Department of Economics

Carleton University

ECON 2030B – Intermediate Microeconomics II: Consumers and General Equilibrium

ASSIGNMENT 3 - Due Mar 16 at the beginning of the tutorial

1. Suppose that by coincidence two markets for separate products had the same demand and supply functions. In each market, $Qd = 50 - p$, and $Qs = p$. The government decides to discourage consumption in both markets. It institutes a \$4 per unit tax in one market, and a quota of 23 units in the other market.

   (a) What is the market equilibrium price and quantity in both markets?

   (b) How do the welfare effects of these policies, the tax and the quota, compare? Explain.

   (a) Prior to the imposition of the tax or quota, the equilibrium in each market was:

$$S = D$$
$$p = 50 - p \rightarrow \boxed{p = 25}$$
$$\boxed{Q = p = 25}$$

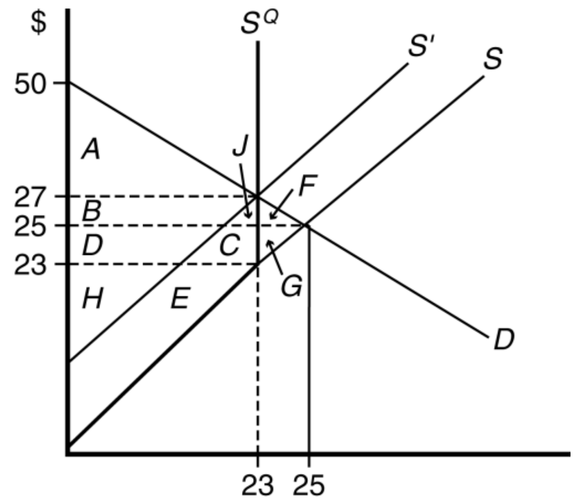
- The effect of a \$4 per-unit tax can be shown as a shift upwards of the supply curve by \$4 to S' (see graph below). The equilibrium in the market is defined by:

$$S' = p + t = 50 - p = D$$
$$2p = 50 - 4 \rightarrow \boxed{p = 23}$$
$$\boxed{S = p = 23}$$

- The effect of the quota is to make the supply curve vertical at 23 units, shown as S^Q.
- In either case, the new equilibrium quantity is 23 units.

   (b) Welfare effects:

   - With the tax, consumer surplus falls in the figure below from $A + B + F + J$ to A, and producer surplus falls from $C + D + E + G + H$ to $E + H$. Area $B + D + C + J$ is collected in tax revenue, and $F + G$ is the deadweight loss.
   - With the quota, no tax revenue is collected. Deadweight loss is unchanged at $F + G$, consumer surplus falls to area A as before. The new producer surplus with the quota is $B + J + D + C + H+$ E. The difference is that firms now keep as producer surplus what was tax revenue with the unit tax.



2. Consider a vegetable fiber traded in a competitive world market and imported into the United States at a world price of \$9 per pound. U.S. domestic supply and demand for this vegetable fiber are given by $Q^S = \frac{2}{3}p$ and $Q^D = 40 - 2p$, respectively, where Q is measured in million pounds.

   (a) Confirm that if there were no restrictions on trade, the United States would import 16 million pounds.

   (b) If the United States imposes a tariff of \$3 per pound, what will be the U.S. price and level of imports? How much revenue will the government earn from the tariff? How large is the deadweight loss? Show these in a graph.

   (c) If the United States has no tariff but imposes an import quota of 8 million pounds, what will be the U.S. domestic price? What is the cost of this quota for U.S. consumers of the fiber? What is the gain for U.S. producers?

