SEE NO EVIL: INFORMATION CHAINS AND RECIPROCITY IN TEAMS

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See No Evil: Information Chains and Reciprocity in Teams*

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Abstract

Transparency in teams can facilitate cooperation. We study contribution decisions by agents when previous decisions can be observed. We find that an information chain, in which each agent directly observes only the decision of her immediate predecessor, is at least as effective as a fully-transparent protocol in inducing cooperation under increasing returns to scale. In a comparable social dilemma, the information chain leads to high cooperation both in early movers when compared to a non-transparent protocol and in late movers when compared to a fully-transparent protocol. we conclude that information chains facilitate cooperation by balancing positive and negative reciprocity.

Keywords: team production, public goods, incentives, externality, information, transparency, conditional cooperation

JEL Classification: C72, C92, D21, J31, M52

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I Introduction

Most economic activities are performed in a social context. More often than not, different agents are working towards a common goal, although each faces individual incentives that may be incongruent to some degree with the common objective. Thus, team performance and the way in which the tension between selfish and social objectives can be alleviated is at the heart of economic interactions.

This issue has been widely acknowledged in two streams of the literature. In a labor context, production is often determined by aggregate team performance. On one hand, individual team members have personal incentives to shirk and free ride on the effort of their peers, while on the other hand, the employer provides them with incentives to contribute to the team productivity. Accordingly, labor economists have dedicated considerable effort to study production in a team and to ascertain optimal ways by which to incentivize multiple agents to exert effort in team environments.[1] A similar situation arises with voluntary contributions to public goods. Here too, individuals hold the objective of raising contributions for the public good, but have a personal incentive to defect and free ride. Numerous theoretical and experimental studies have investigated environments that facilitate contributions to public goods.[2] The reader should keep in mind that the theoretical discussion and the experimental results can be equally applied to both contexts, or to any other context in which multiple agents decide whether to make a costly investment to improve a group outcome.

In this paper we focus our attention on one basic feature of team environments, namely transparency within the team. Most, though not all,

[1] See, e.g.,Che and Yoo (2001), Goerg et al. (2010), Hamilton et al. (2003), Holmstrom (1982), Lin (1997), Mohnen et al. (2008), Winter (2004, 2006).

[2] These include, but are not restricted to Andreoni (1988, 1990), Bergstrom et al. (1986), Cornes and Sandler (1986), Fehr and Gächter (2000), Groves and Ledyard (1977), Laffont (1987), Marx and Matthews (2000), Morgan (2000), Ostrom (1999), Varian (1994). For surveys, see Chen (2008), Ledyard (1995).

theoretical and experimental studies of team performance deal with the simplest case of simultaneous moves. Conversely, in many realistic situations, some team members are likely to obtain information about the decisions already made by their peers. For example, a web developer working on a webpage is aware of the effort invested by the graphic designer in producing the designs for the webpage, and may condition her effort on the quality of the designs; fundraisers often inform potential donors of the money collected so far (Romano and Yildirim, 2001).[3] Accordingly, in this paper, we consider the case where agents move sequentially and may observe some or all of the previous decisions.

Information about the decisions of other team members may influence an agent's decision under several different assumptions. When agents have private information about prospective benefits, uninformed agents should revise their beliefs according to observed actions of informed agents (Potters et al., 2007; Vesterlund, 2003). Alternatively, in the presence of social preferences, observed actions of previous movers can trigger conditional cooperation (e.g., Clark and Sefton, 2001; Levati et al., 2007), or social comparisons (Gächter, Nosenzo and Sefton, 2010a,b).

Several experimental studies explored situations in which some players have information about the contributions of other players at the time of making a contribution. However, in all of the studies we are aware of, informed players have perfect information about all previous moves.[4] Conversely, the aim of our experimental investigation is to test the efficacy of partial transparency, and specifically *information chains*, by which agents observe only the immediate history. Furthermore, we extend this test to different produc-

[3]Publishing current levels of donations is now the standard in online fundraising sites such as *www.firstgiving.com*.

[4]Theoretical studies include Hermalin (1998), Romano and Yildirim (2001), Varian (1994), Vesterlund (2003). Experimental studies include Andreoni et al. (2002), Chen and Komorita (1996), Coats and Neilson (2005), Dorsey (1992), Gächter, Nosenzo, Renner and Sefton (2010), Kurzban et al. (2001), Kurzban and Houser (2005), Levati et al. (2007), Levati and Zultan (2011)

tion technologies in order to study the interaction of transparency and technology. We develop a theoretical model following Winter (2010) to show that partial transparency is predicted to performs as well as full transparency in inducing cooperation under increasing returns to scale. We proceed to argue that if agents are intrinsically conditional cooperators, similar effects might be expected even in the social dilemma (or linear public good) induced by a linear production technology. Furthermore, as early movers should be more likely to contribute as they are observed by more potential followers whereas late movers are less likely to contribute as they observe more potential defectors, we predict that the positive effects of transparency decrease along the production chain.

Our experimental results validate the theoretical predictions under increasing returns to scale, with partial transparency resulting in high cooperation similar to that observed under full transparency. The effects of transparency are not evident at the beginning of the experiment, but develop over time as group members that play according to the equilibrium prediction prompt their partners to follow suit.

Significant conditional cooperation is also observed in the social dilemma, where it is not supported by the monetary payoffs. Subjects are consistently and significantly more likely to contribute if they observe full contribution. However, the magnitude of conditional cooperation is considerably lower than with increasing returns to scale, so that overall contribution levels do not differ significantly between the three information treatments. Nonetheless, we find that transparency has a significantly positive effect on early movers, whereas full transparency has a significantly negative effect on late movers. As a result, highest contribution levels are observed in the informatino chain, as it benefits from the positive effect of reciprocity on early movers, while avoiding the detrimental effect on late movers.

II Transparency with increasing returns to scale

The interaction between transparency and technology was theoretically studied by Winter (2006, 2010), who characterized the optimal reward mechanisms that can induce effort in teams under different information structures and different production technologies. His results show that, when the production function has increasing returns to scales, i.e., the marginal effect of a single contribution increases in the number of contributions made by other agents, transparency allows these complementarities to be utilized to increase efficiency in equilibrium. Due to the complementarities, an observed contribution by one agent can incentivize the observing agents to contribute as well, thereby enhancing the incentives of the observed agent.[5]

However, this clear intuition is not enough to determine the efficacy of different partial-transparency environments. This question was addressed by Winter (2010), who extended the framework to allow for general information structures. Each information structure is represented by an acyclic directed graph, indicating for each pair of agents whether the contribution decision of one is observed by the other. Winter (2010) studied the mechanisms required to induce full cooperation under minimal monetary incentives,[6] to characterize when one information structure involves more transparency, and is thus more favorable for cooperation, than another. The conclusion is that one information structure is more transparent than another if the *closure* of the graph representing the latter is included in the closure of the graph representing the former, i.e., if every arc that exists in one also exists in the other (Proposition 4, p. 13). In other words, if agent i observes agent j,

[5] This may lead to paradoxical incentive reversals, as increasing the incentives of the observing agent may remove the incentives of the observed agent. See Klor et al. (2011), Winter (2009)

[6] The question is framed in a labor context, in which a principal determines the rewards of the agents, contingent on the team outcome. Thus, an optimal mechanism is one under which full contributions to the project are part of a weak-perfect Bayesian equilibrium, at a minimal cost to the principal.

and agent j observes agent k, whether i observes k directly or not does not affect the optimal mechanism required to extract full contributions from the agents. This result is driven by the fact that the effect of the transparency is maximized when each agent benefits from contribution if and only if she does not observe any defections. In this case, when i observes j contributing, she infers that k has also contributed, otherwise it would have been dominated for j to contribute.

It follows that the minimal information structure required to maximize the incentivizing effect of transparency is an *information chain*, such that the agents decide sequentially, and each agent only observes the action of her immediate predecessor. In other words, *indirect* transparency can be as efficient as *direct* transparency in facilitating cooperation in teams.

This is the starting point of our experimental investigation. We create a team production environment in which we can compare behavior under different levels of transparency in the environment. We consider three information treatments:

No information (NI): Agents do not observe the contribution decisions of other agents.

Chain information (CI): Each agent observes only the contribution decision of her immediate predecessor.

Full information (FI): Each agent observes the contribution decisions of all previous movers.

