Information Design: Murat Sertel Lecture

Istanbul Bilgi University: Conference on Economic Design

Stephen Morris

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Mechanism Design and Information Design

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  - Fix an economic environment and information structure
  - Design the rules of the game to get a desirable outcome

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    - Application of "Robust Predictions": Bergemann-Morris (2013, 2015) and co-authors (this talk)
    - "Information Design": Taneva (2015)

This Talk

1. Leading Example to Understand Structure of Problem
2. A General Approach
3. Some Applications:
   - Oligopoly
   - Price Discrimination
   - Auctions
   - Volatility
4. Literature Review

Bank Run: one depositor and no initial information

- A bank depositor is deciding whether to run from the bank if he assigns probability greater than $\frac{1}{2}$ to a bad state

Payoff	θ_G	θ_B
Stay	1	-1
Run	0	0

- The depositor knows nothing about the state
- The probability of the bad state is $\frac{2}{3}$

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- Outcome distribution with no information:

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Stay	0	0
Run	$\frac{1}{3}$	$\frac{2}{3}$

- Probability of run is 1

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  - ... but can choose what information is made available to prevent withdrawals

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Lessons

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   - compare with the revelation principle of mechanism design:
     - without loss of generality, we can restrict attention to mechanisms where each player's message space is equal to his type space

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Is initially more informed depositor good or bad?

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  - ...and initial information, probability of run is $\frac{5}{6}$
- With information design....
  - ...and no initial information, probability of a run is $\frac{1}{3}$
  - ...and initial information, probability of a run is $\frac{1}{2}$
- Initial information always hurts the regulator

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1. Without loss of generality, can restrict attention to information structures where each player's signal space is equal to his action space
2. Prior information limits the scope for information design

Bank Runs: two depositors and no initial information

- A bank depositor would like to run from the bank if he assigns probability greater than $\frac{1}{2}$ to a bad state OR the other depositor running

state θ_G	*Stay*	*Run*
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state θ_B	*Stay*	*Run*
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Run	0	0

- Probability of the bad state is $\frac{2}{3}$

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  - ...with public signals optimal

Bank Runs: two depositors, no initial information and strategic substitutes

- Previous example had strategic complements
- Strategic substitute example: a bank depositor would like to run from the bank if he assigns probability greater than $\frac{1}{2}$ to a bad state AND the other depositor staying

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Stay	$\frac{1}{3}$	0
Run	0	0

outcome θ_B	*Stay*	*Run*
Stay	$\frac{4}{9}$	$\frac{1}{9}$
Run	$\frac{1}{9}$	0

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  - ....with private signals optimal

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2. Prior information limits the scope for information design
3. Public signals optimal if strategic complementarities; private signals optimal if strategic substitutes

Bank Run: two depositors with initial information

have also analyzed elsewhere....

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- Fix a game with incomplete information about payoff states
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  - ....Forges (1993) Bayesian solution if no distributed uncertainty

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- One information structure is "individually sufficient" for another if you can embed both information structures in a combined information structure where a player's signal in the former information structure is sufficient for his signal in the latter...
- This ordering characterizes which information structure imposes more incentive constraints

Application 1: Oligopoly

- Lesson 3:
  - with strategic complementaries, public information is best
  - with strategic substitutes, private (conditionally independent) information is best
- In oligopoly...
  - strategic substitutes
  - if uncertainty about demand, firms would like to have
    - good information about the state of demand
    - BUT would like signals to be as uncorrelated as possible with others' signals
  - in general, intermediate conditionally independent private signals about demand are optimal for cartel problem

Application 2: Price Discrimination

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- Interpret the demand curve as representing single unit demand of a continuum of consumers
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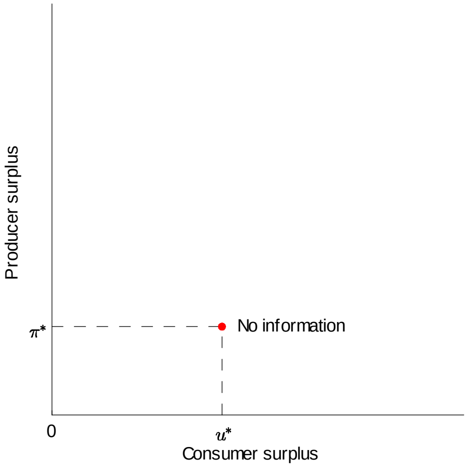
- How much revenue could a monopolist producer/seller get?
- If the seller cannot discriminate between consumers, he must charge uniform monopoly price
- Write u^* for the resulting consumer surplus and π^* for the producer surplus ("uniform monopoly profits")