(a) The domestic equilibrium in a closed economy would be where supply equals demand:

$$\frac{2}{3}p = 40 - 2p$$
$$\frac{8}{3}p = 40 \rightarrow \boxed{p = 15}$$
$$\boxed{Q = 40 - 2p = 10}$$

Therefore, at an international price of \$9, there will be imports equal to the difference between the quantity supplied domestically at that international price and the quantity demanded at that price.

$$Q^S = \frac{2}{3}p = \frac{2}{3}9 = 6$$
$$Q^D = 40 - 2p = 40 - 2 \times 9 = 22$$
$$Imports = Q^D(p = 9) - Q^S(p = 9) = 22 - 6 = 16$$

(b) A tariff of $3 per pound effectively increases the international price by that amount and that is the same price level that will prevail in the US domestically: $3+$9=$12. So now the amount of imports will be the difference between the quantity supplied domestically and the quantity demanded at the international price plus the tariff.

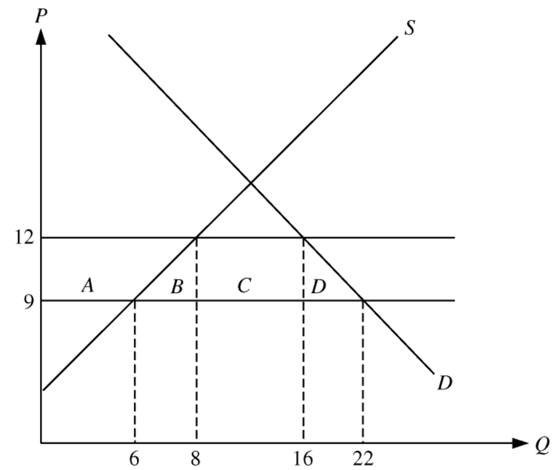
$$Q^S = \frac{2}{3}p = \frac{2}{3}12 = 8$$
$$Q^D = 40 - 2p = 40 - 2 \times 12 = 16$$
$$Imports = Q^D(p = 12) - Q^S(p = 12) = 16 - 8 = 8$$

- The total amount of imports is then 8 million pounds and the total revenue collected from the tariff is $\$3 \times 8$ million $= \$24$ million.
- The deadweight loss can be calculated as the sum of areas $B + D$ in the graph below.
- In the graph, the tariff imposed moves the international price up from $9 to $12 and reduces consumer welfare by the total of area: $A + B + C + D$. However, area C is the tax revenue collected to is is not lost to total welfare and area A is now part of the domestic producer's surplus so it also not lost to total welfare.
- The deadweight loss is then triangles B and D.
  - Area B=(8-6)3/2=3 and Area D=(22-16)3/2=9, in total $12 million.

(c) With an import quota of 8 million pounds, the domestic price will be $12. At $12, the difference between domestic demand and domestic supply is 8 million pounds, i.e., 16 million pounds minus 8 million pounds. This is the same equilibrium as with the $3 tariff. Note you can also find the equilibrium price by setting demand equal to supply plus the quota so that

$$40 - 2P = \frac{2}{3}p + 8$$
$$40 - 8 = \frac{8}{3}p \rightarrow \boxed{p = 32\frac{3}{8} = 12}$$

- The cost of the quota to consumers is equal to area A + B + C + D in the figure above, which is the reduction in consumer surplus. This equals rectangle ABC plus triangle D. The area



of the rectangle is $\$3 \times 16 = \$48$ and the area D we already calculated above to be \$9. So total loss in consumer surplus is $\$48 + \$9 = \$57$ million.

- The gain to producers is area $A = (8 + 6)(12 - 9)/2 = \$21$ million.

3. Suppose that the demand curve for wheat is $Q = 100 - 10p$ and that the supply curve is $Q = 10p$. What are the effects of a subsidy (negative tax) of $s = 1$ per unit on the equilibrium price and quantity, consumer surplus, producer surplus, government subsidy cost, and total welfare?

