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Transaction Costs and Spatial Coordination in Conservation Incentive Schemes: An Experimental Study*

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Abstract

An Agglomeration Bonus is used in some environmental conservation incentive schemes to reward private landowners to spatially coordinate their land use decisions and enhance the supply of environmental benefits--ranging from habitat and species protection, water pollution control, and pollination services. This creates a coordination game with multiple Pareto ranked Nash equilibria corresponding to different spatially coordinated land use patterns. We experimentally analyze the levels of participation and performance when landowners have to incur a transaction cost prior to participating. The experimental design varies (within-session) the transaction costs at two levels, which affects the risks and payoffs of coordinating on the different equilibria. To study spatial coordination, all subjects are arranged on a circular local network with every individual having two strategic neighbors. The experimental results indicate that there is a significant difference in participation levels in the first phase of the experiment – participation is higher under the low transaction cost regime. However over time, subjects' strategic uncertainty in the game gets resolved in favour of the less risky agglomeration game equilibrium that is Pareto inefficient. In the second phase of the experiment, no significant transaction cost treatment effect is observed and participation rates as well as rates of Pareto efficient agglomeration game choices are falling. Focusing on instances of spatial coordination, we observe higher levels of localized coordination on the network where a subject is found to choose the same strategy as their adjacent networked neighbors. These results indicate that the agglomeration is able to provide the incentives necessary for spatial coordination albeit at the local level on the network.

JEL codes: Q15, Q57, Q58

Keywords: agglomeration bonus, spatial coordination, transactions costs, agri-environment schemes, PES.

Introduction

Conservation incentive schemes are now a common element of agricultural and environmental policy in many countries, offering landowners financial incentives in return for contracted actions designed to increase the supply of environmental goods (Hanley et al. 2012). In many instances, spatial coordination is a desirable feature of such schemes, in the sense of delivering greater environmental benefits compared to a situation where the uptake of contracts is spatially un-coordinated. Examples of spatial coordination leading to higher environmental benefits include biodiversity conservation on farmland (Merckx et al. 2009; Dallimer et al. 2010; Wätzold et al. 2010; Wätzold et al. 2010); schemes intended to produce water quality improvements (Lane et al. 2004; Lane et al. 2006); native vegetation restoration (Windle et al. 2009); and species reintroduction programmes on private land where corridors permitting movements are needed , or where a certain minimum size of contiguous habitat is needed (Williams, ReVelle, and Levin 2005; Önal and Briers 2006).

Since the acceptance of conservation contracts by private landowners is voluntary, economists have looked for means of incentivising spatial coordination through the structure of payments offered. One such idea that has gained traction in the literature is the Agglomeration Bonus (Parkhurst and Shogren 2007). The Agglomeration Bonus is a two part payment schedule whereby landowners receive some amount $x per hectare for participating in the scheme, plus a bonus $y if their neighbour also participates. "Neighbour" can be defined in many ways, one of them being when a landowner's property adjoins that of another at any point along a boundary. Lab experiments, field experiments and simulation models have all been used to show that such a payment structure can produce a range of desired simple spatial patterns of enrolled land in a landscape. However, lab experiments have also shown that the agglomeration bonus can often result in an outcome which is a risk-dominant rather than Pareto-dominant Nash equilibrium. Thus the agglomeration bonus may not induce a cost-effective allocation of conservation effort since farmers can be paid more than their true supply price for the environmental good.

As with all conservation incentive schemes, concerns have been raised about the transactions costs of implementing an agglomeration bonus scheme (Shortle, Abler, and Horan 1998; Kampas and White 2004). Such costs include the costs to landowners of negotiating with neighbours and from determining the relative payoffs of signing and not-signing a contract. Transactions costs to the implementing authority include policy design costs, negotiation and contract signing costs, and then monitoring and enforcement costs. Higher transactions costs to farmers have been shown to reduce participation in agri-environment schemes in the European Union (Falconer and Saunders 2002; McCann et al. 2005; Mettepenningen, Verspecht, and Van Huylenbroeck 2009). More complex designs of incentive scheme are likely to face landowners with higher transactions costs, and thus deter sign-ups. It seems likely, then, that the success of an agglomeration bonus scheme in achieving a given spatial pattern of conservation actions will depend on the size of transactions costs relative to the pay-offs of enrolling or staying out.

Variations in transactions costs may be linked to the environmental objectives of a subsidy scheme. For example, a conservation objective which requires the creation of landscape corridors to permit species movements might well involve higher search and bargaining costs than an objective which requires the creation of contiguous "patches" of enrolled land. We make use of this idea in our experimental design, whereby we set up different environmental objectives or outputs which vary in their transactions costs.

The questions which our paper seeks to address are thus the following. First, what is the degree of participation in agglomeration bonus schemes under different levels of transactions costs? Second, what can be said about the nature of spatial coordination between landowners and neighbors when participants face different levels of transaction costs? Finally, how do variations in transaction costs of participation impact individual behaviour?

It is not practical to exogenously manipulate the size of transaction costs for conservation schemes in the field. Therefore, to answer these questions we conduct a controlled laboratory experiment with subjects arranged around a circular local network of size eight. This network structure serves two purposes. First, it attaches location specific identities to decision-makers and allows for an explicit spatial structure for the strategic environment. Second, it allows us to draw on as well as contribute to the body of experimental literature on equilibrium selection and individual behaviour in coordination games on networks (Berninghaus, Ehrhart, and Keser 2002; Cassar 2007). On this network, every individual is connected to two direct neighbors to their left and right and the five other people through their direct neighbours. Our experimental treatment involves a within-subject treatment in which we vary the transaction costs of participation faced by every player. In one type of session, participants face a high transaction cost for the first fifteen periods of the experiment followed by a low one in the remaining fifteen periods. In the second set of sessions, the transaction cost treatment ordering is reversed.

The experimental results indicate that there is a significant difference in participation levels in the first phase of the experiment – participation is higher under the low transaction cost regime. However over time, subjects' strategic uncertainty in the game gets resolved in favour of the less risky agglomeration game equilibrium that is Pareto inefficient. In the second phase of the experiment, no significant transaction cost treatment effect is observed and participation rates as well as rates of Pareto efficient agglomeration game choices are falling. Focusing on instances of spatial coordination, we observe higher levels of localized coordination on the network where a subject is found to choose the same strategy as their adjacent networked neighbors. These results indicate that the agglomeration is able to provide the incentives necessary for spatial coordination albeit at the local level on the network.

