

## EXAMINATION 3 ANSWER KEY “Firms and Competition”

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### Version A

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#### I. Multiple choice

- (1)a. (2)d. (3)a. (4)b. (5)c. (6)d. (7)c. (8)a. (9)c. (10)a.  
 (11)b. (12)a. (13)d. (14)b. (15)b. (16)c.

#### II. Short answer

- (1) a. 7 percent. b. 2 percent.  
 (2) a. 4 units. b. 6 units. c. \$120.  
 d. 12 units. c. \$150.  
 (3) a. 12 thousand (using rule  $P=MC$  to find  $q$ ).  
 b. 0 thousand (because price is below shutdown price).  
 c. 11 thousand (using rule  $P=MC$  to find  $q$ ).  
 d. \$8 (because breakeven price =  $\min(\text{SATC})$ ).  
 e. \$3 (because shutdown price =  $\min(\text{SAVC})$ ).  
 (4) a. import. b. 4 million. c. increase.  
 d. \$9 million. e. decrease. f. \$7 million.  
 g. increase. h. \$2 million.

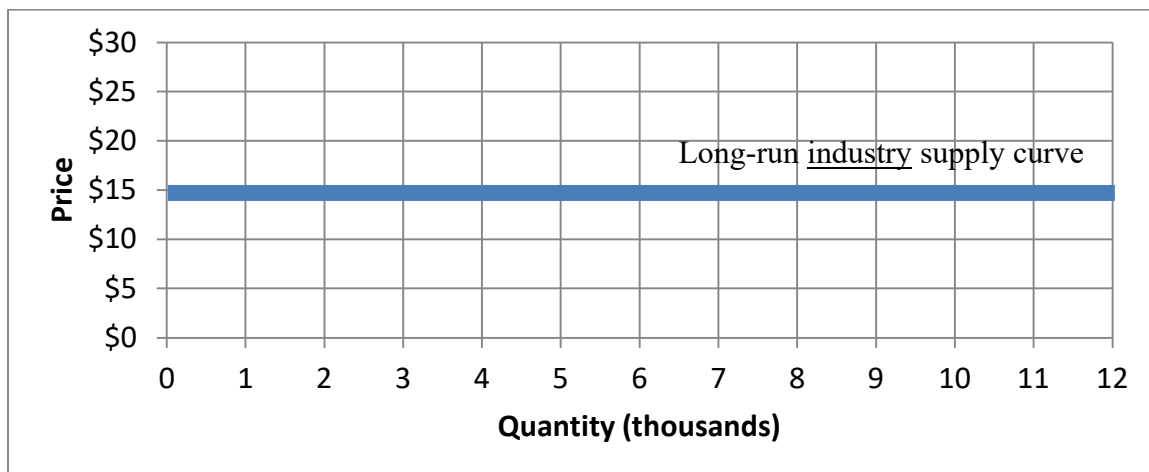
#### III. Problems

- (1) [Input substitution]  
 a.  $MP_1 = 2 + 2x_1^{-1/2}x_2^{1/2}$ . YES, there are diminishing returns to input 1, because as  $x_1$  increases (and  $x_2$  is held constant),  $MP_1$  decreases.  
 b.  $MRSP = \frac{MP_2}{MP_1} = \frac{3 + 2x_1^{1/2}x_2^{-1/2}}{2 + 2x_1^{-1/2}x_2^{1/2}}$ . YES, this function has diminishing MRSP, because as  $x_1$  decreases and  $x_2$  increases, the numerator decreases and the denominator increases. Therefore, MRSP decreases.  
 c. Check returns to scale:  