   - The equilibrium before the subsidy is where supply equals demand:

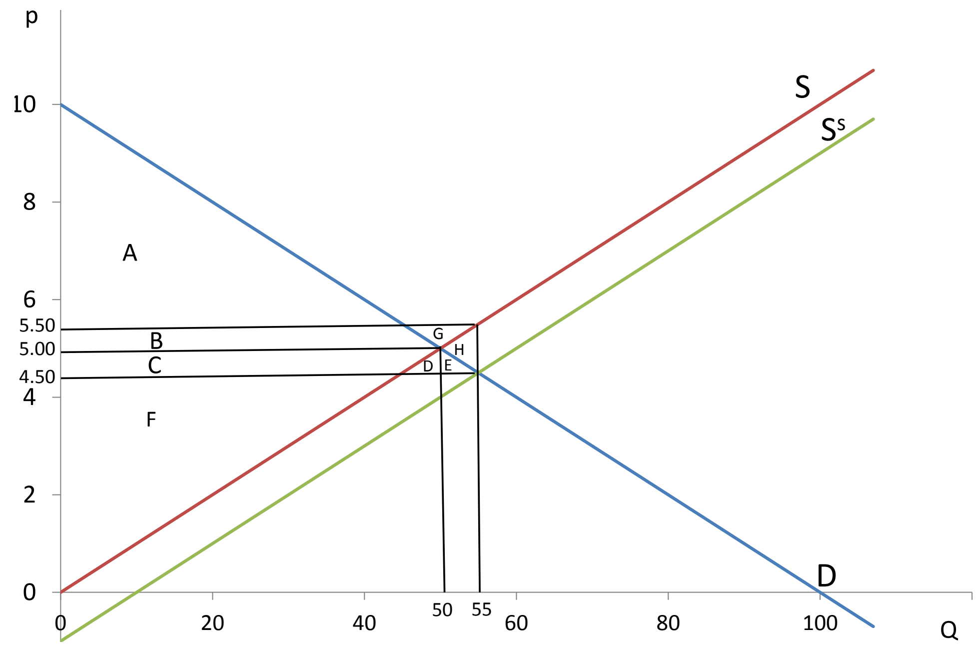
$$100 - 10p = 10p \rightarrow \boxed{p = 5}$$
$$\boxed{Q = 10p = 50}$$

   - With the subsidy the inverse demand curve stays the same but now the inverse supply curve shifts outwards:

$$\text{Inverse demand: } p = 10 - \frac{1}{10}Q$$
$$\text{Inverse supply: } p + s = \frac{1}{10}Q$$

   - The equilibrium is again where supply is equal to demand:

$$100 - 10p = 10 \times (p + 1)$$
$$100 - 10 = 20p \rightarrow \boxed{p = 4.5} \text{ is the price paid by consumers}$$
$$\boxed{p = 4.50 + 1 = 5.50} \text{ is the price paid by producers}$$
$$\boxed{Q = 100 - 10p = 55}$$



- Graphically, the subsidy shifts the supply curve to the right from S to S^s
  - Cost of subsidy: $-(B+C+D+E+G+H) = -Q \times \$1 = -\$55$
  - CS increases by areas: $C+D+E = 0.50 \times 50 + 0.50 \times 5/2 = 25 + 1.25 = \$26.25$
  - PS increases by areas: $B+G = 0.50 \times 50 + 0.5 \times 5/2 = 25 + 1.25 = \$26.25$
  - DWL = Change in welfare = -$H = -1 \times 5/2 = -\$2.50$

4. Suppose the demand and supply of natural gas depend also on the price of oil in the following way:

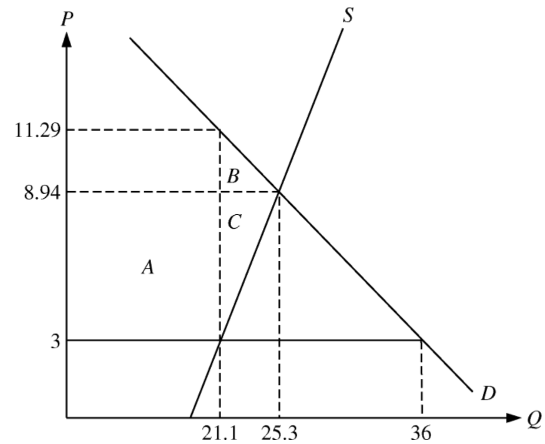
$$Q_S = 15.90 + 0.72 p_G + 0.05 p_O$$
$$Q_D = 0.02 - 1.8 p_G + 0.69 p_O$$

