ESM 204 HW 3:
Distributional consequences of the clean energy transition

Spring, 2023
Due: 5:00pm May 19^{th}

Background

The state of California has been a leader both in pushing for the clean energy transition and in aiming to confront environmental injustices. For example, the state is the first to require a phase-out of gasoline cars and the first to build a comprehensive environmental justice screening tool, called Cal EnviroScreen. In this homework, we will investigate some of the tensions and interactions between these two priorities, with a focus on electric vehicles (EVs) and the toxicity of mining for lithium, an essential mineral in EV battery production.

In California, Senate Bill 535 designated 2,310 census tracts and all federally recognized Tribal lands across California as "disadvantaged" based on a comprehensive calculation involving Cal EnviroScreen (see here for details). In this assignment, we will consider how interventions may differentially influence SB 535 disadvantaged communities, called DACs, versus non-DAC locations across the state.

Throughout the assignment, we recommend using `R` and writing functions to compute your answers wherever possible. However, before opening `R`, it will probably be helpful to write some algebra and draw some graphs to make sure you know where you're headed.

Use the following set of facts:

- We are concerned about the environmental inequities that may arise between DAC and non-DAC communities in California due to mining of lithium needed to produce batteries in electric vehicles (EVs). We therefore will model the California EV market with two consumer groups: DAC and non-DAC.
- Initially, there is no intervention in the EV market.
- The current EV price (without any intervention) is $50,000 per vehicle.
- The marginal cost of producing an EV is linear and has a price-intercept of 0. For the purposes of this exercise, you can assume that California is self-contained in supply and demand (you don't need to worry about global EV or mining markets). This is of course unrealistic, but note there have been large efforts by the Biden Administration to create a domestic battery supply chain, making the tradeoffs analyzed here highly policy relevant.

Questions

1. The data set `HW3_data.csv` provides price (in $) and quantity (in number of EVs) estimates of demand per year for both DAC and non-DAC groups. Run linear regressions (with an intercept) to estimate the demand curves for DAC and non-DAC consumers. What are 2-3 reasons you can think that may explain the differences in demand you estimate?
2. One kilogram (kg) of lithium is estimated to cause $300 dollars worth of damage in health costs to local communities living near mines. Each EV requires a lithium ion battery containing 63kg of lithium. Assuming there are no other externalities caused by EV production, what is the marginal externality cost per EV produced?

3. What is the aggregate annual demand curve for EVs? What is the supply curve for EVs? What is the “benefit” to consumers under the status quo? What is the “benefit” to producers under the status quo? What is the environmental cost under the status quo?
4. How is the current consumer benefit divided between DAC and non-DAC consumers?
5. Derive the optimal EV tax (in $ per vehicle) to internalize the lithium mining externality. Noting that recent research has shown that DACs are far more likely to contain mining activity, assume that the mining externality is borne entirely by the DAC group. What would be the effects of this tax on:
   (a) The amount of EVs produced and consumed
   (b) The price of EVs
   (c) Overall welfare of non-DAC consumers
   (d) Overall welfare of DAC consumers
   (e) EV producers
   (f) Total environmental damage
   (g) Total tax revenue generated
6. Now, assume that all revenue from the EV tax will be redistributed to the consumers in proportion to their pre-tax consumption. For example, if 80% of the EVs were consumed by non-DAC consumers, then they get 80% of the tax revenue. Additionally, consider that emerging scientific evidence suggests the true environmental damages from lithium mining may be much higher than $300. For a range of values of external costs per kg of lithium ($350, $400, $450, and $500 per kg), calculate the effects of an EV tax on:[1]
   (a) Overall welfare of non-DAC consumers
   (b) Overall welfare of DAC consumers
   (c) EV producers
7. Now, consider the fact that the purchase of EVs not only leads to lithium mining, but also helps mitigate climate change by replacing gasoline cars. Suppose that climate change damages fall mostly outside California, to a lesser extent on DAC consumers, and not at all on non-DAC consumers. Qualitatively answer the following (in 1-3 sentences each):
   (a) How does the presence of climate change damages from gasoline cars affect the optimal EV tax in California?
   (b) Assuming tax revenue does not get returned to consumers, are non-DAC consumers more or less likely to support this new tax, relative to the tax that only accounts for the mining externality? Why?
   (c) Assuming tax revenue does not get returned to consumers, are DAC consumers more or less likely to support this new tax, relative to the tax that only accounts for the mining externality? Why?

[1] We highly recommend writing a function that takes as an input the marginal external cost and produces as output the welfare of the three groups (non-DAC consumers, DAC consumers, and EV producers) so that you can automatically answer items (a)-(c) without recomputing by hand each time.