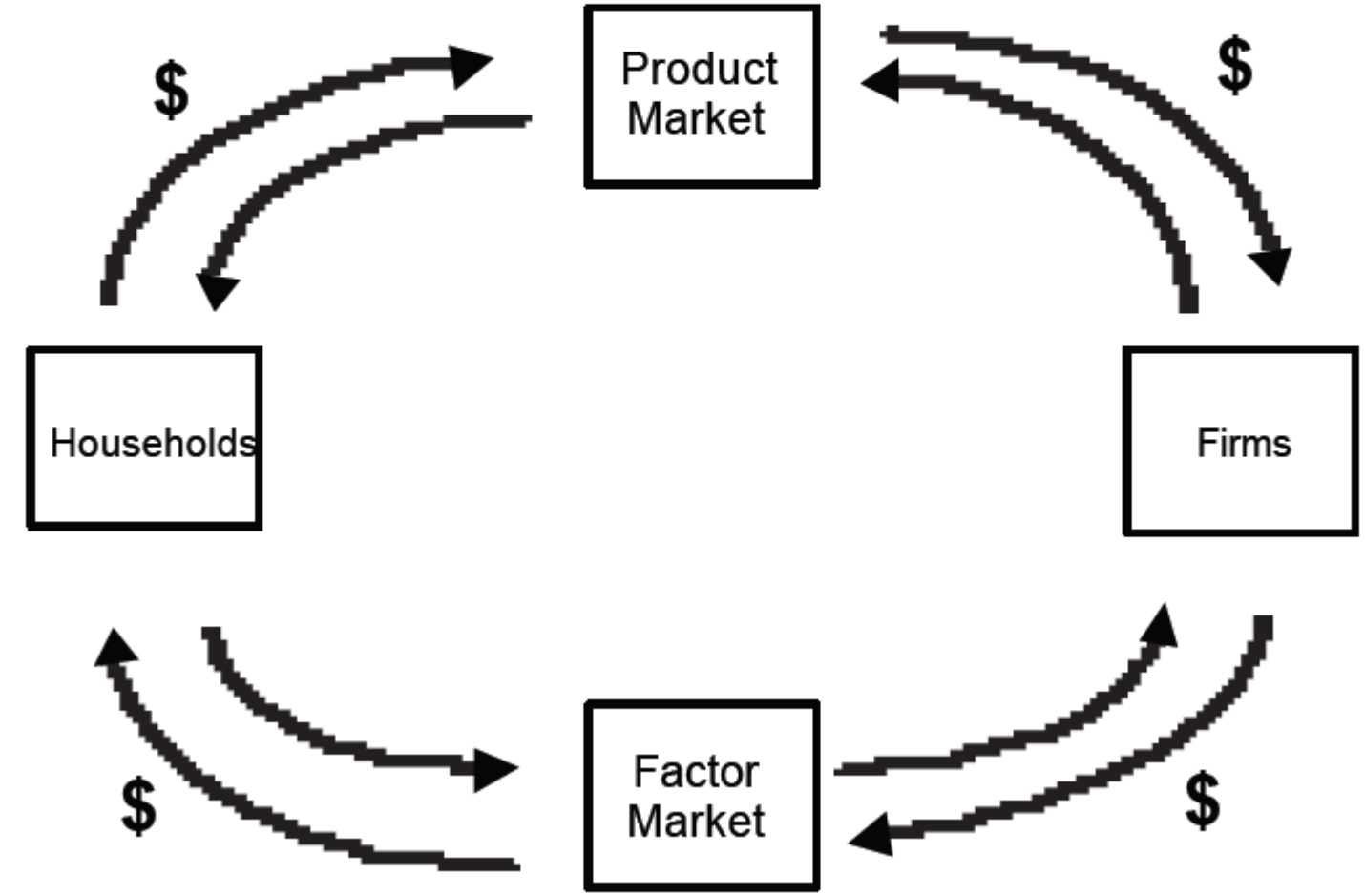
Circular Flow



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Types of Markets

- The type of market determines how firms choose the optimal level of output and price
  - *Many firms selling identical goods*
    - *Perfect Competition*
  - *Many firms selling differentiated goods*
    - *Monopolistic Competition*
  - *Few firms*
    - *Oligopoly*
  - *One firm*
    - *Monopoly*

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Types of Markets

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  - *Many firms selling identical goods*
    - *Perfect Competition*

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Perfect Competition

- Characteristics of Perfectly Competitive Markets
  - *Many firms in the market*
  - *Many buyers in the market*
  - *Identical products*
  - *Free entry*
    - *No barriers to entering the market*
  - *Free exit*
    - *No costs to leaving the market*
  - *Perfect Information*
    - *Sellers and buyers are fully aware of competitors and other market opportunities*

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Perfect Competition

- Key Questions:

1. *How does market demand and market supply determine price (p^*) and market output (Q^*) ?*
2. *How do individual firms in the market choose output (q^*) ?*

   (Using output prices & cost curves instead of isoprofit & production curves)
3. *How are maximum profits (π^*) determined for individual firms ?*

   (Using output prices & cost curves instead of isoprofit & production curves)
4. *How do changes in market demand impact individual firm profit (π^*) ?*
5. *How do changes in market supply impact individual firm profits (π^*) ?*

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Perfect Competition

1. How does market demand and market supply determine price (p*) and market output (Q*) ?
   - *Remember the consumer's optimization problem using strictly convex preferences:*

     b = *number of economics textbooks consumed (* optimal)*

     c = *cups of coffee purchased (* optimal)*

     p_b = *market price of used economics textbooks ($20)*

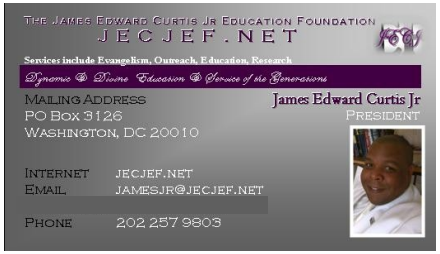
     p_c = *market price of cup of coffee ($5)*

     I = *income ($1000)*

     U = *the utility you obtain from consuming books & coffee*
   - *The consumer chooses b^* and c^* to*

     Maximize $U = b^{1/2} c^{1/2}$

     Subject to $I = p_c c + p_b b$



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1. How does market demand and market supply determine price (p*) and market output (Q*) ?
   - *An individual's demand for books is determined by:*

     $b^* = [a/(a+b)](I/p_b)$

     $= [½/ /(½+ ½)](1000/p_b)$

     $= ½(1000/p_b)$

     $= 500 /p_b$
   - *The market demand is the sum of individual demands*
     - *To obtain market demand (B_D), consider 100 other consumers with the same preferences, budget constraint and demand for books*

     $B_D = 100b^*$

     $= 50{,}000/p_b$

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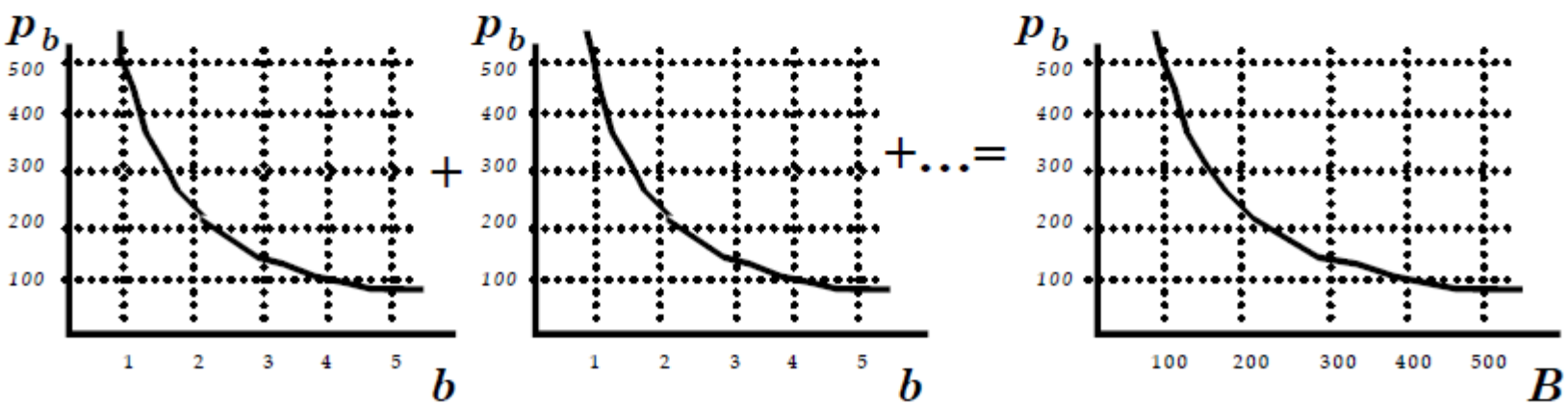
   - *Graphing the individual and market demand curves:*

Individual 1	+	*Individual 2*	+...=	*Market Demand*
$b^* (= 500/p_b)$	+	$b^* (= 500/p_b)$	+...=	$B_D (= 50{,}000/p_b)$



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1. How does market demand and market supply determine price (p*) and market output (Q*) ?
   - *Remember the firm's short-run optimization problem using a strictly convex production function:*

     b_o = *number of economics textbooks produced (fixed)*

     l = *units of labor hours employed to make textbooks (* optimal)*

     k_o = *number of machines employed to make textbooks (fixed at 5)*

     w = *market price of workers ($50)*

     r = *market price of machines ($40)*

     C = *the labor and capital costs you pay to produce textbooks*
   - *The firm chooses l^* to*

