

Impact of Information Provision on Agglomeration Bonus Performance: An experimental study on local networks

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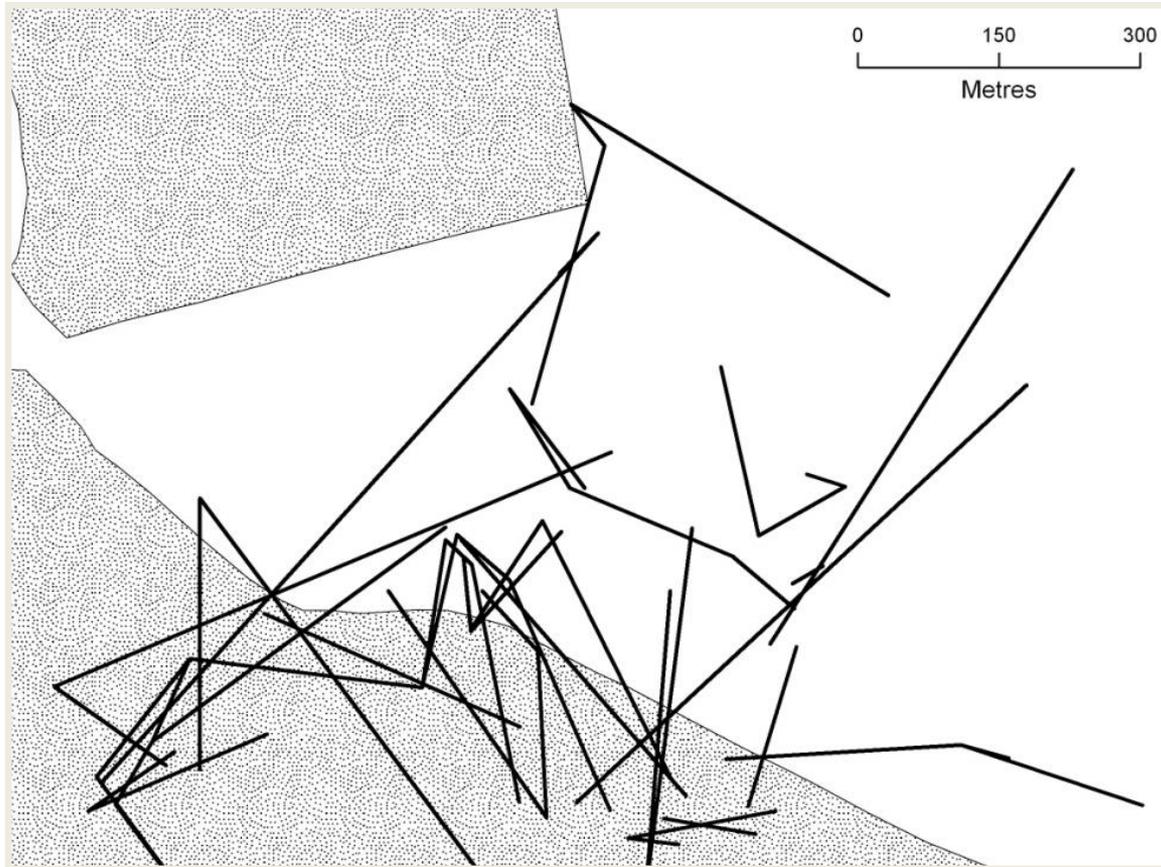
Payment for Ecosystem Services (PES) Schemes

- Many ecosystems delivering a variety of ecosystem services (ES) are located on **private properties**
- **Much biodiversity** is also found on private land
- Delivery of ecosystem services and biodiversity conservation are often contingent on costly changes in **land use patterns**
- **PES schemes** can be used to achieve *spatially coordinated land uses*
- But why are we interested in spatial coordination?

