Welfare effects of Energy Efficiency Policy

Setup

Consider a market for energy-efficient air conditioners where consumers differ in their energy cost savings. Let s represent a consumer's true discounted lifetime energy cost savings from purchasing an efficient AC (relative to an inefficient one), where $s \in [0, \bar{s}]$.

Consumers are uniformly distributed along this savings dimension. We normalize the market size to 1, so $Q \in [0, 1]$ represents the share of consumers purchasing the efficient AC. This will produce graphs that look similar to the one in Allcott and Taubinsky (2015) that we discussed in class.

The **inverse demand function** (willingness to pay as a function of quantity) is:

$$P(Q) = \bar{s}(1 - Q)$$

where $\bar{s}$ is the maximum energy savings (the consumer with highest usage and electricity price).

The efficient AC costs $\Delta c = \$100$ more than the standard model (incremental upfront cost).

Three Demand Functions

1. **Private Rational Demand (Full Information, $\gamma = 1$):** If consumers were fully attentive to energy savings, their inverse demand is:

$$P^{Private}(Q) = 400(1 - Q)$$

2. **Behavioral Demand (Inattention, $\gamma = 0.5$):** Consumers with inattention perceive only $\gamma = 0.5$ of their true energy savings. Their inverse demand is:

$$P^{Behavioral}(Q) = 0.5 \times 400(1 - Q) = 200(1 - Q)$$

   This is the demand curve we observe in the market when consumers are inattentive.

3. **Social Demand (Including Externalities):** Energy consumption creates pollution externalities valued at $\phi\bar{e} = \$100$ per efficient AC. The social inverse demand is:

$$P^{Social}(Q) = (400 + 100)(1 - Q) = 500(1 - Q)$$

Market Equilibrium with Inattention (Baseline)

1. Market Quantity with Inattention

   Consumers make decisions based on their perceived benefits (behavioral demand). Find the equilibrium quantity $Q^{Behavioral}$ where the behavioral inverse demand equals the incremental cost:

$$P^{Behavioral}(Q^{Behavioral}) = \Delta c = 100$$

   Solve for $Q^{Behavioral}$.

2. Private Consumer Surplus (Baseline)

   Although consumers make decisions based on perceived benefits, their **actual private welfare** is determined by their **true** energy savings.

   The private consumer surplus is the area between the true private demand curve $P^{Private}(Q)$ and the price $\Delta c = 100$, evaluated at the quantity $Q^{Behavioral} = 0.5$ that consumers actually purchase:

$$CS^{Private} = \int_0^{Q^{Behavioral}} [P^{Private}(q) - \Delta c]\, dq$$

   Calculate the private consumer surplus under inattention.

3. Social Welfare (Baseline)

   Social welfare uses the social demand curve (which includes externalities):

$$W^{Social} = \int_0^{Q^{Behavioral}} [P^{Social}(q) - \Delta c]\, dq$$

   Calculate social welfare under inattention.

Optimal Subsidy (Correcting Behavioral Bias)

A policymaker wants to help consumers achieve their **privately optimal** choices (ignoring externalities for now). The privately optimal quantity is where true private demand equals cost:

$$P^{Private}(Q^{Private}) = \Delta c$$

4. Privately Optimal Quantity

   Solve for $Q^{Private}$.

5. Required Subsidy

   To induce behavioral consumers to purchase $Q^{Private}$ units, what per-unit subsidy τ is needed?

   The subsidy must satisfy:

$$P^{Behavioral}(Q^{Private}) = \Delta c - \tau$$

   Solve for τ.

6. Private Welfare with Subsidy

   With the subsidy, consumers purchase $Q^{Private}$ units at an effective price of $\Delta c - \tau$.

   Calculate:

   (a) Private consumer surplus with subsidy

   (b) Government cost

   (c) Net private welfare (consumer surplus minus government cost)

   (d) Gain in net private welfare compared to baseline

7. Social Welfare with Subsidy

   Social welfare with the subsidy includes the external benefits:

$$W^{Social,subsidy} = \int_0^{Q^{Private}} [P^{Social}(q) - \Delta c]\, dq$$

Calculate:

(a) Social welfare with subsidy (gross of government cost)

(b) Gain in social welfare compared to baseline

Note: When calculating social welfare, we compute the gross social surplus. The government cost represents a transfer from taxpayers to consumers, not a resource cost to society.

Mandate (Forcing $Q = 1$)

Now consider a mandate that requires **all** consumers ($Q = 1$) to purchase the efficient AC.

8. Private Welfare with Mandate

   Under a mandate, all consumers purchase the efficient AC. Private consumer surplus is:

$$CS^{Private,mandate} = \int_0^1 [P^{Private}(q) - \Delta c]\, dq$$

   Calculate private consumer surplus under the mandate.

9. Social Welfare with Mandate

   Social welfare with the mandate is:

$$W^{Social,mandate} = \int_0^1 [P^{Social}(q) - \Delta c]\, dq$$

   Calculate social welfare under the mandate.