     Minimize $C = wl + rk_o$

     Subject to $b = l^{1/2} k_o^{1/2}$

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   - *An individual firm's supply curve is determined by its marginal cost*

     $C = w\, l^* + \quad rk_o$ *where* $l^* = b^2 / k_o$

     $= 50\, l^* + 40(5)$

     $MC = \partial C / \partial b$

     $= 2wb / k_o = 2\,(50)\, b / 5$

     $= 20\, b$
   - *Market supply is the sum of supply from individual firms*
     - *To obtain market supply (B_s), consider 100 other firms with the same input costs, technologies and marginal cost of books*

     $B_s = 100\, b = 100\, [(1/20)\, MC]$

     $= 5\, MC$

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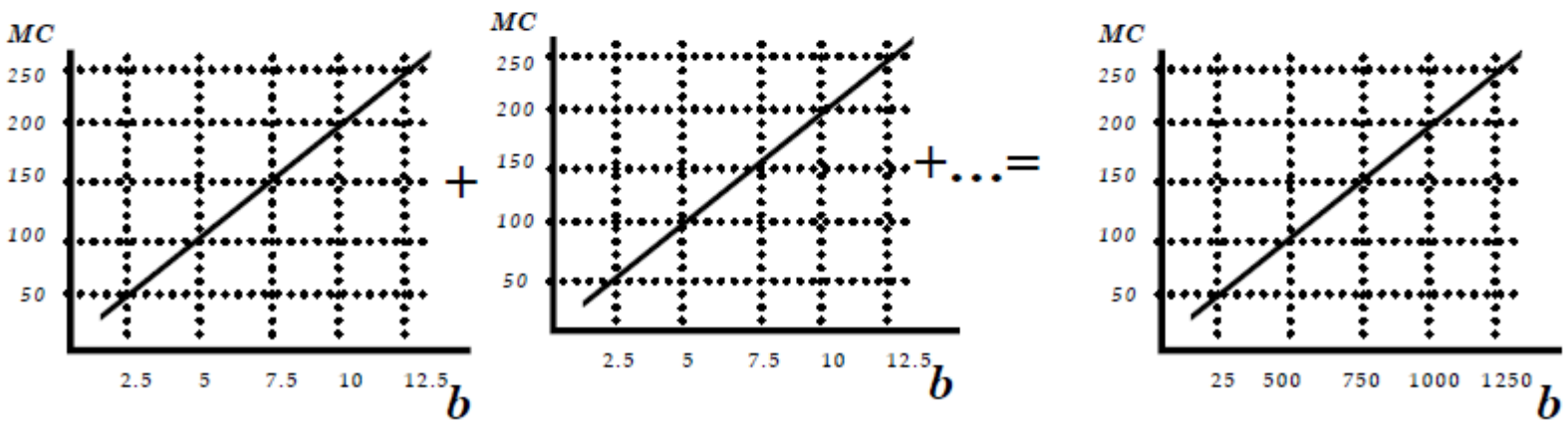
   - *Graphing the individual and market supply curves:*

Firm 1	+	*Firm 2*	+…=	*Market Supply*
b (= 1/20 MC)	+	*b (= 1/20 MC)*	+…=	B_s *(= 5 MC)*



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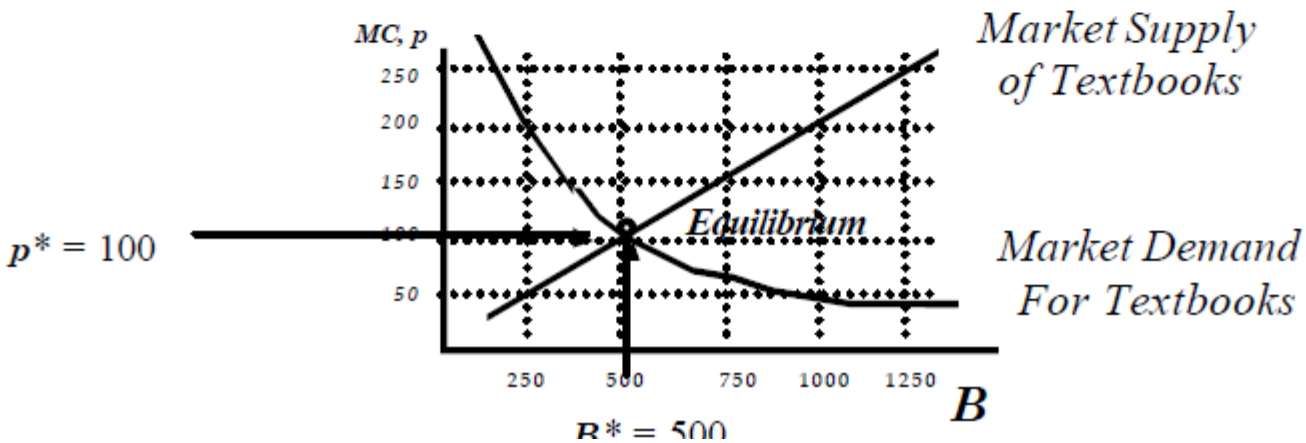
1. How does market demand and market supply determine price (p*) and market output (Q*) ?
   - *Equilibrium market output (B*) occurs where* $B_s = B_D$
   - *Equilibrium market price (p*) occurs where p=MC:*

   Given, $B_s = 5\ MC$ *and* $B_D = 50{,}000/p_b$

   Then, $p^* = 100$ *and* $B^* = 500$



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- Key Questions:
  1. *How does market demand and market supply determine price (p*) and market output (Q*) ?*
  2. *How do individual firms in the market choose output (q*) ?*

  (Using output prices & cost curves instead of isoprofit & production curves)

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2. How do individual firms choose output (q*) ?

– *The firm's short-run optimization problem using strictly convex production function (earlier example) :*

b = *number of economics textbooks produced (* optimal)*

l = *units of labor hours employed to make textbooks (* optimal)*

k_o = *number of machines employed to make textbooks (fixed at 5)*

p_b = *market price of economics textbooks (\$100)*

w = *market price of workers (\$50)*

r = *market price of machines (\$40)*

π = *the profit you obtain from producing textbooks*

– *Choose* l^* *and* b^* *to*

Maximize $\pi = p_b b - (wl + rk_o)$

Subject to $b = l^{1/2} k_o^{1/2}$

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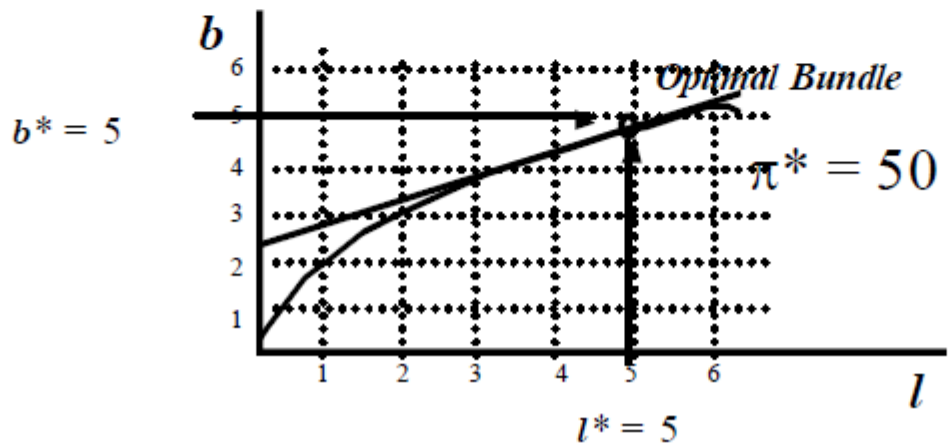
Perfect Competition

2. How do individual firms choose output (q*) ?

– *The optimal choice of textbooks and labor occurs where:*

- *The isoprofit curve is tangent to the production function*
- *The slopes are equal (where* $MP_l = w/p_b = 0.50$*)*
- *The value of marginal product of labor* ($p_b MP_l = 50$) = *wage*($w=50$)

Marginal revenue of labor = Marginal cost of labor



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2. How do individual firms choose output (q*) ?

– *Graphing the firm's optimization problem using cost curves instead of using isoprofit and production curves*

- *Given the firm's short-run profit maximization problem is to choose b^* to:* $\quad Max\ \pi = 100b - (50l + 40k_o)$
  $\quad Subject\ to\ \ b = l^{½}k_o^{½}$

b_f	$l^* = b^2/k_o$	k_{fixed}	$TC = 50l + 40k$	$ATC = TC/b$	$MC = 20b$
1	0.2	5	210	210.0	20
2	0.8	5	240	120.0	40
3	1.8	5	290	96.7	60
4	3.2	5	370	92.5	80
5	5.0	5	450	90.0	100
6	7.2	5	570	95.0	120

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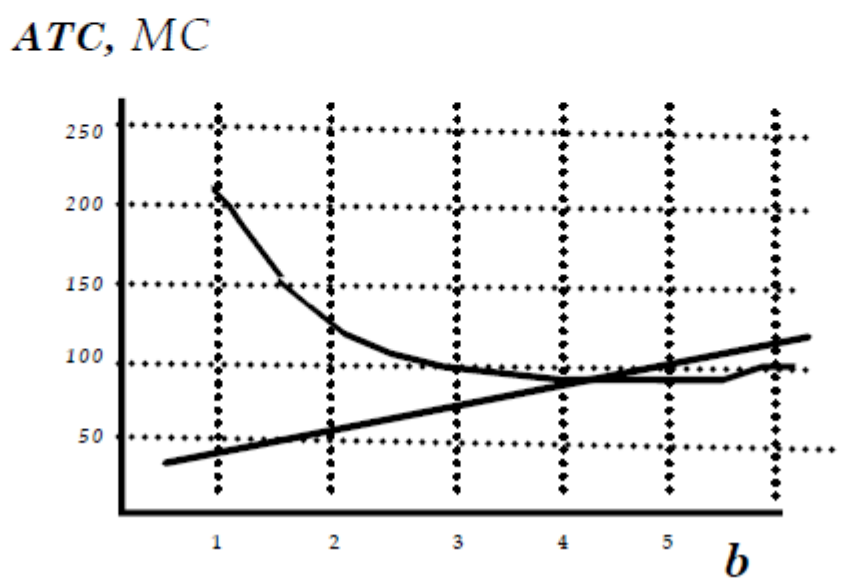

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2. How do individual firms choose output (q*) ?