The Uniform Price Monopoly



- producer charges (uniform) monopoly price
- consumers get positive consumer surplus, socially inefficient allocation

Perfect Price Discrimination

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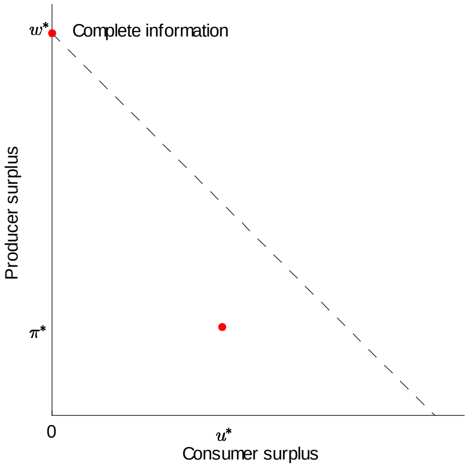
Perfect Price Discrimination

- But what if the producer could observe each consumer's valuation perfectly?
- Pigou (1920) called this "first degree price discrimination"
- In this case, consumer gets zero surplus and producer fully extracts efficient surplus $w^* > \pi^* + u^*$

First Degree Price Discrimination



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- Equivalently, suppose the market is split into different segments (students, non-students, old age pensioners, etc....)
- Pigou (1920) called this "third degree price discrimination"
- What can happen?
- A large literature (starting with Pigou (1920)) asks what happens to consumer surplus, producer surplus and thus total surplus if we segment the market in particular ways

The Limits of Price Discrimination

- Questions:
  - What is the maximum possible consumer surplus, and what segmentation attains it?
  - What consumer surplus and producer surplus pairs could arise, and which segementations attain those pairs?

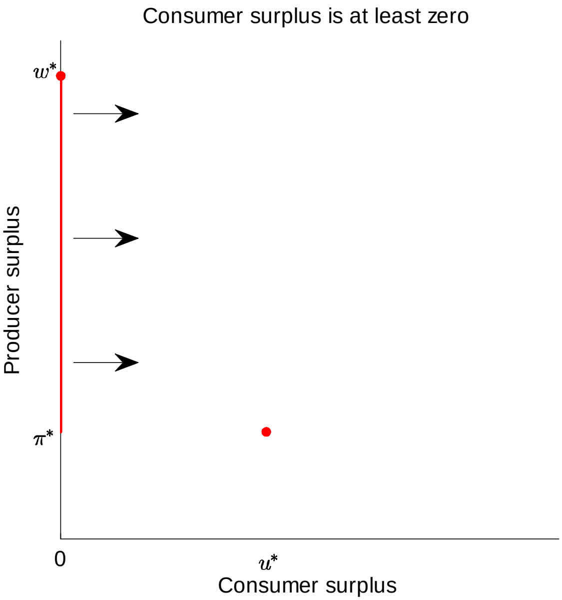
The Limits of Price Discrimination

- Questions:
  - What is the maximum possible consumer surplus, and what segmentation attains it?
  - What consumer surplus and producer surplus pairs could arise, and which segementations attain those pairs?
- These are information design questions:
  - segmenting the market is the same thing as providing information to the monopolist about buyers' valuations
  - by maximizing different (positive and negative) weighted sums of consumer and producer surplus, we will map out feasible consumer surplus and producer surplus pairs