Ecological benefits and space

There are many examples where spatial coordination of landowner actions can improve biodiversity outcomes:

- Corridors for wildlife movement
- Minimum viable habitat size
- Creation of options for re-colonisation
- Species with demands on multiple habitats:



Movements of radio-tagged curlews between heather moorland (grey) and grassland (white)

(source: M.Dallimer, 2010, for a site in the Peak District National Park, England)

Spatial coordination can also be important in other situations

- Eg wetlands restoration (hydrologic connectivity); plant, crop and animal disease control; flood alleviation using soft flood defences (eg creation of grazing marshes).
- Different to spatial *targetting*, where we want to provide bigger incentives to particular landowners on grounds on spatially varying individual property ecological benefits

- Actual payment schemes which target spatial coordination across properties are rather limited:
 - bush corridor auctions in Queensland (Rolfe et al)
 - extra points under Higher Level Stewardship applications in UK
 - others?

The Agglomeration Bonus (AB)

- ..is a **Two-part** PES scheme with participation component & a bonus (*Parkhurst and Shogren 2007*)
- The AB is a **coordination game**
- This game has **Nash Equilibria**, which can be **Pareto Ranked**
- **AB** not likely to be cost-minimizing as farmers can be over-compensated for opportunity costs of participation.
- An important **tension** thus exists between enhancing spatial coordination and cost-minimization.

Agglomeration Bonus

- Experimental evidence suggests that spatial coordination can be incentivized through repeated interactions (Parkhurst & Shogren 2007)
- Extent of pre-play communication also matters (Warziniack et al. 2007)
 - Indeed, communication during the game also likely to matter...
- Likelihood of coordination to a particular equilibrium depends on agents' **information sets**
- Impact of information about others' choices depends on game environment and nature of information shared

Information and AB

- In farming communities, friends and neighbours
 - Exchange information about production methods
 - Share information about friends of friends and/or neighbors' neighbors' decisions
- Participants' land use choices may be impacted by degree of observability of others' choices
- No scientific evidence on impact of information exchange during game on AB outcomes: this is our contribution.

This Study

- Objectives

- Analyse ability of AB to achieve spatial coordination in environments with varying levels of 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 supply of ecosystem services and biodiversity conservation

- **Main results**

- Information produces significant differences in behaviour and Nash Equilibrium obtained between treatments.
- Over time, coordination to desirable ecological outcome declines.

A Local Network

- Unlikely that everyone knows everybody else in a community
 - we mainly interact with friends and neighbors
- Delivery of many ecosystem services influenced by landscape structure
- Global interaction setup inappropriate for AB game suggesting network refinement
- Local Networks: agents linked to a subset of agents directly termed **neighbours**
- Linked to everyone else indirectly through neighbours

Local Networks and Coordination

- Coordination: subjects' ability to coordinate to **Pareto efficient Nash equilibrium**
- Coordination Failure
 - More common on network than non-network environments
 - More frequent on bigger than on smaller networks (Banerjee, Kwansica and Shortle, 2012)
- Why?
 - Direct and indirect network links increase anonymity levels in the strategic environment
 - Increases players' **strategic uncertainty** in the game

AB formally

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

N : land managed for nature

G : land employed for agricultural production

$r(\sigma_i)$: (net) agricultural revenue

$s(\sigma_i)$: participation component

$b(\sigma_i)$: bonus component

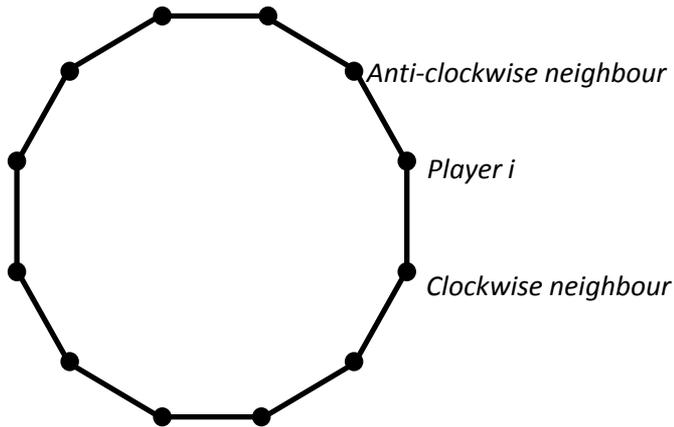
$n_{i\sigma}$: number of neighbours choosing land option σ_i

