Principles of Economics (Double Degree, Fall 2022)
Homework #2

For Chapter 7

1. Textbook, Chapter 7, #4

a. Bert's demand schedule is:

Price	Quantity Demanded
More than $7	0
$5 to $7	1
$3 to $5	2
$1 to $3	3
$1 or less	4

Bert's demand curve is shown in Figure 9.

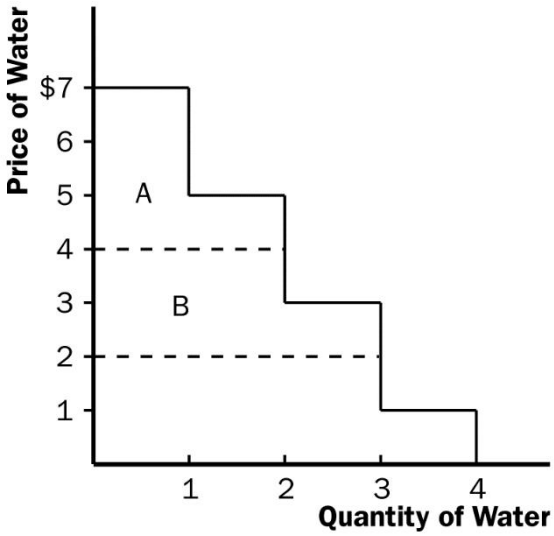


Figure 9

b. When the price of each bottle of water is $4, Bert buys two bottles of water. His consumer surplus is shown as area A in the figure. He values his first bottle of water at $7, but pays only $4 for it, so has consumer surplus of $3. He values his second bottle of water at $5, but pays only $4 for it, so has consumer surplus of $1. Thus Bert's total consumer surplus is $3 + $1 = $4, which is the area of A in the figure.

c. When the price of each bottle of water falls from $4 to $2, Bert buys three bottles of water, an increase of one. His consumer surplus consists of both areas A and B in the figure, an increase in the amount of area B. He gets consumer surplus of $5 from the first

bottle ($7 value minus $2 price), $3 from the second bottle ($5 value minus $2 price), and $1 from the third bottle ($3 value minus $2 price), for a total consumer surplus of $9. Thus consumer surplus rises by $5 (which is the size of area B) when the price of each bottle of water falls from $4 to $2.

2. Textbook, Chapter 7, #5

a. Ernie's supply schedule for water is:

Price	Quantity Supplied
More than $7	4
$5 to $7	3
$3 to $5	2
$1 to $3	1
Less than $1	0

Ernie's supply curve is shown in Figure 10.

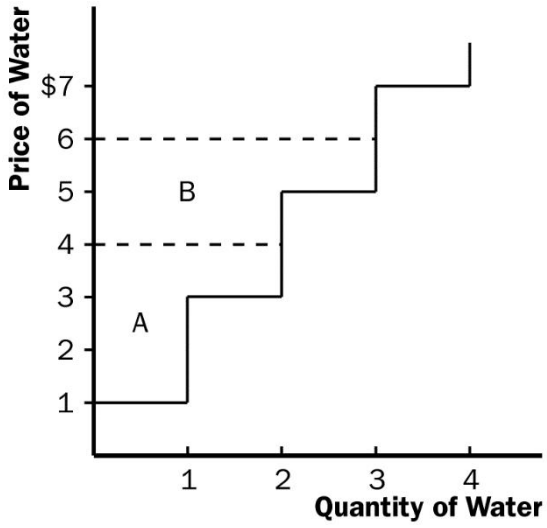


Figure 10

b. When the price of each bottle of water is $4, Ernie sells two bottles of water. His producer surplus is shown as area A in the figure. He receives $4 for his first bottle of water, but it costs only $1 to produce, so Ernie has producer surplus of $3. He also receives $4 for his second bottle of water, which costs $3 to produce, so he has producer surplus of $1. Thus Ernie's total producer surplus is $3 + $1 = $4, which is the area of A in the figure.

c. When the price of each bottle of water rises from $4 to $6, Ernie sells

three bottles of water, an increase of one. His producer surplus consists of both areas A and B in the figure, an increase by the amount of area B. He gets producer surplus of $5 from the first bottle ($6 price minus $1 cost), $3 from the second bottle ($6 price minus $3 cost), and $1 from the third bottle ($6 price minus $5 price), for a total producer surplus of $9. Thus producer surplus rises by $5 (which is the size of area B) when the price of each bottle of water rises from $4 to $6.

3. Textbook, Chapter 7, #6

a. From Ernie's supply schedule and Bert's demand schedule, the quantity demanded and supplied are:

Price	Quantity Supplied	Quantity Demanded
$2	1	3
$4	2	2
$6	3	1

Only a price of $4 brings supply and demand into equilibrium, with an equilibrium quantity of two.

b. At a price of $4, consumer surplus is $4 and producer surplus is $4, as shown in Problems 3 and 4 above. Total surplus is $4 + $4 = $8.

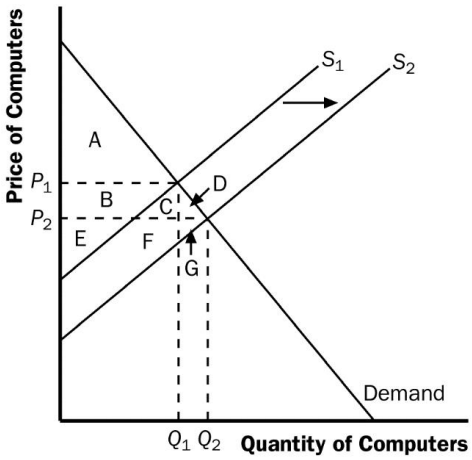
c. If Ernie produced one less bottle, his producer surplus would decline to $3, as shown in Problem 4 above. If Bert consumed one less bottle, his consumer surplus would decline to $3, as shown in Problem 3 above. So total surplus would decline to $3 + $3 = $6.

d. If Ernie produced one additional bottle of water, his cost would be $5, but the price is only $4, so his producer surplus would decline by $1. If Bert consumed one additional bottle of water, his value would be $3, but the price is $4, so his consumer surplus would decline by $1. So total surplus declines by $1 + $1 = $2.