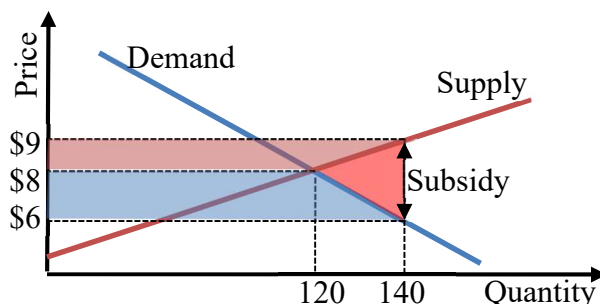
$$\begin{aligned} f(ax_1, ax_2) &= 2(ax_1) + 3(ax_2) + 4(ax_1)^{1/2}(ax_2)^{1/2} \\ &= a2x_1 + a3x_2 + 4a^{1/2}x_1^{1/2}a^{1/2}x_2^{1/2} \\ &= a2x_1 + a3x_2 + a4x_1^{1/2}x_2^{1/2} \\ &= a(2x_1 + 3x_2 + 4x_1^{1/2}x_2^{1/2}) \\ &= aq, \text{ for all } a > 1. \end{aligned}$$
  
 Thus, multiplying all inputs by the same factor ( $a$ ) causes output to increase by the same factor. So, this production function has CONSTANT returns to scale.

- (2) [Cost minimization]
- Equation for isoquant:  $100 = 10 x_1^{1/2} x_2^{1/2}$  or  $10 = x_1^{1/2} x_2^{1/2}$  or  $100 = x_1 x_2$ .
  - $MRSP = MP_2/MP_1 = \frac{5 x_1^{1/2} x_2^{-1/2}}{5 x_1^{-1/2} x_2^{1/2}} = x_1/x_2$ .
  - Set  $MRSP = \$10/\$40$  and solve jointly with  $100 = 10 x_1^{1/2} x_2^{1/2}$ , to get  $x_1^*=5$  and  $x_2^*=20$ .
  - $TC(50) = 5 \times \$40 + 20 \times \$10 = \$400$ .

- (3) [Cost curves; Long-run market equilibrium]
- $AC = TC/q = 0.01 q^2 - 0.6 q + 24$ .  
Set  $0 = dAC/dq = 0.02 q - 0.6$  and solve to get  $q_{ES} = 30$ .
  - Breakeven price = minimum  $AC = AC(q_{ES}) = \$15$ .
  - A firm's supply curve shows how much the firm will produce for any given price. If  $P >$  minimum average cost, the profit-maximizing firm will choose an output level where  $P = MC(q)$ , and if  $P <$  minimum average cost, it will produce nothing. So, this firm's supply curve is given by the following equations.  
If  $P \geq \$15$ ,  $P = MC(q) = dTC/dq = 0.03 q^2 - 1.2 q + 24$ .  
If  $P \leq \$15$ ,  $q = 0$  (firm shuts down).
  - The long-run industry supply curve is a horizontal line at minimum  $AC$ :



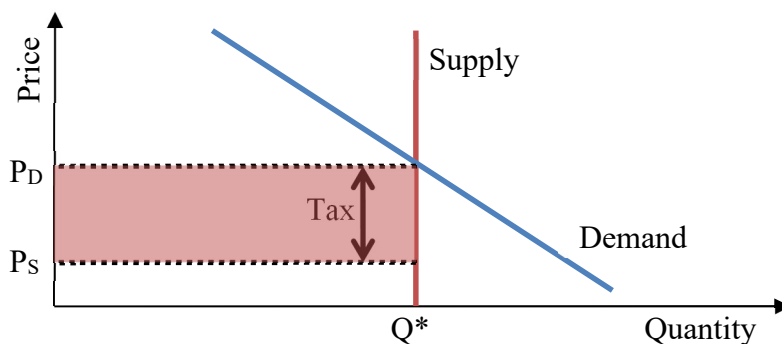
- (4) [Welfare effects of tax or subsidy]
- Set  $P_D = P_S$  and solve to get  $P^* = \$8$  and  $Q^* = 120$ .
  - With subsidy of \$3,  $P_D + 3 = P_S$ . Substituting and solving gives  $Q = 140$ . It is useful to also compute the new net price paid by buyers, excluding the subsidy ( $P_D = \$6$ ), and the new total price received by sellers, including the subsidy ( $P_S = \$9$ ).
  - Consumer surplus increases by \$260, the area of the trapezoid between \$6 and \$8.
  - Producer surplus increases by \$130, the area of the trapezoid between \$8 and \$9.
  - The government pays  $\$3 \times 140 = \$420$  in direct cost, but this is greater than the combined increases of consumer and producer surplus. The loss to society as a whole (also called “deadweight loss”) is \$30, the area of the red triangle in the graph below.



