Problem Set 1

Econ 200

I. Short Case Study Problems

1. At one time, the US domestic wheat supply (in millions of bushels per year) was fairly steady at approximately $S(p) = 1800 + 240p$, where p is the price in \$ per bushel. Demand (mainly for exports) fluctuated over this period, from an estimated $D(p) = 3550 - 266p$ in year 1 to $D(p) = 2580 - 194p$ in year 5.

(a) Compute the market clearing price in year 1 and in year 5.

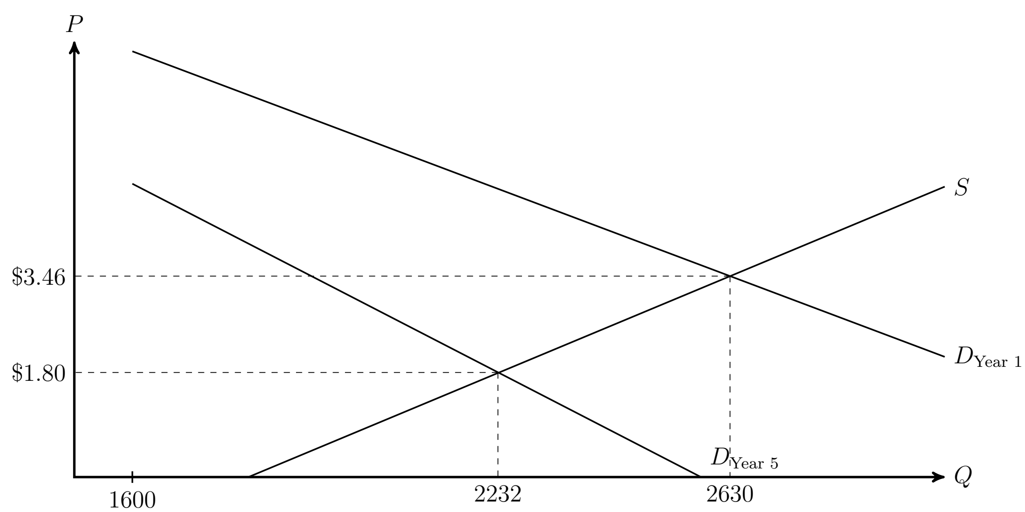
Solution: Set $S(p) = D_{\text{Year 1}}(p)$:

$$1800 + 240p = 3550 - 266p \Rightarrow p_{\text{Year 1}} = \frac{3550 - 1800}{240 + 266} = \$3.46$$

Likewise, $S(p) = D_{\text{Year 5}}(p)$:

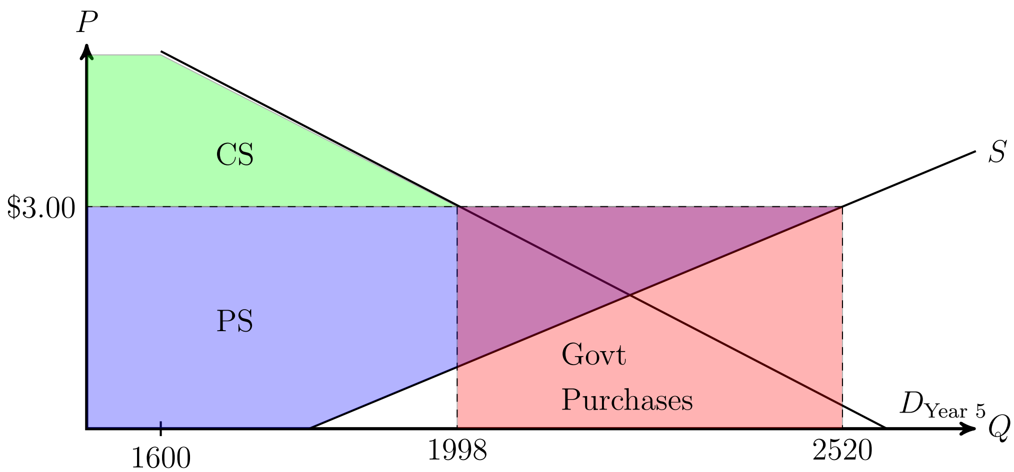
$$1800 + 240p = 2580 - 194p \Rightarrow p_{\text{Year 5}} = \frac{2580 - 1800}{240 + 194} = \$1.80$$

These prices give equilibrium quantities of $q_{\text{Year 1}} = 2630.4$ million bushels and $q_{\text{Year 5}} = 2232$ million bushels.