4. Textbook, Chapter 7, #9

a. The effect of falling production costs in the market for computers resulted in a shift to the right in the supply curve, as shown in Figure 14. As a result, the equilibrium price of computers declined and the equilibrium quantity increased. The decline in the price of computers increased

consumer surplus from area A to A + B + C + D, an increase in the amount B + C + D.



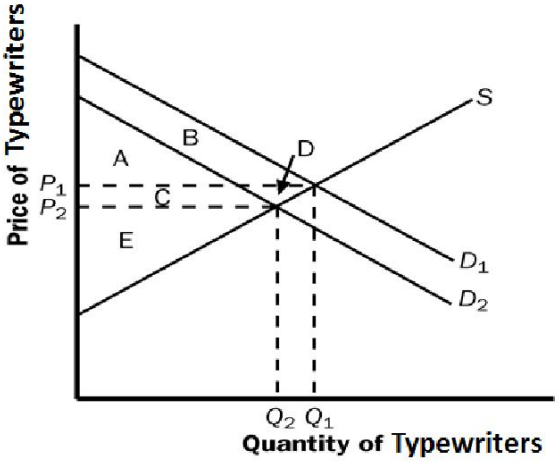


Figure 14 **Figure 15**

Prior to the shift in supply, producer surplus was areas B + E (the area above the supply curve and below the price). After the shift in supply, producer surplus is areas E + F + G. So producer surplus changes by the amount F + G – B, which may be positive or negative. The increase in quantity increases producer surplus, while the decline in the price reduces producer surplus. Because consumer surplus rises by B + C + D and producer surplus rises by F + G – B, total surplus rises by C + D + F + G.

b. Typewriters and computers are substitutes. The decline in the price of computers means that people substituted computers for typewriters, shifting the demand for typewriters to the left, as shown in Figure 15. The result is a decline in both the equilibrium price and equilibrium quantity of typewriters. Consumer surplus in the typewriter market changes from area A + B to A + C, a net change of C – B. Producer surplus changes from area C + D + E to area E, a net loss of C + D. Typewriter producers are sad about technological advances in computers because their producer surplus declines.

c. Software and computers are complements. When the price of computers decreases, the demand for software increases. The demand for software shifts to the right, as shown in Figure 16. The result is an increase in both the price and quantity of software. Consumer surplus in the software market changes from B + C to A + B, a net change of A – C. Producer surplus changes from E to C + D + E, an increase of C + D, so software producers should be happy about the technological progress in

computers.

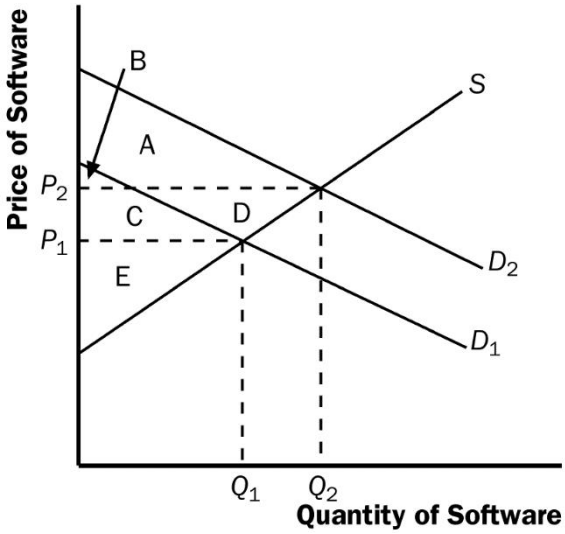


Figure 16

d. Yes, this analysis helps explain why Bill Gates is one the world's richest people. His company produces a lot of software and the producer surplus in the software market increased with the technological advance in computers.

5. Textbook, Chapter 7, #10

a. With Provider A, the cost of an extra minute is $0. With Provider B, the cost of an extra minute is $1.

b. With Provider A, my friend will purchase 150 minutes [= 150 – (50)(0)]. With Provider B, my friend would purchase 100 minutes [= 150 – (50)(1)].

c. With Provider A, she would pay $120. With Provider B, she would pay $100.

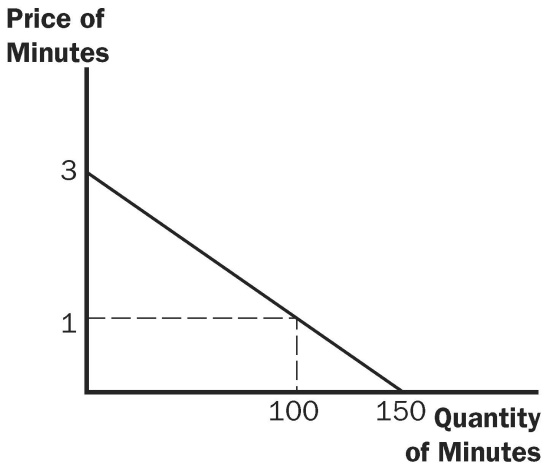


Figure 17

d. Figure 17 shows the friend's demand. With Provider A, she buys 150 minutes and her consumer surplus is equal to (1/2)(3)(150) – 120 = 105. With Provider B, her consumer surplus is equal to (1/2)(2)(100) = 100.

e. I would recommend Provider A because she receives greater consumer surplus when buying from that provider.

6.

(1) 200 人。

(2) 对于每周末得到参观机会的 1000 个居民，第 1 个 100 个居民无需排队且免费入场，人均消费者剩余 150-50=100 元；第 2 个 100 人排 1 个小时入场，人均消费者剩余 150-2*50=50 元。以后的都必须排 2 小时入场，人均消费者剩余为 0。因此，这 1000 人的消费者总剩余等于：100*100+100*50 + 800*0=15,000 元。（或答：0。）

(3) 否。每周最大可能的剩余是 1000*100=100,000 元。目前的总剩余 15,000 元远小于这个数字。

(4) 100 元.