– *Graphing the firm's optimization problem using revenue curves instead of using isoprofit and production curves*

- *Given the firm's short-run profit maximization problem is to choose b^* to:* $\quad Max\ \pi = 100b - (50l + 40k_o)$
  $Subject\ to\ \ b = l^{½}k_o^{½}$

b	$p^* = 100_d$	$TR = pb$	$AR = TR/b$	$MR = p$
1	100	100	100	100
2	100	200	100	100
3	100	300	100	100
4	100	400	100	100
5	100	500	100	100
6	100	600	100	100

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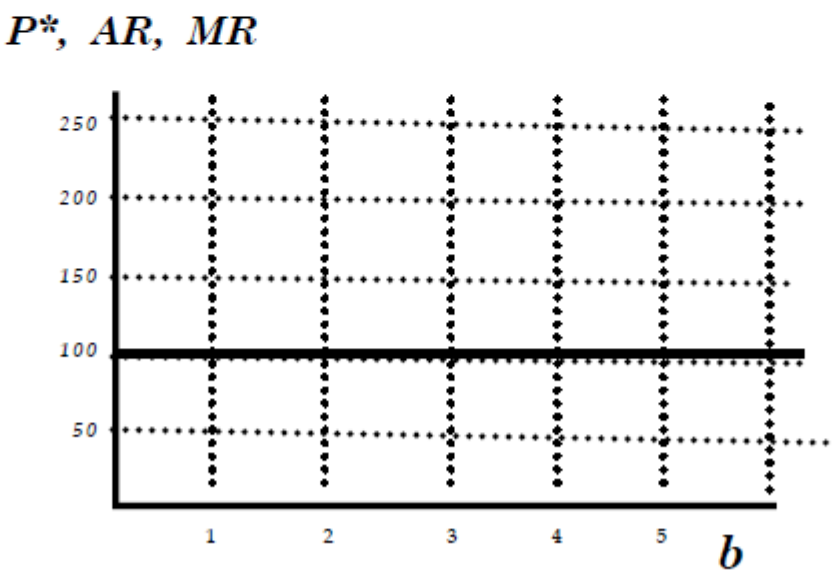

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b	p*	TR	AR	MR	TC	ATC	MC
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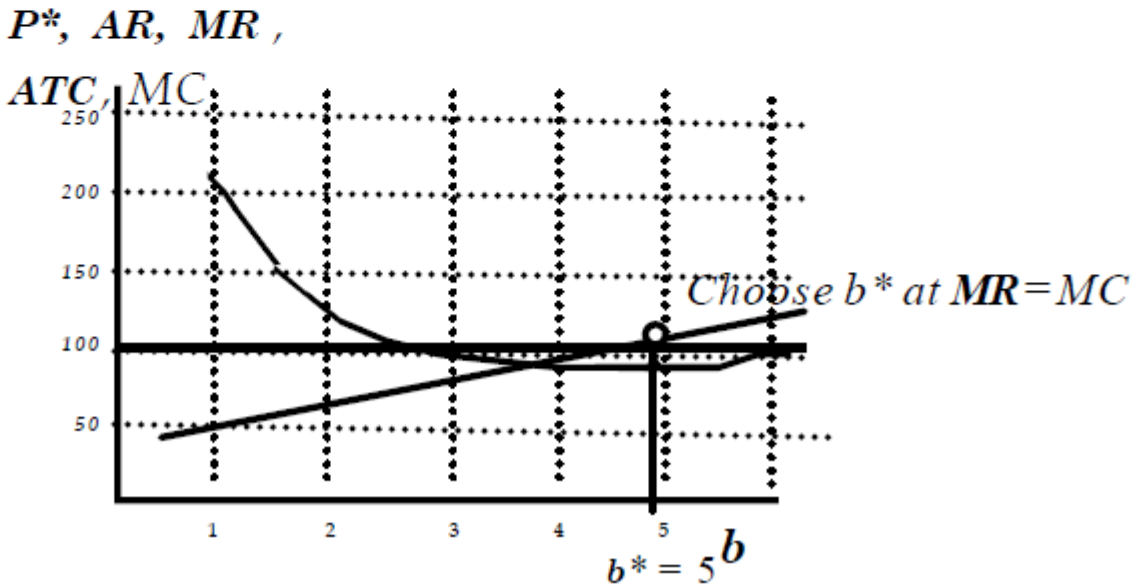

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$$\text{Max } \pi = 100b - (50l + 40k_o)$$
$$\text{Subject to } b = l^{1/2}k_o^{1/2}$$

b	p*	TR	AR	MR	TC	ATC	MC
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2	100	200	100	100	240	120.0	40
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3. How are maximum profits (π^*) determined for individual firms ?

– *Maximum profits are at b* where MR = MC*

b_f	p^*	TR	AR	MR	TC	ATC	MC	Profit
1	100	100	100	100	210	210.0	20	-110
2	100	200	100	100	240	120.0	40	- 40
3	100	300	100	100	290	96.7	60	10
4	100	400	100	100	370	92.5	80	30
5	100	500	100	100	450	90.0	100	50
6	100	600	100	100	570	95.0	120	30

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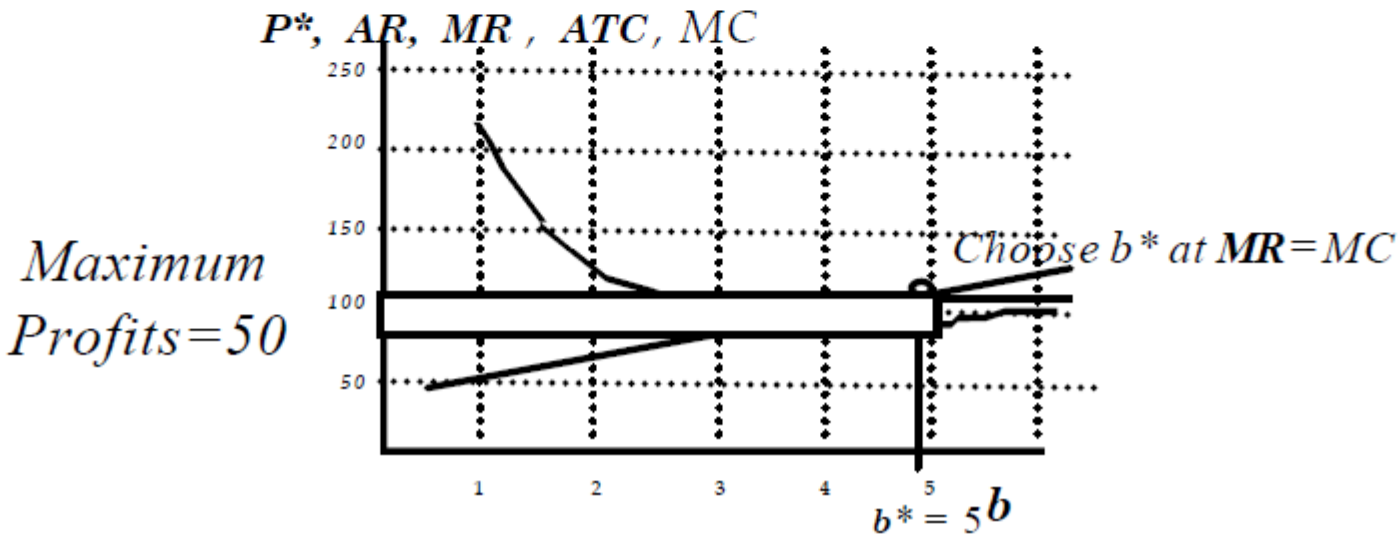
3. How are maximum profits (π^*) determined for individual firms ?

– *Total profit* $= TR - TC = 500 - 450 = 50$

$= b^* (p^* - ATC) = 5 (100 - 90) = 50$

- *Graphically, trace b* to p* & ATC; trace p* & ATC at b* to y-axis*



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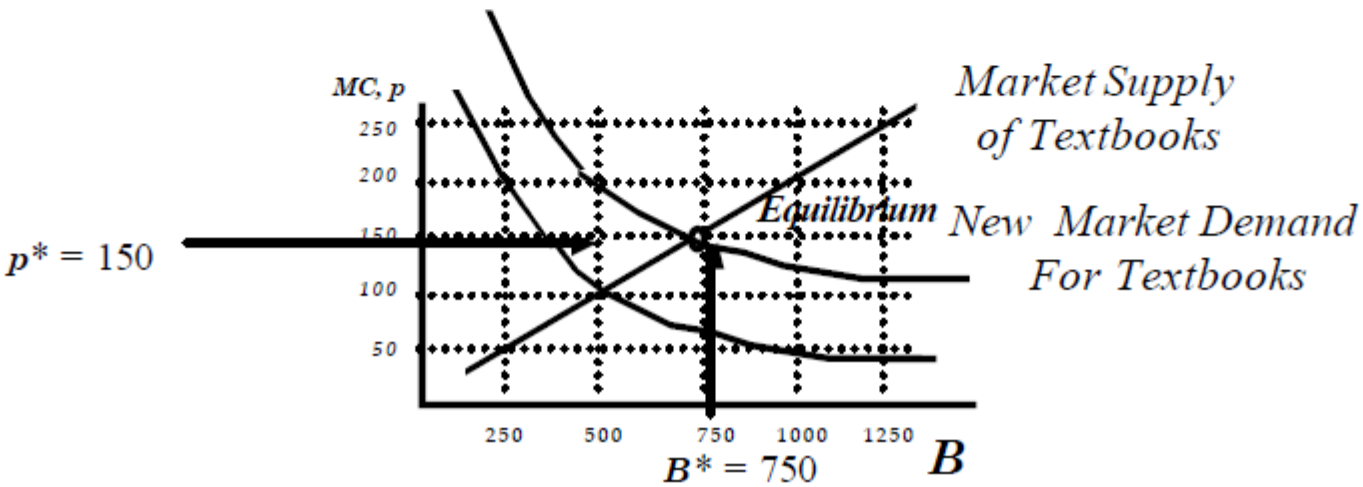
4. How do changes in market demand impact individual firm profit (π^*) ?