(b) Suppose the government supported a $p = \$3.00$ price throughout this period. (This is a rough approximation of actual policy.) Compute the prices and quantities seen by suppliers, demanders, and government price supporters (i.e. taxpayers) in year 1 and year 5. Also, relative to the competitive outcome in part (a), calculate the gains and losses in producer, consumer, and taxpayer surplus, expressed in $billions.

Solution: Note that the competitive price in year 1 is greater than the price floor of $p = \$3.00$. Thus, the government policy has no effect (i.e. the price floor is not binding) in year 1 and the price remains $p_{\text{Year 1}} = 3.46$ and the quantity remains $q_{\text{Year 1}} = 2630.4$ million bushels. There is no change in any of the surpluses.



In year 5, the price floor is binding so that the price becomes $p = \$3.00$. Consumers demand $D_{\text{Year 5}}(3) = 2580 - 194(3) = 1998$ million bushels while producers supply $S(3) = 1800 + 240(3) = 2520$ million bushels. In order to maintain the price floor, the government must buy the excess wheat at a price of $3.00. To calculate the surpluses, we need the inverse demand and supply functions:

$$p_d = \frac{2580}{194} - \frac{1}{194}q$$

$$p_s = \begin{cases} 0 & \text{if } q < 1800 \\ -\frac{1800}{240} + \frac{1}{240}q & \text{otherwise} \end{cases}$$

Thus, the change in consumer surplus is:

$$\begin{aligned}
CS' - CS &= \int_0^{1998} (p_d - 3)dq - \int_0^{2232} (p_d - 1.8)dq \\
&= \int_0^{1998} \left(\frac{1998}{194} - \frac{1}{194}q\right) dq - \int_0^{2232} \left(\frac{2230.8}{194} - \frac{1}{194}q\right) dq \\
&= 10289 - 12826 \\
&= -2537 \ \frac{\$\text{million}}{\text{year}}
\end{aligned}$$

or -2.537 billions of dollars per year. The change in producer surplus is:

$$\begin{aligned}
PS' - PS &= \int_0^{2520} (3 - p_s)dq - \int_0^{2232} (1.8 - p_s)dq \\
&= 3(1800) + \int_{1800}^{2520} (3 - p_s)dq - [1.8(1800) + \int_{1800}^{2232} (1.8 - p_s)dq] \\
&= 2160 + \int_{1800}^{2520} \left(\frac{2520}{240} - \frac{1}{240}q\right) dq - \int_{1800}^{2232} \left(\frac{2232}{240} - \frac{1}{240}q\right) dq \\
&= 2160 + (13230 - 12150) - (10379 - 9990) \\
&= 2851 \ \frac{\$\text{million}}{\text{year}}
\end{aligned}$$

or 2.851 billions of dollars per year. Taxpayer surplus without the price floor is zero. With the price floor, it is a negative amount equal to the total that is spent purchasing the excess wheat. Therefore the change in taxpayer surplus is:

$$TS' - TS = -3(2520 - 1998) - 0 = -1566 \ \frac{\$\text{million}}{\text{year}}$$

or -1.566 billions of dollars per year.

2. The US domestic sugar supply (in billions of pounds per year) is approximately $S(p) = -8.19 + 1.07p$, where p is the price in cents per pound, and domestic demand is approximately $D(p) = 23.86 - 0.25p$. The world price recently was 12 cents and world supply is extremely elastic. The US government has established a quota on imports of 3.0 billion pounds per year and assigns the import rights to specific firms.