Three Welfare Bounds

1. Voluntary Participation: Consumer Surplus is at least zero

Welfare Bounds: Voluntary Participation



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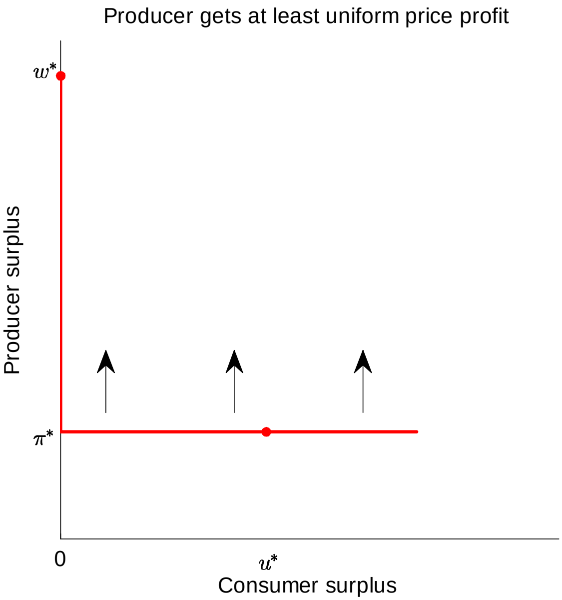
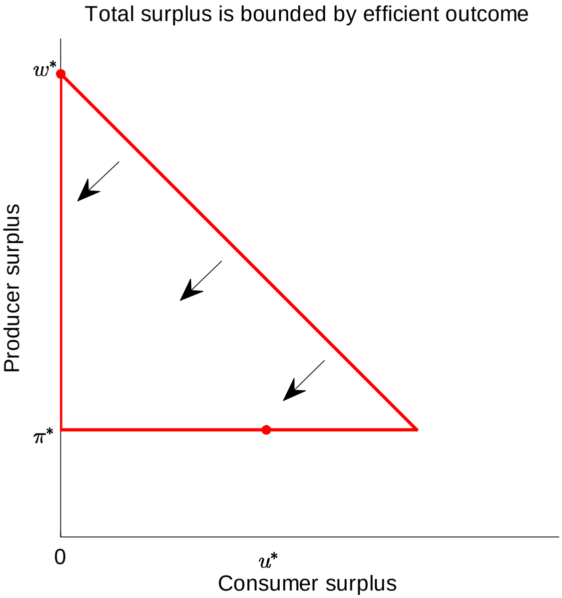
Welfare Bounds: Nonnegative Value of Information



Three Welfare Bounds

1. Voluntary Participation: Consumer Surplus is at least zero
2. Non-negative Value of Information: Producer Surplus bounded below by uniform monopoly profits π^*
3. Social Surplus: The sum of Consumer Surplus and Producer Surplus cannot exceed the total gains from trade

Welfare Bounds: Social Surplus



Beyond Welfare Bounds

1. Includes points corresponding uniform price monopoly, (u^*, π^*), and perfect price discrimination, $(0, w^*)$
2. Convex

Welfare Bounds and Convexity

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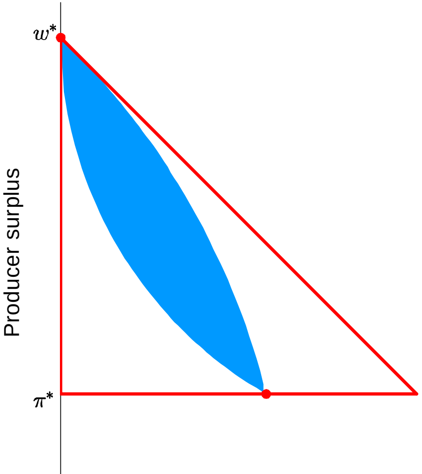
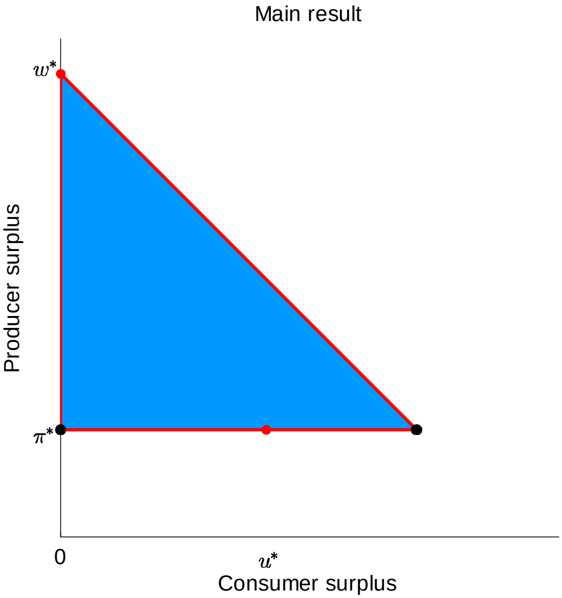
What is the feasible surplus set?