(5) 排队长度 0 人。消费者总剩余 0。生产者总剩余 100*1,000=100,000 元。

(6) 是。因为每周总剩余（全部归生产者）为 100,000 元，等于最大可能的总剩余。

(7) 100 人。消费者剩余：100*(150-50-50)+900*0 = 5,000 元。（或答：0）生产者剩余：50*1000=50,000 元。

(8) 是。但每个参观者获益仅为 5,000/1,000=5 元，远小于 50 元。(或答：否，如果前面回答为 0）。否。此时社会总剩余为 50,000+5,000=55,000 元（或答：50,000），小于最大可能 100,000 元。

(9) 虽然“私有化”后门票价格定在了 100 元，消费者剩余等于

零。但原来的免费方案在考虑税负后，每个参观者的消费者剩余等于 15-50<0（或答：-50）。私有化反而使得消费者变好了。此外，根据前面的分析我们已经知道“私有化”是社会有效率的。总的来说，这个方案无论从公平（分配）还是效率角度，都优于原来的方案。

For Chapter 8

7. Textbook, Chapter 8, #8

8. Figure 7 illustrates the effects of the $2 subsidy on a good. Without the subsidy, the equilibrium price is P_1 and the equilibrium quantity is Q_1. With the subsidy, buyers pay price P_B, producers receive price P_S (where $P_S = P_B + \$2$), and the quantity sold is Q_2. The following table illustrates the effect of the subsidy on consumer surplus, producer surplus, government revenue, and total surplus. Because total surplus declines by area D + H, the subsidy leads to a deadweight loss in that amount.

	Before Subsidy	After Subsidy	Change
Consumer Surplus	A + B	A + B + E + F + G	+(E + F + G)
Producer Surplus	E + I	B + C + E + I	+(B + C)
Government Revenue	0	–(B + C + D + E + F + G + H)	–(B + C + D + E + F + G + H)
Total Surplus	A + B + E + I	A + B – D + E – H + I	–(D + H)

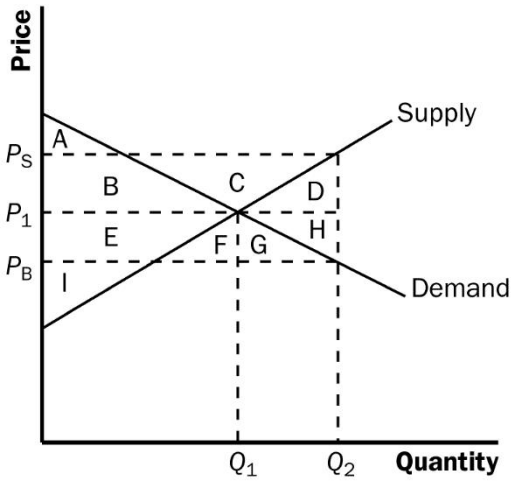


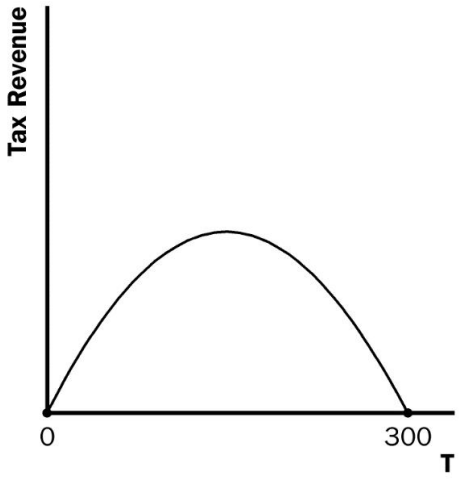
Figure 7

8. Textbook, Chapter 8, #10

10. a. Setting quantity supplied equal to quantity demanded gives $2P = 300 - P$. Adding P to both sides of the equation gives $3P = 300$. Dividing both sides by 3 gives $P = 100$. Substituting $P = 100$ back into either equation for quantity demanded or supplied gives $Q = 200$.

b. Now P is the price received by sellers and $P + T$ is the price paid by buyers. Equating quantity demanded to quantity supplied gives $2P = 300 - (P+T)$. Adding P to both sides of the equation gives $3P = 300 - T$. Dividing both sides by 3 gives $P = 100 - T/3$. This is the price received by sellers. The buyers pay a price equal to the price received by sellers plus the tax ($P + T = 100 + 2T/3$). The quantity sold is now $Q = 2P = 200 - 2T/3$.

c. Because tax revenue is equal to T x Q and $Q = 200 - 2T/3$, tax revenue equals $200T - 2T^2/3$. Figure 10 (on the next page) shows a graph of this relationship. Tax revenue is zero at $T = 0$ and at $T = 300$.



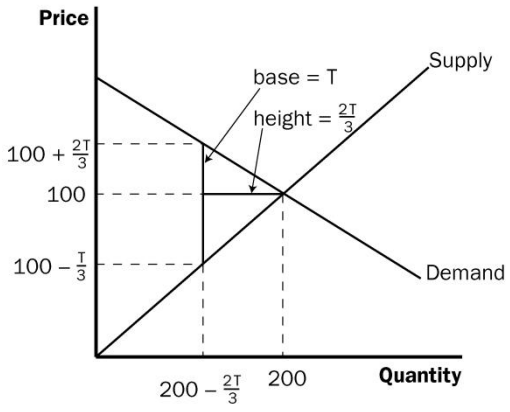


Figure 10 **Figure 11**

d. As Figure 11 shows, the area of the triangle (laid on its side) that represents the deadweight loss is 1/2 × base × height, where the base is the change in the price, which is the size of the tax (T) and the height is the amount of the decline in quantity ($2T/3$). So the deadweight loss equals $1/2 \times T \times 2T/3 = T^2/3$. This rises exponentially from 0 (when $T = 0$) to 30,000 when $T = 300$, as shown in Figure 12.

