Surplus Extraction with Behavioral Types

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Introduction

- We know that in a mechanism design setting, private information leads agents to retain informational rents
- Myerson (1981) and others have shown that if information is correlated then extracting all the rents is possible
- This is usually called *full surplus extraction*
- Cremer and McLean (1985, 1988) identify the key "independence" condition under which full extraction is possible

Main idea

- Here we introduce behavioral types in a classic surplus extraction problem
- We focus on a particular class of behavioral types
- That is, types who doesn't react optimally to incentives and always reveal their private information
- Main result: characterization of the conditions that guarantee full surplus extraction in an environment with behavioral types

Overview

- We consider a *reduced form model* á la McAfee and Reny (1992)
  - Single agent
  - Informational rents generated from unmodeled stage
  - No allocation in current stage, only transfers
  - Exogenous states
  - Correlation represented through beliefs over states
- Finite environment (types, states)

Model

- Single agent with type $t \in T$
- Set of (exogenous) states Ω
- Both types and states are finite

Model

- Each type t associated with
  - Informational rents $v_t \in \mathbb{R}_+$
    - These rents comes from an unmodeled stage (e.g., second price auction)
  - Beliefs $p_t \in \Delta(\Omega)$
    - We assume $p_t \neq p_{t'}$ for all $t, t' \in T$, which implies there is correlation between types and states

Model

- A contract $c : \Omega \to \mathbb{R}$ is a mapping from states into transfers, with $c(\omega)$ the transfer required in state ω
- A mechanism (or menu) $\mathbf{c} = \{c_t : t \in T\}$ is a collection of contracts, one for each type
- Payoff for type t and contract $c_{t'}$ is

$$v_t - \langle p_t, c_{t'} \rangle$$

where $\langle p_t, c_{t'} \rangle = \sum_{\omega \in \Omega} p_t(\omega) c_{t'}(\omega)$

Introducing Behavioral Types

- We allow some types in T to be *behavioral*
- We assume behavioral types always reveal their type regardless of the contracts offered.
- That is, they not need to satisfy any incentive compatibility constraint.
- Let $B \subseteq T$ be the set of behavioral types.
- Similarly, let $S = T \backslash B$ be the set of *strategic* types.

The Designer's Problem

- We are interested on whether the principal/designer is able to extract all the informational rents from the agent using a menu $\mathbf{c}$.
- Such menu should guarantee that each type picks his intended contract

The Designer's Problem

- Formally, a menu achieves full extraction if for all $t \in T$

$$\langle p_t, c_t \rangle = v_t$$

- A menu is incentive compatible if each strategic type chooses his cost minimizing contract, i.e., for all $s \in S$

$$c_s \in \arg\min_{t \in T} \langle p_s, c_t \rangle$$

- We say full extraction with behavioral types is feasible if there exists an incentive compatible menu $\mathbf{c}$ which achieves full extraction

Full extraction without Behavioral Types

- Without behavioral types, Crémer and McLean have identified the key condition for full extraction
- Being that the set of beliefs for all types must be linearly independent (convex independence)
- What we will do next is to provide the characterization if behavioral types are also present

Beliefs and key condition

Definition

A set of beliefs P satisfies the CM condition if for any $p \in P$, $p \notin co(P \backslash \{p\})$

- We denote by P^X the set of beliefs for types in $X \subseteq T$
- Then Crémer and McLean's result could be expressed as requiring that P^T satisfies the CM condition

Main result

Theorem

Full extraction with behavioral types is feasible if

1. P^S *satisfies the CM condition, and*
2. *For all types* $b \in B$, $p_b \notin co(P^S)$

- This imposes no restrictions on the structure of v_t
- CM condition over strategic types still necessary
- Condition over behavioral types slightly relaxed

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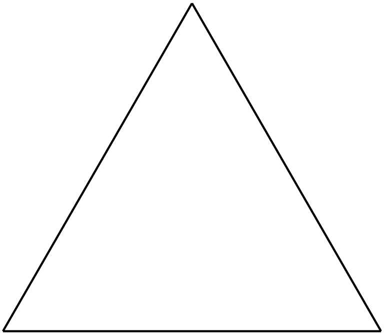

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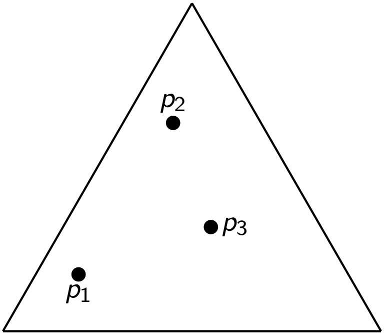