Treatments NI and FI are equivalent to the simultaneous and sequential protocols previously studied in the literature, respectively. We construct the environment such that, with increasing returns to scale, all agents contribute in the unique subgame-prefect equilibrium outcome of FI, whereas no agent contributes in the unique Nash equilibrium in NI. This environment provides a clear backdrop against which to study indirect transparency, as manifested in our CI treatment. Our first hypothesis corresponds to the basic effect of transparency while the second reflects the prediction with regard to partial transparency:

Hypothesis 1. *Contribution levels are higher in FI compared to NI.*

Hypothesis 2. *Contribution levels in CI are not lower than in FI.*

We develop the model underlying Hypotheses 1 and 2 in the next section before proceeding to show how a social dilemma results from changing the production technology to a linear one, and discuss the implication of our analysis in this setting under behavioral assumptions in Section IV.

III Model

A team consist of a set N of n agents who contribute to a joint project. Each agent i decides whether to contribute to the project (contribution $c_i = 1$) or to defect from contributing (contribution $c_i = 0$). Contributing agents pay a personal cost C, which is fixed and equal for all agents. The outcome of the project is given by a production technology $p(k) \in \mathbb{R}$, where $k = \sum_{j \in N} e_j$ is the number of contributing agents, and p is increasing in k. The benefit that agent i receives from the project depends on an individual benefit factor b_i. The overall payoff for i is therefore:

$$\pi_i = p(k)b_i - C$$

The set of agents that an agent i observes is denoted K_i. Therefore, the information available to agent i is $I_i = \{e_j, j \in K_i\}$. A strategy for agent i is a function $s_i : 2^{|K_i|} \to \{0, 1\}$, indicating whether i contributes or defects as a function of the information she observes, i.e., the contribution decisions of all agents in K_i. The three information structures can now be defined thus:

NI: $K_i = \emptyset$ for all $i \in N$

CI: $K_i = \{i - 1\}$ for all $i \in N$

FI: $K_i = \{1, 2, \ldots i - 1\}$ for all $i \in N$

III.A Equilibrium with increasing returns to scale

A technology with increasing returns to scale is characterized by $p(k+1) - p(k) > p(k) - p(k-1)$ for all k. Under such a technology, the vector of benefit factors b can be constructed such that all agents defect in the unique Nash equilibrium of the game induced by NI, and contribute in the unique subgame-perfect equilibrium of the game corresponding to FI. More specifically, the equilibrium strategy of each agent in FI is to contribute if and only if she observes full contribution. we achieve this by imposing two conditions on b:

$$(1) \qquad b_i \geq \frac{C}{p(N) - p(i-1)} \qquad \forall i \in N$$

$$(2) \qquad b_i < \frac{C}{p(N-1) - p(0)} \qquad \forall i \in N$$

Condition (1) ensures that each agent has the monetary incentive to contribute if by that she increases the number of contributing agents from the full set of her predecessors to the full set N. Condition (2) is sufficient to guarantee that no agent can increase her payoff by contributing if at least one other agent did not or will not contribute.

Proposition 1. *Conditions (1) and (2) guarantee that all agents contribute in the unique subgame-perfect equilibrium of FI if and only if they observe full contributions.*

Proof. To see that any defection of a single agent suffices to guarantee that all other agents strictly reduce their payoff by contributing, write k for the number of agents other than i that contribute if i contributes. Thus, if i contributes, she obtains $b_i p(k+1) - C$. Because $p(\cdot)$ is increasing, i obtains by defecting at least $b_i p(0)$. The change in payoff from defection to contribution is therefore smaller than $b_i[p(k+1) - p(0)] - C$, which, by Condition (2) is negative as long as $k < N - 1$.

It follows directly that, in equilibrium, any defection by an agent in K_i leads to a defection by i. It remains to be shown that the converse is also true, i.e. if all agents in K_i contribute, i contributes as well in equilibrium. First, note that in FI, $i \in K_j$ for all $j > i$, implying that by defecting i leads all agents j to defect as well, thus obtaining a payoff of $b_i p(i-1)$. Conversely, if i contributes, all agents j will contribute as well. This can be shown by backward induction. Assuming that all agents j contribute when observing full contributions, i increases her payoff by $[b_i p(N) - C] - [b_i p(i - 1)$ by contributing, which is non-negative by Condition (1). Condition (1) also implies that the assumption holds for agent n, by that completing the backward induction proof. *End of proof.*

As in Winter (2010), Conditions (1) and (2) also ensure that full contribution is a sequential equilibrium in CI.[7] However, there also exist sequential equilibria in which none of the agents contribute. For example, when $s_i = 0$ for all i, i.e., all agents defect regardless of their information. The difference between FI and CI is rooted at the beliefs of an agent who observes her immediate predecessor contributing. In the equilibrium of FI, she knows that all previous movers have also contributed, whereas in CI she can only deduce it from the observed contribution. When the sequential equilibrium in which all agents defect is considered, it is sequentially rational for the agent to keep her prior belief that unobserved agents have defected and attribute the observed contribution to a tremble.

Nonetheless, in the environment we consider, which corresponds to Winter's (2010) optimal mechanism, we can obtain a stronger result if we impose

[7] Winter (2010) considered weak implementation of perfect Bayesian equilibria, though the result easily extends to sequential equilibria. Proposition 2 can be extended to prove a full-implementation result.

a weak constraint on rational beliefs:

Proposition 2. *Conditions (1) and (2) guarantee that all agents contribute in the unique sequential equilibrium of CI that satisfies the requirement that all assessments attribute zero probability to all strictly-dominated strategies.*[8]

Proof. As shown in the proof to Proposition 1, it is strictly dominated for an agent to contribute if she observes a defection. Therefore, if agent i observes agent $i-1$ contributing, she cannot rationally believe that any agent in K_{i-1} has defected. Applying this argument recursively, we find that i believes that all previous movers have contributed. Now the backward induction can be applied as in the proof to Proposition 1. *End of proof.*

In order to make a sharp distinction between FI and NI, we add a third condition to Conditions (1) and (2):

$$(3) \qquad b_i < \frac{C}{p(N) - p(N-1)} \qquad \exists i \in N$$

Condition (3) and the non-concavity of p imply that defection is a dominant strategy for at least one agent in NI. Taken together with Condition (2), it rules out any contributions in equilibrium in NI. Note that Condition (3) cannot apply to all agents. Specifically, it does not apply to agent n by Condition (1). Therefore our environment has some heterogeneity in the benefit factor b.[9]

[8] This requirement was raised by Kreps and Wilson (1982, Section 8) in the paper that introduced the notion of sequential equilibria. It is implied by many refinements of sequential equilibria such as justifiable equilibrium (McLennan, 1985), intuitive criterion (Cho and Kreps, 1987), perfect sequential equilibrium (Grossman and Perry, 1986) and stable set (Kohlberg and Mertens, 1986).

[9] Goerg et al. (2010) have shown in a similar setup that heterogeneity has little to no effect on behavior. Furthermore, we reduce the discrimination in our design by always assigning the same benefit factor to two agents, and rotating the roles of the agents between participants. The design is described in detail in Section V.

III.B *Equilibrium with linear technology*

A linear production technology $p(k)$, is defined as one in which the marginal contribution $d = p(k+1) - p(k)$ is fixed for any k. It follows that a selfish money-maximizing agent contributes iff $b_i \geq C/d$. Since both C and d are exogenous, each agent has a dominant strategy either to contribute or to defect. In other words, the actions of the other agents do not affect the monetary incentives of an agent, hence the equilibrium analysis is not affected by the information agents acquire about the decisions made by previous movers. More specifically, if $b_i < C/d$ for all $i \in N$ and $\sum_{i \in N}(b_i d) > C$, the game is a social dilemma, in which all agents have a dominant strategy to defect, but the outcome of full contributions pareto-dominate the outcome of zero contributions.

IV Transparency in a social dilemma

Hypotheses 1 and 2 crucially depend on the agents playing reciprocal strategies, such that an agent contributes if and only if everyone she observes has contributed. These strategies can be in equilibrium due to the production technology involving complementarities between the contributions of the agents. Nonetheless, it is possible that transparency may lead to cooperation even without the complementarities induced by the explicit production technology, based on an intrinsic tendency people have for conditional cooperation. The experimental literature provides abundant evidence that people have a preference to cooperate at a personal cost — only if others cooperate as well.[10] For example, 32.9% of the subjects in a study by Fischbacher and

[10]A behavioral propensity for conditional cooperation can be supported by underlying preferences defined over beliefs and outcomes (e.g., Charness and Rabin, 2002; Dufwenberg and Kirchsteiger, 2004; Falk and Fischbacher, 2006; Rabin, 1993). A utility function that involves non-monetary benefits derived from mutual cooperation (or mutual defection) involves positive externalities between agents, effectively creating increasing returns to scale in the production technology even if these are lacking from the monetary incentives. For simplicity, we base our analysis on observable strategies and do not attempt a full

Gächter (2010) responded to full contributions of the other group members by contributing their full endowment.[11] If enough agents are conditional cooperators, a contribution made by an observed agent is likely to lead to contributions by subsequent movers. Thus, the effects of transparency predicted under a production technology with increasing returns to scale are also likely to exist under a linear technology, in which there are no complementarities in material payoffs so that all selfish money-maximizing agents have a dominant strategy to defect.

