Market-Based Environmental Policy and Ecosystem Services Delivery

ECO-DELIVERY

European Investment Bank University Research Sponsorship (EIBURS)

Financial and Economic Valuation of Environmental Impacts

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Outline

- Why do we need to create environmental markets?
- Markets with single buyer: examples, challenges
  - Spatial coordination of land-use change and biodiversity conservation
  - Agglomeration Bonus and spatial coordination failure on local networks
- Markets with multiple buyers: examples, challenges

Motivation

- Increasing use of market-based environmental policy schemes; promise efficient delivery of environmental targets.

- Market-based schemes have proven difficult in achieving efficient supply of ecosystem services (ESS).
  - Multitude of resources and processes that are supplied by natural ecosystems (e.g., nutrient and toxins pollution control, flood mitigation, biodiversity, habitat for wildlife and plants, pollination)

Why do we need environmental markets?

- Because of missing markets with respect to ESS.
- Non-rival and non-excludable benefits means we get too few environmental goods in the absence of (government) intervention.
- Incentives motivate actions ➔ Creation of agri-environment schemes / markets.

Market of one buyer and many sellers

- Typically, Government establishes a Payment for Ecosystem Services (PES) scheme acting as a buyer.

- Typically, offers a uniform payment for contract to undertake specified management actions thought to "produce" environmental benefits.
  - e.g., biodiversity increase, water quality improvement, reduction of eutrophication (nutrient pollution)

- May be spatially-differentiated in terms of who can apply and how much they get paid.

- Payment rates usually set at average cost / profits foregone.
  - Opportunity costs of giving up agricultural land.

But this ignores…

- variations in supply price across producers → over-reward all but marginal landowner;
- variations in “ecological productivity” of land;
- variations in supply price according to quantity of environmental good produced.
- Main implication: buy less environmental outputs for a fixed budget.

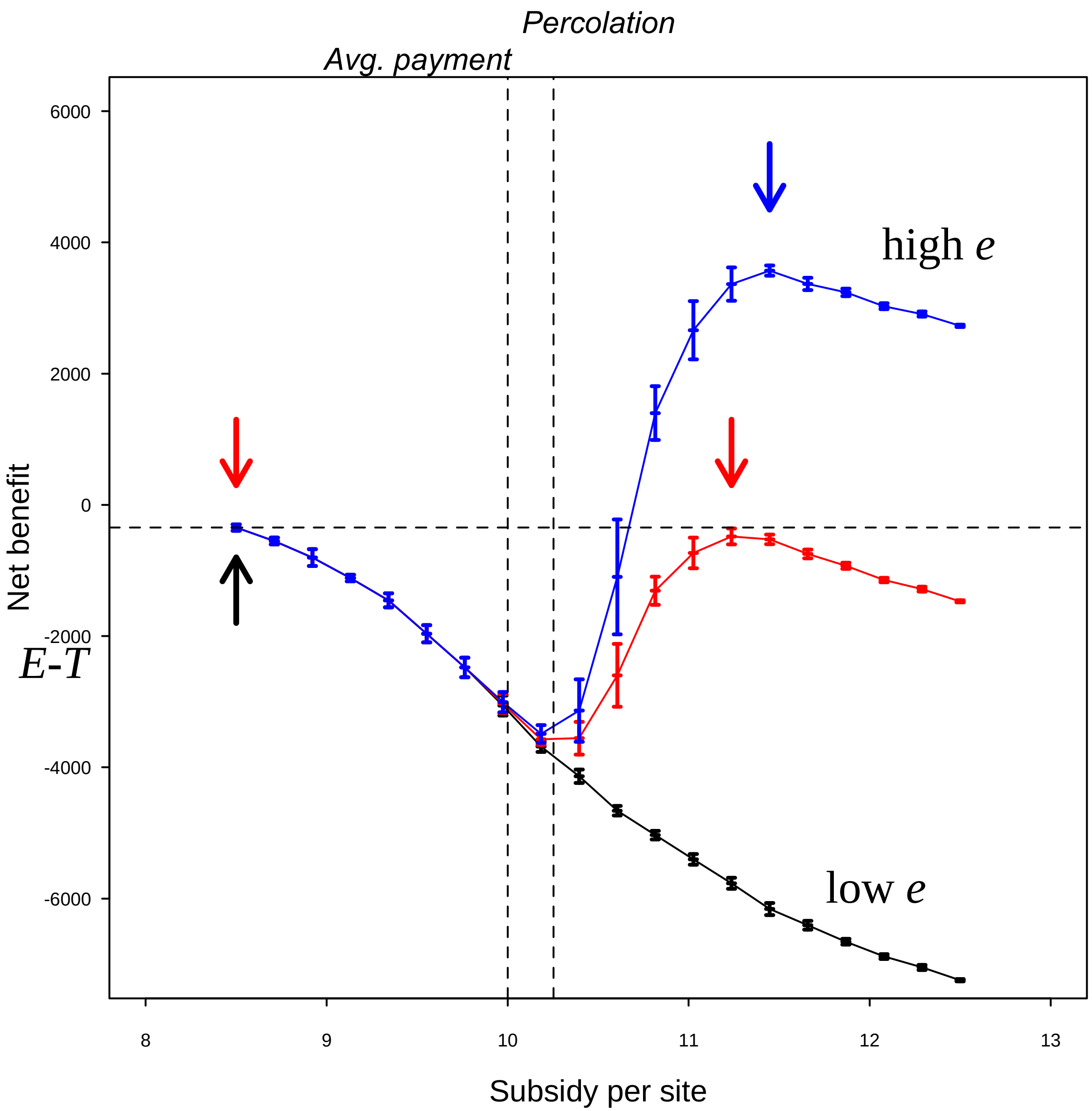
- Main features of the problem from an economic viewpoint are ***unknown variability in costs of actions*** by farmers.

