ESM 204, Homework #2
Simulating a Water Market

Water is used in the production of nearly all goods and services, and its scarcity is increasingly salient. You have been asked to provide guidance on how two adjacent Mexican states (Baja California (BC) and Baja California Sur (BCS)) can reduce water use. In this homework you will conduct data analysis, simulations, and policy analysis to help inform this decision. The dataset for this assignment is available in the file "HW2_Water.csv", available on Gauchospace. The dataset contains estimates of the **marginal cost** of reducing water use in four economic sectors (sectors Agriculture, Meat, Industrial, and Urban), for different levels of reduction (in Acre Feet). A few notes:

- Current water use is: Ag=170 AF, Meat=200 AF, Industrial=230 AF, and Urban=300 AF.
- Sectors Ag, Meat, and Industrial are in Baja California. The Urban sector is in Baja California Sur.
- Prices are in $/Acre Foot and quantities are in Acre Feet (AF).

Your task is to produce a 1 page memo, with supporting appendices, to advise the Baja California and Baja California Sur governments about how best to reduce water use. Your memo and appendices must address the following questions.

1. Start with the Agriculture sector. Plot the data for Agriculture's marginal cost of reducing water (the "marginal abatement cost"). Use regression analysis to estimate the parameters of a **linear function** (which can include a non-zero intercept) to represent this. Repeating this for all four sectors will give you a model of the marginal abatement cost function for each sector. How well do your models fit the data for each sector? Produce a plot of the estimated marginal abatement cost functions in all four sectors (this plot should go in your memo).
2. Using these models (i.e. use the functions you have estimated, not the data themselves) and the current level of water use (provided above), derive each sector's **demand curve** for water use. In other words, how much would each sector be willing to pay for the right to use the first AF of water, second AF, etc.? Plot each sector's demand curve for water use on a graph. Which sector is willing to pay the most for the first AF of water?
3. Now focus on the state of Baja California (which contains the Agriculture, Meat, and Industrial sectors, but not the Urban sector), and assume there are no "co-benefits" from reducing water use. Suppose to have sustainable water use over time, Baja California needs to cut water use in half. For each of the policy options listed below, derive: (1) the total cost of meeting the target in Baja California, (2) the total cost (or benefit) to each sector, and (3) the tax revenue generated.
    a. **Cap on water use**. Each sector (Ag, Meat, Industrial) must cut its water use by 100 AF (thus reducing total water use from 600 down to 300).
    b. **Tax on water use**. To use each AF of water in Baja California, you must pay a tax of $t. You will need to find the tax that accomplishes the desired reduction in total water use.
    c. **Water Cap and Trade**. Each sector (Ag, Meat, Industrial) is freely allocated water use rights equal to their current use minus 100 (same as in (a) above), thus achieving the total reduction of 300. Then, these three sectors are allowed to trade with each other. You will need to derive the outcome of that trading (the trading price for water and the amount of water used after trading).
4. Again, without any co-benefits, suppose that BCS (which only has one water sector, called Urban) has no obligation to reduce its water use, but because the state shares aquifers with BC, there may be some benefit to cooperating on reduced water use. BC asks BCS to enter the BC Water Cap and Trade market (see 3c, above). Doing so would require BCS to put a cap on Urban water use at its current level of use (300 AF), but would then allow BCS to reduce its water use and sell those water rights to the sectors in BC (Ag, Meat, Industrial). Do you think BCS would voluntarily do this? Are there any

incentives for BC to try to attract BCS into its market? Describe these incentives as quantitatively as possible.

5. Now we will account for co-benefits of reduced water use. Assume that every acre-foot of water consumed causes $10 worth of "ecosystem degradation," which can be reversed if less water is consumed (so 1 AF of reduced water use generates $10 in ecosystem benefits). Assume that ecosystem degradation and benefits occur only in the state in which the water is used (for example, an acre foot of water used in BCS causes ecosystem degradation only in BCS). Assume that before these interventions, there are no restrictions on water use in either state.
    a. Suppose a water cap and trade market is implemented for all three sectors in BC (as described above, covering only sectors in BC). After the market is put in place, how much ecosystem damage (in $) would you expect in BC? How much ecosystem damage would you expect in BCS?
    b. If BCS enters the water market (as in question 4 above), how much ecosystem damage will there be in each state, after trading?
    c. What advice can you give BC and BCS about the desirability of allowing trading across jurisdictions? What can be said about the ecosystem implications of allowing trading?