2. The Model

There are $i = 1, \ldots, N$ landowners who face two simultaneous decision opportunities related to their land use. The first decision entails whether or not to participate in a conservation incentive scheme. Let us denote NP_i representing the case of non-participation by landowner i. When a landowner decides to participate, he can choose to use his land for two types of conservation uses: $\sigma_i = A, B$. These types of land uses for conservation provide different levels of ecosystem services. We assume that land use type A delivers higher ecosystem service benefits than land use type B; NP reflects the situation where the landowner devotes their land to profit-based conventional agriculture instead of participating in the agglomeration bonus scheme and hence receives only agricultural returns and no environmental services payments from the conservation agency.[1]

Since we are interested in the spatial coordination of conservation efforts by fostering contiguity of similar land use practices, we assume the government implements an agglomeration bonus scheme following (Parkhurst and Shogren 2007). This scheme consists of two payoff components. The base component is a simple participation subsidy, $s(\sigma_i)$, which a landowner receives if they decide to sign up for the scheme. This payment is the same as the standard environmental services subsidy and is intended to compensate for any opportunity cost of conservation land uses relative to the profit-maximising agricultural practice. An additional bonus, $b(\sigma_i)$, is received if a neighboring landowner implements a

[1] Spatial coordination of traditional agricultural land use practices (NP, in our model) can also deliver ecosystem services such as reduction in soil erosion and biodiversity benefits by providing nesting and foraging habitats for rodents and field birds. These benefits are, however, not additional as they are associated with business-as-usual land use practices. Since one of the criterion for receiving environmental services payments is additionality (Wunder 2007; Engel et al. 2008), such benefits are usually not rewarded by the conservation agency and we do not consider them in our model.

similar land use practice as the landowner *i*. It is assumed that the bonus is proportional to the number of neighbors, with $n_{i\sigma}$ denoting the number of neighbors of landowner i choosing land use type σ_i. We assume that the agency provides agglomeration bonus payments for adoption of pro-conservation land uses on one parcel only, i.e., the landowner cannot choose *A and B* as part of the AB scheme. We make this assumption because conservation incentive schemes usually involve a menu of land use practices out of which landowners can pick one or many which are suitable for their property, and payment scheme budgets are limited so the regulator may not be able to pay for the various types of ecosystem services produced on private properties (Cooper, Hart, and Baldock 2009; Armsworth et al. 2012). Further, let $r(\sigma_i)$ denote the agricultural revenue under land use σ_i.

If landowner *i* chooses to participate in the scheme she incurs transaction costs, T_i. For simplicity, we assume that the transaction costs across landowners are homogeneous, i.e., $T_i = T$. The size of the transaction costs can vary substantially and as such may affect the participation in the scheme. Hence the magnitude of the transaction costs is our treatment variable and we distinguish between two levels of T: *High* or *Low*.

The payoff of landowner i under the agglomeration bonus scheme, $u_i(\sigma_i)$, is now as follows:

$$u_i(\sigma_i) = \begin{cases} r(\sigma_i) + s(\sigma_i) + n_{i\sigma} b(\sigma_i) - T & if\ \sigma_i = A, B \\ r(\sigma_i) & if\ \sigma_i = NP \end{cases} \tag{1}$$

As can be seen from (1), given participation, the payoff derived from the agglomeration component, $n_{i\sigma} b(\sigma_i)$, is driven by the number of neighboring landowners choosing similar land use practice, $n_{i\sigma}$. However, the number of neighbors is contingent on the specific network structure of the landscape on which landowners interact with one another, and this network structure can typically take many forms. Because our focus of the analysis is on the effects of varying transaction costs on participation and spatial coordination, we imposed a simple circular structure following Banerjee, Kwasnica, and Shortle (2012). This network structure, as illustrated in Figure 1, implies that each individual landowner can only interact "locally" with two of its direct neighbors – one to the left-hand side and one to the right-hand side. Hence, on our circular local network $n_{i\sigma}$ can either take the value 0, 1 or 2.

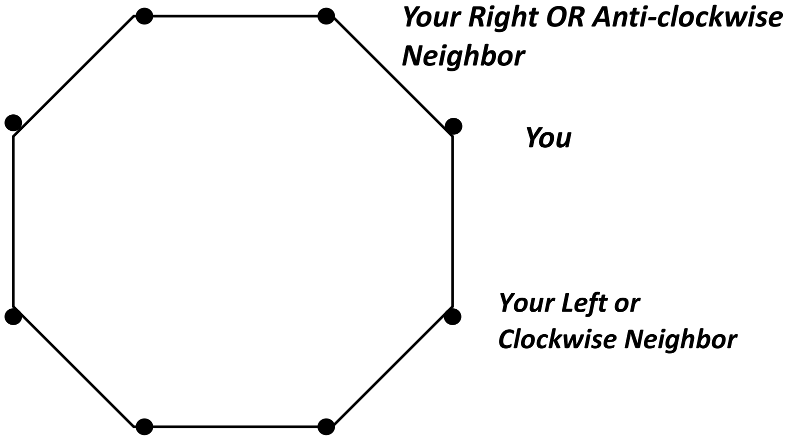


Figure 1: Circular Local Network

Given the specification of the payoff function in expression 1, the agglomeration bonus scheme is a coordination game with multiple Nash equilibria. When the transaction costs are sufficiently high, the policy scheme features two Nash equilibria corresponding to choosing land use option *A* and non-participation *NP*. Choosing land use practice *B* is not an equilibrium in this situation as it is strictly dominated by the outside non-participation option. In contrast, when transaction costs are sufficiently low, then there is an additional Nash equilibrium which corresponds to land use practice *B*. Tables 1a and 1b represent the agglomeration coordination game under the two transaction cost conditions – high and low, respectively, implemented in the experimental parameterization.

Table 1a: Payoff Table for High TC condition

Payoff Table

Actions Chosen by Neighbors

Your Action	Both Participate Choose A	Both Participate and one Chooses A & other B	Both Participate and Choose B	Only one Participates & Chooses A	Only one Participates & Chooses B	No Neighbor Participates
A	210	125	40	125	40	40
B	145	155	165	145	155	145
NP (Non-Participation)	175	175	175	175	175	175

Table 1b: Payoff Table for Low TC condition

Payoff Table

Actions Chosen by Neighbors

Your Action	Both Participate Choose A	Both Participate and one Chooses A & other B	Both Participate and Choose B	Only one Participates & Chooses A	Only one Participates & Chooses B	No Neighbor Participates
A	235	150	65	150	65	65
B	170	180	190	170	180	170
NP (Non-Participation)	175	175	175	175	175	175

3. Experimental Design and Procedures

The goal of this paper is to evaluate the participation decision and individual choices in the Agglomeration Bonus coordination game when subjects face high or low transaction costs of participation. For this purpose, we report data from 16 sessions with 8 subjects per session, producing a data set with 128 subjects.[2] During a session, subjects adopted the role

[2] We also collected data from 64 additional subjects in 8 sessions that featured anonymous online "chat" communication. Each subject could communicate privately in chat windows with each of their adjacent neighbors on the network. This communication was highly effective in promoting coordination on the efficient

of private landowners on an artificial landscape with the option of participating in a land management policy involving selecting one of two specific land management activities on their property. If they decided not to participate, they received a reservation agricultural income while if they decided to participate they had to pay a participation fee which is the transaction cost of participation in the scheme.