– *Consider increase in income of all consumers , then*

Given, $B_s = 5\ MC$ *, then* $B_D = 112{,}500/p_b$

Then, $p^* = 150$ *and* $B^* = 750$



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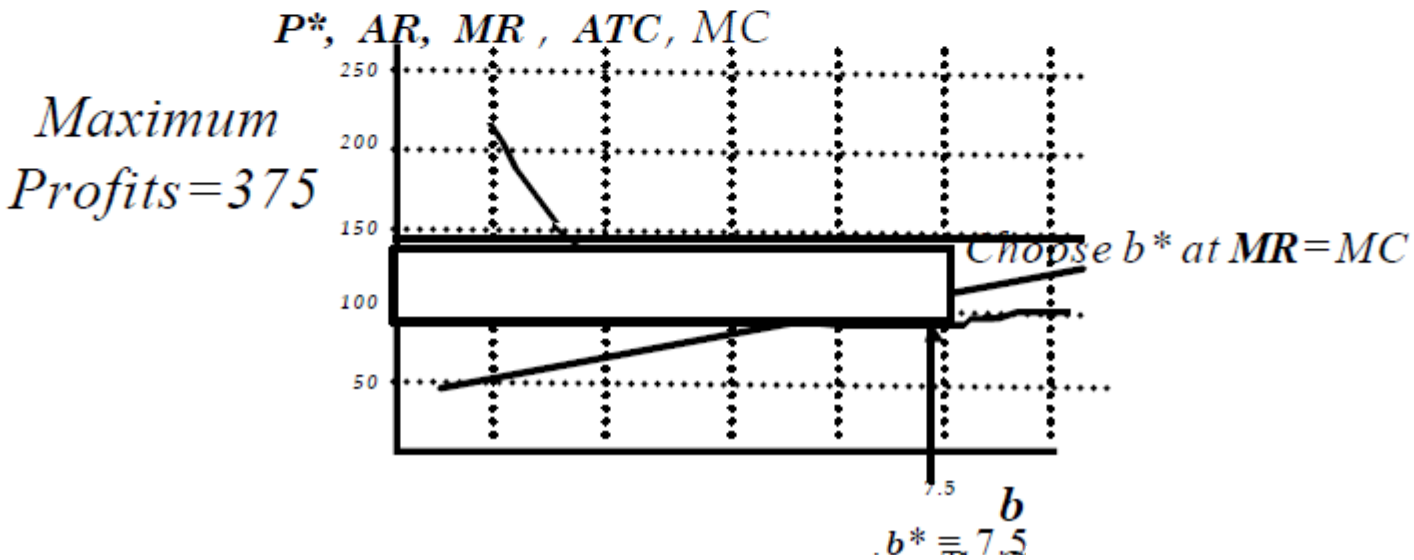
– *Then an increase in demand causes an increase in profits*



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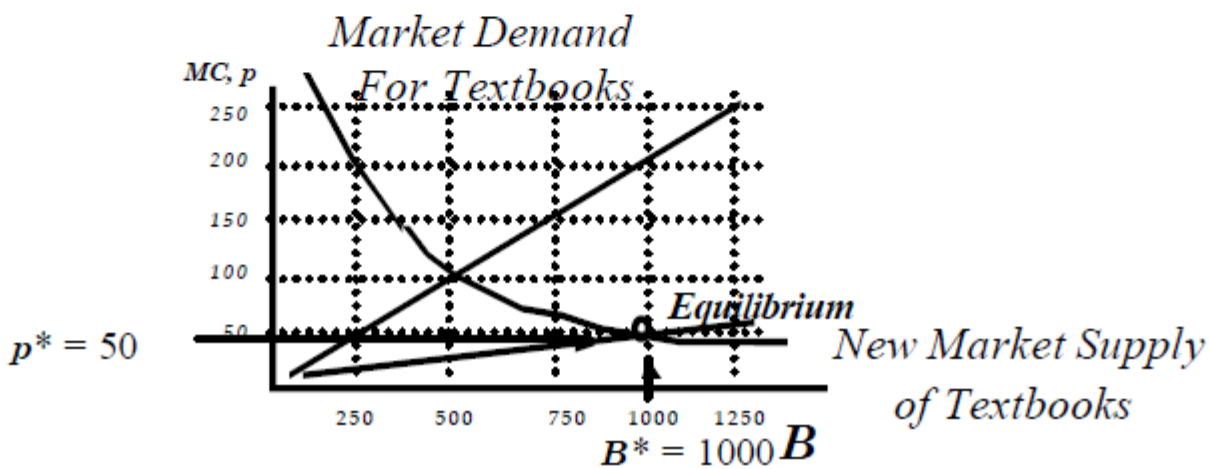
5. How do changes in market supply impact individual firm profit (π^*) ?

– *Business owners observe higher profits in the publishing industry causing 300 new firms to enter the market & 400 total firms in the market:*

Given: $b = 1/20\ MC$ *and* $B_s = 400b = 5MC$, *then* $B_s = 400b$ *and* $B_s = 20\ MC$

Given: $B_D = 100{,}000/p_b$, *then* $p^* = 50$ *and* $B^* = 100$



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2	0.8	5	240	120.0	40
2.5	1.25	5	262.5	105.0	50
3	1.8	5	290	96.7	60
4	3.2	5	370	92.5	80
5	5.0	5	450	90.0	100
6	7.2	5	570	95.0	120

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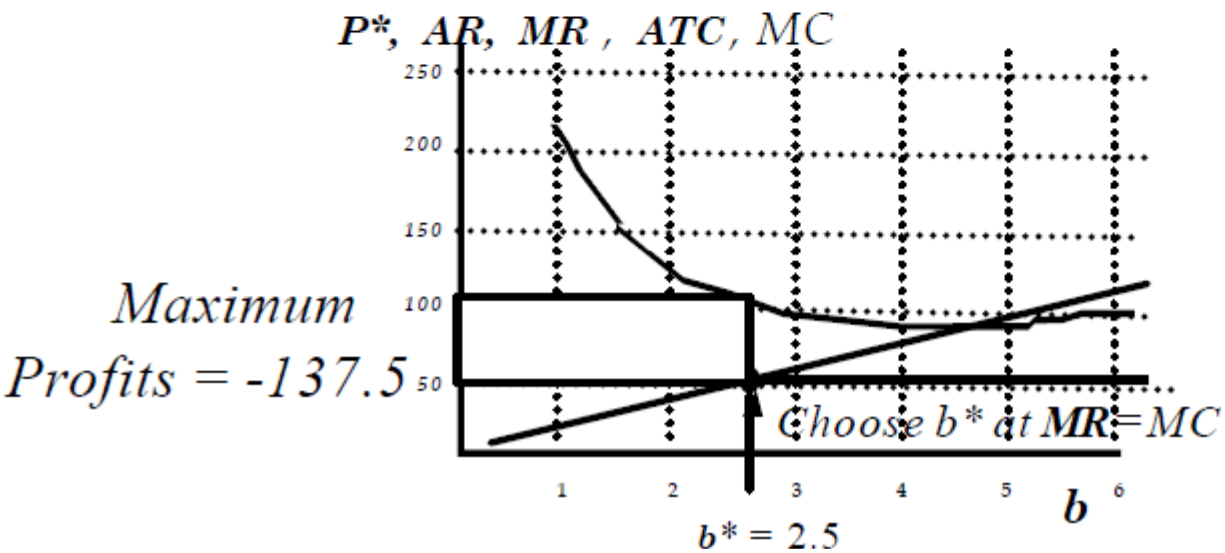
Perfect Competition

5. How do changes in market supply impact individual firm profit (π^*) ?

– *If all 300 firms enter the market, there will be "too many" firms in the market since each firm will earn negative profits*



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Perfect Competition

5. How do changes in market supply impact individual firm profit (π^*) ?
   - *Maximum profits are at b* where MR = MC*

b_f	p^*	TR	AR	MR	TC	ATC	MC	Profit
1	50	50	50	50	210	210.0	20	-160
2	50	100	50	50	240	120.0	40	-140
2.5	50	125	50	50	262.5	105.0	50	-137.5
3	50	150	50	50	290	96.7	60	-140
4	50	200	50	50	370	92.5	80	-170
5	50	250	50	50	450	90.0	100	-200
6	50	300	50	50	570	95.0	120	-270