Note that the effects of transparency require two assumptions to be satisfied; first, that agents who observe cooperation are willing to reciprocate by cooperating at a monetary cost to themselves. More importantly, the observed agents must anticipate conditional cooperation from their followers, otherwise even agents that prefer mutual cooperation over mutual defection would refrain from contributing as first movers. Despite the abundant evidence for the validity of the first assumption, it is not clear that people believe that others will reciprocate their cooperation, even in environments were such conditional cooperation is prevalent. For example, Clark and Sefton (2001) have found substantial levels of conditional cooperation in a sequential Prisoner's Dilemma, however overall cooperation levels were not higher than when the game was played in the standard simultaneous protocol. In Klor et al. (2011, Experiment 2), subjects play in all roles using the strategy method. Although a large majority of subjects choose to reciprocate cooperation at a personal cost when deciding as second movers, the same subjects largely refrain from cooperating as first movers. However, several field experiments have shown that charitable contributions are increased if information about previous contributions is provided (Croson and Shang, 2008; Frey and

characterization of the agents' underlying preferences.

[11]See also Ashley et al. (2010), Brandts and Schram (2001), Fischbacher et al. (2001), Guttman (1986), Keser and Van Winden (2000), Kurzban and Houser (2005), Levati and Neugebauer (2004), Levati and Zultan (2011), Sugden (1984). Gächter (2007) provides a recent review.

Meier, 2004; List and Lucking-Reiley, 2002; Shang and Croson, 2009), so that whether transparency has an effect on contributions in our setup due to intrinsic conditional cooperation is up for empirical investigation.

Our design allows us to compare contribution levels as transparency along the production chain increases, as well as test conditional cooperation as manifested in the observed actions. Accordingly, we draw our third hypothesis:

Hypothesis 3. *Contribution levels are higher in CI and FI with a linear production technology, due to the existence of (intrinsic) conditional cooperation.*

The coin of conditional cooperation has two sides. So far we have considered positive reciprocity, i.e. the tendency to be kind to those who are kind, either due to the explicit incentives structure or to an intrinsic propensity for conditional cooperation. The game-theoretic analysis reveals how increased transparency utilizes positive reciprocity, inducing observed agents to contribute in order to motivate their followers to contribute as well. However, when the assumptions of common knowledge of rationality and selfish money maximization are relaxed, negative reciprocity can play a role as well. Namely, late movers who would have contributed in absence of information about their predecessors' decisions may withhold contributions once observing defection. Thus, in CI (but not in FI), an agent who observes defection, can still expect to establish conditional cooperation with her followers by contributing, even if she believes they withhold contributions after observing a single defection. Accordingly, we hypothesize that both positive and negative reciprocity play a role in contribution decisions, and have an increasing effect as transparency increases. Furthermore, the effect of positive reciprocity diminishes along the production chain, as later movers are observed by fewer agents, and therefore have a decreasing incentive to motivate future movers. Conversely, the effect of negative reciprocity is enhanced along the production chain, as later movers have a higher probability of observing defection.

To see how the order of moves interacts with the information, let us consider how our information treatments affect the set of agents that a specific agent observes and is observed by when the production chain includes four agents. In terms of being observed, and thus the scope for positive reciprocity, the three treatments are distinguished only for the first two movers. The third mover is observed by exactly one agent both in CI and in FI, whereas the forth mover is never observed in all three treatment. The opposite is true for the number of agents one observes, i.e. the scope for negative reciprocity. Namely that the three treatments are identical in this respect with regard to the first mover, CI and FI are indistinguishable with regard to the second mover, so that only the last two movers observe a different set of agents in the three different treatments.[12] Our fourth hypothesis reflects this effect:

Hypothesis 4. *The propensity to contribute is affected by an interaction of the transparency level and the position in the production chain. Agents who move early in the production chain are more likely to contribute as transparency increases from NI to CI and FI, whereas this effect is less pronounced (or reversed) for agents who move late in the production chain.*

V Experimental design and procedure

Participants in the experiments interacted in groups of four in a repeated form of the team production game outlined in Section III. To test our hypotheses regarding the interplay of information and production technology

[12]Whether negative or positive reciprocity carries more weight depends on the beliefs of the agents. For example, if one believes that her predecessors defect, there is no room for negative reciprocity. Our point is that both effects alter systematically along the production change, so that the overall positive effects of increased transparency are predicted to be diminished for later movers. We thank Johannes Abeler for pointing this out.

Table 1
Production technologies

Production technology	# of contributors $k=0$	$k=1$	$k=2$	$k=3$	$k=4$
IRS	180	190	220	310	500
LIN	180	260	340	420	500

in a team setting, we manipulated the production technology and the level of transparency to create a 3x2 between-subject design. The three transparency treatments reflect the three information structures NI, CI and FI, whereas the two production technology treatments are designed to be either with increasing returns to scale (**IRS**) or linear (**LIN**). The experimental technologies are presented in Table 1.

As can be seen in the table, the output in both treatments is increasing in the number of contributors, with $p(0) = 180$ and $p(4) = 500$. The intermediate values vary with the treatment, with the return from a single contribution increasing from 10 to 190 in IRS, compared to LIN, in which the return from each single contribution is fixed at 80.

The cost of contribution was fixed in all treatments to be $C = 650$. In accordance with conditions (1) and (2), the benefit factor was fixed at $b_i = 4$ for the first and second movers, and at $b_i = 5$ for the third and fourth movers.[13] Therefore, the monetary incentives in LIN constitute a social dilemma: every agent loses money by contributing, whereas her payoff is higher if all four agents contribute compared to the equilibrium outcome (cf. Section III.B). The six treatments and the equilibria for selfish money-maximizing agents are summarized in Table 2.

The sessions were conducted in June 2010 at the computerized Max Planck Experimental Laboratory in Jena. Each session was composed of

[13] The mean marginal per-capita return (MPCR) is therefore approximately 0.55.

Table 2
Equilibria in the different treatments

	IRS	LIN
NI	(0,0,0,0)	(0,0,0,0)
CI	(1,1,1,1),(0,0,0,0)	(0,0,0,0)
FI	(1,1,1,1)	(0,0,0,0)

Note: Nash, sequential and subgame-perfect equilibria in treatments NI, CI and FI, respectively. 0=defect, 1=contribute.

32 participants interacting in 8 groups, all in the same treatment. For each of the six treatments we ran two sessions, i.e. 12 sessions + 1 pilot with 400 participants in total. Participants were Jena university students. The experiment was programmed using z-Tree (Fischbacher, 2007) and invitation of participants was managed using ORSEE (Greiner, 2004), which guaranteed that no subject participated in more than one session. Experimental earnings were specified in Experimental Currency Units (ECU), which were converted to money at the end of the experiment at a conversion rate of 150 ECU = 1€. Final payoffs ranged from 5€ to 18€, with an average of 11.73€ per participant.

At the beginning of the experiment, participants read the instructions in private, after which the instructions were read out loud to induce common knowledge and additional questions were answered privately.[14] Once all participants indicated that they understood the instructions, a practice phase commenced, in which participants were given the opportunity to simulate the experiment by playing in all four roles repeatedly.

At the beginning of the experimental phase, participants were randomly assigned to groups of four. Each group interacted over twelve periods in a

[14] We used a labor framing following Goerg et al. (2010). A translation of the German instructions is provided in the appendix.

partners design. At the beginning of each period, the participants in the group were (re)assigned to roles, determining the order of moves within the period (denoted by the letters A, B, C, D).[15] Each participant in her turn was either not informed (NI), informed about the decision of their immediate predecessor (CI), or informed about all previous moves (FI) and decided whether to contribute or not. An on-screen calculator was provided to help the participants work out possible payoffs for different decisions (see screenshot in the appendix). Next, participants were asked to state their expectations about the decisions of the other group members, excluding those they were informed about. Finally, we informed the participants about the number of contributors in their group and of their own period earnings.