Since we are interested in participation under a high and a low transaction cost regime, the experiment was classified into two phases – Phase I and Phase II with 15 periods each during which subjects faced different values of transaction costs. In 8 sessions termed HLTC (abbreviating *High-Low Transaction Cost*) subjects faced a high transaction cost of participation equal to 40 in all 15 periods of Phase I followed by a low transaction cost of 15 in Phase II. In the remaining 8 sessions termed LHTC (abbreviating *Low-High Transaction Cost*), the transaction cost ordering was reversed. This within-subject format of the transaction costs treatment permitted us to minimize within-subject variation across the two treatments.

Our main interest is on the coordination of private land use decisions on geographical landscapes. Thus we consider subjects to be arranged on a circular local network with every subject directly connected to two neighbors in the clockwise and anti-clockwise directions. These neighbors were referred to as left and right neighbors respectively during the experiment. Subjects were indirectly connected to the remaining five individuals via their direct neighbors. We refer to the left and right neighbor as making up the local neighborhood of a player. On this network, every subject's payoffs are determined by their direct neighbors' choices. However indirect neighbors' actions influence a player's choices as well by virtue of their links to a player's direct neighbors. Given this symmetric strategic setup for a player and their direct and indirect neighbors, everyone faces the same degree of upfront strategic

equilibrium in all transaction cost conditions. As these results are relatively uninteresting we do not include them in the paper.

uncertainty in this coordination game.[3] Figure 1 represents this circular network and was presented as a handout to the subjects during the experimental sessions.

At the beginning of the experiment, every subject received a randomly-assigned ID that determined their location and their neighbors' identities on the network. For example, a player with ID equal to 1 was connected to Player 2 to the left and Player 8 to the right. However the instructions noted explicitly that subjects' "game neighbors" were not the individuals that were seated at the physically adjacent computer terminal in the lab. This ID remained the same during all the periods of Phase I implying a fixed matching scheme. We implemented this matching protocol because private land ownership is usually unchanged for long periods on actual geographical landscapes and also because repeated interactions with the same set of players can build reputation for the play of a particular strategy by a player with their local neighborhood. In Phase II, the neighborhood structure was shuffled and every subject received a new ID and a new set of neighbors which remained unchanged till the end of the experiment. We implemented this ID switch in order to break any possible path dependence that is often present in coordination game experiments (Van Huyck, Battalio, and Beil 1991) and which can potentially confound our transaction cost variation treatment when transitioning from Phase I to Phase II.

During each phase of the experiment, subjects received handouts (included in the Appendix) containing information on the payoffs, the transaction cost of participation associated with that phase (15 or 40) and the reservation non-participation income of 175 earned when subjects decided not to participate. At the beginning of a period, subjects first decided whether they wanted to incur the transaction cost and participate in the AB scheme. While they were making this decision, they were unaware of their neighbors' participation

[3] We select a symmetric circular network over others where players have different numbers of direct and indirect links. This is because on the asymmetric networks players would have varying degrees of upfront game strategic uncertainty and would most likely respond to the transaction cost variation treatment differently leading to potential confounding problems.

decisions.[4] If they chose to participate, they moved on to the next stage of the experimental period in which they selected one of the two actions A or B in the coordination game according to the payoff matrices shown in Table 1. Once all choices were made, subjects received information about their own and neighbors' choices for the current period. Additionally, a History table displayed on subjects' computer screens provided information on the number of participating neighbors, own choice and payoffs for current and past periods, and neighbors' current and past period choices within a phase. The experiment then proceeded to the next period.

The transaction costs were chosen with attention to two specific details. First, for the high transaction cost specification (Table 1a), strategy B would be dominated by the non-participation strategy implying only two Nash equilibria – $\sigma_i = NP \; \forall i, \; \sigma_i = A \; \forall i$. Consequently, if a player chose to participate in the coordination game by paying a high fee in the high transaction cost case, they were likely to choose A and not B since choosing B will yield payoffs less than what they would have earned by choosing not to participate. This type of strategic environment also proves useful in analyzing whether subjects follow the forward induction principle (Van Huyck, Battalio, and Beil 1993; Cooper and others 1994; Cachon and Camerer 1996) while making strategy choices in coordination games on local networks. Second, we ensured that under the low transaction costs regime (Table 1b), we would obtain a strategic environment with three Nash equilibria – $\sigma_i = NP \; \forall i, \; \sigma_i = A \; \forall i$ and $\sigma_i = B \; \forall i$.

Experiments were implemented in z-Tree (Fischbacher 2007) and subjects were recruited from the broad undergraduate population using ORSEE (Greiner 2004). All instructions (included in the Appendix) were made available on subjects' computer screens and were identical across subjects. No contextual terminology relevant to ecosystem services

[4] By following this approach, we were able to retain the simultaneous move feature of the coordination game although it comprises of two stages of decision making.

provision other than land use was included in the experimental instructions. We adopted this approach because we wanted to study how financial incentives impact experimental outcomes and also because pro-environmental terminology can potentially trigger various subject behaviors and confound the treatment effect (Cason and Raymond 2011).

In keeping with the coordination game nature of the experiment, the instructions mentioned that subjects' payoffs would in general be higher if they chose the same action as their participating neighbors. They were also informed that the game would be repeated for 30 periods during which all choices would be anonymous. We also provided them with onscreen information on the current period number and total remaining periods at all points during the experiment to ensure that subjects were always aware of the final period when the game would end and hence treat it as a finitely repeated game and not an infinitely repeated one. We also clearly indicated to the subjects that during any period, all subjects would be facing the same payoff table and that all payoffs were net of transaction costs of participation if they chose to participate in the AB game.[5] At the end of Period 15 when the experiment proceeded to Phase II, subjects were instructed that they would now be facing a new payoff table for the next 15 periods. To ensure that everyone clearly understood this treatment variation, we collected the first experimental handout back and then provided everyone with a second one similar to the previous one except with a new payoff table and transaction cost value, and a new ID to indicate the network location and neighbor identity switch.

Before starting the experiment, everyone participated in a quiz about different features of the experiment to verify their understanding of the strategic environment, the game choices, and the associated payoffs. All experiments were conducted with randomly selected student subjects at the Vernon Smith Experimental Economics Laboratory at Purdue University during August and September, 2013. Sessions lasted between 60 and 90 minutes

[5] To ensure that subjects were always clear about the fact that all payoffs were net of transaction costs, we clearly indicated their total payoff for each outcome in the experimental handout provided to them during Phases I and II.

during which subjects were paid a $6 show-up fee and any money made during the experiment (earned in experimental francs). An exchange rate of US$1 for 350 experimental francs was used to convert all earnings. Average earnings (including the show-up fee) under the HLTC treatment was $21.83, for the LHTC treatment was $22.28 and was $22.05 for the entire experiment.

4. Results

This section is organized into three subsections. First, we present a general overview of the individual level choices in the scheme under the two transaction costs treatments. This is followed by an analysis of network-level spatial coordination on the efficient land use choice A. Finally, we present two models of individual behavior for each transaction cost condition and identify factors that influence subjects' likelihood of adopting a particular type of land use.

