Not So Happy Campers, CPR allocation under location and type sensitive agents

By: Will Ottenheimer

Introduction

Research Question?

“How do individual types and spatial distributions affect the socially efficient allocation method of a resource?”

Motivation

Why is this work being presented?

Where does this fit in with the world of environmental economics?

Aims and objectives of the project?

Motivation

Why is this work being presented?

Resource allocation is a fundamental concern for economics

Market outcome is not welfare maximizing (Externalities - non depleting)

Where does this fit in with the world of environmental economics?

Externalities and common pool resources

Aims and objectives of the project?

Determine cases for when and how a mechanism could enhance welfare

Contribution to existing literature

McAffee Miller (2012) - Coordination, campsites

Cao Gong (2017) - Quality Quantity effect, CPR

Chakravarty Kaplan (2013) - Costly signal, single unit of consumption

Choi Espinola (2017) - Bilateral Externalities, incomplete information

Introduction - Narrative

Two rival types - Boy Scouts & Spring Breakers

Spatially sensitive resource - Campsites

A formation of plots of resource - Base case is a line

An externality rule - condition for when externality occurs (positive and negative)

Model - Allocation Methods

Auction - represents market outcome

First price sealed bid auction

Mechanism

A regulator receives a costly signal of both type and value from individuals and allocates plots accordingly to maximize welfare

Model - Assumptions

Types are equally likely

Individuals desire at most one unit

Individuals don’t bid for any specific plot

Values distributed uniformly (0,1)

Strategic independence across individuals

Model - Variable Introduction

M - quantity of resource units

N - number of individuals

Θ_i - Individual type

V_i - Valuation of individual (iid also independent of type), used for bid and signal

V_{co} & V_{ic} - realized values based on externality

U_i - individual utility

$B(v_i)$ & $S(v_i)$ - bid and signal

Social Welfare : = $\Sigma_i^N U_i$ + transfer payments/bids

Model - Auction

P1 - probability of compatible externality

P2 - probability of incompatible externality

Auction Utility

Each individual will select bidding strategy $B(V_i)$ that maximizes

$E(U_A) = [p1(V_{co} - b) + p2(V_{ic} - b)] F^{(n-M)-1}((b^{-1}b(i))$

Model - Mechanism

$T(s_i)$ - transfer payment V_R - realized value

C - cost of sending signal $P_A(s_i)$ - Probability of unit allocation

Each consumer will send signal maximizing following utility iff that utility > 0

$$E(U_M) = P_A(s_i)(V_R - T(s_i) - C) + (1 - P_A(s_i))(-C)$$

Model - Value Realization

Realized value of the individual depends on the type of individuals the rest of the resource is allocated towards.

In our base model the positive and negative externalities will take the forms:

A compatible externality $V_{co} = (1+d)*V_i$ d is degree/severity of externality (0,1)

An incompatible externality $V_{ic} = (1-d)*V_i$

In other words d is how compatible or incompatible types are.

Methodology

We solve for the best consumer and regulatory strategies under the market outcome, Auction, and the externality sensitive mechanism and compare social welfare to determine which regime is most efficient.

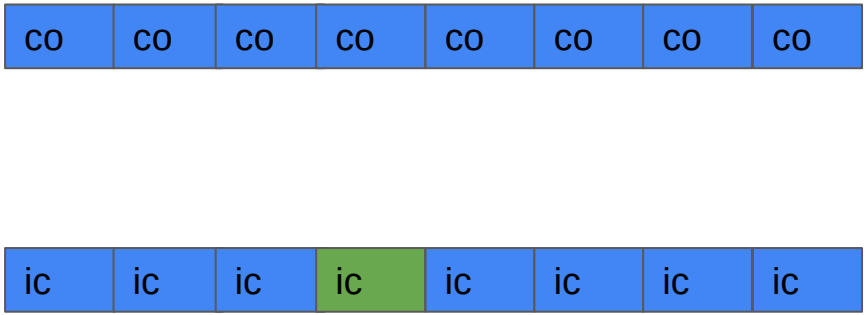
We repeat this process for two different cases of how the externalities are assigned.

Case 1 - No Tolerance

Suppose if there is not complete homogeneity of allocation then every agent suffers V_{ic}

Other examples

Fire risk or Disease vulnerability



Case 1 - Auction Outcome

Optimal bid is solved for

$E(U_A) = [p1(V_{co} - b) + p2(V_{ic} - b)] F^{(n-M)-1}((b^{-1}b(i))$

$$B(Vi) = E(Vi) - \frac{\int_0^{n-m} F^{n-m-1}(T)dT}{F^{n-m-1}(E(Vi))}$$

Proposition 1:

Assuming uniformly distributed valuations

Optimal Bid : $B(V_i) =$

$$E(Vi)\frac{N-M-1}{N-M}$$

Note $dB/dM < 0$

Case 1 - Mechanism Outcome

The central authority will base allocation decision on which combination of individuals and plots yields highest social welfare.