- Also ***unknown spatial variation in ecological benefits*** of given actions.

- ***Risks of non-delivery*** since a range of "external factors" partly determine effects of management actions on ecological outcomes.

Project: Spatial coordination of land-use change and biodiversity conservation: uniform vs. agglomeration payment

- Main findings:
  - Payments adjusted for spatial coordination (APs) generally dominate uniform payment in cost-effectiveness; however, simple AP schemes do not improve the results significantly for "extreme" conservation requirements.
  - Importance of matching scales (correlation, dispersal, payment), information about opportunity costs, and specification environmental benefit function.
  - Plea for designing instruments that allow gaining information about opportunity costs (e.g., conservation auctions).



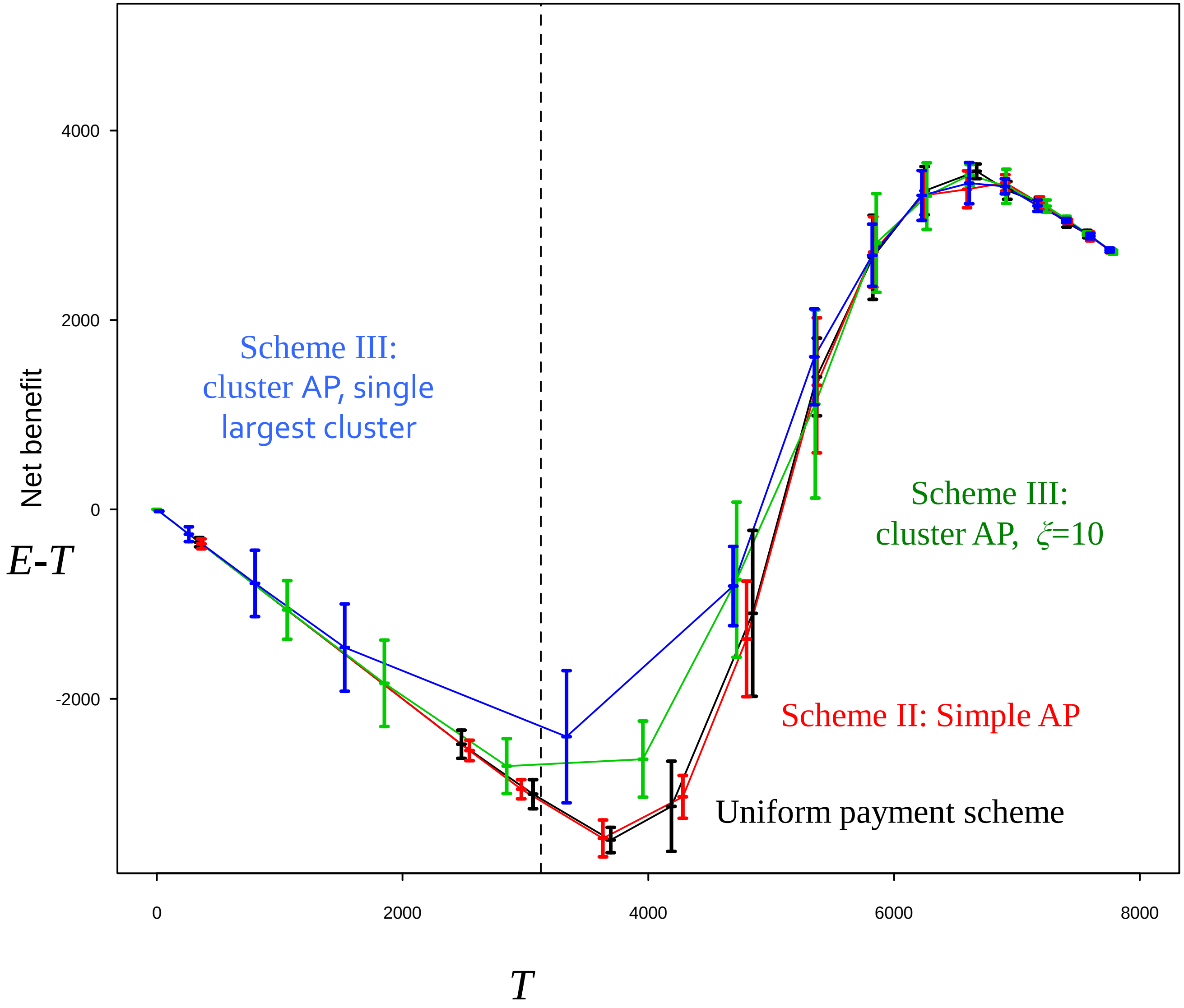
- Social planner regulates *c* to achieve best *E-T*, while individual farmers convert if *c* > *a*

$$T = \sum_{(i,j)\in \text{Converted sites}} c$$

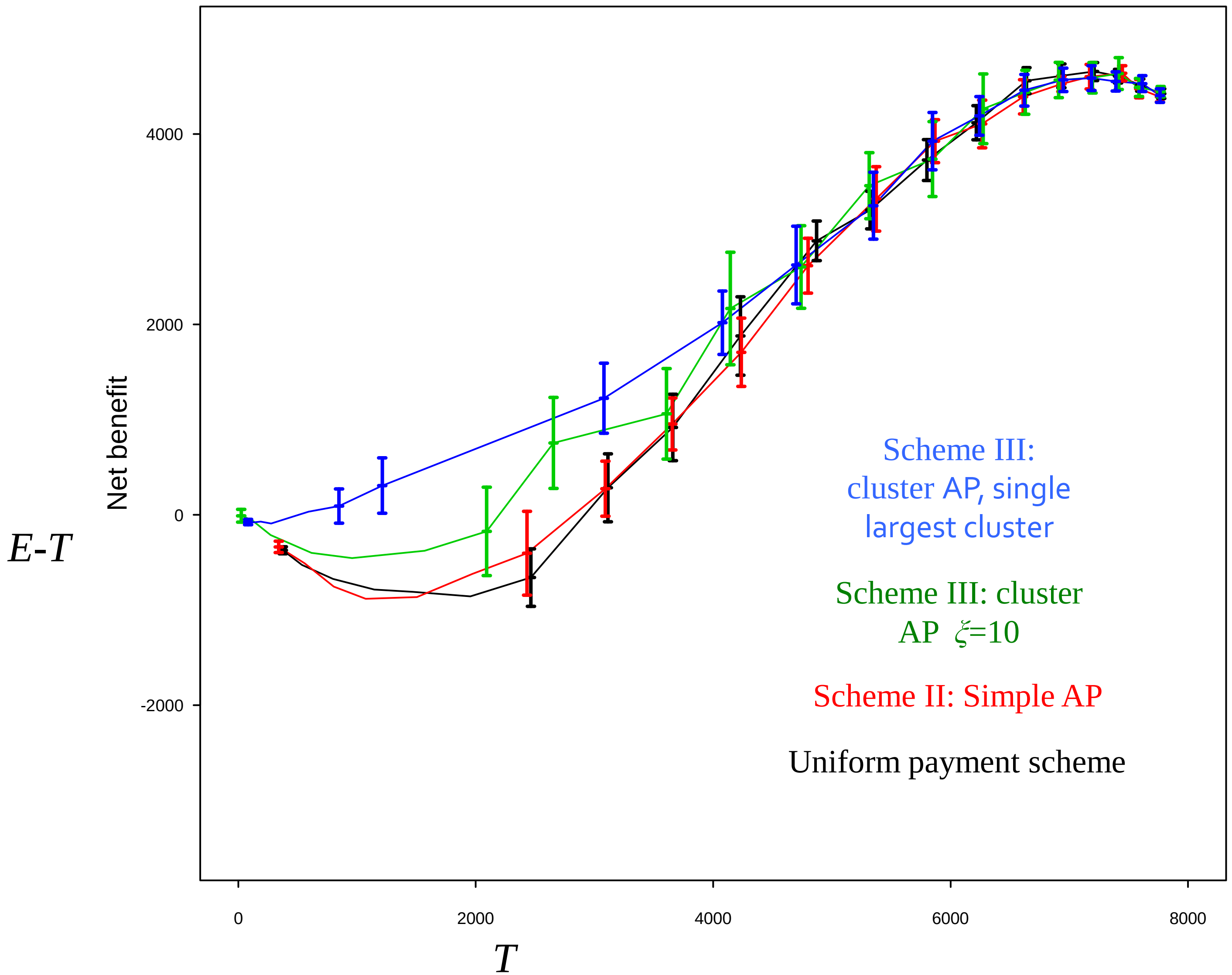
$$E = \sum_{(i,j)\in \text{Sites contributing}} e$$