At the end of the experiment, one period was randomly selected for payoff. Additional 150 ECU were awarded for a correct expectation, randomly chosen from the expectations made in the non-payoff periods. Before leaving the lab participants were asked to fill out a short questionnaire and were paid out privately and individually.

VI Results

We start our analysis by looking at the effects of transparency on contribution levels in the two technology treatments, at the individual and group levels and by roles. We proceed by analysing the strategies employed by our subjects, and specifically the existence of conditional cooperative strategies under partial and full transparency in the two technology treatments. Finally, we look at whether beliefs about past moves in the CI treatment are updated according to belief in conditional cooperation of the intermediate players.

[15] To keep the procedure consistent, we employed the same sequential protocol in all treatments, including NI, which is equivalent to a simultaneous-moves game.

VI.A Contribution levels

The average contribution levels by information treatment and period are shown in Figure 1. First, let's focus on the top panel, representing the IRS treatments. We see that, contrary to the equilibrium prediction, contribution levels start out highest in the NI treatment, with FI performing considerably worse than the other two treatments. Nonetheless, there is considerable increase in contributions in the two information treatments accompanied by a sharp decrease in the baseline NI treatment. By the sixth period, contribution levels stabilize with, on average, around three out of four contributors in CI and FI and under two out of four contributors in NI.

TABLE 3
MEAN CONTRIBUTION LEVELS

	IRS			LIN		
	NI	CI	FI	NI	CI	FI
All periods	0.53	0.74	0.67	0.50	0.59	0.47
	(0.09)	(0.07)	(0.07)	(0.05)	(0.05)	(0.05)
Periods 1-6	0.62	0.69	0.57	0.54	0.62	0.52
	(0.08)	(0.07)	(0.07)	(0.05)	(0.06)	(0.05)
Periods 7-12	0.44	0.79**	0.76*	0.47	0.55	0.42
	(0.11)	(0.08)	(0.09)	(0.05)	(0.06)	(0.06)
Last period	0.41	0.78**	0.72*	0.30	0.48†	0.20
	(0.11)	(0.10)	(0.11)	(0.05)	(0.09)	(0.06)

Note: Standard errors in parentheses.

*,** denote significant difference from NI at the 10 and 5 percent level, respectively, two-sided Mann-Whitney test.

† Mean contributions in the last period are significantly higher in CI than in FI at the 5 percent level, two-sided Mann-Whitney test..

The average contribution levels in the IRS treatment are presented on the left-hand side of Table 3, for the entire experiment as well as for blocks of 6 periods and for the very last period. Non-parametric tests confirm the pattern evident in Figure 1. Although overall contribution levels do not differ

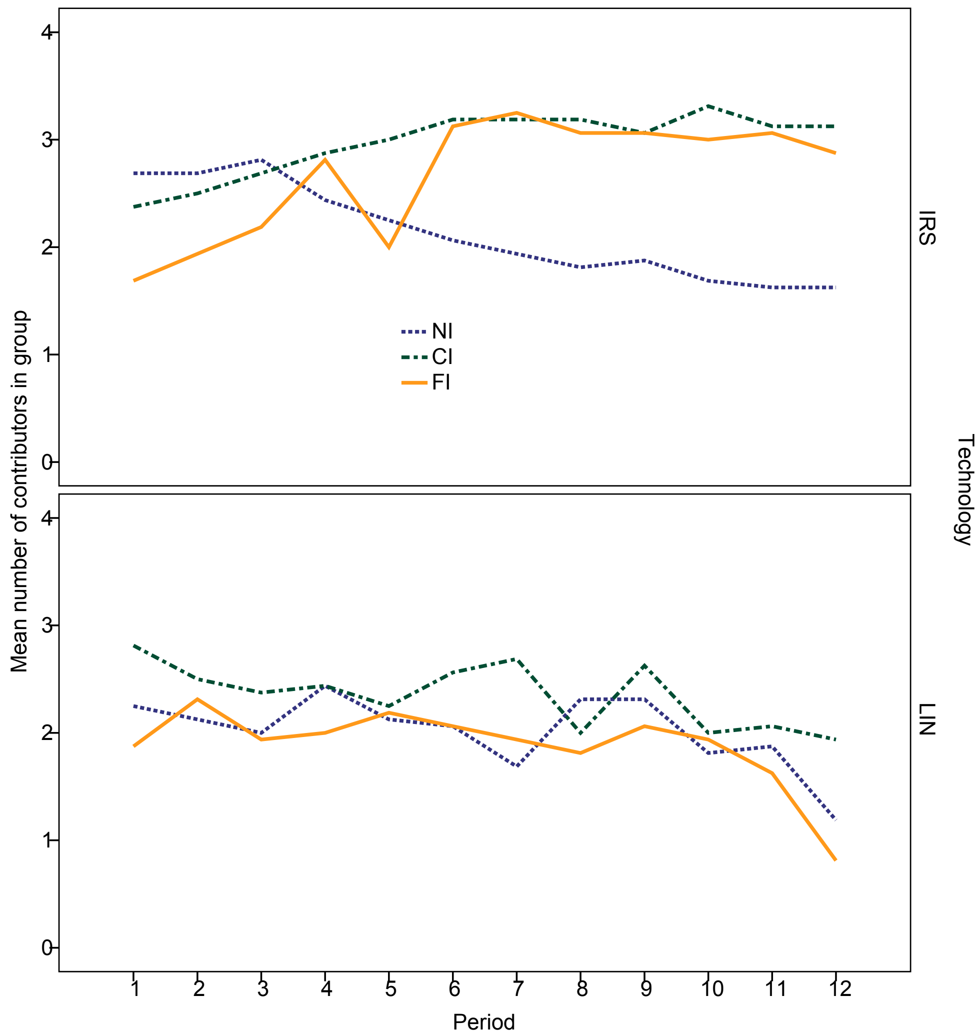

FIGURE 1
MEAN CONTRIBUTIONS

between information treatments, they are significantly higher than NI in both other treatments for the second half of the experiment. This pattern is also confirmed in the mixed-effects probit regression reported in column (1) of Table 4. Contributions significantly decline in NI and significantly increase in CI ($\beta = 0.090$, $SE = 0.018$, $p < 0.001$) and in FI ($\beta = 0.124$, $SE = 0.017$, $p < 0.001$).[16] The mean contribution observed in FI in the first period is significantly lower than that observed in NI ($\beta = 1.315$, $SE = 0.529$, $p = 0.013$), but not when compared to CI ($\beta = 0.702$, $SE = 0.527$, $p = 0.183$). Nor is the difference between the two other treatments significant ($\beta = 0.613$, $SE = 0.533$, $p = 0.250$). We attribute this adverse effect of full transparency as evidence for the immediate effect of negative reciprocity. Conversely, the positive effects of reciprocity require of the first movers to apply high-level strategic thinking and belief in the rationality of their followers, and therefore become evident only after a learning period.

Observation 1. *Contributions under increasing returns to scale converge towards the equilibrium predictions with time. Full transparency leads to lower contribution rates in the beginning of the experiment, but increase with time, while contribution rates under zero transparency decrease. Partial transparency performs at least as well as full transparency.*

Thus, our Hypotheses 1 and 2 are validated by the data. Columns (3) and (4) in Table 4 apply a similar analysis on the group level to reveal the dynamics behind the effects. As is evident in the top panels of Figure 2, the proportion of groups that achieve full cooperation in the first period is similar in all information treatments. In NI, this proportion remains stable throughout the experiment, and, in fact, from period 5 onwards there is no change in the identity of the fully-cooperative groups. Thus, groups that happen to consist of cooperative individuals manage to maintain cooperation over time. The decline in average contributions in this treatment is due to the increase in the proportion of groups in which no member contributes. The existence of free riders in a group leads early contributors to defect in later periods.

[16] All coefficients reported in the text are based on a test on the corresponding linear combinations of coefficients estimated following the regressions reported in the tables.

