Equity and Efficiency: Policy Design in Coordination Problems Under Uncertainty
(*Old title: Global Policy Design*)

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Introduction

Policy Design in Coordination Problems

Policy design in coordination problems is difficult

$\rightarrow$ Equilibrium multiplicity and/or complex strategic interdependencies

Strategic beliefs are important for policy

$\rightarrow$ Effect depends upon agents' expectations about others' decisions

$\rightarrow$ Higher-order beliefs

At the sane time, policy crucial in shaping strategic beliefs

Policy both input and output of agents' beliefs

Ann and Bob

Ann and Bob must choose whether to adopt an electric vehicle (EV)

$\rightarrow$ Outside option is driving a "dirty" fossil fuel car

The net benefit of driving a dirty car is 0

The cost of an EV, relative to a dirty car, is $c > 0$

The inherent benefit of an EV, relative to a dirty car, is x

If both adopt an EV, a charging station gets built

The benefit of a charging station, conditional on adopting an EV, is $b > c$

Ann and Bob

$$\text{Agent } i\text{'s payoff} = \begin{cases} x - c & \text{if only } i \text{ adopts} \\ x + b - c & \text{if both adopt} \\ 0 & \text{if } i \text{ does not adopt} \end{cases}$$

The Planner and Subsidies

Suppose a planner offers subsidies to induce EV adoption

Goal: make mutual adoption unique equilibrium

How high should these subsidies be?

How expensive is an *efficient*, or least-cost, subsidy policy?

The Planner and Subsidies

$$\text{Agent } i\text{'s payoff w/ subsidies} = \begin{cases} x - c + s_i & \text{if only } i \text{ adopts} \\ x + b - c + s_i & \text{if both adopt} \\ 0 & \text{if } i \text{ does not adopt} \end{cases}$$

Common Knowledge & Discrimination

Common Knowledge

Suppose payoffs (b, c, x) are **common knowledge**

To reduce notation, assume that $x = 0$

Suppose the planner offers Ann subsidy equal to c

What will happen?

The Direct and Indirect Effect of Subsidies

A subsidy equal to c makes adoption **strictly dominant** (for Ann)

Direct effect: Ann adopts

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Direct effect: Ann adopts

$\rightarrow$ Should Bob decide to adopt, the charging station gets built

A charging station makes adoption strictly dominant for Bob ($b > c$)

Indirect effect: Bob adopts, even without subsidy

N.B. the planner can even tax adoption by Bob!

$\rightarrow$ Up to indifference ($t \leq b - c$)

$\rightarrow$ Extract his full surplus to recover part of the cost of Ann's subsidy

Equity vs. Efficiency

A policy that subsidizes Ann by c and taxes Bob by $b - c$ discriminates

→ Otherwise identical agents treated unequally

Nobody likes discrimination... so why do we care?

Efficiency: this discriminatory policy is cheap

→ Minimizes sum of subsidies needed to uniquely induce adoption

→ Special case of seminal results by (Segal, 1999, 2003; Winter, 2004)

Trade-off between equity and efficiency in coordination problems

→ Segal (1999, 2003) & Winter (2004): cheapest subsidies must discriminate

→ Many subsequent generalizations

This Paper

The equity-efficiency trade-off is not robust to uncertainty

Equity & Efficiency

Uncertainty and Noisy Signals

Suppose agents' payoff functions are uncertain

For example, Ann and Bob do not know x (the benefit of an EV)

Common knowledge that $x \sim F$ on $\mathbb{R}$, with F a continuous distribution

Agent i in addition receives a **noisy private signal** x_i^ε, where

$$x_i^\varepsilon = x + \varepsilon \cdot \eta_i$$

η_i is idiosyncratic noise in i's signal

Common knowledge that $\eta_i \sim G$ on $[-1, 1]$, G continuous
$\rightarrow$ $\varepsilon > 0$ is a scaling factor for the noise in agents' signals

Information structure gives a **global game** (Carlsson & Van Damme, 1993)

Iterated Dominance

For very high signals x_i^ε, adoption is **strictly dominant** for agent i

Let $\overline{x}$ bound the "dominance region": for all $x_i^\varepsilon > \overline{x}$, adoption is dominant

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(i) What will agent i do when $x_i^\varepsilon > \overline{x}$?