- avg. payment = paying average opportunity costs
- "percolation" payment = payment enough to create a connected cluster

Scheme comparison



Correlated opportunity costs



Importance of opportunity costs – problem of asymmetric information

- Policy typically operates in setting of incomplete (and asymmetric) information.
- Government (regulator) may have better knowledge about relationship land management changes and environmental benefits.
- Landowners typically may have better (private) knowledge about their business (opportunity costs of production) than government.

Conservation auctions – one buyer

- Government is typically the single buyer, declares a demand for the "good" and invites bids from potential sellers (landowners).
- Landowners offer projects (land management actions) and decide price. Projects can have different costs and environmental benefits that vary across landowners.
- Projects selected which offer best value for money (until budget constraint is met).
- Competitive bidding: Lowest prices win the contracts (adjusted for expected environmental performance).

Advantages

- Information provision: bids reveal the "type" of landowner to the government (high versus low cost).

- Cost effectiveness: Compared to uniform subsidy schemes, means lowest cost suppliers participate.

Conservation auctions – examples

- Australia: numerous schemes under MBI programme for native bush conservation (BushTender) and water quality in NSW, Victoria, Queensland, WA.

- US: Conservation Reserve Programme (CRP).
    - Objective: funds be allocated on competitive basis; landowners make offers to obtain CRP cost share assistance based on environmental benefit index (scores on conservation priority areas, wildlife, water and air quality, erosion).

Problems with conservation auctions (1)

- Transaction costs of running auctions (competitive bidding).
  - Complex process, enforceability (monitoring compliance and possible sanctioning).

- If contract is over land management actions, will this deliver expected environmental benefits? (Can the auction discriminate effectively over expected environmental outputs anyway?)

- Spatial coordination: if environmental benefits depend on spatial spillovers, can auctions achieve such coordination?
  - Some evidence that the answer is yes – landscape corridor auction in Queensland

- Collusion amongst bidders can lead to erosion of cost savings over time (bidders "in the middle").

Problems with conservation auctions (2)

- Participation
  - Landowner experience, costly or complex process entering bid.

- Response of *unsuccessful* landowners (see Whitten et al, CSIRO, 2007)
  - Very little known about this.
  - Crowding out: unsuccessful bidders (landowners) stop making voluntary contributions to public good.
  - Crowding in: Bidders (landowners) learn about ecosystem services supply and see it is valued by community.