Welfare Bounds are Sharp



Maximizing Consumer Surplus

- Any (consumer surplus, producer surplus) pair consistent with three bounds arises with some segmentation / information structure
- In particular, there exists a *consumer surplus maximizing segmentation* (corresponding to the bottom right hand corner) where

1. the producer earns uniform monopoly profits
2. the allocation is efficient
3. the consumers attain the difference between efficient surplus and uniform monopoly profit.

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- Consider a finite set of values
- Create a segment consistent of all consumers with the lowest value and the proportion of consumers with all other higher values such that the monopolist is indifferent between charging the lowest value and uniform monopoly price
- Then a segment consistent of all remaining consumers with the second lowest value and the proportion of consumers with all other higher values such that the monopolist is indifferent between charging the second lowest value and uniform monopoly price

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- And so on...

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- Charge lowest price in each segment

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- Charge lowest price in each segment
- Monopolist earns uniform monopoly profit

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- Charge lowest price in each segment
- Monopolist earns uniform monopoly profit
- Allocation is efficient

An Information Structure Attaining Consumer Surplus Maximizing Segmentation

- Consider a finite set of values
- Create a segment consistent of all consumers with the lowest value and the proportion of consumers with all other higher values such that the monopolist is indifferent between charging the lowest value and uniform monopoly price
- Then a segment consistent of all remaining consumers with the second lowest value and the proportion of consumers with all other higher values such that the monopolist is indifferent between charging the second lowest value and uniform monopoly price
- And so on...
- Charge lowest price in each segment
- Monopolist earns uniform monopoly profit
- Allocation is efficient
- Consumer earns total feasible surplus minus uniform monopoly profit

Application 3: First Price Auction

- Four Cases:
  1. Symmetric / Complete Information (Bertrand Competition)
  2. Independent Private Values
  3. a few more special cases, e.g., Affiliated Values
  4. (this paper) All Information Structures

A Leading Example

- 2 bidders with private values uniformly distributed on the interval $[0, 1]$; bidders know their private values

1. Symmetric Information (Bertrand Competition):
    - each bidder bids lower value
    - revenue is expectation of lower value $= \frac{1}{3}$
    - total efficient surplus is expectation of higher value $= \frac{2}{3}$
    - bidder surplus is $\frac{1}{3}$ ($\frac{1}{6}$ each)

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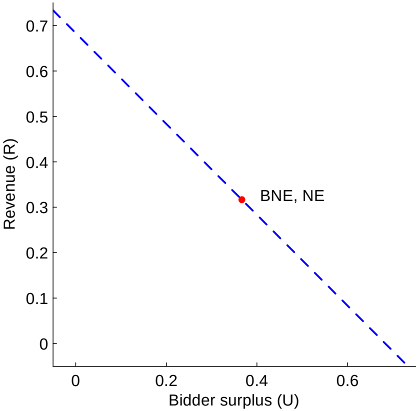
2. No Additional Information = Independent Private Values

A Leading Example

- 2 bidders with valuations uniformly distributed on the interval $[0, 1]$

1. Symmetric Information (Bertrand Competition)
2. Independent Private Values
   - each bidder bids half his value
   - revenue equivalence holds....as under complete information or second price auction...
     - revenue is expectation of low value $= \frac{1}{3}$
     - total efficient surplus is expectation of high value $= \frac{2}{3}$
     - bidder surplus is $\frac{1}{3}$

Graphical Representation



Failure of Revenue (and Surplus) Equivalence: Intuition

- Increase revenue, lower bidder surplus by telling bidders who is the highest valuation bidder and giving the high valuation bidder *partial* information about highest loser's value