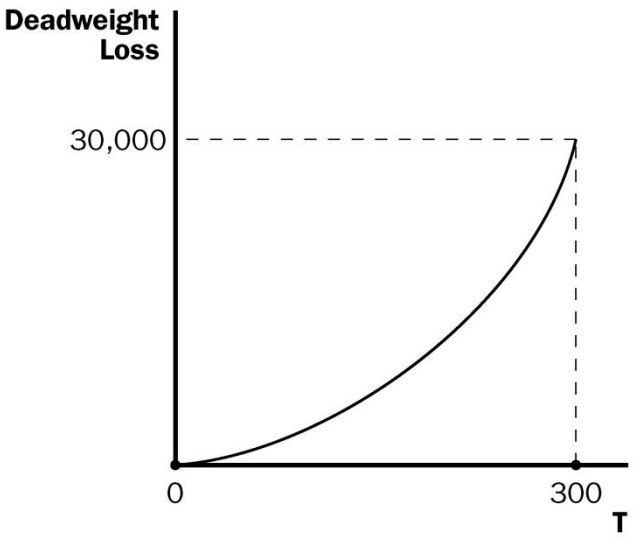


Figure 12

e. A tax of $200 per unit is a bad policy, because tax revenue is declining at that tax level. The government could reduce the tax to $150 per unit, get more tax revenue ($15,000 when the tax is $150 versus $13,333 when the tax is $200), and reduce the deadweight loss (7,500 when the tax is $150 compared to 13,333 when the tax is $200).

For Chapter 9

9. Textbook, Chapter 9, #3

3. a. For a country that imports clothing, the effects of a decline in the world price are shown in Figure 7. The initial price is P_{w1} and the initial level of imports is $Q^d_1 - Q^s_1$. The new world price is P_{w2} and the new level of imports is $Q^d_2 - Q^s_2$. The table below shows the changes in consumer surplus, producer surplus, and total surplus. Domestic consumers are made better off, while domestic producers are made worse off. Total surplus rises by areas D + E + F.

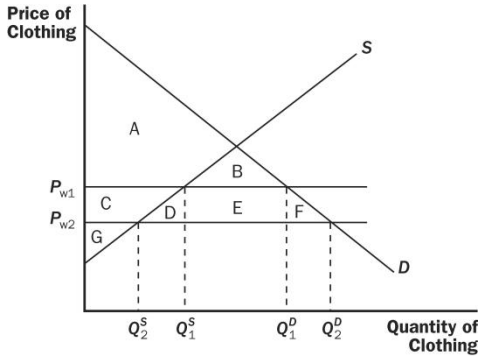


Figure 7

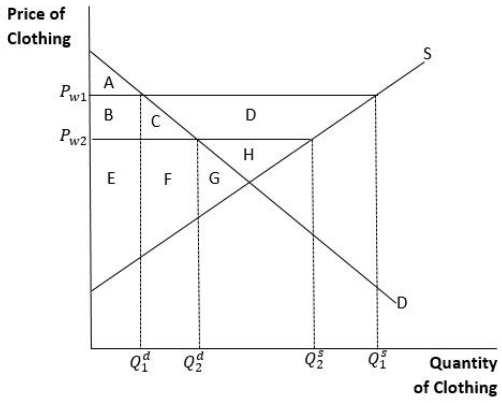


Figure 8

	P_{w1}	P_{w2}	CHANGE
Consumer Surplus	A+B	A+B+C+D+E+F	C+D+E+F
Producer Surplus	C+G	G	–C
Total Surplus	A+C+G	A+B+C+D+E+F+G	D+E+F

b. For a country that exports clothing, the effects of a decline in the world price are shown in Figure 8. The initial price is P_{w1} and the initial level of exports is $Q^s_1 - Q^d_1$. The new world price is P_{w2} and the new level of exports is $Q^s_2 - Q^d_2$. The table below shows the changes in consumer surplus, producer surplus, and total surplus. Domestic consumers are made better off, while domestic producers are made worse off. Total surplus falls by area D.

	P_{w1}	P_{w2}	CHANGE
Consumer Surplus	A	A + B + C	B + C
Producer Surplus	B + C + D + E + F + G + H	E + F + G + H	–B – C – D
Total Surplus	A + B + C + D + E + F + G + H	A + B + C + E + F + G + H	–D

c. Overall, importing countries benefit from the fall in the world price of clothing, while exporting countries are harmed.

10. Textbook, Chapter 9, #6

6. a. Figure 10 shows the market for grain in an exporting country. The world price is P_W.

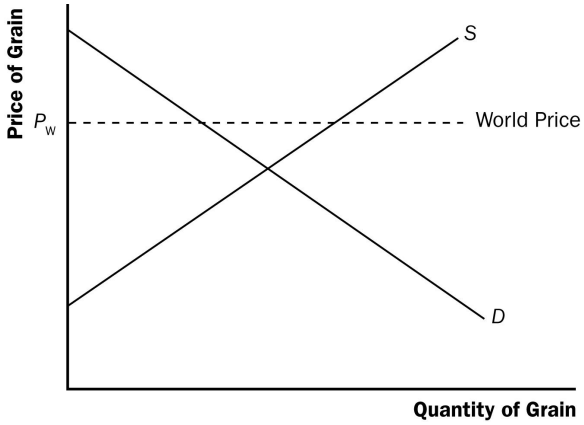


Figure 10

b. An export tax will reduce the effective world price received by the exporting nation.

c. An export tax will increase domestic consumer surplus, decrease domestic producer surplus, and increase government revenue.

d. Total surplus will fall because the decline in producer surplus is less than the sum of the changes in consumer surplus and government revenue. Thus, there is a deadweight loss as a result of the tax.

11. Textbook, Chapter 9, #9

9. a. When a technological advance lowers the world price of televisions, the effect on the United States, an importer of televisions, is shown in Figure 13. Initially the world price of televisions is P_1, consumer surplus is A + B, producer surplus is C + G, total surplus is A + B + C + G, and the amount of imports is shown as "Import$_1$". After the improvement in technology, the world price of televisions declines to P_2 (which is P_1 – 100), consumer surplus increases by C + D + E + F, producer surplus declines by C, total surplus rises by D + E + F, and the amount of imports rises to "Import$_2$".

