Technical Appendix

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1. Marginal Cost of Abatement by Sector

Using the data provided, regression analysis is conducted to find the marginal cost of abatement curve for 4 different sectors.

Sector A

$Marginal\ Cost\ Abatement\ Sector\ A = 0.5768419 * q + -8.6444767$

Sector B

$Marginal\ Cost\ Abatement\ Sector\ B = 0.1987443 * q + 9.3176977$

Sector C

$Marginal\ Cost\ Abatement\ Sector\ C = 0.7838266 * q + -11.6550307$

Sector D

For linear fit: $Marginal\ Cost\ Abatement\ Sector\ D = 0.2599275 * q + 9.6875061$

For quadratic fit: $Marginal\ Cost\ Abatement\ Sector\ D = -0.0437836 * q + 0.0020247 * q^2 + 16.774099$

2. Demand for Carbon Emissions

Demand Curves

Demand curve for carbon emissions is found for each sector by pluging in (Current Emission-q) for q in the marginal cost of abatement equation. The cost of abatement of quantity q is equal to willingness to pay for emitting (Current Emission-q). Plugging in O for q will result in the willingness to pay for the right to pollute the first unit.

Sector A: $Price\ of\ Emissions = 0.5768419 * (180 - q) + -8.6444767$
- Willingness to Pay for First Unit = $95.2

Sector B:

$Price\ of\ Emissions = 0.1987443 * (200 - q) + 9.3176977$

- Willingness to Pay for First Unit = $49.12

Sector C:

$Price\ of\ Emissions = 0.7838266 * (220 - q) + -11.6550307$

- Willingness to Pay for First Unit = $160.78

Sector D:

$Price\ of\ Emissions = 0.2599275 * (300 - q) + 9.6875061$

- Willingness to Pay with Linear Function: $87.69

$Price\ of\ Emissions = -0.0437836 * (300 - q) + 0.0020247 * (300 - q)^2 + 16.774099$

- Willingness to Pay for First Unit = \$185.46

Note: The rest of the anlaysis will use the linear demand equations for each sector.

3. Country X

Suppose to meet the Paris Accord commitments, Country X (which contains sectors A, B, and C) needs to cut all carbon emissions in half. For each policy option derive the following:
1. The total cost of meeting the target in Country X
2. The cost (or benefit) to each sector
3. The tax revenue generated

a. Cap on Carbon

Marginal cost of abatement curve is used to calculate the total cost of abating by 100 tons for each sector.

1. Total Cost of Carbon Cap
   $Total\ Cost = 6698.882897$
2. Cost/Benefits to each Sector
   $Cost\ to\ Sector\ A = 2019.761768$

$Cost\ to\ Sector\ B = 1925.491278$

$Cost\ to\ Sector\ C = 2753.629851$

3. Tax Revenue

There is no tax revenue with a carbon cap.

b. Tax on Carbon

To find the tax that accomplishes the desired reduction of 300, aggreagate marginal cost curve for 3 sectors in Country X is found. Marginal cost of 300th unit on the aggregate marginal cost curve is equal to the tax required.

1. Total Cost of Carbon Cap

The total cost of the carbon cap is the area under the aggregate cost curve from 0 to 300.

2. Cost/Benefits to each Sector

Plugging in the marginal cost of abatement(the tax in the case) will result in the quantity abated by each sector. The areas underneath the marginal cost curves for each sector from 0 to the quantity abated will give the total cost of abatement for each sector.

3. Tax Revenue

Tax revenue is calculated by multiplying the total emissions by the amount of tax. Total emissions is found by subtracting the amount of abatement from the total initial emissions of 600 tons.

c. Cap and Trade

Even though they are initially allocated current emissions minus 100, cap and trade will satisfy the equal marginal principle and the total reduction of 300 will be distributed between the three sectors just like in the part b. The marginal cost of abatement will be equal for all sectors which is equal to the marginal cost of abatement of 300th unit on the aggregate cost curve.

1. Total Cost of Carbon Cap

The total cost of the cap and trade is the area under the aggregate cost curve from 0 to 300.

2. Cost/Benefits to each Sector

The areas underneath the marginal cost curves for each sector from 0 to the quantity abated will give the total cost of abatement for each sector.

3. Tax Revenue

There is no tax revenue with a cap and trade

4. Country Y

Country Y contains only Sector D and is not obligated to reduce its emissions. To enter into Country X's carbon market Country Y would need to cap its emissions at its current level (300 tons) but allows them to sell credits to Sectors A, B, and C in Country X.

Sector D's marginal cost of abatement curve is flipped and put on the same graph with the aggregate marginal cost curve for country X. Before the equilibrium point, it is cheaper for Country Y to abate, then country X. So, at a price between Country X and Country Y's cost, both of the countries are better off.

Incentives for Country Y to enter the carbon market:

Incentives for Country X to attract Country Y to the carbon market:

5. Local Air Pollution

Now assume every ton of carbon emissions creates one ton of local air pollution. Local air pollution only causes economic damages in the country where it is emitted. Neither Country X nor Country Y have local air pollution regulations.

a. Carbon Cap and Trade Market only Covering Country X

How much local air pollution would you expect in Country X and Country Y?

- If Cap and Trade is only covering country X, country X will be emitting 300 tons of carbon emissions and that will result in 300 tons of local air pollution.
- Since there is no cap and trade in country Y, they will continue to emit at the same level as their current emissions which is 300 tons of carbon, and that will result in 300 tons of air pollution.

b. Country Y enters the Carbon Market of Country X

How much local air pollution would you expect in Country X and Country Y?

From the previous question, if country Y enters the carbon market, Country X will be emitting, so the amount of air pollution will be ...

Since the Country Y will be abating XX more, they will be emitting XX tons of carbon, and that will result in XX tons of air pollution.

c. Advice on International Trade of Carbon Emission Credits

Allowing international trade of carbon emissions is economically efficient but the local impacts of carbon emissions is not captured by this model. If Country Y enters to the market, Country X will be emitting more carbon which will cause a lot of local air pollution.