- Evidence from Australia from experimental studies and from actual schemes is that cost-savings can be realised.
- Design of environmental metric to weight bids is crucial.
- Role of information on others' bids; motivations; repeated rounds; transaction costs.
- Can have auctions where the contract is partly over outcomes (e.g. number of farmland birds) and partly over actions (Murray River, NSW).

Other design options/parameters

- Agglomeration bonus (AB): a two-part payment with (*i*) base payment and (*ii*) additional payment if neighbour signs up as well.
- Shogren and Parkhurst (several papers) show that this can produce a range of spatial patterns of enrolled land, but not likely to be cost-effective.
- Role of information on the offers of others; role of social capital.
- Varying contract length.
- Paying for outputs rather than management actions.
- Mixed schemes (part outcomes, part actions).

AB and spatial coordination failure on local networks: Implications for ESS delivery

- **AB: Two-part** PES scheme with participation component and bonus (*Parkhurst and Shogren 2007*).

- Strategic environment is **coordination game**
  - Landowners have to coordinate their actions

- Game has multiple strategies and **Pareto ranked Nash Equilibria.**

- **Repeated interactions** and **communication** leads to spatial coordination in lab experiments.

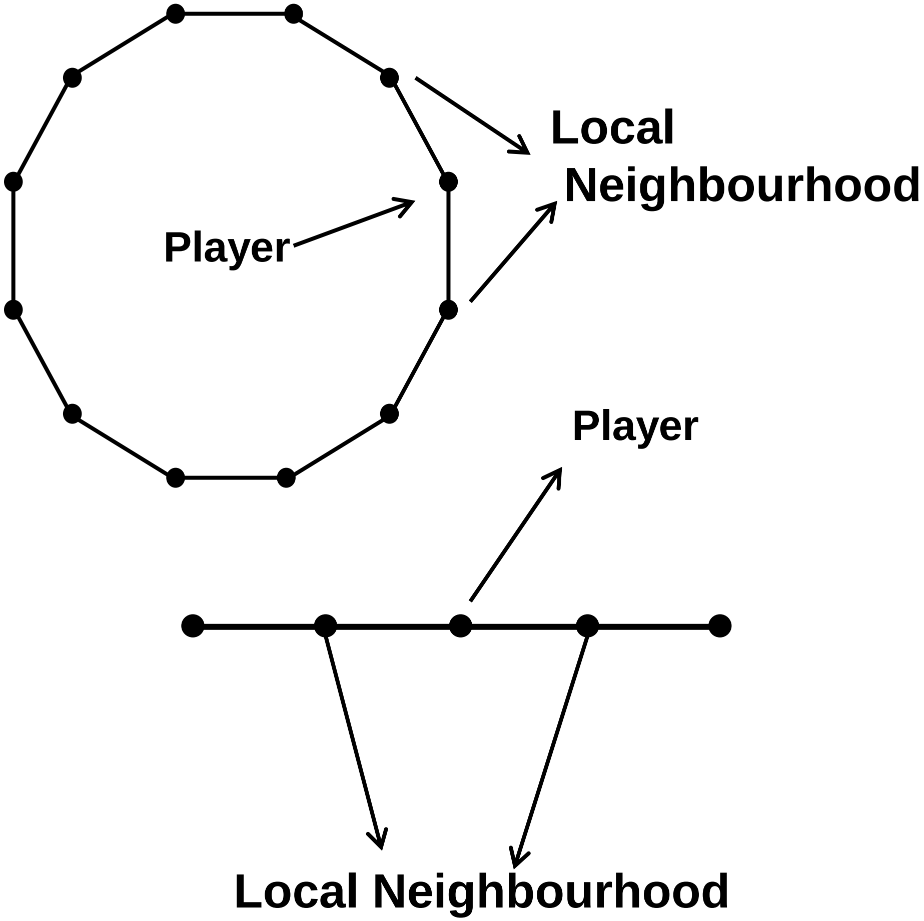
This study

- Objectives
  - Analyse ability of AB to achieve spatial coordination in environments with and without information about others' land management actions.
  - Identify factors (precedence, learning/experience, neighbours choices) which influence coordination and individual behaviour on local networks.
  - Derive lessons for (efficient) supply of ESS

- Main results
  - Spatial coordination incentivized with AB.
  - Information produces significant differences in behaviour and Nash Equilibrium obtained between treatments.