Table 4
Contribution decisions

	IRS				LIN			
	(1) Individual contribution	(2) Individual contribution	(3) Group full contribution	(4) Group zero contribution	(5) Individual contribution	(6) Individual contribution	(7) Group full contribution	(8) Group zero contribution
Period[a]	-0.136***	-0.140***	-0.002	0.312***	-0.039***	-0.042***	-0.057	0.052
	(0.018)	(0.019)	(0.053)	(0.063)	(0.014)	(0.014)	(0.042)	(0.043)
CI	2.090***		3.658***	-1.842***	0.243		0.493	0.344
	(0.533)		(1.120)	(0.636)	(0.228)		(0.525)	(0.429)
FI	1.797**		3.255***	-1.822***	-0.147		0.039	0.795*
	(0.527)		(1.087)	(0.615)	(0.229)		(0.552)	(0.411)
Period[a] x CI	0.225***	0.233***	0.229***	-0.308***	-0.000	0.003	-0.019	0.042
	(0.026)	(0.026)	(0.072)	(0.074)	(0.020)	(0.020)	(0.054)	(0.060)
Period[a] x FI	0.259***	0.266***	0.238***	-0.386***	-0.008	-0.009	-0.011	0.005
	(0.025)	(0.026)	(0.069)	(0.073)	(0.020)	(0.020)	(0.058)	(0.053)
Second mover		-0.043				0.015		
		(0.176)				(0.138)		
Third mover		0.466**				0.729***		
		(0.176)				(0.139)		
Fourth mover		0.477**				0.479***		
		(0.175)				(0.136)		
CI x								
First mover		2.667***				0.724***		
		(0.572)				(0.267)		
Second mover		2.510***				0.651**		
		(0.570)				(0.267)		
Third mover		1.819***				-0.053		
		(0.567)				(0.265)		
Fourth mover		1.600***				-0.258		
		(0.564)				(0.264)		
FI x								
First mover		2.310***				0.557**		
		(0.563)				(0.268)		
Second mover		2.134***				0.416		
		(0.562)				(0.268)		
Third mover		1.487***				-0.691***		
		(0.559)				(0.267)		
Fourth mover		1.384***				-0.913***		
		(0.558)				(0.270)		
Constant	-0.387	-0.626	-1.753**	0.083	-0.206	-0.529***	-1.983***	-1.384***
	(0.373)	(0.399)	(0.792)	(0.439)	(0.161)	(0.189)	(0.411)	(0.324)
Observations	2304	2304	576	576	2304	2304	576	576

Notes: Probit regressions with random effects for groups. Standard errors in parentheses.

[a] The last period is taken as the baseline.

*,**,*** denote significance at the 10, 5 and 1 percent level, respectively.

Conversely, in the two information treatments, it is the free riders in the mixed groups that learn to cooperate, in line with the equilibrium, so that groups that start out with heterogeneous contributions become fully cooperative within a few periods. Thus, when free riders and cooperative types find themselves in the same group, each type pulls in his direction, and the one backed by the monetary incentives triumphs. Moreover, some of the groups that started out with zero contributions in FI learn to overcome the initial hurdle, as observed in the decrease in proportion of zero-contribution groups in this treatment ($\beta = -0.074$, $SE = 0.036$, p=0.037). This proportion is stable in CI ($\beta = 0.004$, $SE = 0.040$, p=0.921).

Observation 2. *Under incresing returns to scale, fully-cooperative groups tend to stay cooperative over time regardless of the information structure. The decrease in contributions when actions are not observed, and the increase in contributions with partial and full transparency are mainly due to groups with heterogeneous contributions in the first period that learn to converge to the equilibrium.*

Compared to the strong effects of information observed in the IRS treatments, no significant effect of the information treatments on overall contributions is found in LIN, as can be seen in the bottom panel of Figure 1, the right-hand side of Table 3, and columns (5), (7) and (8) in Table 4. However, there is a weakly-significant tendency for more zero-cooperation in groups when the full history is observed within the period. A weak but significant negative time effect is evident in all information treatments, with a sharp decrease in contributions in NI and FI, that is not evident under CI (although the difference in the last period is only significant when comparing FI and CI). Thus, Our Hypothesis 3 is not supported by the aggregate data. Nonetheless, an analysis of the contribution decisions made by the subjects when playing in the different roles reveals significant patterns that differ according to the information structure.[17]

[17]Although not the focus of this paper, it's worth noting the effect of technology when

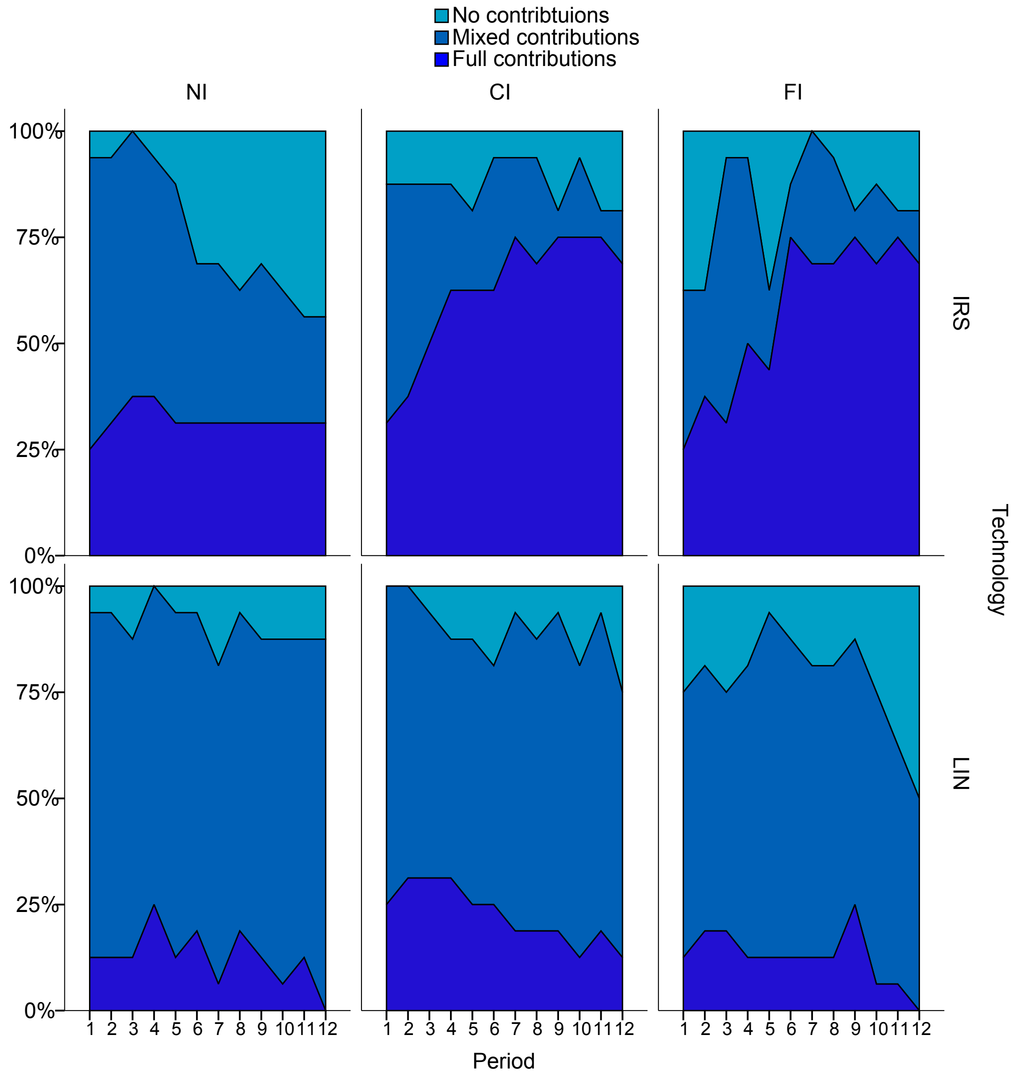

FIGURE 2
GROUP COMPOSITION

previous moves are unobserved. The unique equilibrium in NI is zero contributions, regardless of the production technology. However, only in the social dilemma of LIN, this equilibrium is in strictly dominant strategies, whereas in IRS a higher level of reasoning is required from the high-reward agents. Accordingly, contributions start higher in IRS,