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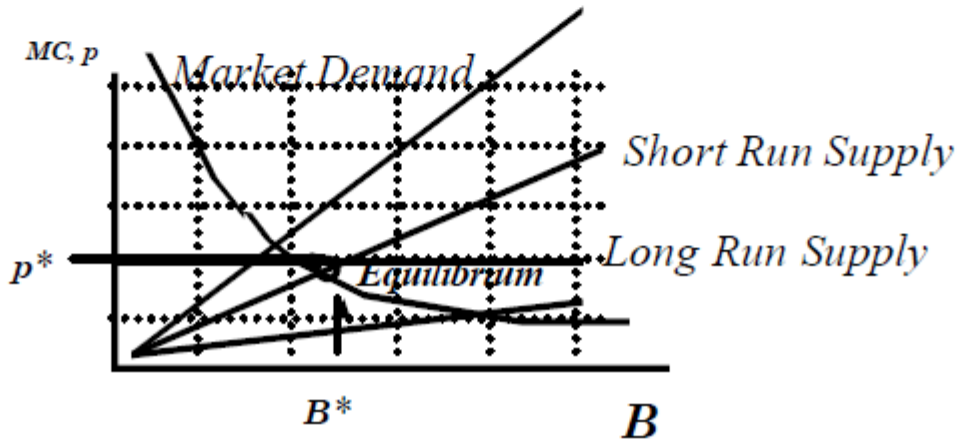
Perfect Competition

5. How do changes in market supply impact individual firm profit (π^*) ?

– *In the long run, positive profits cause firms to enter and negative profits cause firms to exit the market. Leading to:*

- *Shifts (or pivots) in the short-run market supply curve*
- *Changes in equilibrium market price and market quantity*
- *Unchanged long-run market supply curve*



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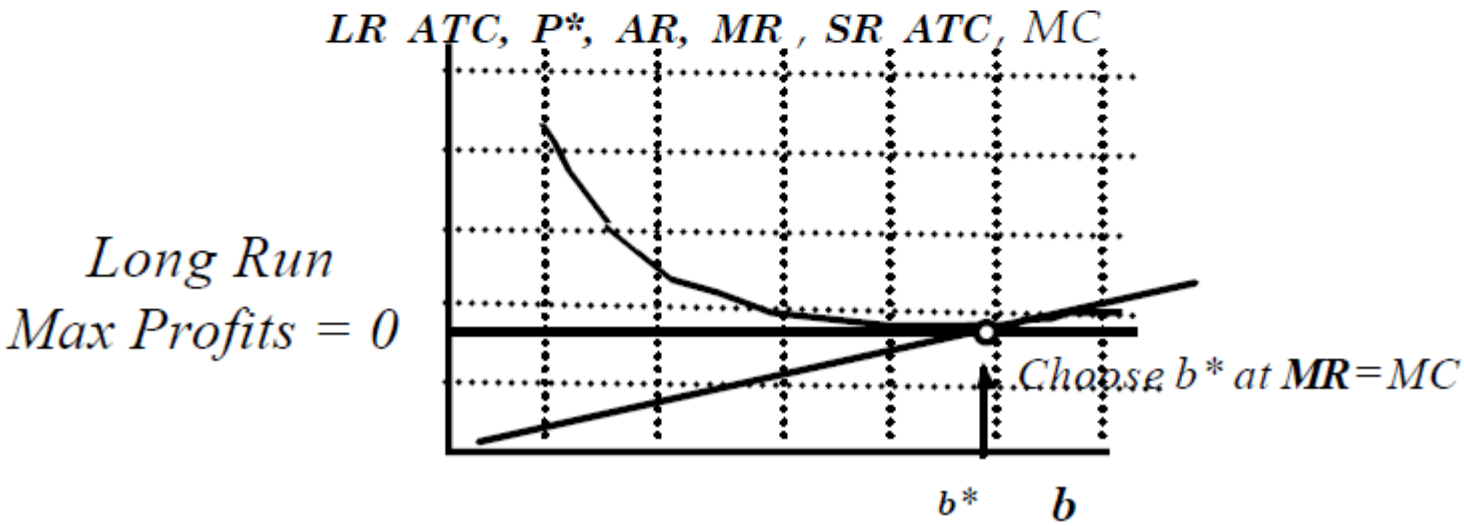
Perfect Competition

5. How do changes in market supply impact individual firm profit (π^*) ?

– *Assuming CRS technology, in the long run, free entry and free exit causes zero profits for individual firms at the minimum of the short-run ATC (which is equal to long-run ATC)*



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Types of Markets

- The type of market determines how firms choose the optimal level of output and price
  - *Many firms selling identical goods*
    - *Perfect Competition*
  - *One firm*
    - *Monopoly*

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Monopoly

- Characteristics of Markets with Monopolies
  - *One firm in the market*
  - *Many buyers in the market*
  - *Identical products*
  - *Barriers to entry*
    - *Government copyrights and patents prevent firms from entering market*
      - *Intellectual property such as new methods in social science research and new pharmaceutical drug formulas*
    - *Laws regulate limited/sole providers of some goods*
      - *Electricity*
    - *Increasing returns to scale technology makes entry inefficient*
      - *Natural monopolies: cheaper for one firm to produce rather two or more*

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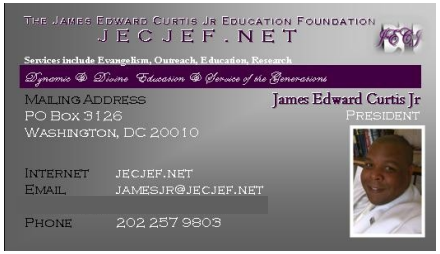
Monopoly

- Key Questions:
  1. *How does market demand and market supply determine market output (Q*) and price (p*)?*
  2. *How are maximum profits (π*) determined ?*
  3. *How is efficiency determined ?*



Monopoly

- Key Questions:
  1. *How does market demand and market supply determine market output (Q*) and price (p*)?*

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Monopoly

1. How does market demand and market supply determine market output (Q*) and price (p*)?
   - *Remember the consumer's optimization problem using strictly convex preferences:*

     b = *number of economics textbooks consumed (* optimal)*

     c = *cups of coffee purchased (* optimal)*

     p_b = *market price of used economics textbooks ($20)*

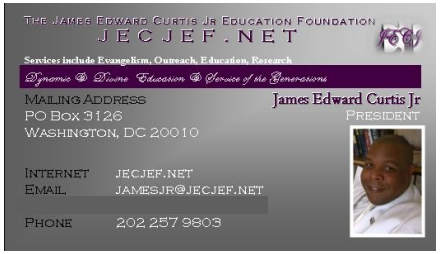
     p_c = *market price of cup of coffee ($5)*

     I = *income ($1000)*

     U = *the utility you obtain from consuming books & coffee*
   - *The consumer chooses b^* and c^* to*

     Maximize $U = b^{1/2} c^{1/2}$

     Subject to $I = p_c c + p_b b$



Monopoly

1. How does market demand and market supply determine market output (Q*) and price (p*)?
   - *Consider the following linear approximation of the individual's demand for books:*

     $b^* = I \quad - [(a + b) \ / \ a]^* p_b$

     $= 1000 - [(½ + ½) / ½] p_b$

     $= 1000 - 2\, p_b$
   - *The market demand is the sum of individual linear demands*
     - *To obtain market demand (B_D), consider 100 other consumers with the same preferences, budget constraint and demand for books*

     $B_D = 100\, b^*$

     $= 100{,}000 - 200\, p_b$

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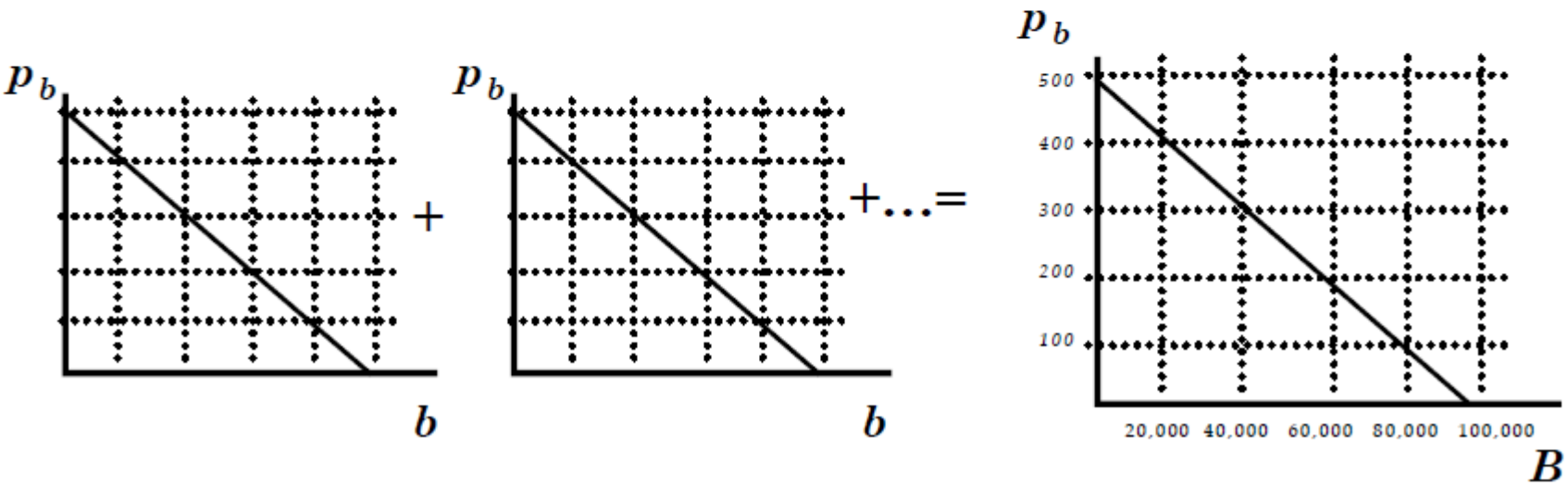
Monopoly