4.1 General Results

Table 2 presents the proportions of the three actions (A, B and NP) by the TC treatment. Levels of participation differ across transaction costs values. On average, when faced with a high transaction costs of participation, about 51% of choices pertain to NP. Conversely, under a low transaction cost scenario, not only do we observe more participation, we also observe a higher percentage of A choices (64%). Thus on the basis of our experimental parameterization, this suggests that with a high costs of participation in PES schemes, potential participants are more likely to fall back on their reservation agricultural income. This lower participation rate is an interesting result for our strategic setting as there is no coordination problem in the game when the transaction cost is high: post-participation strategy B is dominated by NP. Hence, in theory it is possible for subjects to use the principle of forward induction to participate and then choose A. The fact that they do not seem to be using this principle can be attributed to two factors.

Table 2: Proportion of Actions by Treatment

	Transaction Cost Treatment		
Action	**Low**	**High**	**Total**
A	0.644	0.452	0.548
B	0.213	0.039	0.126
Not Participate (NP)	0.143	0.510	0.327

First, players face a high level of strategic uncertainty given their positions on the local network, since both direct and indirect neighbors influence payoffs but only past choices of direct neighbors are visible. Thus, rather than participate and face the strategic uncertainty in the coordination game and then try to coordinate with their direct neighbors to earn the payoffs associated with the efficient Nash equilibrium, many agents choose the safe choice that is not influenced by others' actions. Second, the structure of the AB payoffs is such that participation and coordination on choice A is profitable only when both neighbors participate. This feature makes the deviation loss for NP (135 with respect to A and 30 for B) greater than that for A and B. Thus, unlike in previous studies on forward induction in coordination games (Van Huyck, Battalio, and Beil 1993; Plott and Williamson 2000), in our environment the outside option is a less risky Nash equilibrium. Hence, the risk of a potential payoff loss in the event that neighbors do not participate is high even if there is no coordination problem under the high transaction cost regime.

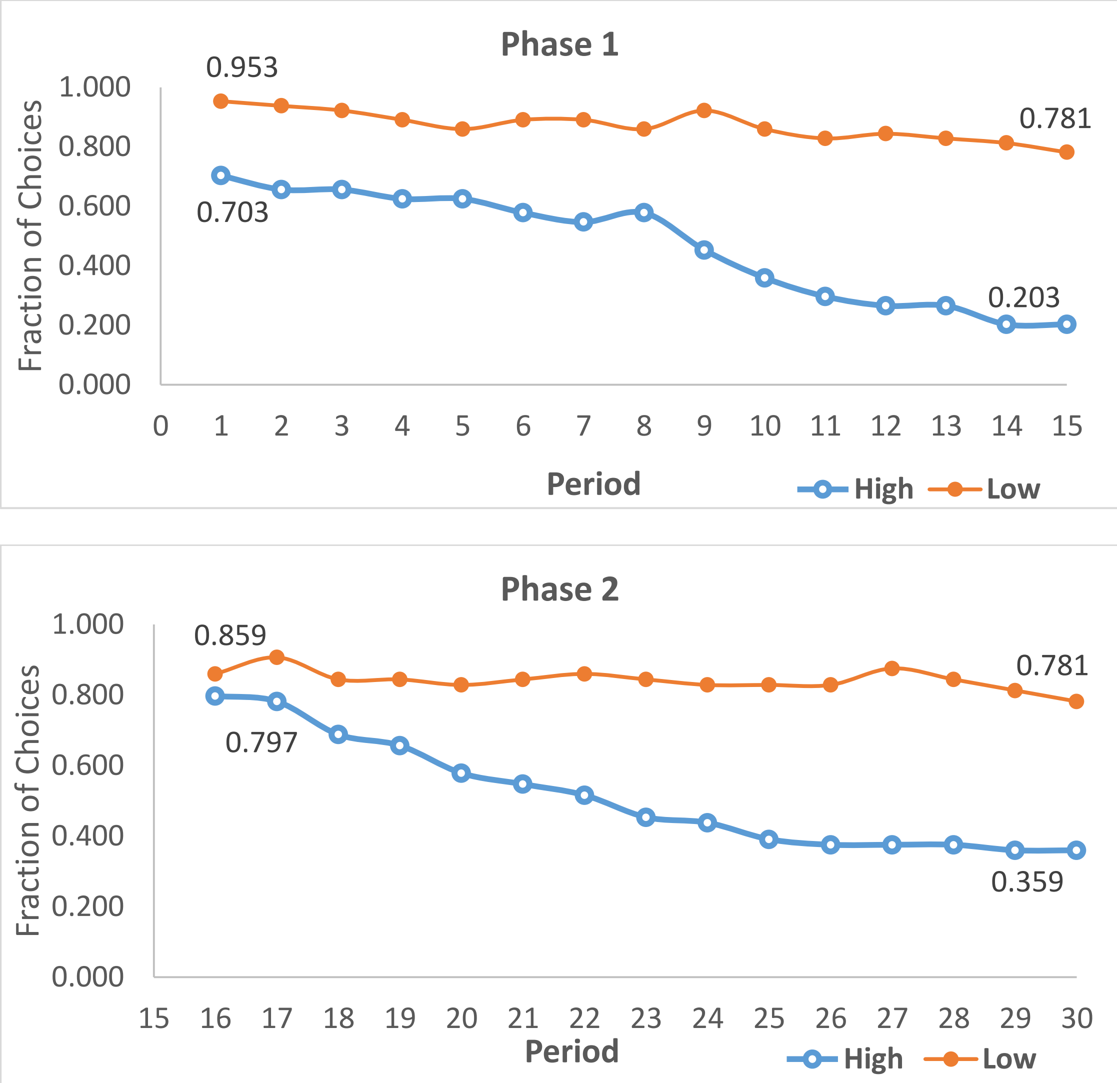
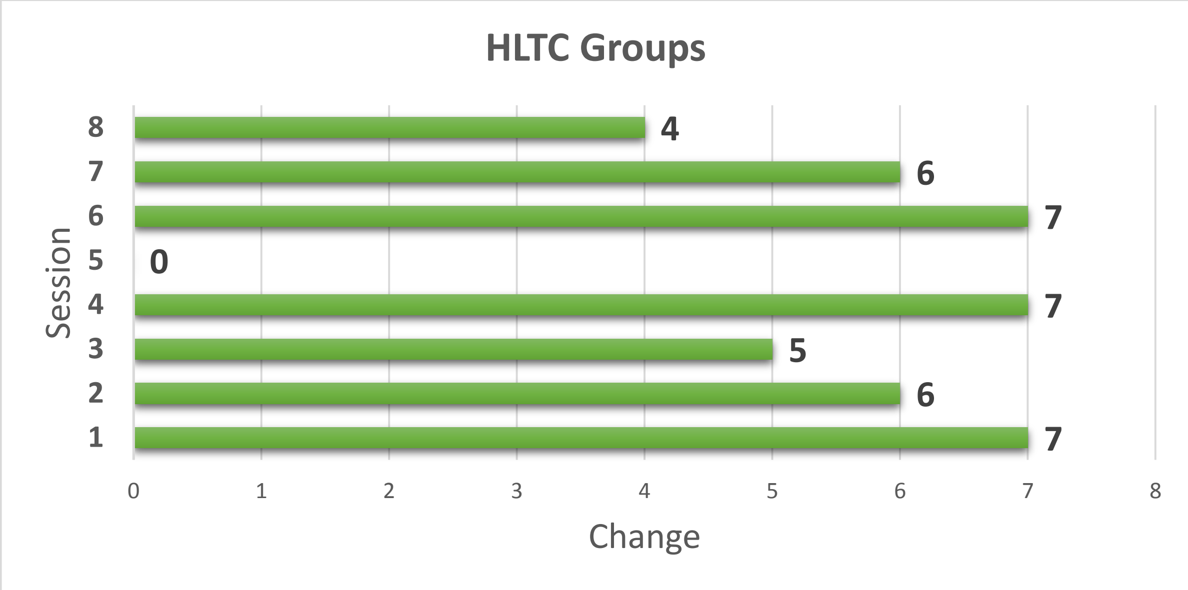