(ii) What will agent i do when $x_i^\varepsilon > \overline{x} - \delta$ for small enough $\delta > 0$?

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Must repeat this argument over and over: **iterated dominance**

Implementability: A Useful Characterization

Let $s = (s_i)$ be a **subsidy scheme**

Proposition

For all ε sufficiently small, the game has a unique equilibrium. There exists a unique vector of **switching points** *$x(s) = (x_i(s))$ such that, in equilibrium, agent i adopts and EV for all signals $x_i^\varepsilon > x_i(s)$ and does not adopt for all $x_i^\varepsilon < x_i(s)$. The relationship between $x(s)$ and s is one-to-one.*

Result delineates the scope of subsidies as a tool to influence behavior

Yield's a natural definition of the planner's problem

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State-Contingent Implementation: The Planner's Problem

The planner assigns each agent i a **critical state** $\tilde{x}_i$

She seeks the **global subsidies** $\tilde{s} = (\tilde{s}_i)$ such that $x_i(\tilde{s}) = \tilde{x}_i$ for all i

$\rightarrow$ We know that, for ε sufficiently small, $\tilde{s}$ is unique

Focus today: both agents assigned the **same** critical state $\tilde{x}_i = \tilde{x}$ for all i

Global Subsidies

Theorem

Let $\tilde{x} \in \mathbb{R}$. For all ε sufficiently small, the subsidy scheme $\tilde{s}$ such that $x_i(\tilde{s}) = \tilde{x}$ is unique. For each $\delta > 0$, there exists $\varepsilon(\delta) > 0$ such that $|\tilde{s}_i - s_i^*(\tilde{x})| < \delta$ for all $\varepsilon < \varepsilon(\delta)$ and all i, where

$$s_i^*(\tilde{x}) = c - \tilde{x} - \frac{b}{2}$$

A Judicious Choice

If agents have equilibrium switching point $\leq -\varepsilon$, both adopt when $x = 0$

$\tilde{s}^{\varepsilon}$ that solves $x_A(\tilde{s}^{\varepsilon}) = x_B(\tilde{s}^{\varepsilon}) = -\varepsilon$ is given by

$$\tilde{s}_i^{\varepsilon} = c - \frac{b}{2} + \varepsilon, \quad i \in \{\text{Ann, Bob}\}$$

and hence

$$\tilde{s}_A^{\varepsilon} + \tilde{s}_B^{\varepsilon} = 2c - b + 2\varepsilon$$

so

$$\limsup_{\varepsilon \to 0} \{\tilde{s}_A^{\varepsilon} + \tilde{s}_B^{\varepsilon}\} = 2c - b$$

Equity and Efficiency

We saw that $\limsup_{\varepsilon\to 0}\{\tilde{s}_A^\varepsilon + \tilde{s}_B^\varepsilon\} = 2c - b$

Furthermore, $\tilde{s}_A^\varepsilon = \tilde{s}_B^\varepsilon$ — no discrimination

Recall: "optimal" discriminatory policy also costs $2c - b$

Trade-off between equity and efficiency disappears under uncertainty!

Generalizations

The base game in my paper is more general

→ More than two agents

→ Allows for asymmetry between (subsets of) agents

→ Allows asymmetric equilibria implementation

I study several extensions and applications of the base model

→ Games of regime change here

  → Morris & Shin (1998), Angeletos et al. (2006, 2007), Sákovics & Steiner (2012), Basak & Zhou (2020), Halac et al. (2020)

→ Incentives in teams here

  → Winter (2004), Halac et al. (2020, 2022, 2023)

→ Heterogeneous externalities/games on networks here

  → Matthew & Yariv (2009), Galeotti et al. (2020), Leister et al. (2022)

→ Continuous action spaces, payoffs linear in own actions here