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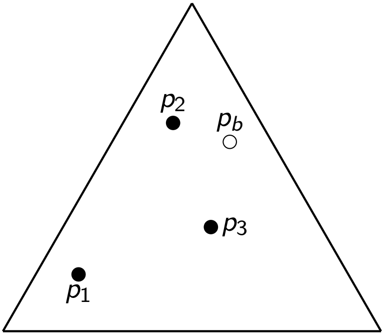

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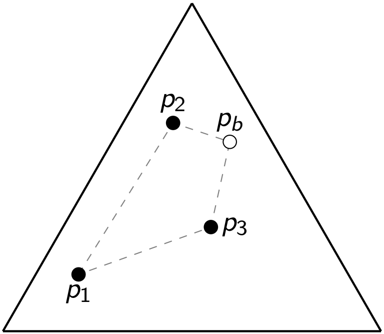

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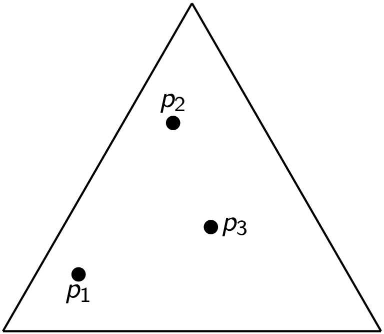

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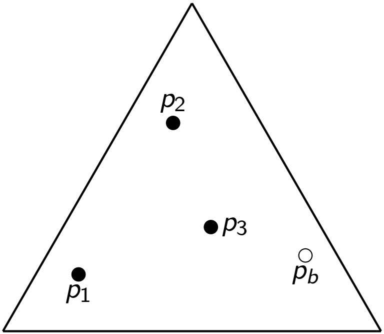

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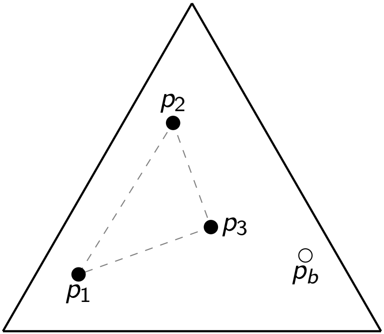

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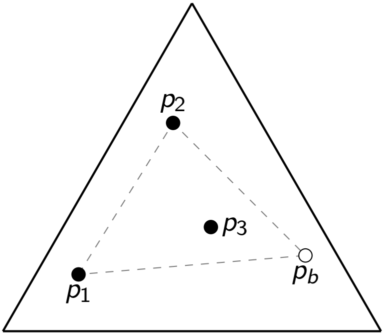

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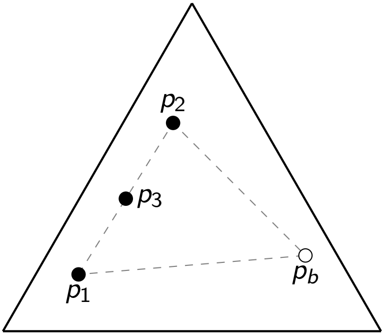

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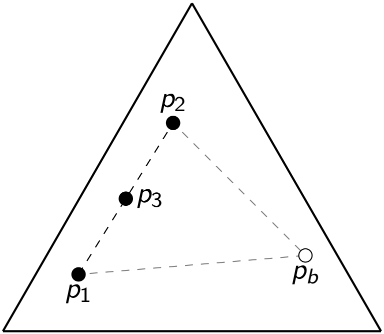

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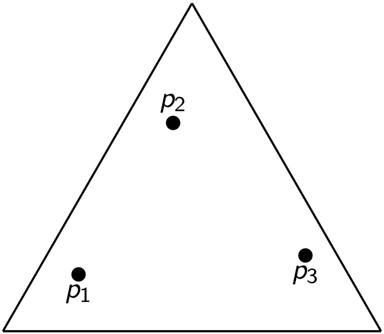

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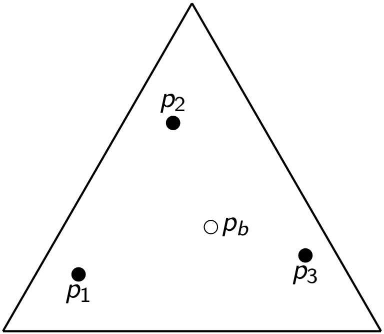