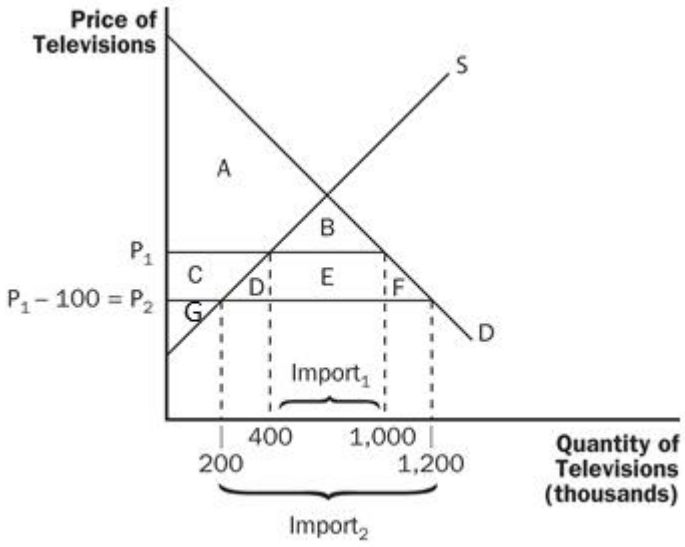


Figure 13

	P_1	P_2	CHANGE
Consumer Surplus	A + B	A + B + C + D + E + F	C + D + E + F
Producer Surplus	C + G	G	–C
Total Surplus	A + B + C + G	A + B + C + D + E + F + G	D + E + F

b. The areas are calculated as follows: Area C = 200,000($100) + (0.5)(200,000)($100)
= $30 million. Area D = (0.5)(200,000)($100) = $10 million. Area E = (600,000)($100) = $60 million. Area F = (0.5)(200,000)($100) = $10 million.

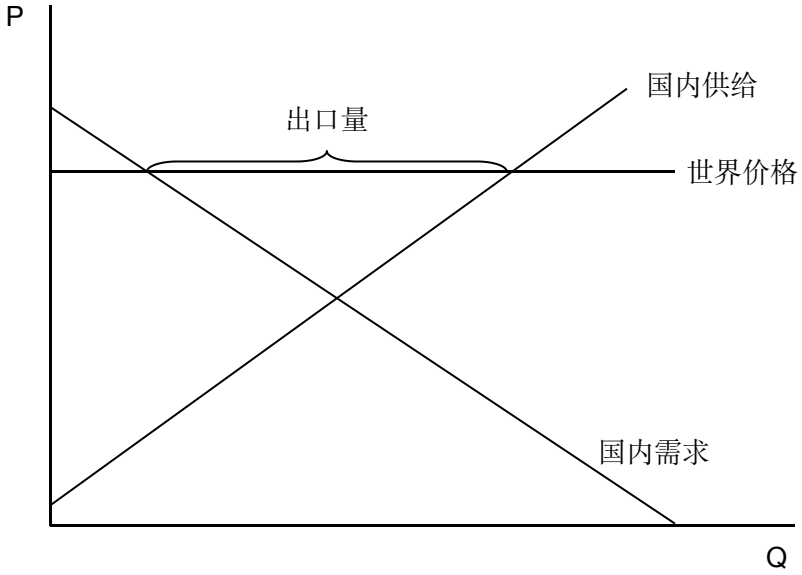
Therefore, the change in consumer surplus is $110 million. The change in producer surplus is -$30 million. Total surplus rises by $80 million.

c. If the government places a $100 tariff on imported televisions, consumer and producer surplus would return to their initial values. That is, consumer surplus would fall by areas C + D + E + F (a decline of $110 million). Producer surplus would rise by $30 million. The government would gain tariff revenue equal to ($100)(600,000) = $60 million. The deadweight loss from the tariff would be areas D and F (a value of $20 million). This is not a good policy from the standpoint of U.S. welfare because total surplus is reduced after the tariff is introduced. However, domestic producers will be happier as they benefit from the tariff.

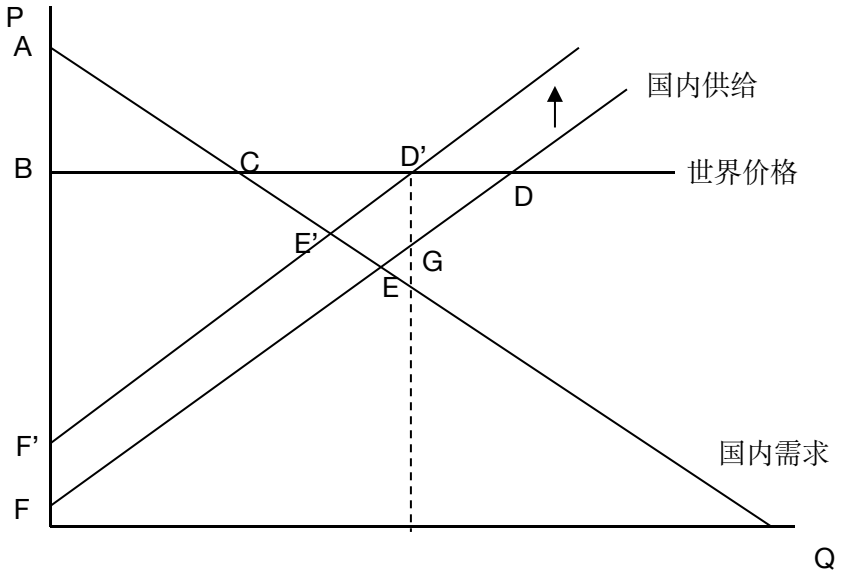
d. It makes no difference why the world price dropped in terms of our analysis. The drop in the world price benefits domestic consumers more than it harms domestic producers and total welfare improves.

12.

（1） 如下图。



（2） 国内生产者产量下降，从线段 BD 缩短到线段 BD’。国内消费者消费量不变，仍为线段 BC。出口量下降，从线段 CD 缩短到 CD’。
消费者福利不变，仍为面积 ABC。（原因：消费者仍在世界价格下购买）
生产者福利下降，从面积 BDF 减少到面积 BD’F’。
政府税收增加，从零增加到面积 F’D’GF。
该国总福利下降，减少面积 D’GD。（原因：企业产量下降带来无谓损失。）
该国从国际贸易中获益减少，从面积 CDE 减少到面积 CD’E’。