Local network environment

- Networks where agents linked to a subset of agents directly.
- Agents organized around circle (or line) are all part of local networks.
- Neighbours: Agents with **direct** links to an agent.
- Farming communities may be arranged as local networks on the basis of geography and nature of ecosystem services considered.



Research questions

- Does the AB incentivize spatial coordination on local networks?
- Which (Nash) Equilibrium gets selected on local networks?
- How does information feedback about others' actions impact behaviour and Equilibrium achieved on the network?
- What are the implications for ESS supply?

AB formally

$$u(\sigma_i) = r(\sigma_i) + s(\sigma_i) + n_{i\sigma} b(\sigma_i) \qquad \sigma_i = N, G$$

N: land abandoned to nature

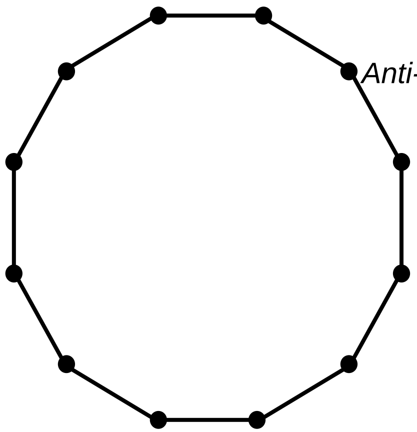
G: land employed for agricultural production

$r(\sigma_i)$	(net) agricultural revenue
$s(\sigma_i)$	participation component
$b(\sigma_i)$	bonus component
$n_{i\sigma}$	number of neighbours choosing land option σ_i

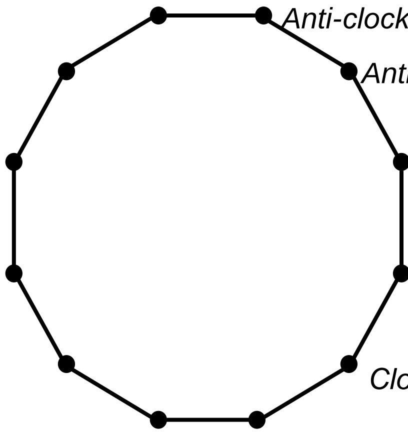
$r(N) = 0$	$s(N) = 10$	$b(N) = 40$
$r(G) = 50$	$s(G) = 10$	$b(G) = 10$

Experimental design (1)

Local Network for NO-INFO Sessions



Local Network for INFO Sessions



Neighbours' Choices

My Choice	*NN*	*NG*	*GG*
N	90	50	10
G	60	70	80

Source: Berninghaus et al. 2002, *Games and Economic Behaviour* 39(2)

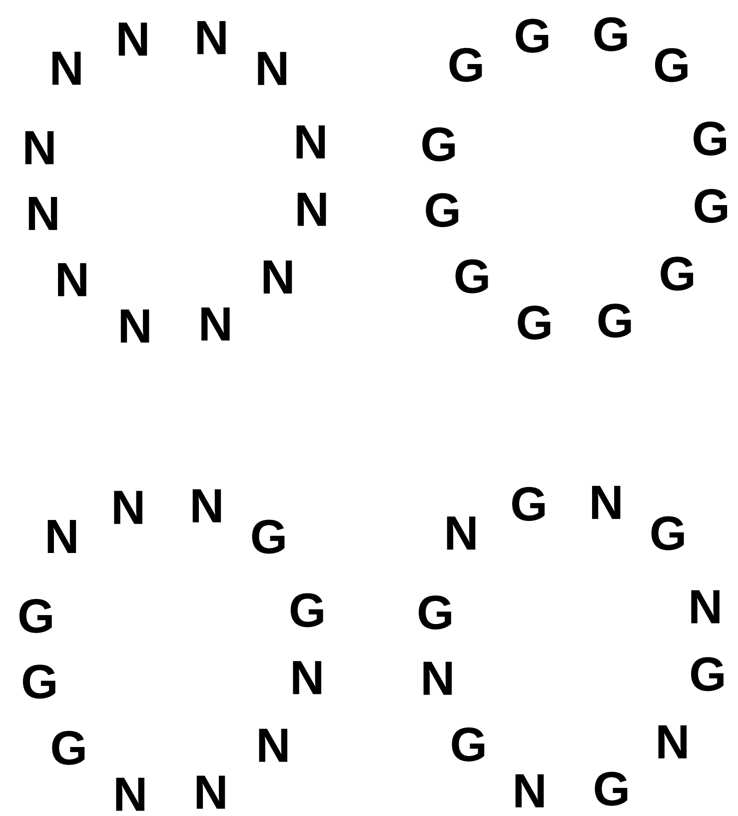
	Treatment	
	NO-INFO	INFO
# of sessions	6	6
# of players per session	12	12
# of periods per session	30	30
Payment structure	$5 show up fee Exchange rate – 150 ECU for US$1	