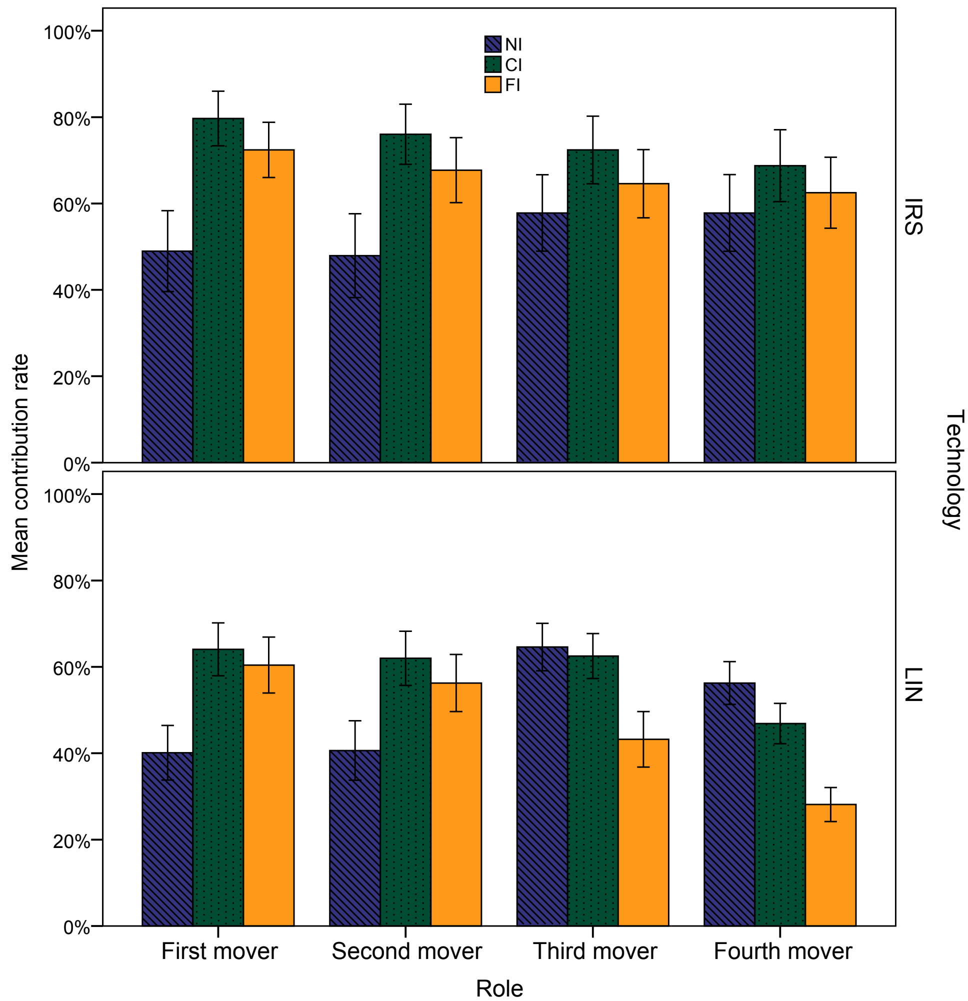

FIGURE 3
CONTRIBUTIONS BY ROLE

Mean contribution rates by role for all treatments are presented in Figure 3. According to our hypothesis, the effects of transparency diminish along the production chain, as much as reversing for the late movers in the LIN treatments. The regressions in columns (2) and (6) in Table 4 bear out

but decline over time to the same levels as in LIN.

this effect. First, note that the last two movers are more likely to contribute than the first two, an effect that can be attributed to the higher reward factor.[18] Of more interest are the effects of the two information treatments by the different roles. In IRS, all coefficients are positive and highly significant, indicating that subjects are more likely to contribute with both partial and full transparency.[19] However, the coefficients are decreasing in value along the production chain, with a significant difference in coefficients between the second and third mover ($\beta = -0.691$, $SE = 0.251$, $p = 0.006$ in CI; $\beta = -0.647$, $SE = 0.241$, $p = 0.007$; $p \geq 0.372$ for all other comparisons between two consecutive roles).

Moving to the LIN treatment presented in Column (6) in Table 4, the contributions levels of the two late movers do not differ significantly between NI and CI, and are significantly *lower* in FI. The difference between FI and CI is also significant ($\beta = 0.637$, $SE = 0.267$, $p = 0.017$ for the third mover; $\beta = 0.654$, $SE = 0.279$, $p = 0.015$ for the fourth mover). We conclude that for early movers, CI significantly outperforms NI while not doing worse than FI. For late movers, on the other hand, CI outperforms FI while not doing significantly worse than NI.[20]

Observation 3. *Positive reciprocity due to increased transparency mostly affects early movers, whereas negative reciprocity mainly affect late movers. With increasing returns to scale, where the effects of positive reciprocity are*

[18]In the post-experimental questionnaire, one subject commented that he contributed if and only if when the reward factor was 5.

[19]Column (2) in Table 4. Note that the coefficients relate to the effects at the end of the experiment. Non-parametric tests for group averages over all periods yield significant results only for the comparison of NI and CI for the first and second movers ($p = 0.019$ and $p = 0.053$, respectively, two-sided Mann-Whitney test).

[20]This conclusion is fully supported by non-parametric two-sided Mann-Whitney tests for the group averages over all periods presented in Figure 3. For the first two movers, CI leads to contribution rates higher than NI ($p = 0.021$ and $p = 0.039$, respectively), but not significantly different from those under FI ($p = 0.776$ and $p = 0.544$, respectively). For the third and fourth movers, contributions under CI are significantly higher than under FI ($p = 0.035$ and $p = 0.006$, respectively), but not significantly different from those under NI ($p = 0.834$ and $p = 0.303$, respectively).

backed by the monetary incentives, they outweigh the effects of negative reciprocity. In the social dilemma, however, contributions of late movers suffer from too much transparency. Partial transparency thus provides the best environment for cooperation, benefiting from positive effects of transparency, while avoiding the detrimental effects of negative reciprocity.

VI.B Conditionally cooperative strategies

Cooperation with partial and full transparency is sustained by conditional cooperation, i.e. all agents contribute if and only if everyone they observe has contributed. In IRS, these strategies are supported by the monetary incentives as the equilibrium strategies. In LIN, however, such conditionally cooperative strategies should exist only due to intrinsic preferences. The regression models presented in Table 5 study the effect of observed cooperation on contributions. We find that, in LIN, subjects are significantly more likely to contribute if they observe contribution, supporting the hypothesis that (some of) our subjects are intrinsically conditional cooperators. The effect over observed full cooperation is stable over time.

Conditional cooperation is drastically enhanced in IRS, where it is dictated by the monetary incentive structure. Furthermore, The effect of the technology slightly increases over time, as subjects gain experience with this structure.[21]

Observation 4. *Conditional cooperation is evident even in the social dilemma, but is considerably stronger when supported by the monetary incentives.*

VI.C Beliefs about unobserved previous movers

The theoretical analysis in section III predicts that an information chain is as efficient as full transparency in facilitating cooperation in our setup. The

[21] The effect of time may be underestimated, as in the second part of the experiment most groups become homogeneous, so that their members only observe cooperation, respectively defection, leaving no room for conditional cooperation to manifest itself.

Table 5
Conditional cooperation

	CI	FI
Period[a]	-0.036	-0.079***
	(0.027)	(0.022)
IRS	-0.454	-0.133
	(0.453)	(0.358)
Period[a]x IRS	0.012	0.068*
	(0.053)	(0.041)
Observing full contributions	0.824***	1.109***
	(0.223)	(0.235)
Observing full contributions x IRS	2.126***	2.163***
	(0.485)	(0.459)
Observing full contributions x Period[a]	0.002	0.049
	(0.034)	(0.034)
Observing full contributions x IRS x Period[a]	0.119*	0.122**
	(0.064)	(0.061)
Constant	-0.502**	-1.045***
	(0.208)	(0.190)
Observations	1152	1152

Notes: Probit regressions with random effects for groups. Standard errors in parentheses.
[a] The last period is taken as the baseline.
*,**,*** denote significance at the 10, 5 and 1 percent level, respectively.

crux of this result is that a contribution made by the immediate predecessor signals full contributions in the past. To test whether our subjects indeed make this deduction, we look at the effect of observed contributions on beliefs

Table 6
Beliefs about unobserved previous movers in CI

	Third mover's belief about	Fourth mover's belief about	
	First mover	First mover	Second mover
Period[a]	0.017	-0.053	0.048
	(0.053)	(0.049)	(0.054)
IRS	-2.605	-0.770	-1.254
	(1.668)	(0.669)	(0.823)
Observing contribution	1.879***	0.909**	1.767***
	(0.453)	(0.396)	(0.454)
Observing contribution x Period[a]	0.017	0.089	-0.059
	(0.070)	(0.062)	(0.072)
IRS x Period[a]	-0.257	0.049	-0.064
	(0.181)	(0.086)	(0.105)
Observing contribution x IRS	3.567**	1.669**	2.032**
	(1.739)	(0.776)	(0.959)
Observing contribution x IRS x Period[a]	0.312	-0.075	0.142
	(0.195)	(0.109)	(0.130)
Constant	-0.647*	-0.178	-0.420
	(0.354)	(0.324)	(0.341)
Observations	384	384	384

Notes: Probit regressions with random effects for groups. Standard errors in parentheses.