$$r(N) = 0 \quad s(N) = 10 \quad b(N) = 40$$

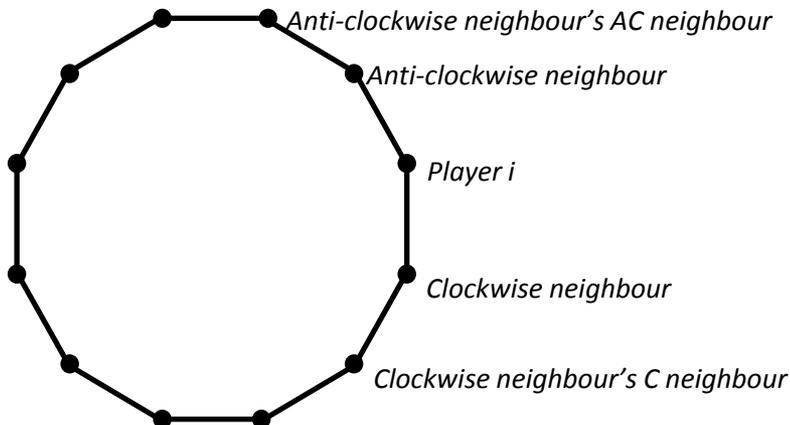
$$r(G) = 55 \quad s(G) = 5 \quad b(G) = 10$$

Experimental Design (1)

Local Network for NO-INFO Sessions



Local Network for INFO Sessions



Payoff Table

Neighbours' Choices

My Choice	Neighbours' Choices		
	<i>NN</i>	<i>NG</i>	<i>GG</i>
<i>N</i>	90	50	10
<i>G</i>	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. ..15

Z-Tree Input Screen

Strategy Chosen by My Neighbors

Period 1

	Both Choose M	One Chooses M & Other K	Both Choose K
Choose M	90	50	10
Choose K	60	70	80

My Strategy

Choose M

Choose K

Strategy you choose this period: M K

OK

Z-Tree Results Screen

Choice for the Present Period : choice of all players

Player ID	2	3	4	5	6	7	8	9	10	11	12	1
Player Choice				M	M	M	M	M				

History Table



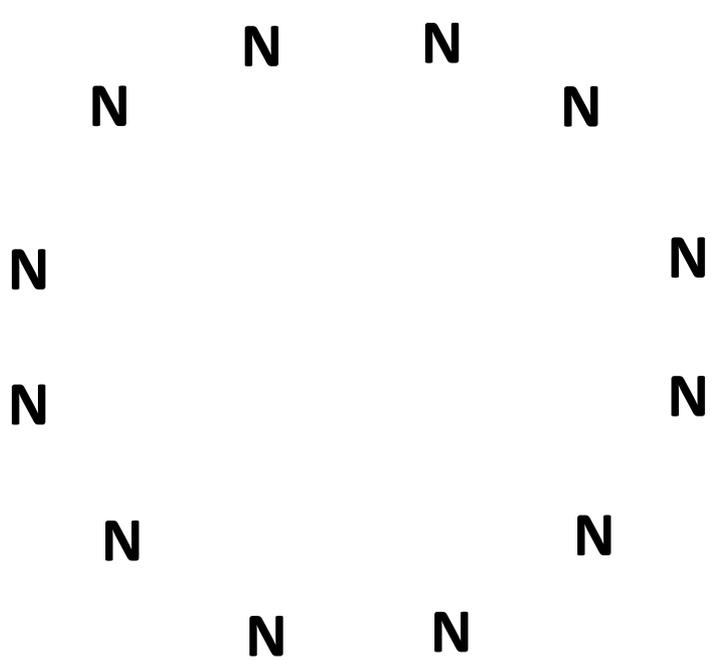
Period	Your ID	Your choice for the present Period	Your Profit for the present Period	Your C neighbor's choice for the present Period	Your C neighbor's Profit for the present Period	Your C neighbor's C neighbor's choice for the present Period	Your C neighbor's C neighbor's Profit for the present Period	Your AC neighbor's choice for the present Period	Your AC neighbor's Profit for the present Period	Your AC neighbor's AC neighbor's choice for the present Period	Your AC neighbor's AC neighbor's Profit for the present Period	Your Total Profit
1	7	M	0	M	0	M	0	M	0	M	0	0