Experimental design (2)

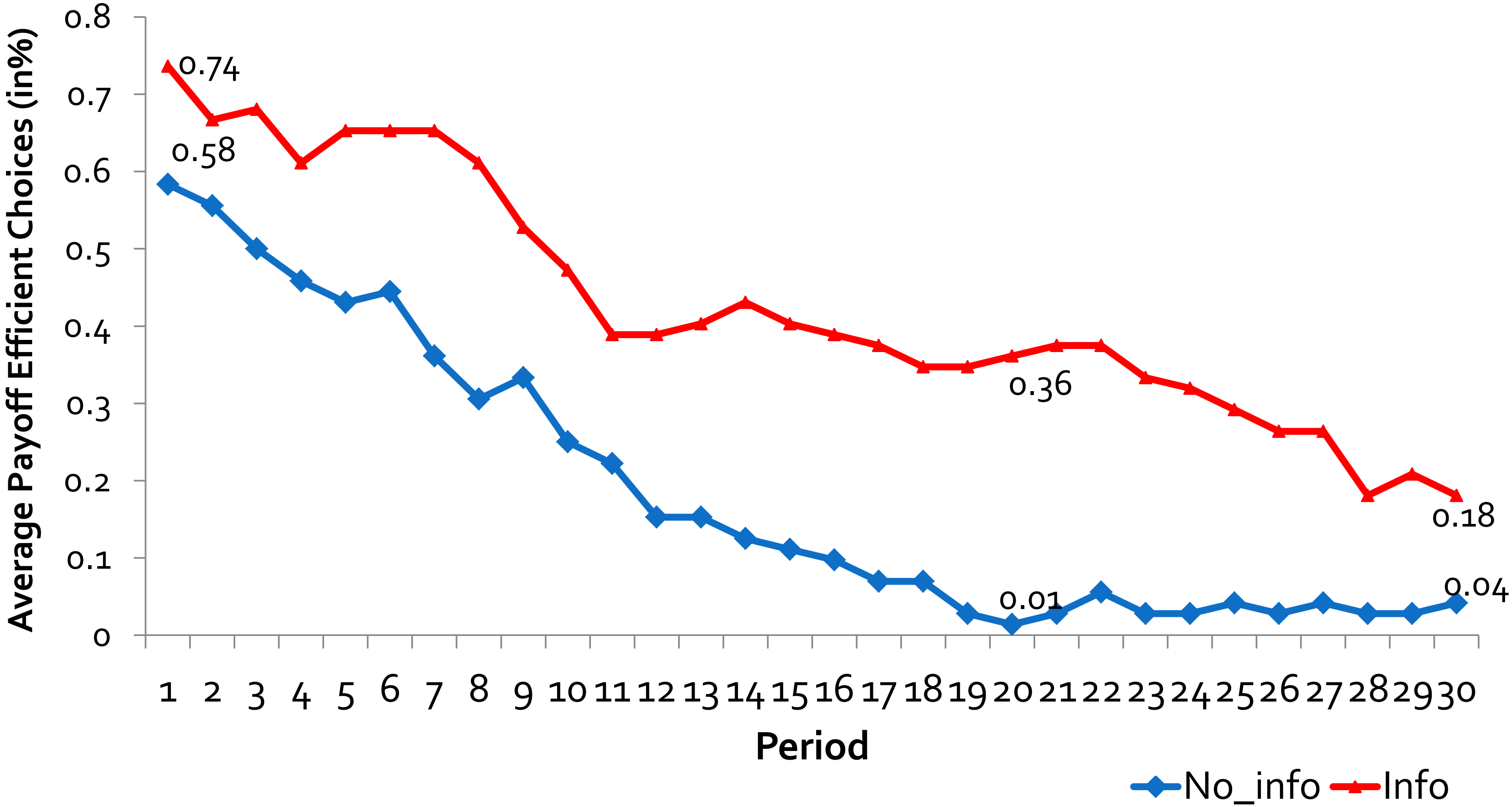
- 12 players on a circle with interaction neighbourhood of size 2.
  - Circle and individual locations shown to subjects before beginning experiment
- Coordination game has two strategies, *N* & *G*, and payoffs presented in Payoff Table.
  - Two Pareto ranked Nash equilibrium in pure strategies: $\sigma_i = N$ for all *i* (Payoff Dominant) and $\sigma_i = G$ for all *i* (Risk Dominant)
- In baseline **No-INFO** sessions players view choices and payoffs of neighbours in **interaction neighbourhood** at the end of every period.
- In treatment **INFO** sessions, players view choices and payoffs of direct and indirect neighbours in **information neighbourhood**.
- Players are able to see payoff table **whenever** they make a choice.
- Experiments conducted at Penn State University (Feb 2012) using Z-Tree.