(3) 国内消费者消费量下降，从线段 BC 缩短到 BC'。国内生产者的生产量不变，仍为线段 BD。出口量增加，从线段 CD 延长到 C'D。

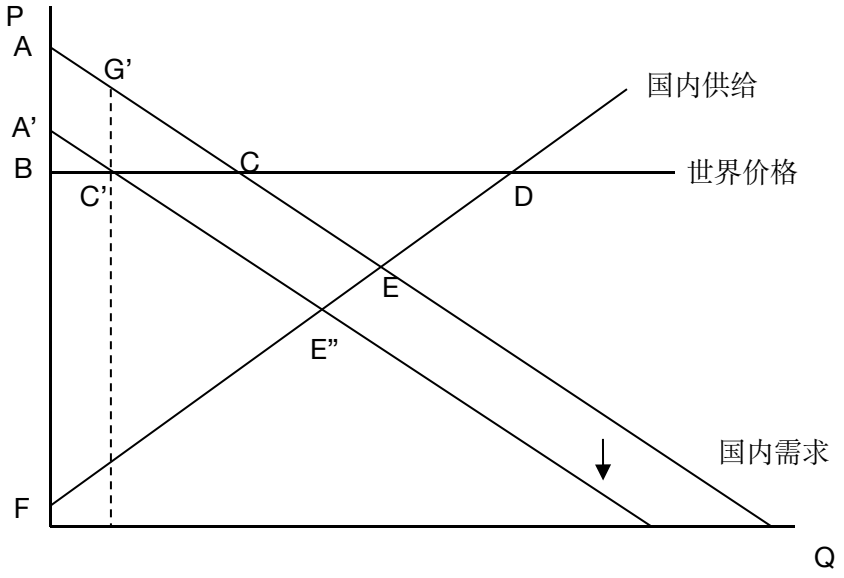
消费者福利下降，从面积 ABC 下降到 A'BC'。

生产者福利不变。（原因：生产者仍然在既定成本下面对世界价格生产。）

政府税收增加，从零增加到面积 AA'C'G'。

该国总福利下降，减少面积 C'CG'。（原因：企业既定产量无法配置给支付意愿高于世界价格的部分消费者，带来无谓损失。）

该国从国际贸易中获益增加，从面积 CDE 增加到面积 C'DE"。



(4) 答案如下：

(a) 正确。产量从线段 BD'恢复到 BD。

(b) 错误。出口企业的出口量比无税时增加了。出口量从线段 CD 增加到 C'D。（直观解释：此时国内消费者因税收负担减少了消费量，国内生产者面对世界价格不变，因

而产量不变，则出口增加。）

（c） 错误（或不一定）。无谓损失从面积 D'GD 变为 C'G'C。两个面积的大小不定，取决于供求弹性。当需求弹性大于供给弹性时，出口退税的福利损失更大。（提示：考虑到线段 C'G'和线段 DG 是等长度的——都等于税收规模）。

For Chapter 10

13. Chapter 10, #5

注：b、d 问中"每个人的总剩余"意指总剩余除以总人数。

5. a. At a price of $1.50, each Whovillian will consume 4 bottles of Zlurp. Each consumer's total willingness to pay is $14 (= $5 + $4 + $3 + $2). The total spent by each Whovillian on Zlurp is $6 (= $1.50 × 4). Therefore, each consumer receives $8 in consumer surplus (=$14 – $6).

   b. Total surplus would fall by $4 to $4.

   c. If Cindy Lou only consumes 3 bottles of Zlurp, her consumer surplus is $4.50. Her willingness to pay for 3 bottles is $5 + $4 + $3 = $12. She pays $1.50 x 3 = $4.50 and the externality is $1 x 3 = $3. Thus, Cindy Lou's consumer surplus is $12 - $4.50 - $3.00 = $4.50. Cindy's decision increases consumer surplus in Whoville by $0.50 ($4.50-$4.00).

   d. The $1 tax raises the price of a bottle of Zlurp to $2.50. (The entire tax will be borne by consumers because supply is perfectly elastic.) Each resident will purchase only 3 bottles at the higher price and each consumer's total willingness to pay is now $12 (= $5 + $4 + $3). Each resident pays $7.50 (= $2.50 × 3). Therefore, each resident receives $4.50 ($12-$7.50) in consumer surplus.

   Because each bottle has an external cost of $1, the per-resident external cost is $3 ($1 per bottle x 3 bottles). The government collects $3 per resident in revenue. Total surplus with the tax is equal to $4.50 - $3.00 + $3.00 = $4.50.

   e. Yes, because total surplus is now higher than before the tax.

14. Chapter 10, #9

9. a. The firms with the highest cost of reducing pollution will buy permits rather than reduce their pollution. Firms that can sell their permits for more than it costs them to reduce their pollution will sell.

Because firm B faces the highest costs of reducing pollution, $30 per unit, it will keep its own 20 permits and buy 20 permits from the other firms, so that it can still pollute 40 units. Thus, firm B does not reduce its pollution at all.

Of the two remaining firms, firm A has the higher cost of reducing pollution so it will keep its own 20 permits and reduce its pollution by 10 units at a cost of $20 x 10 units = $200.

Firm C sells all 20 of its permits to firm B and reduces its pollution by 20 units at a cost of $10 × 20 = $200. The total cost of pollution reduction is $400.

b. If the permits could not be traded, then firm A would have to reduce its pollution by 10 units at a cost of $20 × 10 = $200, firm B would have to reduce its pollution by 20 units at a cost of $30 × 20 = $600, and firm C would not have to reduce its pollution because its permits would cover the 20 units it emits. The total cost of pollution reduction would be $800, $400 higher than in the case in which the permits could be traded.

15.

（1） 能。共同的好处是：(1/2)*(11,600-10,000)=800。
戴尔向艾伦支付转会费“差价”为：(3,500+400)-2,900=1,000。（理由：根据题意，他需要使得艾伦从协议中获得好处最终等于 400，同时注意到协议后艾伦的门票收入等于(1/2)*(1/2)*11,600=2,900。）
所有队员的赛季收入及其来源如下：
艾伦：3,900，其中：门票收入 2,900，转会费收入 1,000；
艾伯特：2,900，均为门票收入。
戴尔：1,900，其中：门票收入 2,900，转会费支付 1,000；
戴维：2,900，均为门票收入。

（2） 可以。因为艾伦从协议中得到的收益是 400；而艾伯特从协议中受到的损害是 3,500-2,900=600，大于艾伦的收益。具体的，如果艾伯特向艾伦支付 400-600 之间的任意金额，都可以阻止艾伦转会，双方都好于转会后的处境。