Continue

Results

Network Level Spatial Patterns

Spatial Patterns on Networks



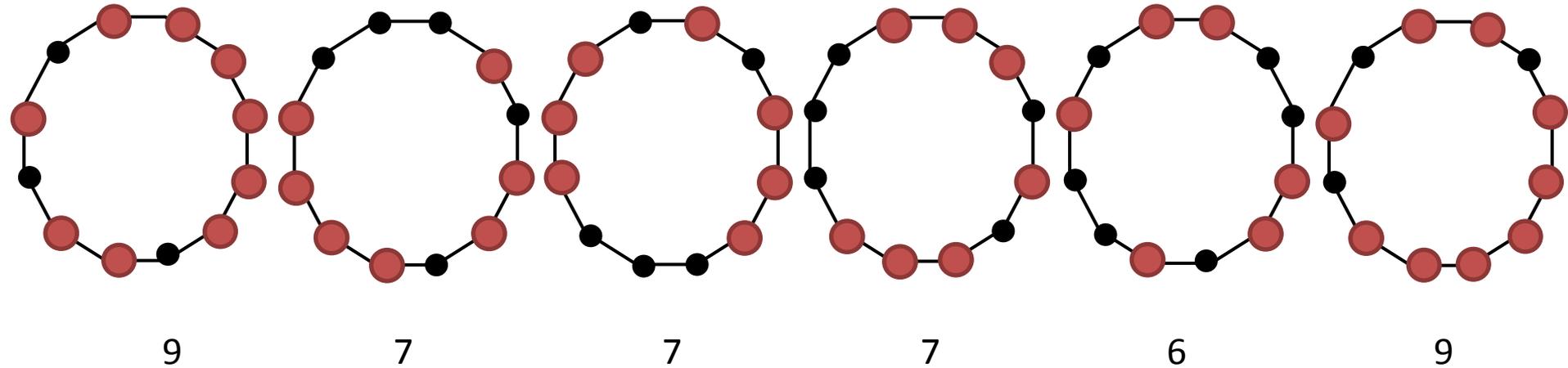
**First Best Globally Coordinated
Social Optimum**



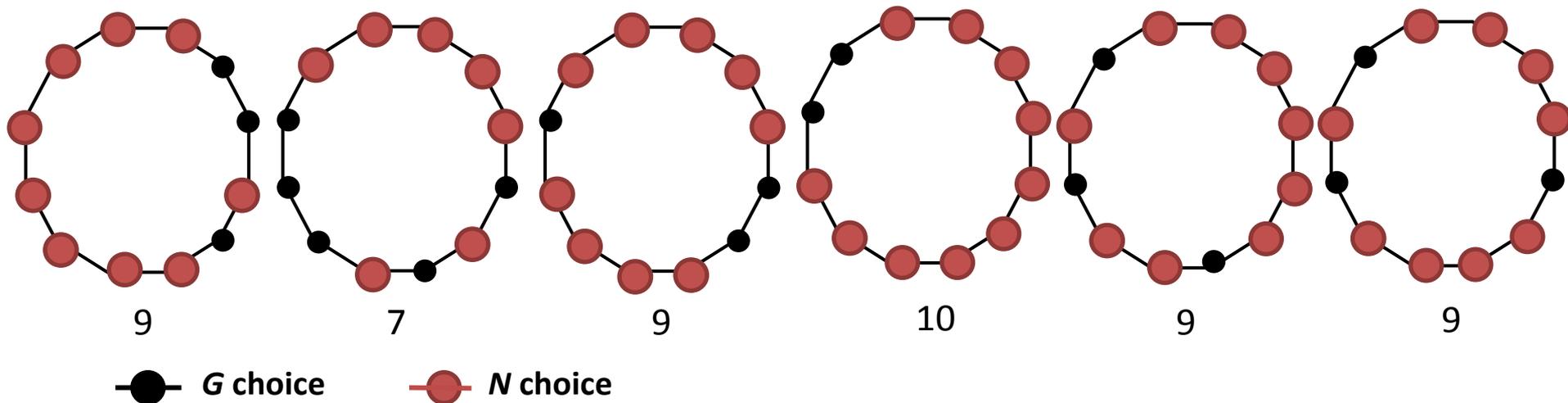
Second Best Globally Coordinated Outcome