[a] The last period is taken as the baseline.

*,**,*** denote significance at the 10, 5 and 1 percent level, respectively.

about previous movers in CI.[22] The results of regressions by the role of the observing and unobserved agents are presented in Table 6. We see that late movers are indeed more likely to believe that the early movers have contributed, if the observed intermediate agent has contributed, indicating a belief in conditional cooperation of others. This effect is significant in

[22] A graphical summary of the accuracy of all of the elicited beliefs across treatments and roles is provided in the appendix.

LIN, but is considerably enhanced in IRS, where conditional cooperation is expected in equilibrium.[23] Thus, our final observation mirrors the previous observation:

Observation 5. *Beliefs in conditional cooperation are evident even in the social dilemma, but are considerably stronger when supported by the monetary incentives.*

VII Conclusion

This paper studies information chains in teams and their effect on individual and group performance. We analyze an environment designed to be conductive to cooperation under full transparency and increasing returns to scale, and show theoretically that this environment is also predicted to induce cooperation in the unique equilibrium that emerges under an information chain, conditional on a weak epistemic requirement that agents (are commonly known to) strongly believe that others never play dominated strategies.

We designed an experiment to test this insight, and extended the experimental investigation to test the effects of the information chain in a comparable social dilemma. The results support the theoretical predictions, as cooperation in the information chain is weakly higher than in the full-transparency environment. We find that the effects of transparency emerge quickly over time, as agents learn to trust their peers to understand the incentive structure.

Behavior and beliefs in the social dilemma exhibit substantial conditional cooperation, which has the potential to lead to higher contributions as transparency increases. However, when the social preferences are not supported by the monetary incentives, we do not observe the crisp effect found under increasing returns to scale. An analysis of behavior along the production chain

[23]Note, however, that conditional cooperation and belief therein is only manifested if the observed mover sometimes plays *out of equilibrium*.

reveals the conflicting effects of transparency-induced reciprocity. Transparency is found to have significant positive effects on agents who are mainly observed, but negative effects on agents who mainly observe others.[24]

The importance of transparency for incentivizing agents in teams has been acknowledged in the theoretical literature (e.g, Andreoni and Samuelson, 2006; Che and Yoo, 2001; Marx and Matthews, 2000; Mohnen et al., 2008; Varian, 1994)and studied in the field (e.g., Falk and Ichino, 2006; Heywood and Jirjahn, 2004) and in the lab (e.g., Clark and Sefton, 2001; Gächter, Nosenzo, Renner and Sefton, 2010; Nosenzo and Sefton, in press). These studies focused on full transparency, looking at how transparency can be utilized to increase cooperation by way of conditionally-cooperative strategies. To this literature we introduce the notion of partial transparency, as manifested in the information chain, as a way to extract the potential for cooperation inherent in transparency while mitigating the detrimental effects associated with full transparency, which have been largely neglected so far.[25]

Our results suggest that an information chain is not only sufficient to induce cooperation (as in Winter, 2010), but has the potential to surpass the benefits of full transparency. Full transparency is shown to perform almost as well as partial transparency when there are strong positive externalities between the agents and sufficient opportunity for learning. However, in early rounds, and when the externalities are weak, the relative advantage of partial transparency increases, in particular with respect to agents who are positioned later in the production chain.

This conclusion has practical implications across several domains. In designing work environments, it has been suggested that co-location of workers

[24]An interesting extension to this line of research would be to study behavior of intermediate agents as the production chain increases in length.

[25]Bag and Pepito (2011) have shown that outcome transparency can reduce contributions in a two-period two-players production game, in which effort is fully observed. The notion of partial transparency, however, is irrelevant to games of two players, which have also been the focus of the majority of the theoretical and empirical studies mentioned above.

is likely to increase productivity (Heywood and Jirjahn, 2004; Teasley et al., 2002). Our results suggest that some partitioning of workers is advisable in order to contain the effects of 'rotten apples'. Conditional strategies in the work environment can also be contractually implemented rather then rise from the flow of information. The design of contracts should take into account that allowing to condition on extensive peer performance may be inferior to more restricted contracting. Finally, fundraisers know that providing information about past donations is instrumental in attracting new donations. Our results suggest that a full revelation of the history may be harmful. In comparison, reporting the donations over a fixed recent time period (e.g., a week, a month, etc.) may have the advantage of avoiding any lasting effects of low donations.

In sum, we find that, in line with previous theoretical and empirical findings, increased transparency generally has a beneficial effect on contributions to a joint project. Although some studies failed to find such an effect, to the best of our knowledge this is the first experimental study to find that transparency has some detrimental effect on cooperation (in early periods and for late movers). More importantly, we find that an information chain can be effective in balancing the advantages and drawbacks of transparency. Furthermore, we look at the way in which transparency interacts with the production technology to influence the balance between positive and negative reciprocity. The aim of this paper is to establish the beneficial potential of partial-transparency structures, and in particular that of information chain, under different technologies. Future research is required to test the generality and boundaries of our conclusions with regard to different environments. For example, when contributions are continuous or incremental, or with larger groups.

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Appendix A: experimental instructions

Welcome! Please end now all conversation with other participants, switch off your cell phone and read the following instructions carefully. If something is unclear, please raise your hand and we will come to you and answer your question individually.

The instructions are identical for all participants. During the experiment you remain anonymous. This means that none of the other participants will learn your identity. The experiment consists of two parts. In the first part you will have the opportunity to familiarize yourself with the software and the rules of the experiment. In the second part you interact in 12 repetitions (rounds) with other participants. You can earn money in each of these 12 rounds. How much money you earn will depend on your own and on the decisions of other participants. However, only one round will be paid out: at the end of the experiment the computer will decide at random which round will be relevant for the calculation of the earnings. The earnings of each participant of the experiment will then be calculated based upon the earnings in that round.

During the experiment all sums of money are listed in ECU (for Experimental Currency Unit). Your earnings during the experiment will be converted to Euro at the end and paid to you in cash. The exchange rate is 150 ECU = 1 Euro.

At the beginning of the experiment you and three other participants will be assigned to a group. The assignment is random and will remain fixed throughout the experiment. The members of a group work jointly, one after the other on a project. There are four roles in each group A, B, C and D. A works first, then B, C and last D. Each group member has to decide whether he or she works hard or normal on the project. The revenue of the project increases with the number of hard working group members. The income of each member depends on the revenue as well as the individual wage factor. The wage factor depends on the position in the production process: the factor increases for later movers.

We will now explain a round in detail. At the beginning of each round you will be assigned one of the four roles at random. The assignment is done at the beginning of each round via a random mechanism. Your role determines your position in the production process and thus also your wage factor. Then each member decides, one after the other, about his or her effort level, which can be hard or normal. As the graph shows, A decides first then B then C and at last D.

NI To decide on your effort level in a round, you have to wait until the roles before you have decided. You will learn at the end of the round, how the other members in your group have decided.

CI To decide on your effort level in a round, you will have to wait until the roles before you have decided. Before you make your effort decision, you will learn what your predecessor has decided. If you have for instance role C, you will learn whether B decided to work normal or hard. Equally your successor D will learn, before he or she decides, whether you C has worked hard or normal.

FI To decide on your effort level in a round, you will have to wait until all the roles before you have decided. Before you make your effort decision for this round, you will learn how many of your predecessors have decided to work hard. For instance, if you have role C, you will learn how many of your predecessors (A and B) have decided to work hard. Equally your successor D will learn, before he or she decides, how many of his predecessors (A, B and C) have decided to work hard.

The more members decide to work hard, the higher is the return of the project. The return is generated according to the following table:

IRS

Number of hard working members	0	1	2	3	4
individual return from project	180	190	220	310	500

LIN

Number of hard working members	0	1	2	3	4
individual return from project	180	260	340	420	500

IRS For instance if all members of the group decide to work normal, the return is 180. If you and exactly one other member decide to work hard the return will be 220 etc.

LIN For instance if all members of a group decide to work normal, the return per member is 180. If you and exactly one other member decide to work hard the return will be 260. etc.

Return and Costs For each unit produced, the members receive – contingent on their particular role – ECU. The return is distributed according to the following table.