（3） 有。戴尔只要让出部分的协议总收益，使得艾伦从转会中所得大于 600；此时自己仍然可能变好——只要艾伦得到好处小于 800。

（4） 可以。
只要戴尔与戴维谈判，请戴维支付最小 1,600-800=800，最大 2,400（不使戴维受损）的金额。然后戴尔使得艾伦得到的协议好处不少于 1,600（以避免艾伯特的阻

挠）；并确保艾伦不会受损（这是可能的）。

(5) 可以实现。
此时转会给两个队带来的总的好处是 11,600-10,000=1,600。则每队得到 8,00，每名队员得到 4,00。由此可计算最终收入，得到：艾伦：3,900，艾伯特：3,900；戴尔：1,900；戴维：1,900。

(6) 同样有效率（但协商转会可能具有更高的交易成本）；后者更加公平（因为他使得水平相当的球员不因是否转会而产生收入差别）。

(7) “常胜将军”的出现并不是整个联赛收入最大化的选择，而势均力敌的比赛才是。在存在“转会”制度的前提下，根据科斯定理，人们可以通过“转会”这样的科斯谈判，使得总收入最大，这必然导致“势均力敌”的场面。
这种谈判给每个队都带来好处。虽然强队变弱了，但并没有吃亏，因为他们从转会费中得到好处。

For Chapter 11

16. Chapter 11, #5

5. a. Within the dorm room, the showing of a movie is a public good. None of the roommates can be excluded from viewing the movie. Because one roommate's viewing does not affect the ability of another roommate to view the movie, the good is also not rival in consumption.

   b. The roommates should rent three movies because the value of the fourth film ($6) would be less than the cost ($8).

   c. The total cost would be $8 × 3 = $24. If the cost were divided evenly among the roommates, each would pay $6. Steven values three movies at $18 so his surplus would be $12. Peter values three movies at $12 so his surplus would be $6. James values three movies at $6, so his surplus would be $0. Christopher values three movies at $3 so his surplus is -$3. Total surplus among the three roommates would be $15.

   d. The costs could be divided up by the roommates based on the benefits they receive. Because Steven values the movies the most, he would pay the greatest share. The problem is that this gives each roommate an incentive to understate the value of the movies to him.

   e. Because they are going to pay equal shares, Steven has an incentive to tell the truth about the value he places on movies to ensure that the group rents three movies. He values each of the movies more than his cost per movie ($2).

   f. The optimal provision of public goods will occur if individuals do not have

an incentive to hide their valuation of a good. This means that each individual's cost cannot be related to his valuation.

17. Chapter 11, #7

7. a. In Bayport, the sum of the benefits ($50 + $100 + 300 = $450) is greater than the cost of the fireworks show ($360), so fireworks would pass a cost-benefit analysis.

b. If the cost is split equally among all residents, the cost per resident would be ($360 / 3 =) $120. Frank would vote against because his value ($50) is less than the cost. Joe would vote against because his value ($100) is less than the cost. Callie would vote in favor because her value ($300) is greater than the cost. The result of the referendum vote would be against the fireworks, so the referendum would not yield the same answer as the cost-benefit analysis.

c. In River Heights, the sum of the benefits ($20 + $140 + $160 = $320) is less than the cost of the fireworks show ($360), so fireworks would not pass a cost-benefit analysis.

d. If the cost is split equally among all residents, the cost per resident would be ($360/3) $120. Nancy would vote against because her value ($20) is less than the cost. Bess would vote for because her value ($140) is greater than the cost. Ned would vote in favor because his value ($160) is greater than the cost. The result of the referendum vote would be for the fireworks, so the referendum would not yield the same answer as the cost-benefit analysis.

e. The optimal provision of public goods is challenging because the total benefit may exceed the total cost when the average benefit is less than the average cost, or vice versa.

18.

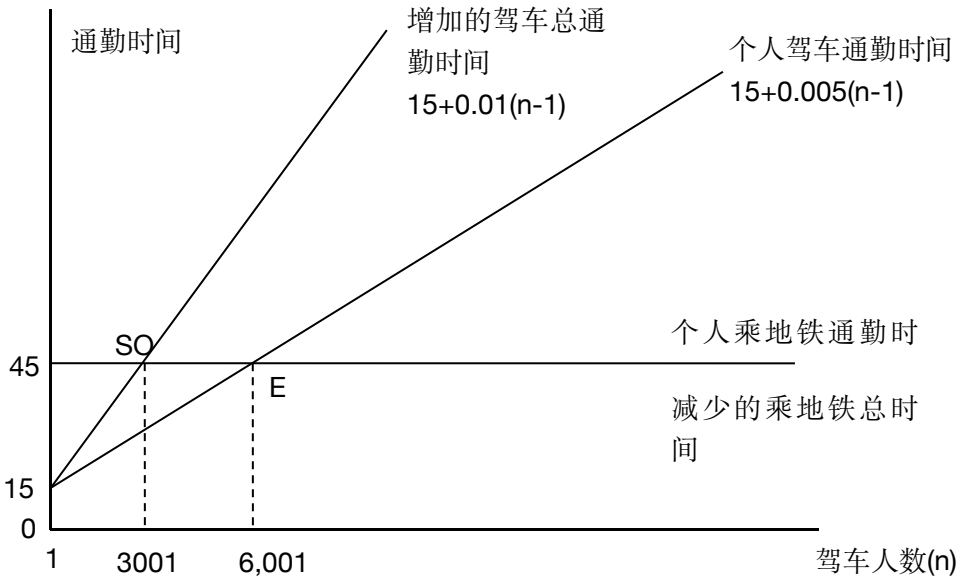
（1） 每个驾车人需要花费的时间是 15+0.005(n-1)=14.995+0.005n。

（2） 该人选择驾车的通勤时间为：15+0.005n；他选择乘坐地铁的通勤时间为 45。则该人选择驾车当且仅当：

$$15+0.005n \le 45, \text{ 即：} n \le 6{,}000。$$

则最终选择驾车的人为 6,001 人，乘地铁的人为 1,999 人？

(3) 如下图。交点 E 对应 n=6,001，通勤时间为 45 分钟，此时驾车时间与乘地铁相同。交点对应均衡时选择驾车的人数和相应的通勤时间。



(4) 社会总的通勤时间为：

$$(15+0.005(n-1))*n+45*(8,000-n) = 0.005n^2 - 30.005n+360,000\approx 0.005*(n-6,001/2)^2+315,000。$$