(a) Relative to competitive equilibrium, estimate the impact of the quota on price, domestic competition of sugar, and surplus of domestic producers and of import right holders.

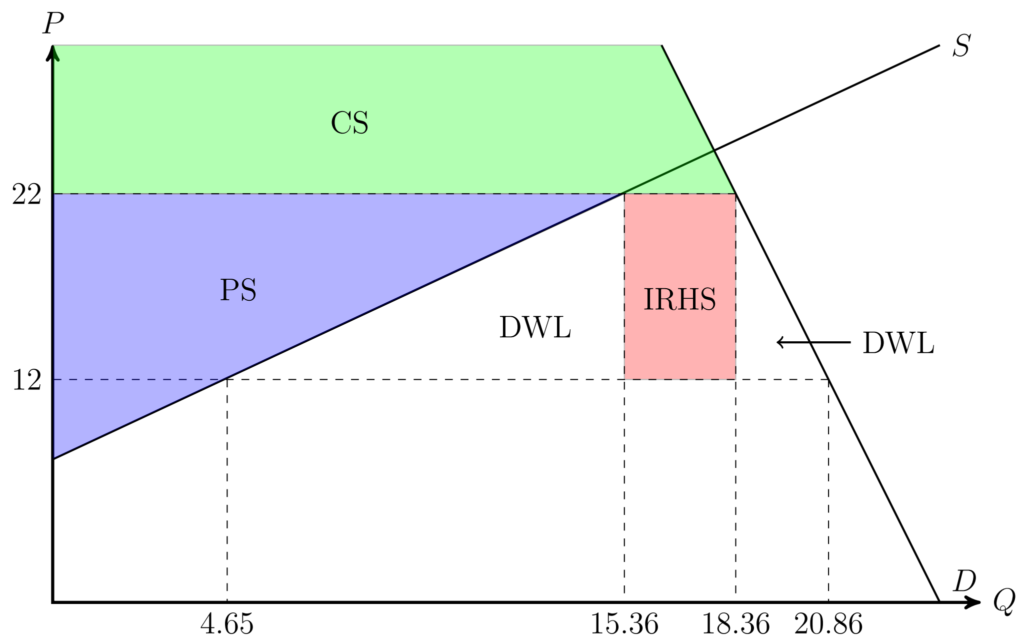
Solution: For this problem, we assume that world supply being "extremely elastic" means that it is perfectly elastic. The first step is to find the equilibrium in the absence of the quota. The price of sugar in this case is just the world price, $p^* = 12$. Then domestic supply is $S^* = 4.65$ and domestic consumption is $D^* = 20.86$.

Since imports would be $20.86 - 4.65 = 16.21$ billion pounds without the quota, the quota is effective in limiting the quantity of imports. With the quota, we know that $S_{\text{Quota}} + 3 = D_{\text{Quota}}$. Therefore,

$$-8.19 + 1.07p + 3 = 23.86 - 0.25p \Rightarrow p_{\text{Quota}} = 22.01 \text{ cents/pound}$$

which gives $S_{\text{Quota}} = 15.36$ and $D_{\text{Quota}} = 18.36$. Therefore, the quota has the following effect on price and domestic consumption:

$$\Delta p = p_{\text{Quota}} - p^* = 10.01 \text{ cents/pound}$$
$$\Delta D = D_{\text{Quota}} - D^* = -2.5 \text{ billion pounds/year}$$



The inverse supply function is

$$p_s = 7.654 + 0.935q$$

Therefore the change in domestic producer surplus is:

$$\begin{aligned} PS' - PS &= \int_0^{15.36} (22.01 - p_s)dq - \int_0^{4.65} (12 - p_s)dq \\ &= 100 \ (\frac{\text{billion pounds}}{\text{year}})(\frac{\text{cents}}{\text{pound}}) \\ &= \$1 \text{ billion/year} \end{aligned}$$

The change in the surplus of import right holders is:

$$\begin{aligned} 3(22.01 - 12) - 16.21(12 - 12) &= 30.0 \ (\frac{\text{billion pounds}}{\text{year}})(\frac{\text{cents}}{\text{pound}}) \\ &= \$300 \text{ million/year} \end{aligned}$$

(b) What is the maximum willingness to pay (in \$millions to be spent on campaign contributions, lobbying, etc) of the last two groups to maintain the existing quota system? What is the total efficiency loss?