- $Q_S =$ quantity of gas supplied in thousand cubic feet (mcf)
- $Q_D =$ quantity of gas demanded in thousand cubic feet (mcf)
- $p_G =$ price of natural gas in \$/mcf
- $p_O =$ price of oil in \$/barrel

(a) If the price of oil were \$60 per barrel, what would be the free-market price of gas? How large a deadweight loss would result if the maximum allowable price of natural gas were \$3.00 per thousand cubic feet?

(b) What price of oil would yield a free-market price of natural gas of \$3?

(a) If the price of oil were \$60 per barrel, what would be the free-market price of gas?



- We find the equilibrium by replacing the price of oil in the supply and demand for gas and making supply equal to demand:

$$Q_S = Q_D$$
$$15.90 + 0.72p_G + 0.05 \times 60 = 0.02 - 1.8p_G + 0.69 \times 60$$
$$18.9 + 0.72p_G + 1.8p_G = 41.42$$
$$p = \frac{41.42 - 18.9}{2.52} = 8.94$$
$$Q = 25.34$$

(a) How large a deadweight loss would result if the maximum allowable price of natural gas were \$3.00 per thousand cubic feet?

- If a price ceiling is imposed, then the graph below illustrates the situation:
- The quantity of gas produced is the one that comes from replacing the maximum price in the supply curve: $15.90 + 0.72 + 0.05 \times 60 = 21.1$
- The quantity of gas demanded is the one that comes from replacing the maximum price in the demand curve: $0.02 - 1.8 + 0.69 \times 60 = 36$. But this total amount won't be sold because suppliers are only willing to sell 21.1 mcf.
- The equilibrium quantity is 21.1 at the price of \$3. The deadweight loss created by the maximum price is equal to areas $B + C$.
- To find the size of area B, we need to find the price on the demand curve that corresponds to the quantity 21.1.

$$0.02 - 1.8p + 0.69 \times 60 = 21.1$$
$$-1.8p = 21.1 - 41.42 \rightarrow p = 11.29$$

- Area $B = (11.29 - 8.94)(25.3 - 21.1)/2 = 4.9$
- Area $C = (8.94 - 3)(25.3 - 21.1)/2 = 12.5$
- Deadweight loss$= B + C = 17.4$

(b) What price of oil would yield a free-market price of natural gas of $3?

- Here we set demand equal to supply and replace the price of natural gas to be $3 and solve for the price of oil:

$$
\begin{aligned}
Q_S &= Q_D \\
15.90 + 0.72 \times 3 + 0.05 p_O &= 0.02 - 1.8 \times 3 + 0.69 p_O \\
23.44 &= 0.64 p_O \rightarrow \boxed{p_O = 36.625}
\end{aligned}
$$

5. Suppose that Country A and Country B both produce wine and cheese. Country A has 800 units of available labor, while Country B has 600 units. Prior to trade, Country A consumes 40 pounds of cheese and 8 bottles of wine, and Country B consumes 30 pounds of cheese and 10 bottles of wine.

	Country A	Country B
Workers per pound of cheese	10	10
Workers per bottle of wine	50	30

(a) Which country has a comparative advantage in the production of each good? Explain.