则社会最优的驾车人数为 6,001/2=3,000.5≈3001（答 3000 也算对）。这一数量小于均衡的驾车人数（6001 人）。

(5) 增加一个驾车人后该驾车人的通勤时间为：

$$15+0.005(n-1)。$$

增加一个驾车人增加的所有驾车人的通勤时间为：

$$(15+0.005(n-1))*n-(15+0.005(n-2))*(n-1)=15+0.01(n-1)>15+0.005(n-1)。$$

也就是说，该驾车人自己付出的时间成本小于整个社会为这一行动付出的时间成本（也可以说，他从乘地铁转而驾车的个人节约的时间小于社会为此行动得到的时间节约），该驾车人造成了负外部性。

(6) 如上图。注意到第 2 条曲线和乘地铁通勤时间曲线重合（即为 45 分钟的水平线）。交点处 SO 的 n=3,001，驾车通勤时间 15+0.005*(n-1)=30 分钟（注意不是交点对应的时间）。

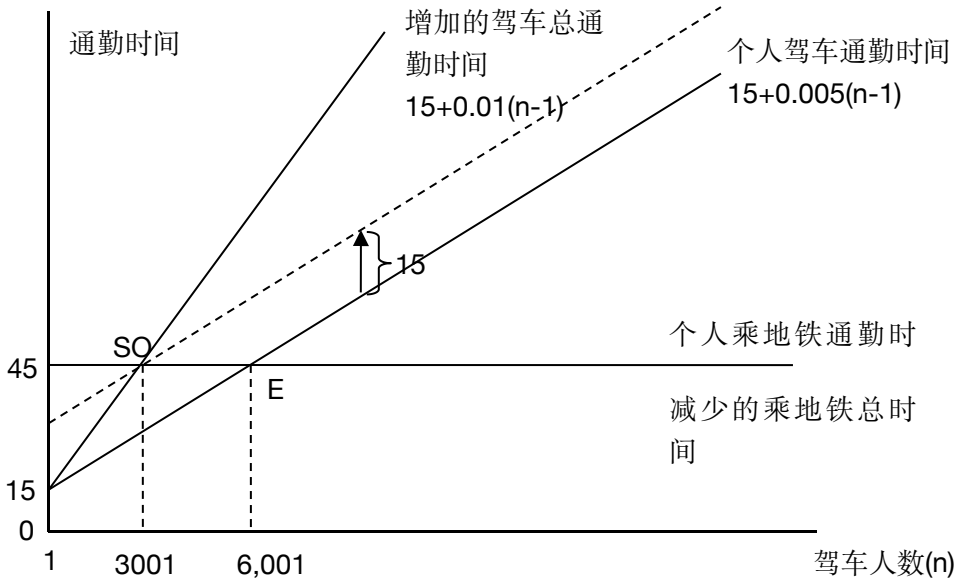
该交点代表社会最优的驾车人数量（与第（4）问仅近似相等是因为单位差分和导数仅近似相等）。直观来说，当驾车人数量为 3,001 时，增加该驾车人带来的社会收益（即减少的乘地铁总时间，45 分钟）等于增加的社会成本（即增加的驾车总时间，也为 45 分钟）。

(7) 道路通行费即为庇古税（或矫正税）。

设该道路通行费为 t 元，则为了使驾车人自动选择最优数量 n=3001，应使第 3001 个驾车人选择驾车和乘地铁的个人收益相等：

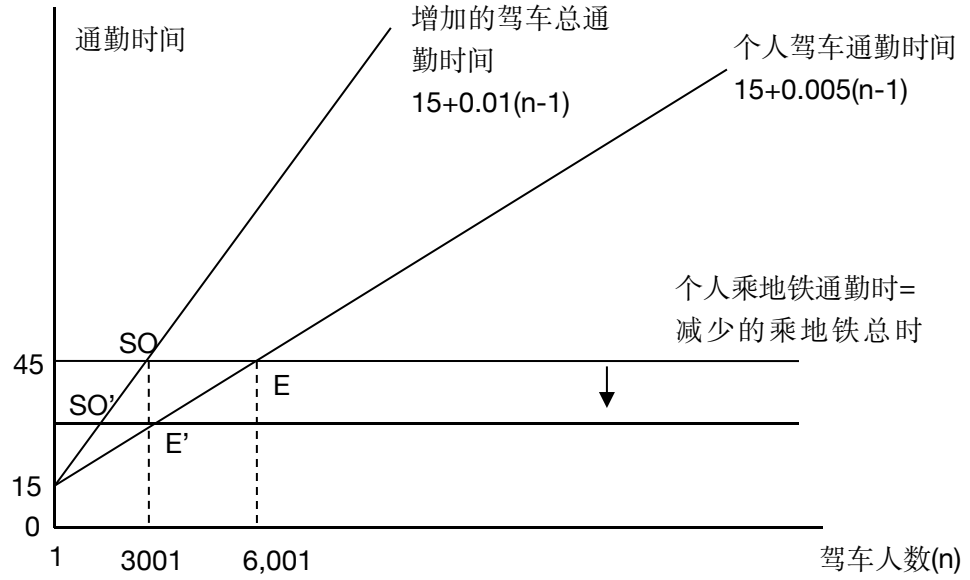
$$15+0.005*(3001-1)+t*1=45，即 t=15 元。$$

图形表示为将个人的驾车通勤时间曲线上移 15 分钟。（如下图）



(8) 如下图。从缩短了所有人的通勤时间（都等于减少后的地铁通勤时间）上看这一办法解决了交通问题。但从负外部性依然存在（或者说，社会最优的通勤总时间并未实现来看，这一办法并未从根本上解决交通问题，图形上表现为社会最优点 SO'和均衡点 E'依然未重合。

政府必须把乘坐地铁时间减少到 15 分钟才能从根本上消除负外部性问题。



(9) 这个题目的答案是开放的。

应该说最好的政策是二者的结合。通过修建地铁可以减少所有人的通勤时间，但无法消除无效率。而征收道路使用费即可以减少愿意支付该费用的人的通勤时间，又可以消除无效率，但毕竟效果有限，同时，这一方法可能带来不公平。