1st Period Decisions

No-Info Sessions



Info Sessions

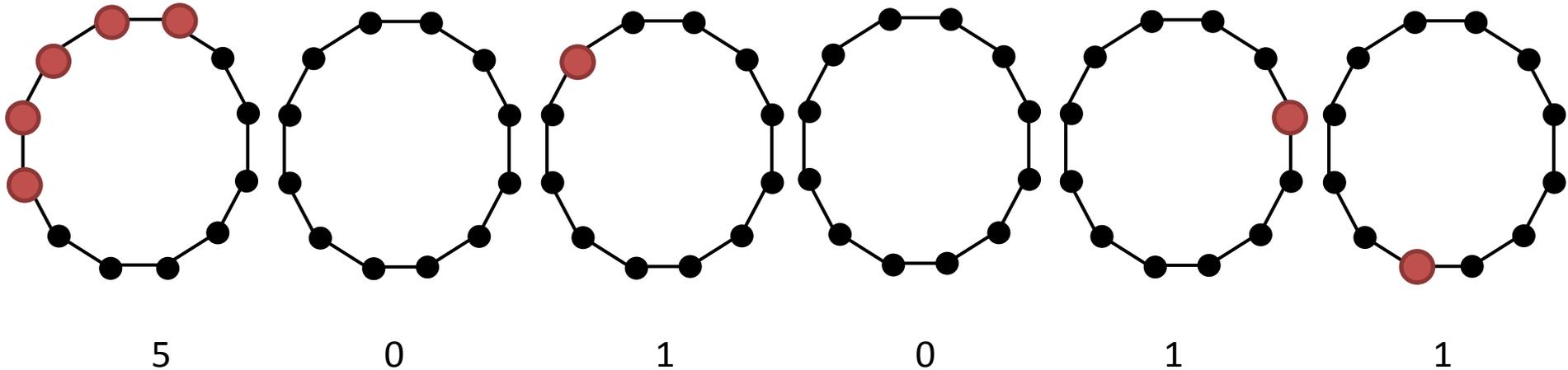


● G choice

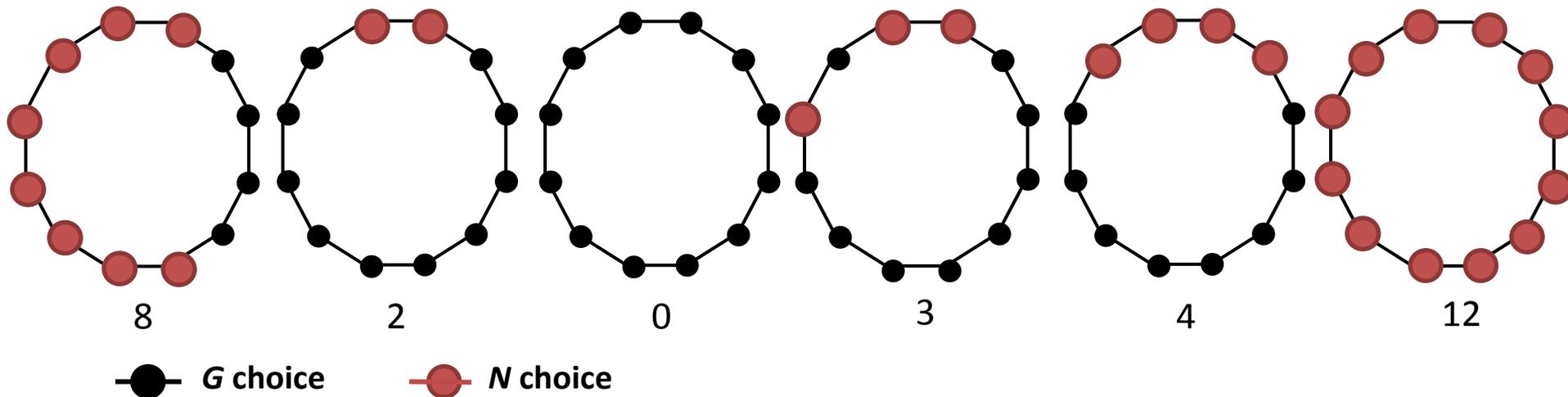
● N choice

15th Period Decisions

No-Info Sessions

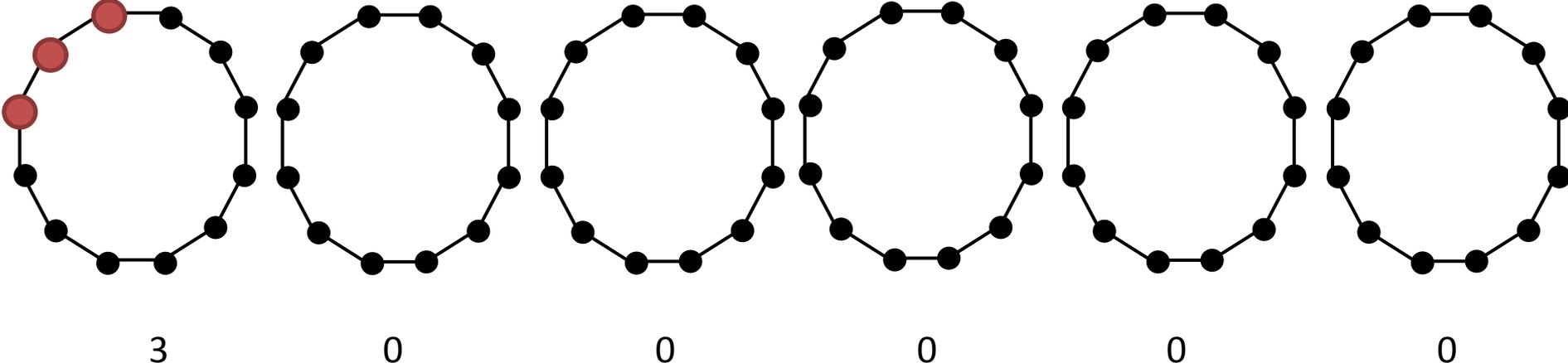


Info Sessions

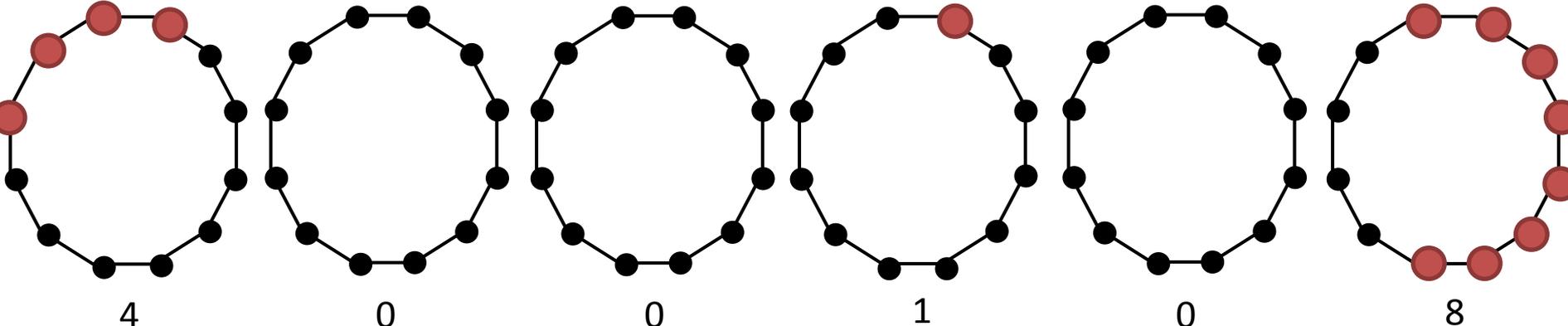


30th Period Decisions

No-Info Sessions



Info Sessions



● G choice

● N choice

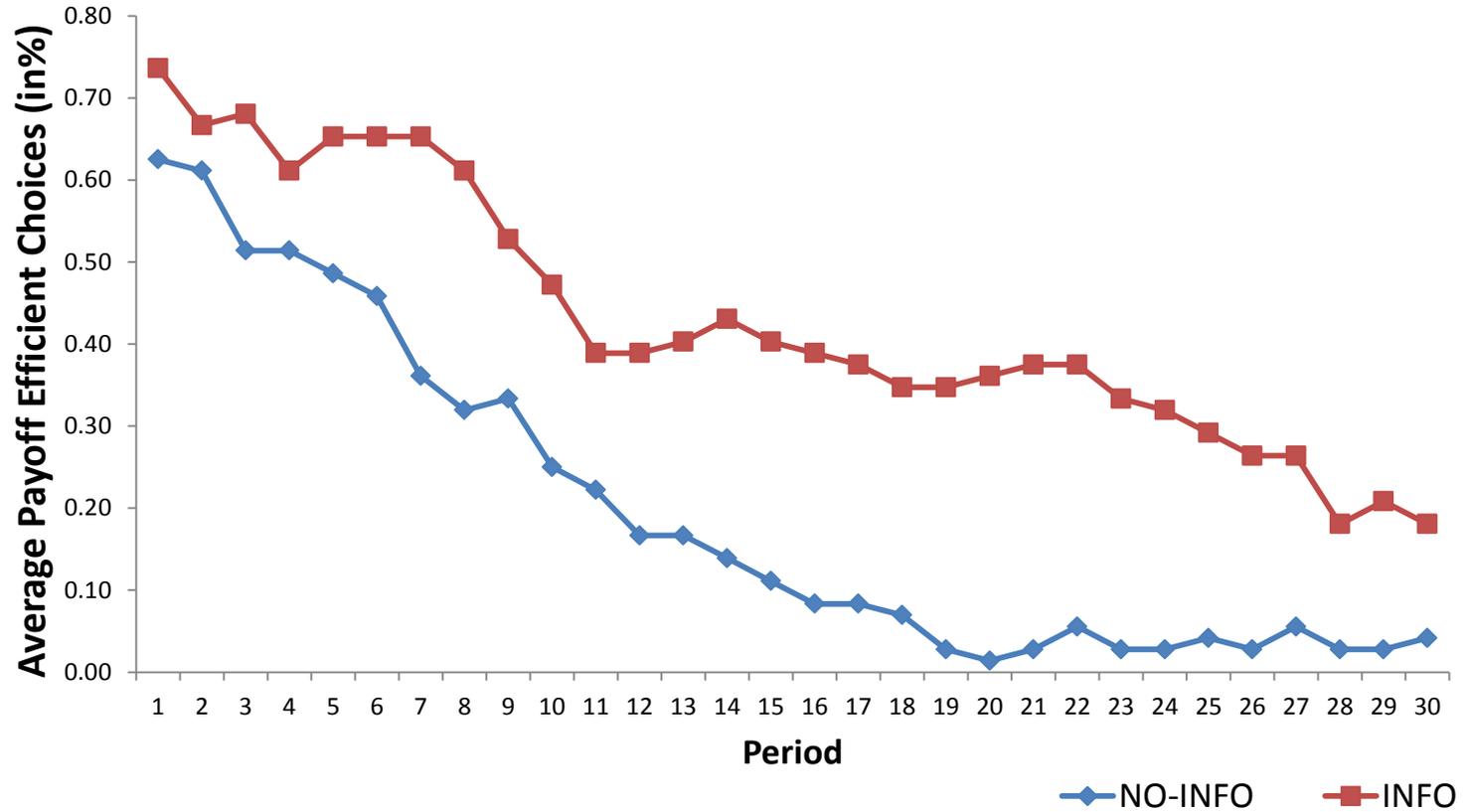
Study Findings

- AB configurations **significantly different** between treatments
- *All-G* & few *N-clusters* more likely in the long run
 - *All-G* owing to strategic uncertainty
 - *N-clusters* owing to network structure: **localized coordination**
- *N-clusters* more likely in **INFO** sessions
- ***All-N* configuration never produced in long run**
 - Owing to very large group size & **high strategic uncertainty**

Results

Determinants of Individual Behavior

Individual N choices



Study Findings