#### IV. Critical thinking

(1) Payments to banks and suppliers are essentially fixed costs, and sunk costs by the time the firm goes bankrupt. As long as revenues still exceed variable costs, the firm can pay at least some of its debts to banks and suppliers if it continues to operate in the short run. So, if revenues exceed variable costs, creditors will be anxious to keep the firm operating in the short run, even if it is losing money.

(2) To find the burden of a tax, first find the quantity traded. After a tax is imposed, the quantity traded is where the demand curve is higher than the supply curve by the amount of the tax. If supply is *perfectly inelastic* (vertical) then there is no change in the quantity traded ( $Q^*$ ) as a result of the tax. However, the sellers pay all of the tax. That is, the tax causes the sellers' price ( $P_S$ ) to fall by the amount of the tax, but the buyers' price ( $P_D$ ) is unchanged. Similarly, the loss of producer surplus equals the quantity traded multiplied by the tax rate, but there is no loss of consumer surplus. So, in this special case, sellers bear the entire burden of the tax, as shown in the graph below.



## Version B

### I. Multiple choice

- (1)c. (2)b. (3)b. (4)d. (5)d. (6)b. (7)a. (8)c. (9)a. (10)b.  
(11)b. (12)b. (13)b. (14)d. (15)a. (16)c.

### II. Short answer

- (1) a. 5 percent. B. 3 percent.  
(2) a. 4 units. b. 6 units. c. \$120.  
d. 3 units. c. \$150.  
(2) a. 0 thousand (because price is below shutdown price).  
b. 8 thousand (using rule  $P=MC$  to find  $q$ ).  
c. 11 thousand (using rule  $P=MC$  to find  $q$ ).  
d. \$6 (because breakeven price =  $\min(\text{SATC})$ ).  
e. \$2 (because shutdown price =  $\min(\text{SAVC})$ ).  
(4) a. export. b. 8 million. c. decrease.  
d. \$12 million. e. increase. f. \$20 million.  
g. increase. h. \$8 million.