Figure 2: Frequency of Participation Choices Over Time

Next, we present a discussion of subject level choices for Phases I and II to evaluate the role of the order in which the transaction cost treatment is implemented and subjects' experience in the game on choices. Figure 2 presents information on the percentage of participation decisions in the two phases of the experiment for both values of transaction cost. In Period 1 of the LHTC sessions 95% of individuals choose to participate while participation rates in HLTC for this period is 70%. This difference in participation rates is significant at the 1% level on the basis of a Mann-Whitney test (*p-value* = 0.018). Since players have access to the payoff table in the handouts we provided to them at the beginning of the experiment, this significant difference indicates that players respond to the transaction cost values from the very onset of the experiment even if they have not received any feedback information about their neighbors choices.

Participation rates fall steadily down during Phase I to 20% in Period 15 in the HLTC cohorts. By contrast, subjects in LHTC sessions are still able to maintain relatively high levels of participation with only a weak negative trend (in Figure 2a the Period 15 participation rate is 78%). A non-parametric Wilcoxon Mann-Whitney test based on session-level average rates of participation in Phase I indicates a statistically significant difference at the 1% level (*p-value* =0.015). Thus, participation rates are significantly different between groups facing high and low transaction cost in Phase I.

Beyond Period 15, in keeping with the within-subject treatment variation, the transaction cost ordering is reversed: groups in the low TC condition in Phase I face a high transaction cost of 40 in the current phase (and vice versa for the remaining groups). Figure 2b represents the percentage participation rates for Phase II of the experiment. A substantial jump in participation rates occurs between Period 15 and Period 16 (from 20% to 80%) in the HLTC. This increase is statistically significant (Wilcoxon-signed rank test *p-value* = 0.013) when conducted with data presented in Figure 3a and can be attributed to the increase in the frequency of A choices between these two periods (B choices are very near zero at 3% in all periods in the high transaction cost condition.)



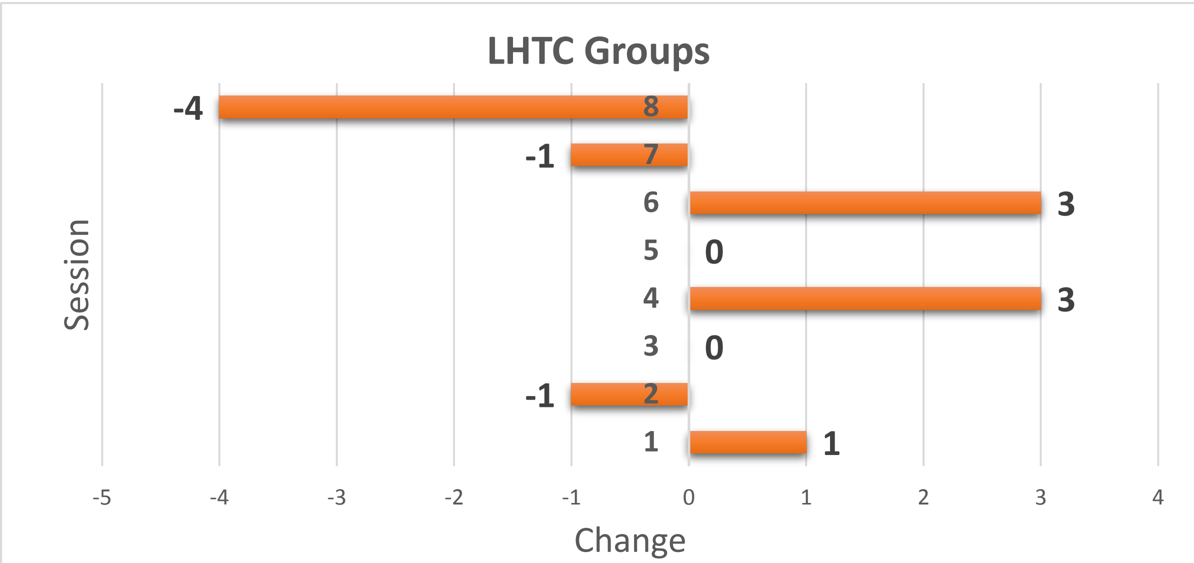


Figure 3: Change in "Participation" frequency from Period 15 to 16 by Group

The change in participation rate from 78% to 80% at the treatment switchover point for the LHTC group is however not statistically or economically significant (Wilcoxon-signed rank test *p-value* = 0.943) based on participation rate data shown in Figure 3b. This result suggests a path dependence in outcomes, which has been observed in other coordination games that do not have a spatial structure (Van Huyck, Battalio, and Beil 1991). Such path dependence implies that groups who have experienced favorable participation conditions because of low transaction cost are less likely to change their behavior immediately when their participation circumstances deteriorate. Such sluggish behavior has been variously termed strategy inertia (Blume 1993) or the precedent effect whereby subjects do not change their behavior in a new strategic setting immediately. One of the many reasons offered to explain this hysteresis is that any change is cognitively effortful (Kahneman 2003).

In Phase II there is very little downward trend in participation decisions in the HLTC groups since the conditions for participation have improved. Additionally, owing to the presence of the transaction cost ordering effect for the LHTC groups, high participation rates carry over into Phase II for these groups. Consequently, we obtain no significant difference in behavior between the HLTC and LHTC groups in Phase II on the basis of a Wilcoxon Mann-Whitney test (*p-value* = 0.14). Finally, we note that while average levels of participation are always positive in every period, it is never 100%. Thus, regardless of the magnitude of transaction cost given our payoff parameterization and local network setup with limited information flows, the strategic uncertainty inherent in the two-step Agglomeration Bonus coordination game is high enough for some individuals to never participate in a period and only earn a low but risk-free payoff.