Role	A	B	C	D
Factor	4	4	5	5

If you for instance have the role A in a particular round. Your wage factor in this round is 4. You will then receive with a return of 180 units 720 ECU. With a return of 500 units you will receive 2500 ECU etc.

Costs Working hard causes costs of 650 ECU. If you decide to work hard 650 ECU will be deducted from your return. If you decide to work normal nothing will be deducted.

IRS: For instance if you have the wage factor 5 in a particular round, and you and exactly one other group member decides to work hard the return from the project will be 220. You will then receive $220x5 = 1100ECU$, minus costs of 650 ECU for working hard, and your return in this round will be 450 ECU.

LIN: For instance if you have the wage factor 5 in a particular round, and you and exactly one other group member decides to work hard, the return of the project is 340. You will then receive $340x5 = 1360ECU$, minus costs of 650 for working hard, and your return in this round will be 450 ECU.

Procedure You will first have the opportunity to test the software for five minutes. Here you will be acting in all four roles simultaneously. Nothing that you will do in these five minutes will have any implication on your payoff. Also no other participant will be able to observe what you are doing. After the five minute test phase the second phase starts.

NI At the beginning you will learn which of the four roles you were assigned to in this round. Then, as explained above, the participants will decide one after the other whether to work hard or normal in this round (first A then B then C etc.) After you have taken your decision we will ask about your expectations. Please state how you think the other members have decided. At the end of the round you will be informed about the decision of the other members and your payoff in this round. In the next round the random mechanism will again assign you one of the four roles.

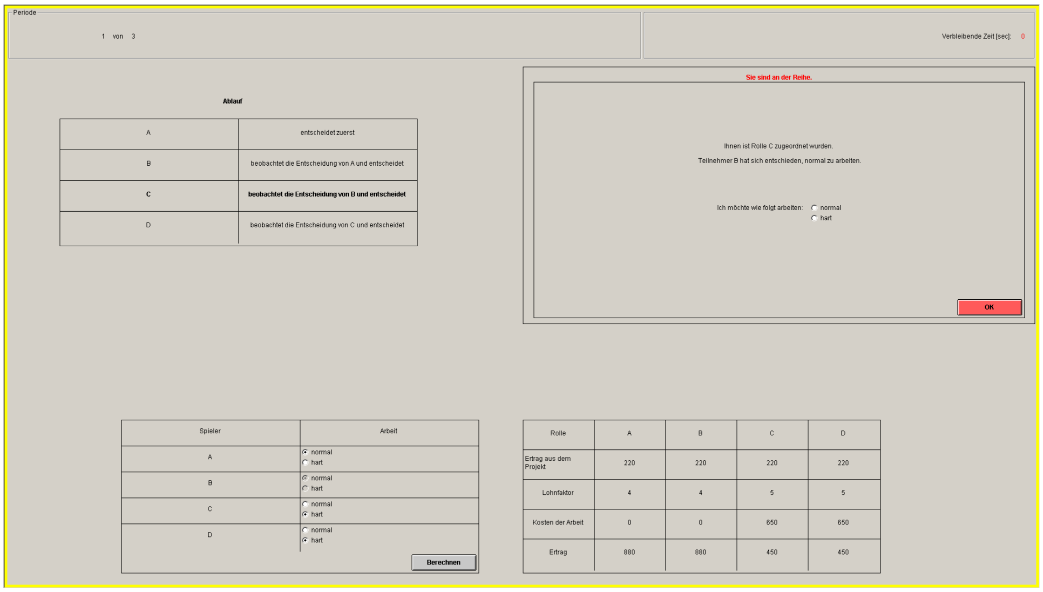
CI At the beginning you will learn which of the four roles you have in this round. Then, as explained above the participants will decide one after the other whether to work hard or normal in this round (first A then B then C etc.) Before you take your decision you will learn the decision of your predecessor. This means that B knows A's decision, C knows B's decision and D knows C's decision. After you have taken your decision we will ask about your expectations. Please state how you think the other members have decided. At the end of the round you will be informed about the decision of the other members and your payoff in this round. In the next round the random mechanism will again assign you one of the four roles.

FI: At the beginning you will learn which of the four roles you have in this round. Then, as explained above, the participants will decide one after the other whether to work hard or normal in this round (first A then B then C etc.) Before you take your decision you will learn the decision of all your predecessors. This means that B knows A's decision, C knows A's and B's decision and D is aware of A's, B's and C's decision. After you have taken your decision we will ask you – where appropriate – about your expectations. Please state how you think the other members have decided. At the end of the round you will be informed about the decision of the other members and your payoff in this round. In the next round the random mechanism will again assign you one of the four roles.

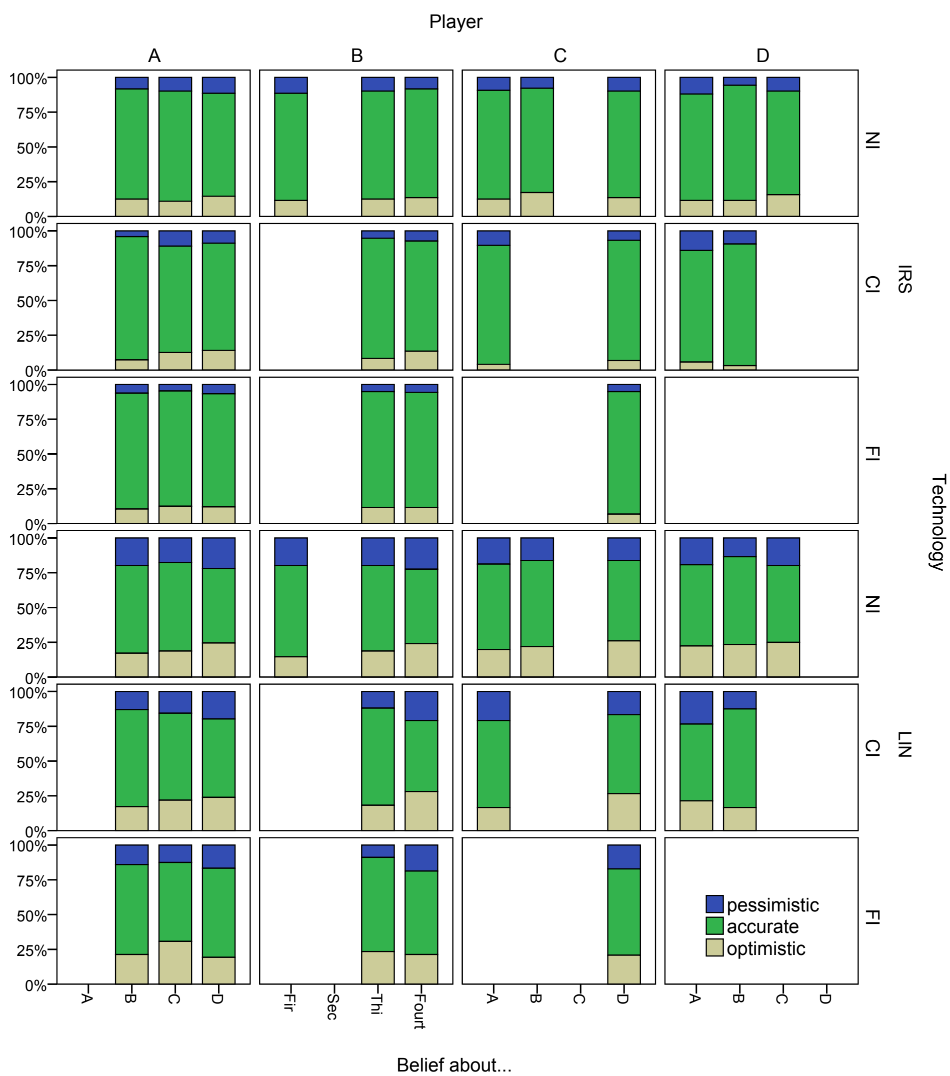
The end of the experiment

After you have completed the 12 rounds the experiment is over. One round will be selected at random for payment. For every participant his or her payoff is the return achieved in that round. Also for ever participant one round will be selected at random for the expectations. However, this round will not be the same as the one chosen for payment. A correct expectation will be rewarded with 150 ECU. At the end we will ask you to fill out a questionnaire. Please remain seated until we call your cabin number. Thank you for participating in this experiment and have a nice day.

Appendix B: screenshot



Appendix C: beliefs accuracy



Note: a belief is categorized as optimistic (pessimistic) if a player guessed that the other player contributed (did not contribute), when in fact the opposite was true.