Subsidizing cleaner products

- Fixed gov't revenue R
- Want to subsidize adoption of new class of cleaner products. Multiple products on the market.

Goal: want to maximize total quantity of product sold while keeping in mind equity concerns with who is receiving the benefit of the subsidy.

We have:

- Estimated demand for products in this class (with cleaner tech.)
- Demand est. separately for each product and by demographic group (e.g., income)

Focus of paper:

- Theory model
- Demand estimates
- Policy simulations that use demand estimates to shed light on theory

Model: should give principles for how subsidies should be structured to maximize diffusion of cleaner products.

To develop concepts, I'm going to start with a simple model, modified slightly from Sarah Armitage's JMP[1], where the demand estimation is a modification of the BLP-style discrete choice modeling.[2] I also use Nevo (2000) as a helpful guide.[3] While I wanted to start with a 1 period model below for simplicity to understand the situation, I think an important considering is inter-temporal substitution among different cleaner products – this is what Armitage's method is useful for.

Setup:

- Start with static model – 1 period
- This is a nice setup for discrete choice since many consumer products that policy makers may want to incentivize are large appliances that you would only buy one of.
- product $j \in J$ in market $t \in T$, with observed & unobserved product characteristics $\boldsymbol{x_{jt}}$, $\boldsymbol{\xi_{jt}}$
- consumer $i \in I_t$, with vector of demographics $\boldsymbol{D_i}$
- Indirect utility for individual i purchasing one unit of product j in market t:
  $U_{ijt} = \boldsymbol{x_{jt}\beta} - \alpha \boldsymbol{p_{jt}} + \boldsymbol{\xi_{jt}} + [-\boldsymbol{p_{jt}} \quad \boldsymbol{x_{jt}}] \cdot (\Pi \boldsymbol{D_i} + \Sigma \nu_i) + \varepsilon_{ijt}$
  $\boldsymbol{p_{jt}}$ market price (can be replaced with $\boldsymbol{p_{jt}} + t_j$, where t_j is the tax (subsidy) on good j)
  $\alpha, \boldsymbol{\beta}$ all-consumer taste parameters (estimated)
  Π demographic taste parameters (estimated)
  Σ idiosyncratic random coefficients

[1] Armitage, Sarah. "Technology Adoption and the Timing of Environmental Policy: Evidence from Efficient Lighting." Job Market Paper, November 14, 2021. `https://scholar.harvard.edu/files/sarmitage/files/armitage_jmp_harvard.pdf`.

[2] Berry, Steven, James Levinsohn, and Ariel Pakes. "Automobile Prices in Market Equilibrium." Econometrica 63, no. 4 (1995): 841–90. `https://doi.org/10.2307/2171802`.

[3] Nevo, Aviv. "A Practitioner's Guide to Estimation of Random-Coefficients Logit Models of Demand." Journal of Economics & Management Strategy 9, no. 4 (Winter 2000): 513–48. `https://doi.org/10.1162/105864000567954`.

- Consumers can also choose the outside option to not purchase any thing this period (and stay with their already-owned dirty good?); utility of outside option normalized to zero.
- Only can choose one product in the period.
- The products have per-unit externalities e_j such that $e_D > e_{C2} \geq e_{C1} \geq 0$
- Q_j = total quantity of good j sold
- Gov't budget constraint: $R = \sum_j -t_j Q_j$
- Pigouvian prescription would be to set the tax on each good equal to the marginal damages from each good: $\tau_j^* = e_j$
- Assume we cannot set a tax on the dirty good. What taxes (subsidies) would we place on the clean goods?

Proposition 3 from Armitage: When the social planner is constrained to implement a tax schedule on one clean good only and there are three goods, the efficient second-best pricing policy on the first clean good is given by

$$\hat{t}_{c_1} = (1/\frac{\partial s_{c_1,c_1}}{\partial t_{c_1}})[\underbrace{(\zeta_d - \zeta_{c_1})\frac{\partial s_{d,d}}{\partial t_{c_1}}}_{\textit{Impact on } C_1/D \textit{ margin}} + \underbrace{\zeta_{c_1}(\frac{\partial s_{c_1,c_1}}{\partial t_{c_1}} + \frac{\partial s_{d,d}}{\partial t_{c_1}} + \frac{\partial s_{d,c_2}}{\partial t_{c_1}} + \frac{\partial s_{0,c_2}}{\partial t_{c_1}})}_{\textit{Impact on } C_1/\textit{no adoption margin}}$$
$$+ \underbrace{(\frac{\zeta_d + \lambda\zeta_{c_2}}{1+\lambda} - \zeta_{c_1})\frac{\partial s_{d,c_2}}{\partial t_{c_1}} + (\frac{\lambda\zeta_{c_2}}{1+\lambda} - \zeta_{c_1})\frac{\partial s_{0,c_2}}{\partial t_{c_1}}}_{\textit{Impact on } C_1/C_2 \textit{ margin}}]$$

This is if the C_2 good only comes to market after the C_1 good has been subsidized. A similar derivation could be used to find the second-best tax on all the clean goods if the dirty good cannot be taxed.

In estimating demand though the BLP framework, we get estimates of the average and demographic-specific price sensitivity (α, first row of Π). We can use these to understand how people will react to the subsidies – estimating shares of the population, by demographics, that will switch to the different products given a vector of subsidies (negative taxes).

We want to maximize the social welfare function over the choice of subsidies, subject to our revenue R budget constraint. If these second-best optimal subsides show to be regressive, we may choose subsidies that do not achieve this optimum but are more progressive instead.

Questions:

- How will subsidizing these different products affect market structure? We probably care about the long-run effects of this (Armitage, 2021)
- What does the social welfare function look like?
- Separability: could we just use the second-best optimal subsidies using $R - R_1$ of the revenue, and then additionally target R_1 funds to giving rebates to specific households under a certain income level?