4.2 Analysis of efficient coordination

In order to obtain insights about the nature of spatial coordination of land management choices under the Agglomeration Bonus scheme, we present an analysis of location-specific choices for all individuals who have participated in it. Figure 4 illustrates the spatial coordination for Period 15, using a snapshot of the location of individual choices in the 8 LHTC groups. All A choices are marked by grey patterned circles, B choices by grey blank circles and NP decisions by black triangles. Note that the A and B choices tend to be spatially clustered on the network giving rise to locally coordinated zones of similar land management activity. Some cohorts exhibit efficient coordination on A at the global level as well. Thus, independent of the costs of participation, this spatially targeted PES scheme provides incentives to encourage spatial coordination both locally and at the network level.

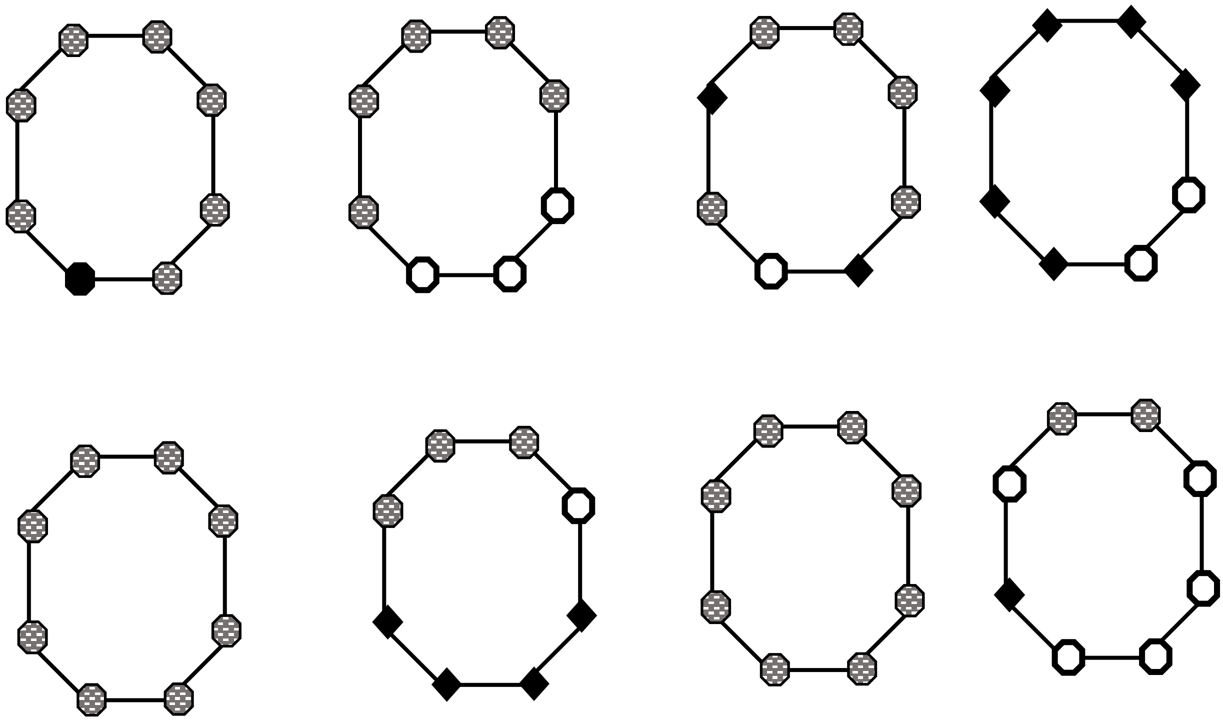


Figure 4: Period 15 Decisions – LHTC

For a formal analysis of location specific choices on the network post participation, we develop an efficiency metric as the measure of every instance in which a player and their two neighbors are able to locally coordinate on the same strategy. As a result of such localized coordination, a player earns payoffs associated with a Nash equilibrium strategy profile. In a network of 8 players, a maximum of 8 instances of localized coordination can be realized when the group is perfectly coordinated on either strategy A or B so that everyone is earning Nash equilibrium payoffs.

Figure 5 presents the frequency and percentage of efficient localized coordination (an A choice by a player and their two neighbors) in both groups for Phases I and II by Period. In our analysis, we focus on localized coordination for several reasons. First, on geographical landscapes, for specific environmental problems such as non-point source water pollution control, localized coordination may be sufficient for effective delivery of many ecosystem services, if it is combined with targeting. Second, in our game environment a player's payoff is determined by the actions of their left and right neighbors. Third, focusing on network level conventions constituting the same strategy would mask the multiple instances of localized coordination that is more common on the network.[6] We focus on A choices only since B choices correspond to the selection of the Pareto inferior strategy which is economically inefficient and because we wish to analyze the levels of spatially coordinated efficient strategy choice due to changes in the transaction cost of participation.