- Information about direct and indirect neighbors increases the likelihood of choosing N
- Significant difference in behavior from the outset of the experiment
- Negative impact of experience on likelihood of choosing N
- Information about choices of indirect neighbors delays onset of *all-G* in INFO but does not prevent it in long run

Random Effects Probit Regression

Independent Variables	Dependent Variable: Binary Variable Taking 1/0 value for N choice		
	Model 1	Model 2	Model 3
Treatment	1.223** (0.475)	0.705* (0.231)	0.196* (0.069)
Period	-0.108* (0.021)	-0.074* (0.013)	-0.036* (0.013)
Action in Previous Period	--	1.381* (0.19)	1.49* (0.132)
Previous Action X Period	--	0.029 (0.02)	-0.003 (0.01)
Neighbors in Previous Period Choosing N	--	--	0.871* (0.086)
Previous Neighbors X Period	--	--	0.023* (0.005)
Constant	-0.088 (0.287)	-0.764* (0.164)	0.196* (0.069)

* represents 1% level of significance, ** represents 5% level of significance with robust standard errors (clustered at group level) in parentheses.

Estimation Results

- Significant treatment effect indicating greater likelihood of choosing N in INFO than in NO-INFO
- Increasing experience leads to a fall in the frequency and likelihood of N choices in both treatments
- There is a significant positive precedent effect on likelihood of current period N choices
- Significant positive impact of neighbors' (in interaction neighborhood) N choices on the likelihood of choosing N in current period
- Interaction between neighbors' choices and experience positive & significant

Summary

- Objective
 - Analyze impact of varying information structures on AB policy performance on local networks
- Experimental Design:
 - Baseline NO-INFO sessions: inform about choices of direct neighbours
 - Treatment INFO: inform about choices of direct & indirect neighbours
- Main results:
 - More information has significant effects on spatial patterns and individual behaviour within an AB.
 - But over time, get less coordination to ecologically-desirable outcome.

What can we say about policy?

- AB provides incentives for spatially coordinated land management
- AB configurations correspond to ecologically superior outcomes in the “more information on neighbours” case
- Note we avoided problems of “hold outs” (Lennox and Armsworth) and edge effects
- Producing socially optimal outcomes will require more information about other players or other mechanisms to reduce strategic uncertainty (eg reduce transactions costs)

- Also, gains from enhanced spatial coordination associated with the AB will vary according to ecological/ES targets → not the best option for all cases, especially if landowners earn high rents.
- Relative importance of communication versus information provided?

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