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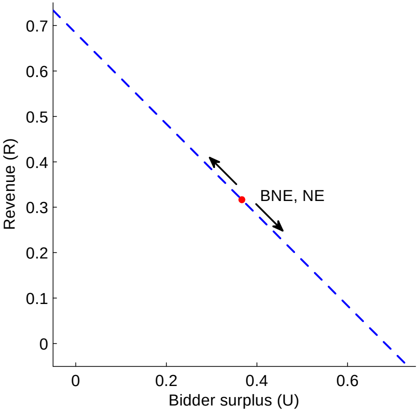
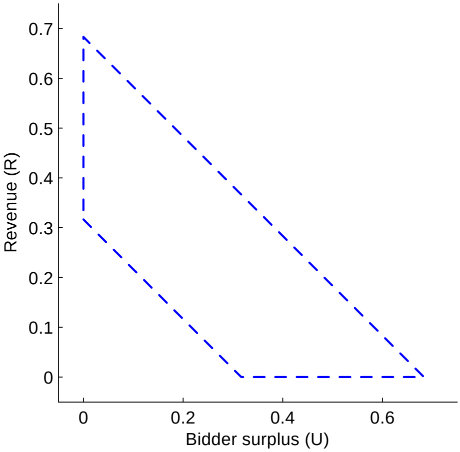
- Increase revenue, lower bidder surplus by telling bidders who is the highest valuation bidder and giving the high valuation bidder *partial* information about highest loser's value
- Decrease revenue, increase bidder surplus by maintaining bidder uncertainty about whether they will win and having all constraints on bidding higher binding (and no constraints on bidding lower)

Failure of Revenue (and Surplus) Equivalence



Feasibility and Participation Bounds



Two Cases: Known and Unknown Values

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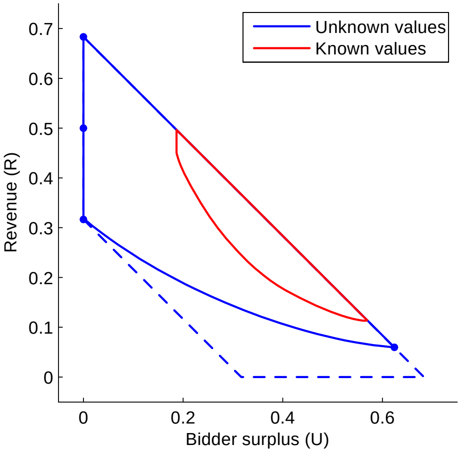
- More obedience constraints in known values case

Incentive Constraints



Application 4: Aggregate Volatility

- Fix an economic environment with aggregate and idiosyncratic shocks
- What information structure generates the most aggregate volatility?

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- Fix an economic environment with aggregate and idiosyncratic shocks
- What information structure generates the most aggregate volatility?
  - In general (symmetric normal) setting, confounding information structure (Lucas (1982))
  - Without aggregate uncertainty, intermediate information with common shock

Leading Example References

- Single player case with no information is leading example in Kamenica-Gentzkow (2011)
- Two player two action example with prior information analysed in Bergemann-Morris (2015)
- Goldstein and Leitner (2014) develop (rich) stress test application

References

- General Approach:
  - Bergemann and Morris (2013), **Robust Predictions in Incomplete Information Games**, *Econometrica*.
  - Bergemann and Morris (2015), **Bayes Correlated Equilibrium and the Comparison of Information Structures**, forthcoming in *Theoretical Economics*.
- Applications:
  - Oligopoly, Ecta paper
  - Price Discrimination: Bergemann, Brooks and Morris (2015), **The Limits of Price Discrimination**, *American Economic Review.*
  - Auctions: Bergemann, Brooks and Morris (2015), **Information in the First Price Auction**.
  - Volatility: Bergemann, Heumann and Morris (2015), **Information and Volatility**, forthcoming in *JET*

Information Design Recap

- **Mechanism Design**:
  - Incentive constraint: truth-telling
  - Other constraint: participation
- **Information Design**
  - Incentive constraint: obedience
  - Other constraint: prior information