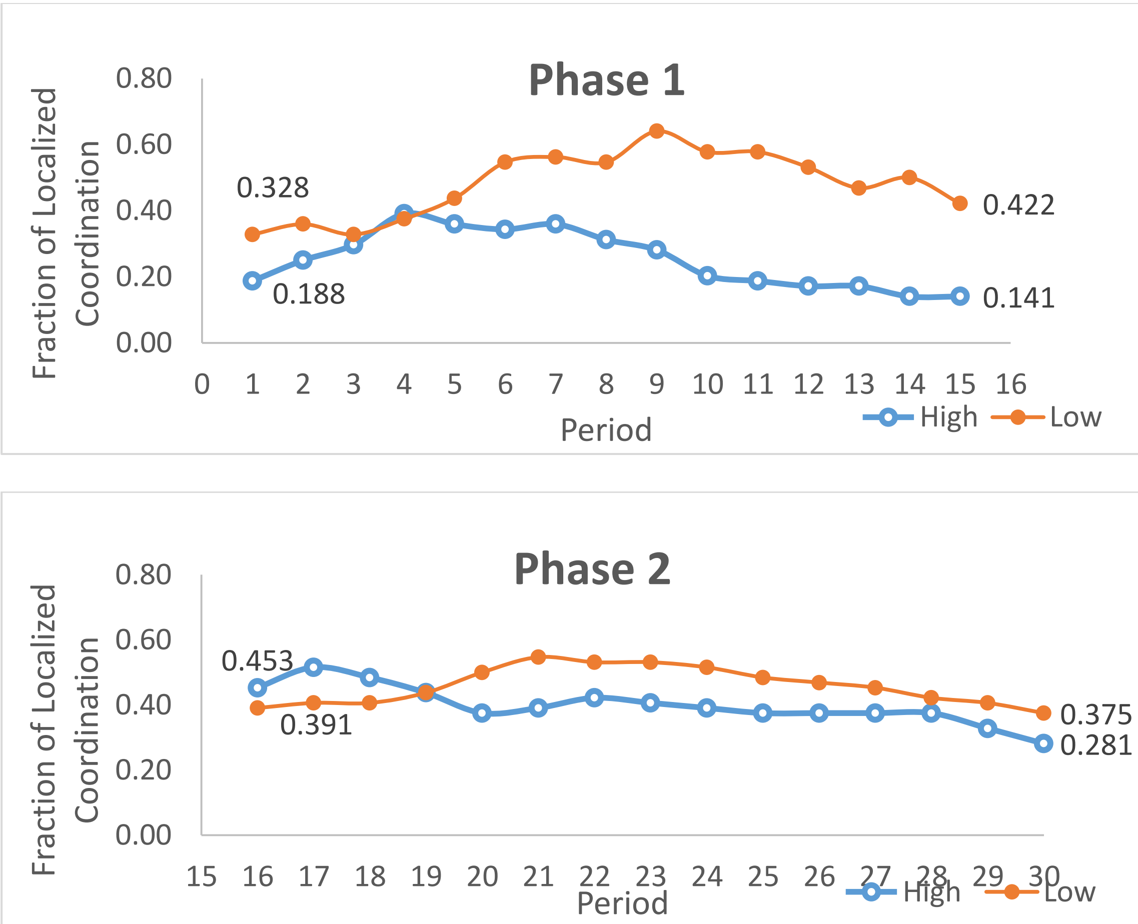


Figure 5: Localized Efficient Coordination: Agent and Both Neighbors Choose "A"

[6] Localized spatial clustering of efficient choices has been observed in other experimental studies such as Banerjee et al. (2012, 2014).

Figure 5 indicates that on average the level of efficient localized coordination is greater with low transaction cost in both phases of the experiment in most periods. On the basis of a Wilcoxon Mann-Whitney Test for session level average values of efficient coordination, we are only able to detect a significant treatment effect (*p-value* = 0.05) in Phase I after Period 8. Thus, in the initial periods of the game when subjects are learning about the strategic environment and gathering more game experience, most A choices are either not adjacent to each other or only two adjacent players select A in both treatments. Localized clustering of efficient choices does increase initially under both transaction cost conditions, with the rise continuing longer in LHTC (until Period 9) than in HLTC (until Period 4 only).

In Phase II no significant difference exists between the two groups, a result that is in line with the lack of a significant treatment effect in participation rates in Phase II. However the improvement in participation circumstance of the HLTC group ensures that in Period 30 average levels of efficient localized coordination has improved (from a value of 19% in Period 1 to 38% in Period 30). Moreover, owing to the beneficial treatment ordering effect in the LHTC groups (as mentioned in Section 4.1) average levels of efficient coordination do not deteriorate extensively.

4.3 Analysis of Individual Behavior

This section presents the results of two models of individual behavior, one for each transaction cost condition. Since strategy B is dominated by the NP choice in the high TC condition, in theory the frequency of B choices should be zero. In fact since there are only 3% of B choices in the data for the high TC groups, we eliminate these choices from our data set and run a binary logit regression where every A choice in a period is coded as 1 and a NP choice as 0. For the low transaction cost, this model specification is not appropriate since the game consists of three Nash equilibria each corresponding to one strategy. For all individuals facing the low transaction cost, we thus run a simple multi-nomial logit regression with choice B as the base category. For both models, we cluster the standard errors at the subject level as choices by the same subject are correlated between multiple periods of the experiment.

The set of independent variables considered in the two models include a Phase dummy variable taking a value of 1 for Phase II and 0 otherwise. In order to capture the impact of familiarity with the strategic environment on likelihood of making a particular choice, we include the 1/Period variable. This specification allows the rate of learning about the experimental environment to be higher in the early periods owing to subjects' unfamiliarity with the experimental setting or treatment change, and then falling asymptotically through stationary repetition of the experiment through multiple periods. Finally we include a group of categorical variables that captures the state experienced by a player in any period when they are making their participation and A or B choices. The state is determined by the player's own actions and those of their neighbors from the preceding period. Table 3 represents the various states, with the Nash equilibrium states marked in bold.

Table 3: Previous period states for two transaction cost conditions (Nash equilibria in bold)

Neighbors' Previous Period Choices	Player's Previous Period Choice		
	A	NP	B
AA	**AAA**	NPAA	BAA
ANP	AANP	NPANP	BANP
NPNP	ANPNP	**NPNPNP**	BNPNP
AB	AAB	NPAB	BAB
BNP	ABNP	NPBNP	BBNP
BB	ABB	NPBB	**BBB***

*BBB is a Nash equilibrium for the low transaction cost treatment.

Table 4 presents the results for the high transaction cost treatment and Table 5 contains results for the low transaction cost treatment. In Table 4 the estimate for the 1/Period variable is positive and significant, reflecting that strategy A is chosen less frequently across time relative to NP, consistent with Figure 2. We also obtain a significant and negative Phase effect indicating that subjects from LHTC groups are less likely to make an A choice when their transaction cost of participation increases than players in HLTC who face this adverse participation environment initially. This in an interesting finding especially in light of the fact that for the individuals in the LHTC groups, at the treatment switchover point, there is no significant difference in behavior (as previously noted from Figure 3b). Thus, the beneficial effects of a previous exposure to a low transaction cost environment disappear within a few periods of the treatment change.

We offer two possible explanations for this outcome. First, limited information flow on the network and the substantially lower risk of the NP strategy implies that subjects' strategic uncertainty regarding an A choice never disappears although many players coordinate locally to obtain Pareto efficient payoffs of 235 when transaction costs are low. Second, the change in neighbor identity at the beginning of Period 16 eliminates any kind of reputation that subjects may have built for choosing A in Phase I within their local neighborhood. As a result, over time subjects are more likely to transition to the safe action NP than to try to locally coordinate on A with their new Phase II neighbors who like them may have been exposed to efficient localized coordination in Phase I but with other players.

The positive estimates for the ANPNP, AANP (and AAB which is isomorphic to AANP) and ABNP states captures two types of effects which have been observed in coordination games in both network and non-network environments. The first is the role of strategy inertia, whereby a subject is more likely to make the same choice in the current period that they chose in the previous period. The second is voluntary loss making behavior

Table 4: Binary logit model (standard errors in parentheses) for High Transaction Cost Condition

Independent Variables[+]	Dependent Variable = 1 for A choice & 0 for Non-Participation choice
Phase (=1 for Phase II, 0 otherwise)	-0.583* (0.246)
1/Period [α]	2.703** (0.788)
Previous Period State (Subject's Choice First)	
BANP	3.551** (0.673)
BAA	4.660** (0.968)
BAB	4.762** (1.799)
BNPNP	1.975 (1.109)
AANP	5.125** (0.490)
AAA	9.796** (0.770)
AAB	5.989** (0.605)
ANPNP	3.502** (0.599)
ABNP	3.971** (0.710)
NPANP	1.908** (0.539)
NPAA	5.057** (0.629)
NPAB	1.879 (1.118)
NPBNP	1.295 (0.715)
Constant	-4.248** (0.511)
Number of Observations	1722
Number of Subject Clusters	128