1. How does market demand and market supply determine market output (Q*) and price (p*)?
   - *Graphing the individual and market demand curves:*

Individual 1	+	*Individual 2*	+…=	*Market Demand*
$b^* (= 1{,}000 - 2p_b)$	+	$b^* (=1{,}000 - 2p_b)$	+…=	$B_D (=1{,}000{,}000 - 200\,p_b)$



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Monopoly

1. How does market demand and market supply determine market output (Q*) and price (p*)?
   - *Graphing the market marginal revenue (MR) curves:*

Given: $B = 100{,}000 - 200\, p_b$, *then* $p_b = 500 - 1/200\, B$

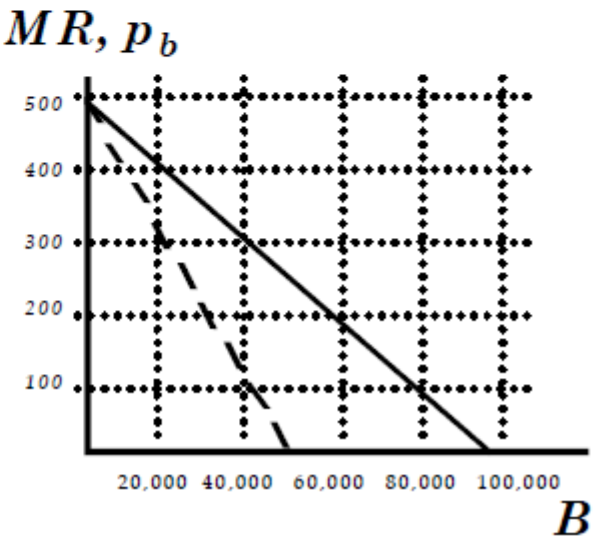
then $TR = p_b B = 500\, B - 1/200\, B^2$

Then: $MR = \partial TR / \partial Q$

$= \partial (p_b B) / \partial B$

$= 500 - (1/100)\, B$

- *The market marginal revenue curve is steeper and below the demand curve*



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Monopoly

1. How does market demand and market supply determine market output (Q*) and price (p*)?
   - *Case 1: Using CRS technology to determine MC & ATC*
   - *Remember the firm's short-run optimization problem using a strictly convex production function:*

     B = number of economics textbooks produced (fixed)

     l = units of labor hours employed to make textbooks (optimal)*

     k_o = number of machines employed to make textbooks (fixed at 10,000)

     w = market price of workers ($50)

     r = market price of machines ($40)

     C = the labor and capital costs you pay to produce textbooks
   - *The firm chooses l^* to: Minimize $C = wl + rk_o$*

     Subject to $B = l^{1/2} k_o^{1/2}$

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Monopoly

1. How does market demand and market supply determine market output (Q*) and price (p*)?

– *Graphing the market supply curve:*

$$C = w\,l^* + \quad rk_o \text{ where } l^* = B^2 / k_o$$

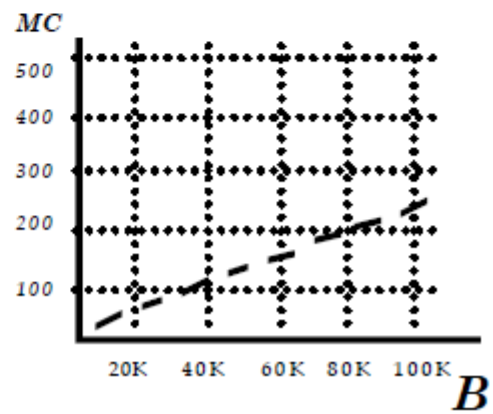
$$= 50\,l^* + 40\,(40{,}000)$$

$$MC = \partial C / \partial B$$

$$= 2wB / k_o = 2\,(50)\,B / 40{,}000$$

$$= (1/400)\,B$$

$$B_s = 400\,MC$$



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Monopoly

1. How does market demand and market supply determine market output (Q*) and price (p*)?

   – *B* and p* occurs where MR = MC*

B	p = 500-1/200B	TR=pB	AR	MR	l* = B²k₀	TC = 50l+1.6M	ATC	MC
0	500	0	-	-	0	1.6M	-	0
20K	400	8M	400	300	10K	2.1M	105	50
40K	300	12M	300	100	40K	3.6M	90	100
60K	200	12M	200	-100	90K	6.1M	102	150
80K	100	8M	100	-300	160K	9.6M	120	200
100K	0	0	-	-500	250K	14.1M	141	250

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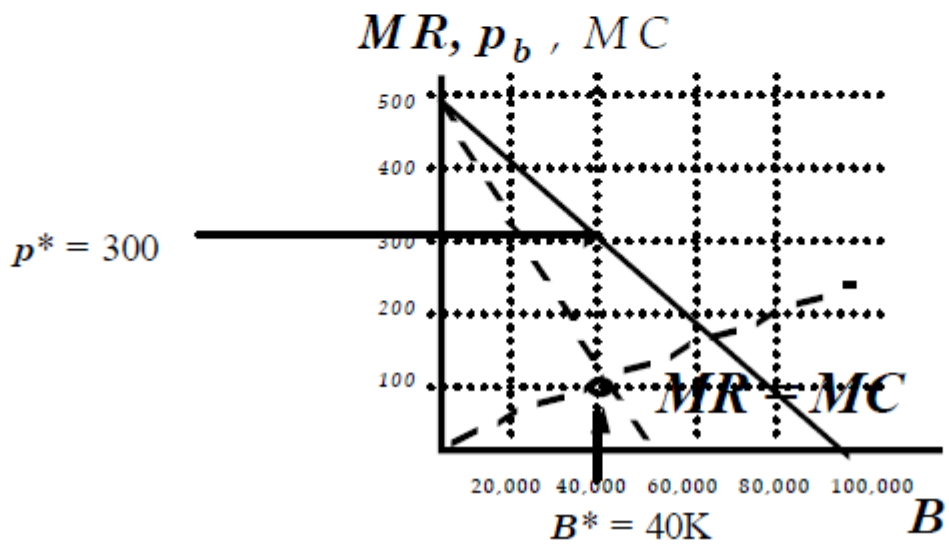
Monopoly

1. How does market demand and market supply determine market output (Q*) and price (p*)?
   - *Combining demand, marginal revenue and marginal cost*



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Monopoly

- Key Questions:
  1. *How does market demand and market supply determine price (p*) and market output (Q*) ?*
  2. *How are maximum profits (π*) determined ?*

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Monopoly

2. How are maximum profits (π^*) determined ?
   - *B^*, p^* and maximum profits occur where MR = MC*

B	p =500-1/200B	TR=pB	AR	MR	l* =B²k₀	TC = 50l+1.6M	ATC	MC	Profit
0	500	0	-	-	0	1.6M	-	0	-1.6M
20K	400	8M	400	300	10K	2.1M	105	50	5.9M
40K	300	12M	300	100	40K	3.6M	90	100	8.4M
60K	200	12M	200	-100	90K	6.1M	102	150	5.9M
80K	100	8M	100	-300	160K	9.6M	120	200	-1.6M
100K	0	0	-	-500	250K	14.1M	141	250	-14.1M

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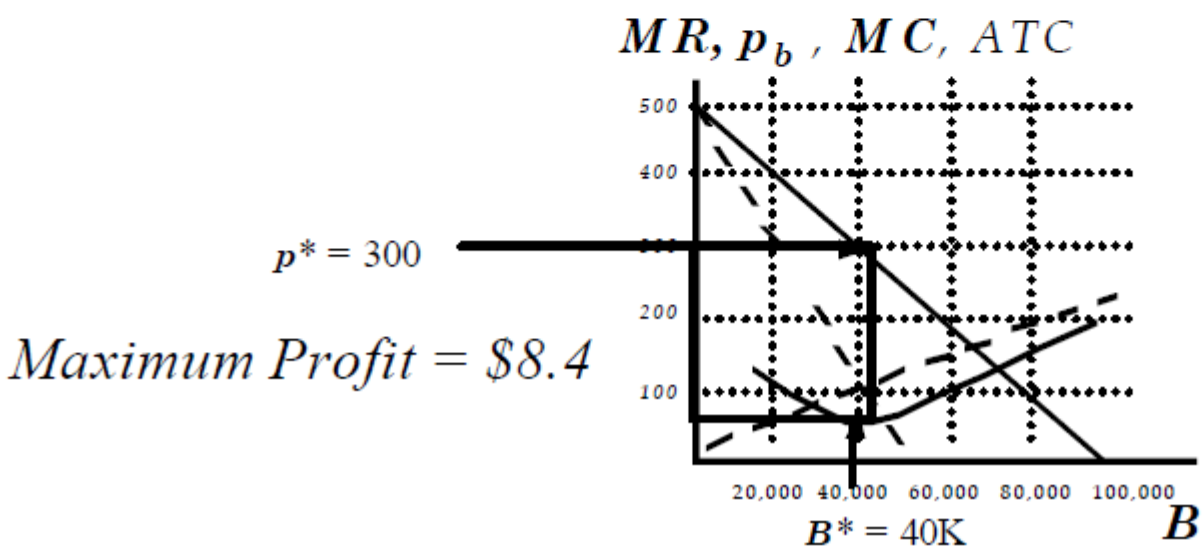
Monopoly

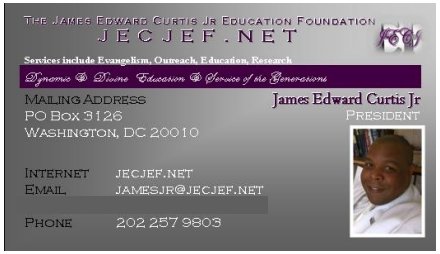
2. How are maximum profits (π^*) determined ?