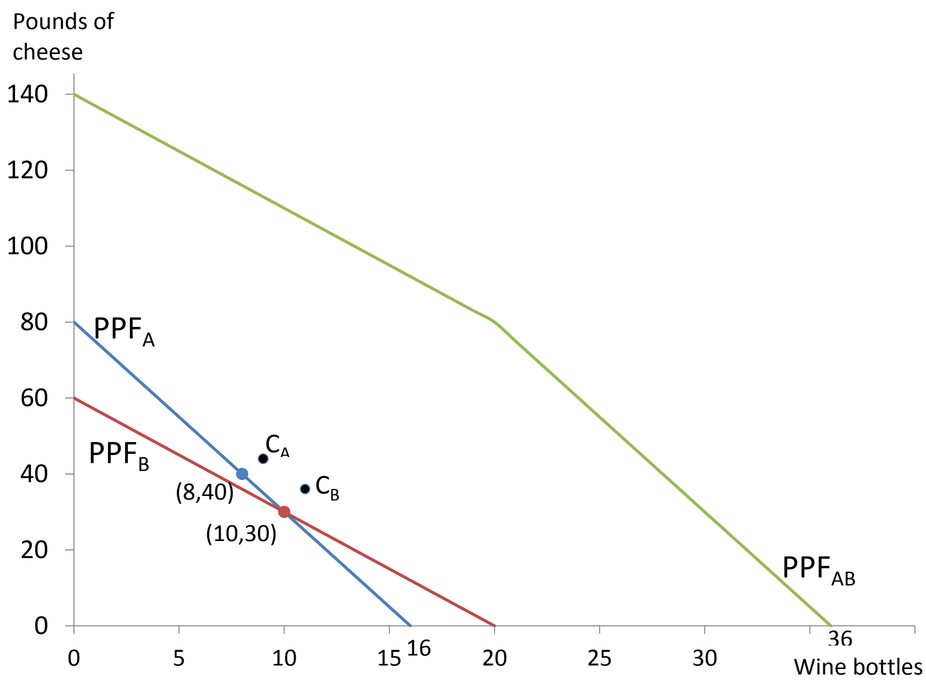
(b) Graph the production possibilities frontier (PPF) of each country and the PPF for the two countries combined on the same chart. Draw wine bottles on the x-axis and pounds of cheese on the y-axis. Show the pre-trade consumption points in each country.

(c) If each country produces only the good for which it has a comparative advantage and if 36 pounds of cheese and 9 bottles of wine are traded, label the post-trade consumption point C_A for country A and C_B for country B.

(d) Prove that both countries have gained from trade.

(a) Which country has a comparative advantage in the production of each good? Explain.

- To produce another bottle of wine, Country A needs 50 units of labor, and must therefore produce 5 fewer pounds of cheese. The opportunity cost of a bottle of wine is therefore 5 pounds of cheese. For Country B the opportunity cost of a bottle of wine is 3 pounds of cheese. Since Country B has a lower opportunity cost, it has the comparative advantage and should produce the wine and Country A should produce the cheese.



- Country A has the comparative advantage in producing cheese because the opportunity cost of cheese in A is 1/5 of a bottle of wine while in Country B it is 1/3 of a bottle of wine.

(b) Graph the production possibilities frontier (PPF) of each country and the PPF for the two countries combined on the same chart. Draw wine bottles on the x-axis and pounds o cheese on the y-axis. Show the pre-trade consumption points in each country.

(c) If each country produces only the good for which it has a comparative advantage and if 36 pounds of cheese and 9 bottles of wine are traded, label the post-trade consumption point C_A for country A and C_B for country B.

- If each country specializes in its comparative advantage, Country A will produce 80 pounds of cheese and country B will produce 20 bottles of wine.
- If they trade 36 pounds of cheese and 9 bottles of wine, then Country A consumes 80-36=44 pounds of cheese and 9 bottles of wine while Country B consumes 20-9=11 bottles of wine and 36 pounds of cheese. See points C_A and C_B in the graph above.

(d) Prove that both countries have gained from trade.

- Both countries have gained from trade because they can now both consume more of both goods than they could before trade. Graphically we can see this by noticing that the consumption points after trade are beyond the production possibilities frontier of each country.