### III. Problems

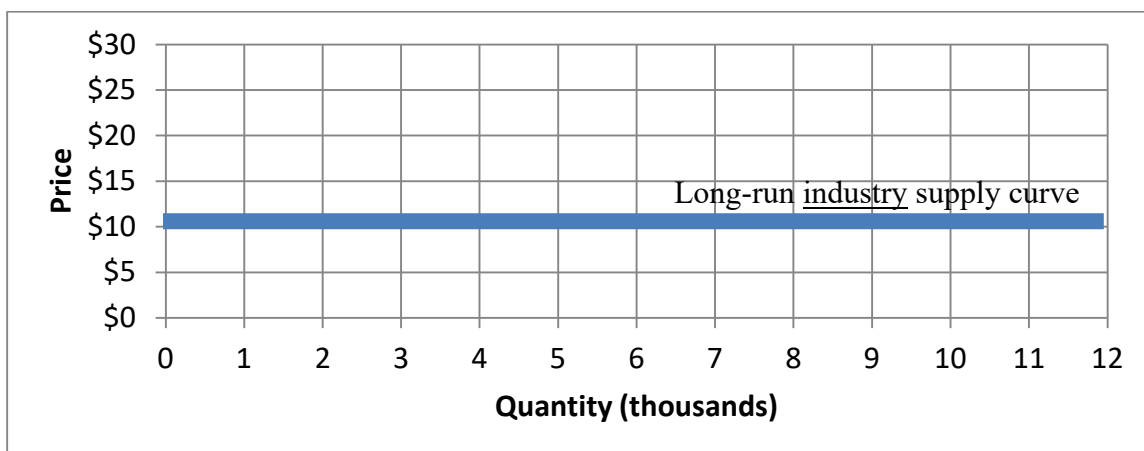
- (1) [Input substitution; Returns to scale]  
a.  $MP_1 = 2x_1^{-1/3}x_2^{2/3}$ . Yes, there are diminishing returns to input 1, because as  $x_1$  increases (and  $x_2$  is held constant),  $MP_1$  decreases.  
b.  $MRSP = MP_2/MP_1 = \frac{2x_1^{2/3}x_2^{-1/3}}{2x_1^{-1/3}x_2^{2/3}} = \frac{x_1}{x_2}$ . Yes, this function does have diminishing  $MRSP$ , because as  $x_1$  decreases and  $x_2$  increases,  $MRSP$  diminishes.  
c. Check returns to scale:  
$$f(ax_1, ax_2) = 3(ax_1)^{2/3}(ax_2)^{2/3} = 3a^{2/3}x_1^{2/3}a^{2/3}x_2^{2/3}$$
$$= a^{2/3}a^{2/3}(3x_1^{2/3}x_2^{2/3}) = a^{4/3}q > aq, \text{ for all } a > 1.$$
Thus, multiplying all inputs by the same factor ( $a$ ) causes output to increase by a larger factor. So this production function has INCREASING returns to scale.  
(2) [Cost minimization]  
a. Equation for isoquant:  $30 = 2x_1^{1/2}x_2^{1/2}$  or  $15 = x_1^{1/2}x_2^{1/2}$  or  $225 = x_1x_2$ .  
b.  $MRSP = MP_2/MP_1 = \frac{x_1^{1/2}x_2^{-1/2}}{x_1^{-1/2}x_2^{1/2}} = x_1/x_2$ .  
c. Set  $MRSP = \$10/\$90 = 1/9$  and solve jointly with  $30 = 2x_1^{1/2}x_2^{1/2}$ , to get  $x_1^*=5$  and  $x_2^*=45$ .  
d.  $TC(30) = 5 \times \$90 + 45 \times \$10 = \$900$ .  
(3) [Cost curves; Long-run market equilibrium]  
a.  $AC = TC/q = 0.01q^2 - q + 35$ .  
Set  $0 = dAC/dq = 0.02q - 1$  and solve to get  $q_{ES} = 50$ .  
b. Breakeven price = minimum  $AC = AC(q_{ES}) = \$10$ .

c. A firm's supply curve shows how much the firm will produce for any given price. If  $P > \text{minimum average cost}$ , the profit-maximizing firm will choose an output level where  $P = MC(q)$ , and if  $P < \text{minimum average cost}$ , it will produce nothing. So the firm's supply curve is given by the following equations.

If  $P \geq \$10$ ,  $P = MC(q) = dTC/dq = 0.03q^2 - 2q + 35$ .

If  $P \leq \$10$ ,  $q = 0$  (firm shuts down).

d. The long-run industry supply curve is a horizontal line at minimum AC:



(4) [Welfare effects of tax or subsidy]

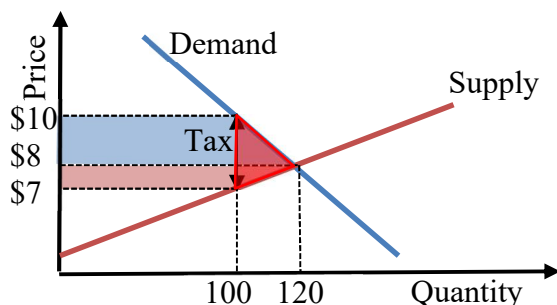
a. Set  $P_D = P_S$  and solve to get  $P^* = \$8$  and  $Q^* = 120$ .

b. With an excise tax of \$3,  $P_D = P_S + 3$ . Substituting and solving gives  $Q = 100$ . It is useful to also compute the new total price paid by buyers, including the tax ( $P_D = \$10$ ), and the new net price received by sellers, excluding the tax ( $P_S = \$7$ ).

c. Consumer surplus decreases by \$220, the area of the trapezoid between \$8 and \$10.

d. Producer surplus decreases by \$110, the area of the trapezoid between \$7 and \$8.

e. Although the government collects  $\$3 \times 100 = \$300$  in tax revenue, this is less than the combined decreases of consumer and producer surplus. The loss to society as a whole (also called “deadweight loss” or “excess burden of the tax”) is \$30, the area of the red triangle in the graph below.



#### IV. Critical thinking

(Same as Version A above.)

[end of answer key]