– *Total profit* $= TR - TC = 12M - 3.6M = 8.4M$

$= B^* (p^* - ATC) = 40{,}000\ (300 - 90) = 8.4M$

- *Graphically, trace B^* to ATC and demand curve ; then trace to y-axis*





Monopoly

- Key Questions:
  1. *How does market demand and market supply determine market output (Q*) and price (p*)?*
  2. *How are maximum profits (π*) determined ?*
  3. *How is efficiency determined ?*

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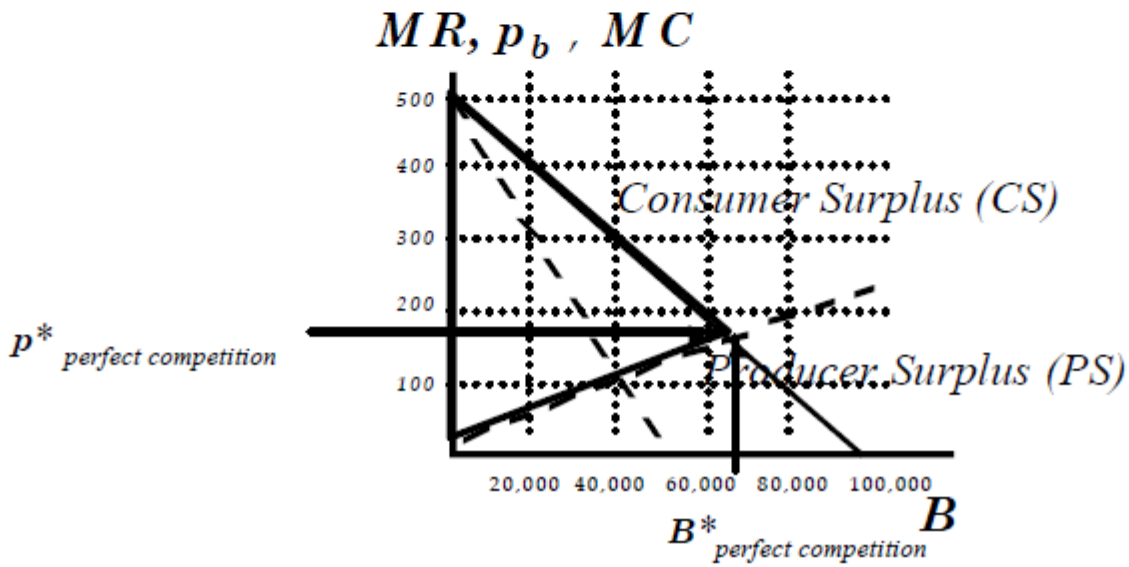
Monopoly

3. *How is efficiency determined ?*

– *Efficiency = Maximum Total Surplus (CS + PS)*

– *Consider the total surplus at the perfectly competitive price*

- *Since total surplus is maximized, markets with perfect competition are efficient*



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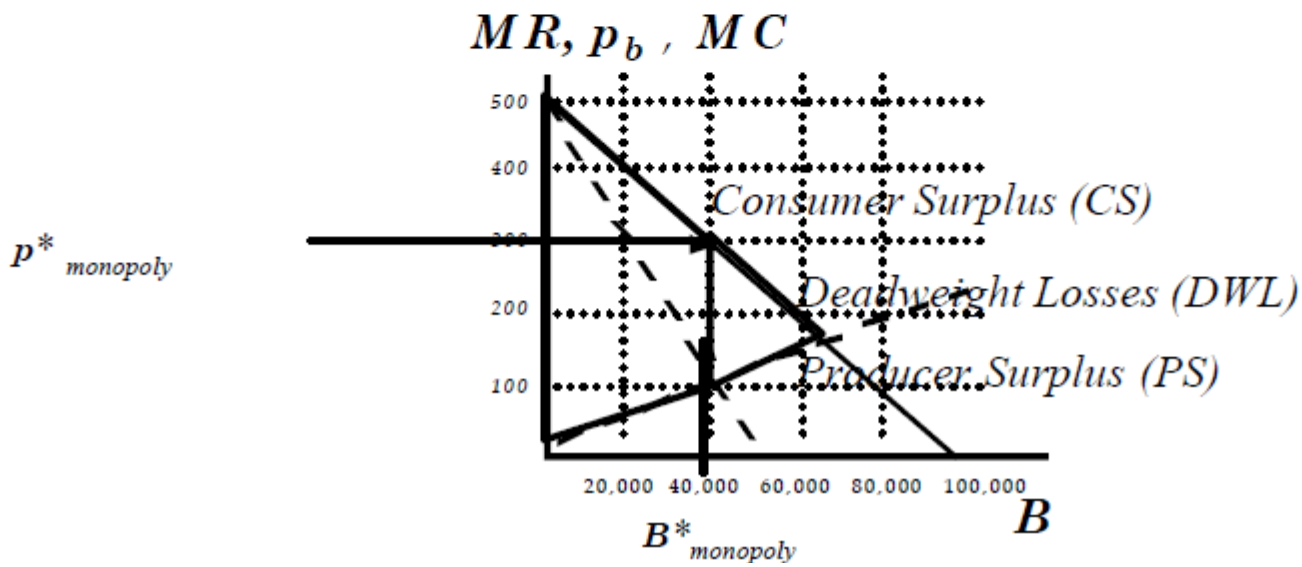
Monopoly

3. *How is efficiency determined ?*

– *Efficiency = Maximum Total Surplus (CS + PS)*

– *Consider the total surplus at the monopoly price*

- *Since total surplus is not maximized due to deadweight losses, markets with monopolies are not efficient*



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Types of Markets

- The type of market determines how firms choose the optimal level of output and price
  - *Many firms selling identical goods*
    - *Perfect Competition*
  - *One firm*
    - *Monopoly*
  - *Few firms*
    - *Oligopoly*

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Oligopoly

- Characteristics of Markets with Oligopolies
  - *Few firms in the market*
  - *Many buyers in the market*
  - *Identical products*
  - *Output is interdependent on other firms in the market*

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Oligopoly

- Key Questions:
  1. *How does market demand and market supply determine market output (Q*) and price (p*)?*
  2. *How are maximum profits (π*) determined ?*

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Oligopoly

1. How does market demand and market supply determine market output (Q*) and price (p*)?
   - *Remember the consumer's optimization problem using strictly convex preferences:*

     b = *number of economics textbooks consumed (* optimal)*

     c = *cups of coffee purchased (* optimal)*

     p_b = *market price of used economics textbooks ($20)*

     p_c = *market price of cup of coffee ($5)*

     I = *income ($1000)*

     U = *the utility you obtain from consuming books & coffee*
   - *The consumer chooses b^* and c^* to*

     Maximize $U = b^{1/2} c^{1/2}$

     Subject to $I = p_c c + p_b b$

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Oligopoly

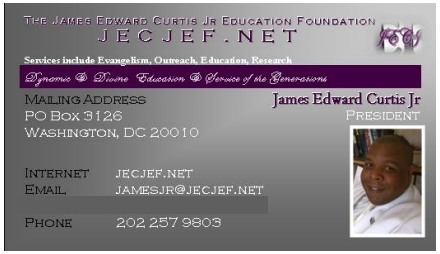
1. How does market demand and market supply determine market output (Q*) and price (p*)?
   - *Consider the following linear approximation of the individual's demand for books:*

     $b^* = I \quad -[(a + b) \ / \ a]^* p_b$

     $= 1000 - [(½ + ½) / ½]p_b$

     $= 1000 - 2\, p_b$
   - *The market demand is the sum of individual linear demands*
     - *To obtain market demand (B_D), consider 100 other consumers with the same preferences, budget constraint and demand for books*

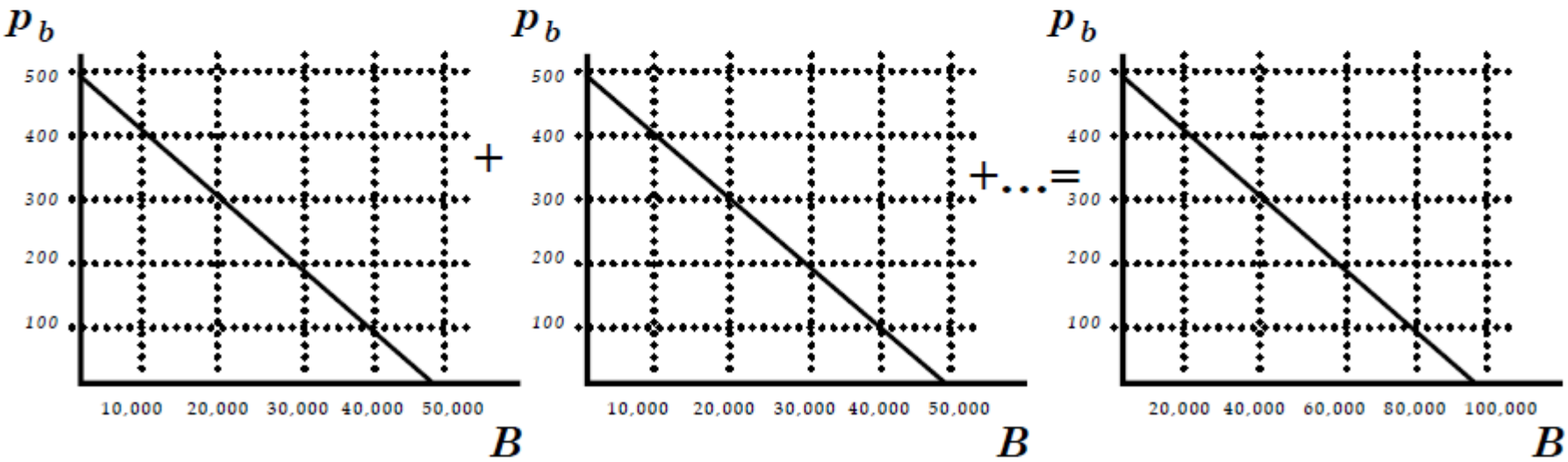
     $B_D = 100\, b^* = 1{,}000{,}000 - 200\, p_b$
   - *If two firms decide to split the market demand (duopoly), then:* $B_D = 50{,}000 - 100\, p_b$