Spatial coordination on network

- **Coordination**: Choice of efficient *N* strategy by everyone on the network
- **Coordination failure**: Choice of *G* by everyone
  - But still ecologically viable
- **Localized coordination**: Choice of *N* by 3 or more directly linked players
  - Also indicates localized coordination failure
- Ecologically-economically **inefficient outcome**
  - Alternating *N* & G
  - Fragmented land management



Individual *N* choices



Main observations

- Frequency of payoff efficient decisions falling over time.
- Significant treatment-specific differences between sessions.
- Systematic difference in behaviour from first period of experiment itself.
- Information about choices in larger information neighbourhood delays onset of inefficient *G* convention in INFO but may not prevent it in long run.

Summary of AB study

- Motivation:
  - Investigate spatial coordination and AB performance on local networks
  - Test impact of information available to subjects on land management choices
- Design:
  - Baseline NO-INFO: inform about choices of direct neighbours
  - Treatment INFO: inform about choices in information neighbourhood
- Main results:
  - Spatial coordination fostered by AB mechanism
  - Significant treatment-specific difference in selection of socially optimal Nash Equilibrium
    - **Localized area of coordination** in INFO treatment
    - More ESS delivered through social optimum in INFO treatment

Market of many buyers and many sellers

Government sets up the market by creating tradeable entitlements

- Can be related to a "cap" or "floor" on actions.
- "Firms" can buy and sell these entitlements.
- Demand and supply creates market.
- Potentially ***efficient*** solution for environmental policy, since results in a price being set for environmental actions.
- Can also increase returns to land management.
- Internationally, can result in financial transfers to developing countries.

- Most obvious example: pollution permits (cap and trade) – SO_2 trading in US, carbon trading in EU.

- Others:
  - Wetlands banking
  - Species banking (red cockaded woodpecker habitat)
  - Carbon trading related to land use
  - Point-nonpoint pollution trading for nutrient pollution reductions

Our work

- Investigating potential trading in “wetland offsets” in context where:
  - Developer needs to acquire offsetting new wetland hectares to allow development of existing wetland.
  - Ecological potential and value of different sites varies.
  - Relative ecological value between sites A and B determines the “exchange rate” for wetlands trading.
  - Multiple landowners offer wetland credits for sale, but exchange rate varies between each.

- Our research questions are:
  - How to best design such offset markets and
  - What kind of cost-savings are available from using an offset trading scheme relative to other kinds of policy where the regulator wishes to protect some target amount *and quality* of habitat.

- We are investigating this using:
  - Theoretical modelling
  - Simulation model for a UK estuary

But…

- How to initially allocate rights? Choice can create problems from rent seeking.
- Transactions costs of trading and enforcement.
- Duration of entitlements.
- Spatial coordination, again.

What would be useful?

- Knowing under what circumstances environmental markets work best.
- Knowing how to resolve problems related to participation, spatial coordination, and reducing transaction costs (simpler processes and monitoring, increased experience of administrators and bidders).
- Conservation auctions "in the field" are increasingly being deployed, although mainly at small scale level.
- Pilot projects in UK, learning from experience in US and Australia.

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