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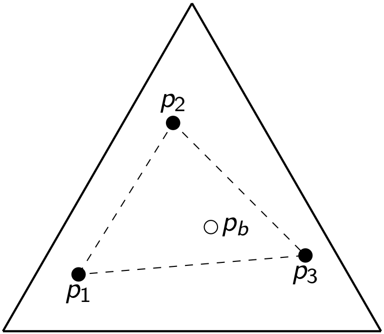

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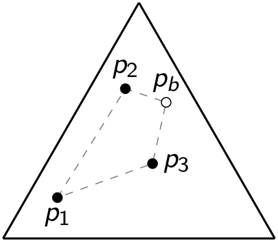
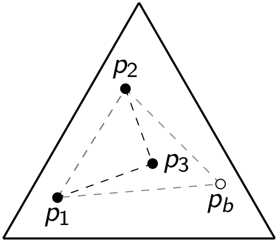
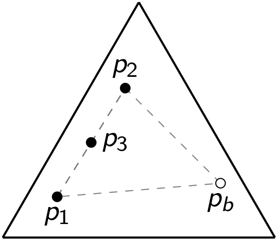


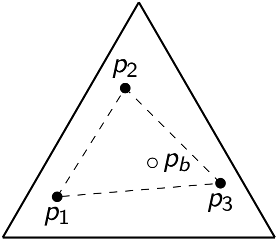
(a) Crémer and McLean's theorem applies



(b) Main theorem applies



(c) Condition (i) fails



(d) Condition (ii) fails

Sketch of proof

- We start with the contract for types in S
- Ignoring types in B
- Condition (i) implies a contract which fully extract among types in S exists
- So far, we have $(c_t)_{t \in S}$

Sketch of proof

- Now, we construct the contract for types in B
- For $b \in B$, consider the following contract:

$$c_b = v_b + \alpha_b z_b$$

- We want (vector) z_b that allows us to separate b from types in S
- That is,

$$\langle p_b, z_b \rangle = 0$$

$$\langle p_s, z_b \rangle > 0, \quad \forall s \in S$$

- Condition (ii) implies such z_b exists
- Choosing α_b big enough guarantees IC
- Repeat for all other types in B

From the main theorem

- Without loss to consider $|B| = 1$ since contract for b is independent from contract for $b' \neq b$
- Moreover, contract offered to b is independent of the contracts offered to any other type $t \in T : t \neq b$

What if conditions in the Theorem fail?

- We have two complementary results in the case some of the conditions in the main theorem fail

What if conditions in the Theorem fail?

Corollary

Consider a particular behavioral type $b \in B$. Let c_{-b} be an incentive compatible contract menu for types $t \neq b$. If $p_b \notin co(P^S)$ then there exists a contract c_b such that the contract menu (c_b, c_{-b}) is incentive compatible and $\langle p_b, c_b \rangle = v_b$.

- In short, Condition 2 allows for full extraction from behavioral types even if not possible for strategic types (i.e., Condition 1 fails)

What if conditions in the Theorem fail?

Proposition

Suppose P^S satisfies the CM condition. Let $\hat{B} = \{b \in B : p_b \in co(P^S)\}$. Then, full extraction with behavioral types is feasible if for each $b \in \hat{B}$

$$v_b \geq \sum_{s \in S} \lambda^b(s) v_s,$$

where $\lambda^b \in \Delta(S) : p_b = \sum_{s \in S} \lambda^b(s) p_s$.

- If Condition 2 fails, full extraction still feasible if informational rents of behavioral types are "big enough"

Related literature

- Classics: Myerson (1981), Cremer and McLean (1985, 1988), McAfee and Reny (1992)
- Genericity: Heifetz and Neeman (2006), Barelli (2009), Chen and Xiong (2011, 2013)
- Recent: Farinha Luz (2013), Lopomo, Rigotti, and Shannon (2020, 2021), Krahmer (2020), Fu et al (2021)
- "Behavioral": Eliaz (2002), Severinov and Deneckere (2006), Saran (2011), De Clippel, Saran and, Serrano (2018)

Concluding Remarks

- We characterize full surplus extraction in the presence of behavioral types
  - We identify a relaxation of the standard convex independence condition that guarantees full extraction
  - Full extraction is easier in this environment but still doesn't comes for free as some conditions are required

Concluding Remarks

- Future steps
  - Alternative behavioral assumptions on behavioral types
  - Beyond reduced form approach
  - Necessary conditions for full extraction