Oligopoly

1. How does market demand and market supply determine market output (Q*) and price (p*)?
   - *Graphing the individual and market demand curves:*

Firm 1's Demand	+	*Firm 2's Demand*	=	*Market Demand*
$b^*(=50{,}000-100\,p_b)$	+	$b^*(=50{,}000-100\,p_b)$	=	$B_D(=100{,}000-200\,p_b)$



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Oligopoly

1. How does market demand and market supply determine market output (Q*) and price (p*)?
   - *Graphing the individual marginal revenue (MR) curve:*

Given: $B = 50{,}000 - 100\, p_b$, *then* $p_b = 500 - 1/100\, B$

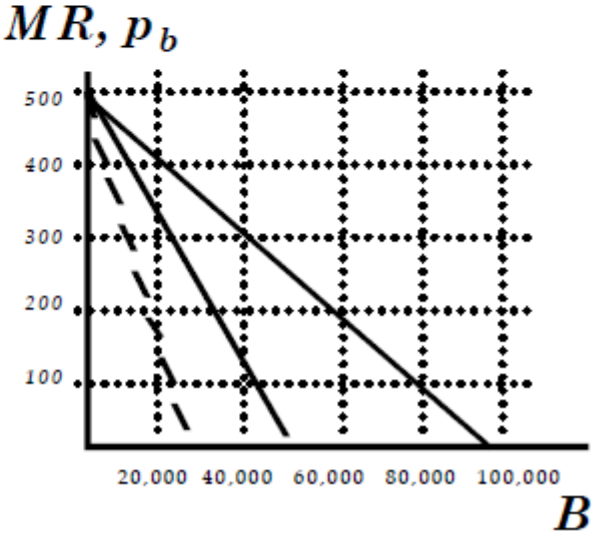
then $TR = p_b B = 500\, B - 1/100\, B^2$

Then: $MR = \partial TR / \partial Q$

$= \partial (p_b B) / \partial B$

$= 500 - (1/50)\, B$

- *The market marginal revenue curve is steeper and below the demand curve*



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Oligopoly

1. How does market demand and market supply determine market output (Q*) and price (p*)?
   - *Using CRS technology to determine short-run MC & ATC*
   - *Remember the firm's short-run optimization problem using a strictly convex production function:*

     B = number of economics textbooks produced (fixed)

     l = units of labor hours employed to make textbooks (optimal)*

     k_o = number of machines employed to make textbooks (fixed at 10,000)

     w = market price of workers ($50)

     r = market price of machines ($40)

     C = the labor and capital costs you pay to produce textbooks
   - *The firm chooses l^* to: Minimize $C = wl + rk_o$*

     Subject to $B = l^{1/2} k_o^{1/2}$

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Oligopoly

1. How does market demand and market supply determine market output (Q*) and price (p*)?

– *Graphing the market supply curve:*

$$C = w\,l^* + \quad rk_o \text{ where } l^* = B^2 / k_o$$

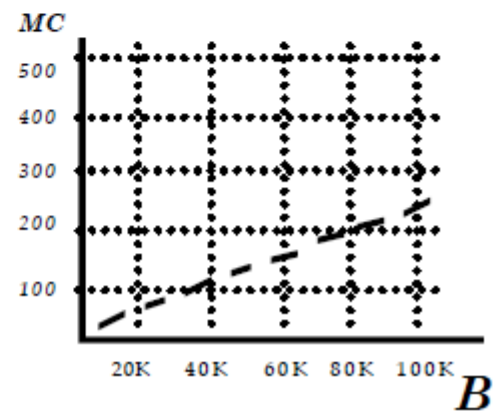
$$= 50\,l^* + 40\,(40{,}000)$$

$$MC = \partial C / \partial B$$

$$= 2wB / k_o = 2\,(50)\,B / 40{,}000$$

$$= (1/400)\,B$$

$$B_s = 400\,MC$$



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Oligopoly

1. How does market demand and market supply determine market output (Q*) and price (p*)?

   – *B* and p* occurs where MR = MC*

B	p = 500-1/200B	TR=pB	AR	MR	l* = B²k₀	TC = 50l+1.6M	ATC	MC
0	500	0	-	-	0	1.6M	-	0
20K	400	8M	400	300	10K	2.1M	105	50
40K	300	12M	300	100	40K	3.6M	90	100
60K	200	12M	200	-100	90K	6.1M	102	150
80K	100	8M	100	-300	160K	9.6M	120	200
100K	0	0	-	-500	250K	14.1M	141	250

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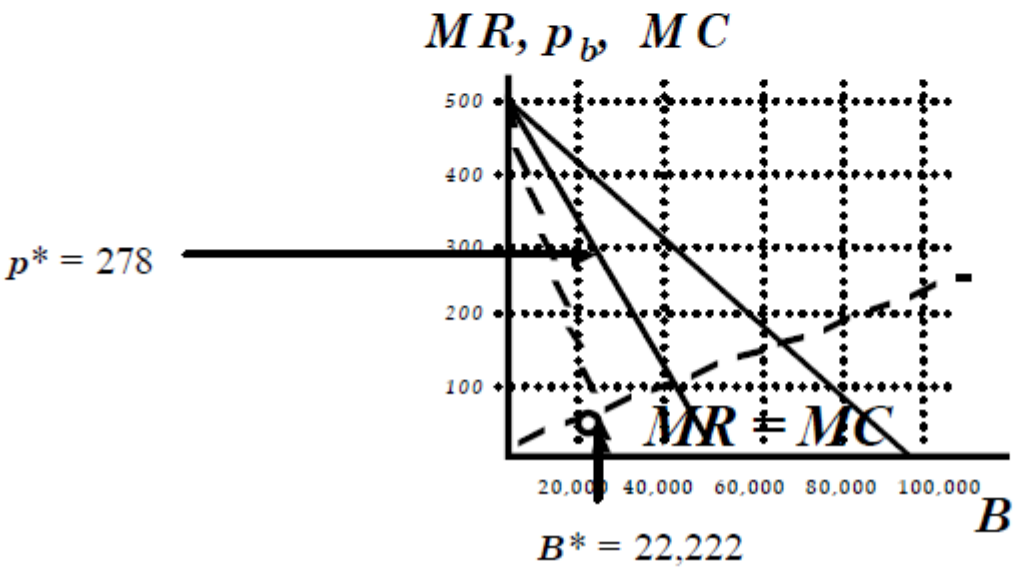
Oligopoly

1. How does market demand and market supply determine market output (Q*) and price (p*)?
   - *Combining demand, marginal revenue and marginal cost*



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Oligopoly

- Key Questions:
  1. *How does market demand and market supply determine price (p*) and market output (Q*) ?*
  2. *How are maximum profits (π*) determined ?*

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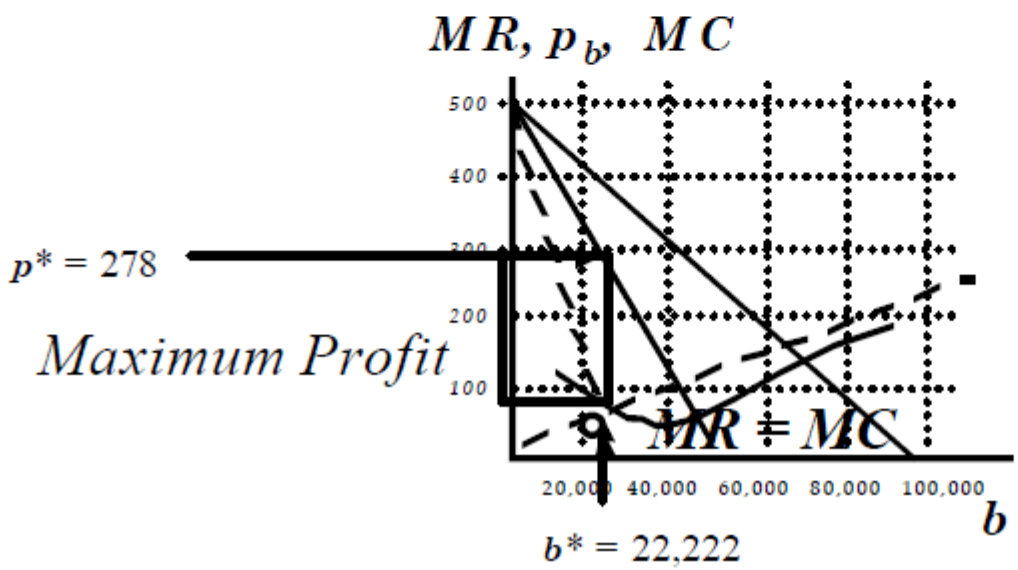
Oligopoly

2. How are maximum profits (π^*) determined ?

– *Total profit* $= TR - TC = b^* (p^* - ATC)$

Graphically, trace B to ATC and demand curve ; then trace to y-axis*



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Oligopoly

- Key Questions:
  1. *How does market demand and market supply determine market output (Q*) and price (p*)?*
  2. *How are maximum profits (π*) determined ?*
  3. *How is efficiency determined ?*

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