Solution: The total efficiency loss is the loss that consumers experience minus the benefits that producers and import rights holders receive:

$$\begin{aligned} \Delta CS + \Delta PS + 30.0 &= -66.3 \ (\frac{\text{billion pounds}}{\text{year}})(\frac{\text{cents}}{\text{pound}}) \\ &= \$663 \text{ million/year} \end{aligned}$$

Together, domestic producers and import rights holders are willing to pay up to their combined benefit from the quota, \$1.3 billion per year, in order to maintain the current system. If the import regime is determined every x years, then domestic producers and import rights holders would be willing to contribute the net present value (NPV) of their total expected benefit over the x-year term. (Issues to think about: what discount rate should be applied? how to adjust for risk?)

3. Suppose that demand for gasoline has elasticity -0.3 in the short run and -0.8 in the long run, that supply elasticity is 0.6 in both SR and LR, that the current price is \$3.50/gal and that current quantity is 0.5 billion gallons/day with essentially no

sales tax. A \$0.35/gal sales tax is proposed.

(a) Predict the impact of the proposed tax on price, quantity, tax revenue, and producer and consumer surplus.

Solution: In the short run, $\frac{\partial p_d}{\partial t} = \frac{0.6}{0.6+|-0.3|} = \frac{2}{3}$. The impact on p_d is

$$\Delta p_d = \frac{\partial p_d}{\partial t} \cdot \Delta t = \frac{2}{3}(0.35) = \frac{0.7}{3}$$

In the short run the tax raises the price consumers pay from \$3.50/gal to \$3.73/gal (of which producers receive \$3.38/gal) and the quantity sold falls by

$$\Delta D = \frac{\partial D}{\partial p_d}\Delta p_d = \epsilon_d \frac{D}{p_d}\Delta p_d = -0.3\left(\frac{0.5}{3.5}\right)\frac{0.7}{3} = -0.01$$

from 0.5 to 0.49 billion gallons per day. The tax revenue raised is

$$(0.35\ \frac{\$}{\text{gallon}})(0.49\ \frac{\text{billion gallons}}{\text{day}}) = \$172 \text{ million/day}$$

The easiest approach to find the change in producer and consumer surplus is to assume that supply and demand are linear. If this is the case, then the loss in consumer surplus is given by the area of the rectangle, $0.49(3.73-3.5)$, plus the area of the triangle, $0.5(0.5-0.49)(3.73-3.5)$. This sum is equal to 0.114, or \$114 million/day. Likewise, the loss in producer surplus is

$$0.49(3.5-3.38) + 0.5(0.5-0.49)(3.5-3.38) = 0.0594$$

or \$59.4 million/day.

In the long run, $\frac{\partial p_d}{\partial t} = \frac{0.6}{0.6+|-0.8|} = \frac{3}{7}$. Compared to the short run where the majority of the tax was born by consumers, in the long run consumers bear less than half the tax. The price for consumers rises from \$3.50/gal to \$3.65/gal (of which producers receive \$3.30/gal) and the quantity sold falls from 0.5 to 0.483 billion gallons/day. The tax revenue raised is $0.35(0.483) = 0.169$, or \$169 million/day. The loss in consumer surplus is now

$$0.483(3.65-3.5) + 0.5(0.5-0.483)(3.65-3.5) = 0.0737$$

or \$73.7 million/day and the loss in producer surplus is now

$$0.483(3.5-3.30) + 0.5(0.5-0.483)(3.5-3.30) = 0.0983$$

or \$98.3 million/day.