Incentive Compatibility:

A truthful signal about individual valuation results from the same procedure as the auction however with more shading since the signal is costly

A truthful signal about type is harder to advocate. The assumption of equally likely types is crucial. It means individuals can no longer anticipate the planner allocation strategy.

Case 1 - Mechanism Outcome

Based on the severity of the externality the planner may seek to only allocate the resource to a single type, this strategy gains further traction as m increases. When M increases the magnitude of the negative externality increases.

For the cases where the effect of the externality is less severe the welfare maximization strategy then prioritizes highest valuations. This mimics the auction outcome.

Resource will be fully allocated if $N/2 > M$

Case 1 - Comparison

V’ is average valuation of M highest individuals

Recall SW = $\Sigma_i U_i$ + transfer payments/bids

Auction E(SW) = .5^M*(1+d)(V’)*M + (1-.5^M)(1-d)(V’)*M

Mechanism E(SW)

V’’ is average valuation of M highest individuals of the same type

M*(1+d)(V’’) -C*N’ <= homogenous allocation

Or

.5^M*(1+d)(V’)*M + (1-.5^M)(1-d)(V’)*M - C*N’ <= mimic of auction

*Note $V' \geq V''$

Case 1 - Comparison

V’ is average valuation of M highest individuals

V’’ is average valuation of M highest individuals of the same type

The values of V’ and V’’ are random outcomes that determine the superiority of each regime.

Despite meticulous planning if the m highest value individuals are all the same type the market outcome is efficient (unlikely)

Comparative Statics

Increases in d and M make the signal mechanism more welfare enhancing

Increases in C and N make the market outcome more competitive

Case 2 - Localized Externality

V_{co} will occur when both neighboring plots go towards compatible types

V_{ic} will occur if at least one neighboring plot is allocated towards an incompatible type

Thick trees about the campgrounds

Case 2 - Auction Outcome

Individual strategy is the same as previous case

SW calculation changes as the probability of compatibility is much higher

Now

Auction E(SW) = $[.25(1+d) * \sum_{i=1}^{M-2} (Vi) + .75(1-d) * \sum_{i=1}^{M-2} (Vi)] + 2Vi$

Compatible

Incompatible Endpoints

Case 2 - Mechanism Outcome

The severity of the externality is scaled by the valuation so the social planner wants to ensure the highest value individuals receive compatible neighbors

If the two highest individuals are different types they each receive plots placed at the endpoints

Case 2 - Mechanism Outcome

Proposition 2

the social planner might find it optimal to not fully allocate the resource but instead leave a buffer zone if:

Some valuations are exceptionally high withs large gaps

very high negative externalities exist

This is a quality vs quantity effect

Case 2 - Mechanism Outcome

Planner will not fully allocate the resource if

$$(1-d)\sum_{i=1}^{2}(Vi) \leq (1+d)(Vi)$$

Case 2 - Comparison

Both expected SW are larger as the externality condition is less stringent

Auction E(SW) =

Signalling Mechanism

$$[.25(1+d) * \sum_{i=1}^{M-2} (Vi) + .75(1-d) * \sum_{i=1}^{M-2} (Vi)] + 2Vi$$

Fully allocated SW:

$$(1+d) \sum_{i=1}^{M-2} (Vi) + 2(1-d)Vb - CN'$$

Vb is average valuation at externality border

Buffer zone SW:

$$(1+d) \sum_{i=1}^{M-1} (Vi) - CN'$$

*There is a chance a homogenous allocation is optimal as in case 1

Results

Recall question : “How do individual types and spatial distributions affect the socially efficient allocation method of a resource?”

The type sensitive mechanism for high d,m and low c will likely perform better than the market result (auction)

In case 1 a higher n favors the market outcome but in case 2 this effect is diminished. The comparative statics match from case to case.

Complete information case - Social planner welfare always ≥ market outcome welfare as they consider externalities and allocate accordingly (no costs)

Extensions

Complete market individuals pay a fee to neutralize externalities (HOA)

Endless possibilities of spatial arrangements (Bricks, Grids, non geometrical plots)

Valuations dependent on types

Introduce additional types of individuals

Different externality schemes values diversity (Betta fish)

Possible Extension Case 3 - Downstream sensitivity

V_{co} will be realized when there are no upstream allocations outside of your type

V_{ic} will be realized if there is any upstream allocation outside your type

Ex:

Incompatible chemical pollutants