** Represents statistical significance at 1% level and * at 5% level
[+]Omitted base category is NPNPNP; categories BBB, BBNP & NPBNP are omitted as they predict A or NP choice perfectly after eliminating all observation where B is chosen. Coefficient for ABB not estimated since this state is not obtained under T=40 condition.
[α] Period takes a value between 1 and 15

Table 5: Multinomial logit model (standard errors in parentheses) for Low Transaction Cost condition

Independent Variables+	Non-Participation (0)	A (1)
Phase (=1 for Phase II, 0 otherwise)	-0.072 (0.264)	-0.472* (0.213)
1/Periodα	-1.634 (0.925)	-0.558 (0.788)
	Previous Period State (Subject's Choice First)	
BANP	2.974** (0.578)	1.622** (0.587)
BAA	2.409** (0.713)	3.812** (0.561)
BAB	1.269* (0.609)	1.541** (0.516)
BNPNP	3.460** (0.684)	-11.945** (0.581)
BBNP	1.156* (0.578)	-0.294 (1.127)
ABB	2.273** (0.660)	1.621* (0.659)
AANP	4.063** (0.578)	4.634** (0.504)
AAA	2.465* (1.073)	7.412** (0.589)
AAB	3.056** (0.579)	4.390** (0.507)
ANPNP	2.427* (1.238)	-12.745** (0.727)
ABNP	3.497** (0.626)	2.297** (0.630)
NPBB	3.219** (0.823)	1.245 (0.679)
NPANP	5.231** (0.603)	1.790* (0.759)
NPAA	5.225** (0.913)	4.989** (0.736)
NPAB	4.460** (0.669)	2.317* (0.910)
NPBNP	5.343** (0.677)	0.885 (1.149)
NPNPNP	7.266** (1.154)	2.734 (1.473)
Constant	-3.273** (0.492)	-2.060** (0.520)
Number of Observations	1792	
Number of Subject Clusters	128	

** Represents statistical significance at 1% level and * at 5% level
[+] Omitted base category is BBB

(Brandts and Cooper 2006; Banerjee, Kwasnica, and Shortle 2012) on the part of a player to influence their neighbors to participate and choose A if at least one of them did not previously. The positive and large estimate for AAA is to be expected since a choice of A in response to left and right neighbors choosing A corresponds to a best-response behavior. We also obtain positive estimates for NPAA and NPANP, suggesting that a subject is likely to perceive at least one previous A choice in their local neighborhood as a circumstance favorable for making an efficient choice in the current period even if they did not choose A themselves. Finally, Table 4 presents positive and significant estimates for the states in which a subject chose B and at least one neighbor picked A (i.e., BANP, BAA, BAB). Since B is a dominated strategy in the high transaction cost game, this outcome is to be expected. Moreover, these results indicate that a player interprets a previous A choice in their local neighborhood as a signal to choose A rather than NP in the current period.

We next focus on the factors influencing the likelihood of making an A and NP choice in the low TC condition relative to choice B. Since there are many significant estimates, we present a discussion of only the most interesting results for brevity. The negative and significant Phase effect indicates that when subjects transition from high transaction cost to low transaction cost treatments, the likelihood of making an A choice falls relative to a B choice compared to subjects whose initial exposure is the low transaction cost condition. This result can be explained by noting that first, the risk of a payoff loss associated with B is less than that with A, making B more likely than A. This result is similar to evidence provided in studies on network coordination games with limited informational flows where the risk dominant strategy is contagious (Ellison 1993; Berninghaus, Ehrhart, and Keser 2002; Alós-Ferrer and Weidenholzer 2006). Second, the individuals in Phase I faced a choice between the high risk A strategy and risk free NP choice. In Phase II, when B is no longer dominated by NP, agents have the option to choose B that is relatively low risk compared to A and also earns a higher payoff relative to NP. As a result they were more likely to choose B than A. Hence many subjects henceforth transition to B.

The estimates for the ANPNP and BNPNP states in the A column are large and negative, implying that when no neighbor participated, regardless of the current period A or B choice, a subject is less likely to choose A than B. This effect is not surprising given that from Table 1b the payoff for choosing B when no neighbor participates is 170 which is greater than 60 that the player would make if they chose A. Also, the signs of the estimates for the states in which at least one neighbor chooses A and the player chooses either B or NP (BANP, BAA and BAB and NPANP, NPAB, NPAA) are positive. Thus, if at least one neighbor chooses A, a positive precedent for B does not develop increasing the likelihood of selecting A relative to B. Finally, all the state estimates in the NP column are positive and significant. This indicates that, relative to the omitted case of BBB coordination, any other previous period history increases a player's likelihood of choosing NP.

5. Conclusion

The Agglomeration Bonus has appeal as a conservation policy instrument for two reasons. First, the predominant effective property rights regime in many countries such as the UK, USA, New Zealand and Australia requires that landowners be offered payments to encourage the supply of ecosystem services and biodiversity conservation, rather than being compelled to supply them by regulation: the "provider gets" principle (Hanley et al. 1998). Second, for many environmental outcomes, spatial coordination increases the size of conservation benefit for a given level of enrollment in voluntary contracts for pro-conservation actions. However, the Agglomeration Bonus faces a number of problems including the tendency over time for participants to converge on risk-dominant outcomes, the lack of cost-effectiveness, and, like many incentive programmes, the size and nature of transactions costs. Such transactions costs are likely to vary with the number of potential participants in the scheme, and with the complexity of the coordination arrangements that the regulator is trying to induce.

In this paper, we use experiments to investigate how variations in private transactions costs affect the degree of participation in an agglomeration bonus scheme, the efficiency of the scheme, and the patterns of spatial coordination. Results show that higher transactions costs lead to greater non-participation as would be expected, whilst lower transactions costs produce a greater degree of coordination onto the most preferred environmental outcome. Localized coordination also improves under lower transactions costs. However, partly due to the nature of the network we employ, increasing experience with the bonus leads to a fall in coordination onto the environmentally-preferred outcome, due to increasing strategic uncertainty, although the rate of decline is lower when transactions costs are smaller.

The policy implications are obvious: if the regulator can design the agglomeration bonus in a way which keeps transactions costs low relative to the payoffs of coordination, then it will be easier for them to achieve both local and global spatial coordination which produces the "best" environmental outcome. However, the degree of coordination on this desirable outcome is likely to fall over time. Indeed, if achieving a given environmental objective requires writing complicated rules for potential participants (e.g. with regard to which actions need to be monitored, or how monitored, or if targeting is also required rather than simply coordination), then there is a trade-off between improving environmental effectiveness and increasing coordination.

In terms of further work, it would be interesting to investigate the effects of variations in transactions costs in other types of spatial configuration of neighbours than that used here, and to contrast the effects of an agglomeration bonus with a conservation auction which scores bids partly on whether neighbours bid together (Windle et al, 2009). Finally, including a monetary assessment of the environmental outcomes would enable equilibria to be compared in terms of net social benefit.

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