(b) What is the deadweight loss as conventionally computed? What important additions and subtractions do you think are warranted in a sensible public interest cost-benefit analysis of the tax?

> **Solution:** The conventional deadweight loss in the short-run is
>
> $$0.5(0.35)(0.5 - 0.49) = 0.00175 = \$1.75 \text{ million/day}$$
>
> while in the long-run it is \$2.98 million/day. If one believes there are social costs to gasoline consumption (pollution, traffic) that are not captured in the market price of gasoline, then a reduction in gasoline consumption also reduces these social costs, offsetting some of the conventional deadweight loss.

4. Abel, Bob and Chris each are interested in purchasing an hour long amateur Chiropractic adjustment (ACA). Abel values an ACA at \$30, Bob at \$40 and Chris at \$60. Ryan, Sam and Trudy are amateur Chiropractors. In their day jobs, Ryan earns \$10 per hour, Sam earns \$20 per hour and Trudy earns \$50 per hours; each would have to miss work to offer an appointment. Assume each supplier can only supply one ACA and each demander can only consume one ACA.

(a) Use the competitive equilibrium model to predict price and quantity. Who gets ACAs and who supplies them? What is the consumer, producer and total surplus?

> **Solution:** We can construct the following supply and demand schedules:
>
> | Quantity | Demand Price | Supply Price | Joint Surplus |
> |---|---|---|---|
> | 1 | 60 | 10 | 50 |
> | 2 | 40 | 20 | 20 |
> | 3 | 30 | 50 | -20 |
>
> In the competitive equilibrium, two ACAs are sold by Ryan and Sam. The market price cannot be lower than \$20, otherwise Sam would not be willing to supply the second ACA. Similarly, the market price cannot be higher than \$40 or else only Chris would be willing to buy an ACA. If the price were less than \$30, then both Abel or Bob would be willing to buy the second ACA.

In equilibrium, however, Bob should be the one to purchase the second ACA since he is able to pay more than Abel and still benefit from the transaction. Therefore the market price must be $p^* \in [30, 40]$.

Consumer surplus is $(60 - p^*) + (40 - p^*) = 100 - 2p^*$. Producer surplus is $(p^* - 10) + (p^* - 20) = 2p^* - 30$. Total surplus is $(100 - 2p^*) + (2p^* - 30) = 70$.

(b) Imagine that a phone app does the matching, using an algorithm that maximizes the number of ACA transactions. Suppose for the moment that consumers truthfully report their valuations to the app, and suppliers report their true costs. What matching would you predict? What is the corresponding consumer, producer and total surplus?

Solution: The app can match consumers and producers such that three transactions are made. One such match would be: Chris-Trudy, Bob-Sam, and Abel-Ryan. The total surplus for this match is $(60-50)+(40-20)+(30-10) = 50$. The app would have to assign a different price to each transaction. The magnitudes of the resulting consumer and producer surplus therefore depend on how the app divides total surplus between buyer and seller.

(c) Briefly compare the feasibility of implementing the models/algorithms suggested in (a) and (b) above. Which algorithm would you recommend for the app? NB: you don't have to restrict yourself to (a) or (b).

Solution: The algorithm in part (b) depends on truthful reporting of valuations and costs. As both buyers and sellers can benefit by lying, this throws the feasibility of the algorithm in doubt. The competitive equilibrium, on the other hand, requires no knowledge about any of the market participants.

Part (b) may still be preferable if the app's revenues depend on the number of transactions conducted. In the long run, however, the app may attract more users if it maximizes total surplus by charging the competitive price.

II. Short Essays

1. Print shop

Solution: Explain using non-technical language: (1) the fact that marginal revenue is negative at certain points and (2) why that is a bad pricing scheme.

2. Water conservation

Solution: Again using non-technical language, explain that (per Dr. Friedman) consumers optimize at the margin so increasing the unit price for the last unit of water is what promotes conservation by selfish rational consumers.