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Going Green: Framing Effects in a Dynamic Coordination Game

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Abstract

We experimentally study decision-making in a novel dynamic coordination game. The game captures features of a transition between externality networks. Groups consisting of three subjects start in a stable benchmark equilibrium with network externality. Over seven rounds, they can transit to an alternative stable equilibrium based on the other network. The alternative network has higher payoffs, but the transition is slow and costly. Coordination is required to implement the transition while minimizing costs. In the experiment, the game is repeated five times, which enables groups to learn to coordinate over time. We compare a neutral language treatment with a 'green framing' treatment, in which meaningful context is added to the instructions. We find the green framing to significantly increase the number of profitable transitions, but also to inhibit the learning from past experiences, and thus it reduces coherence of strategies. Consequently, payoffs in both treatments are similar even though the green framing results in twice as many transitions. In the context of environmental policy, the experiment suggests general support for 'going green', but we also find evidence for anchoring of beliefs by green framing; proponents and opponents stick to their initial strategies.

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1 Introduction

The choice for technology standards in software and hardware, and membership of social networks are typical examples where individual and social benefits of participation in an activity increase with the number of participants. Network externalities extend from the local level, e.g. standardization of procedures within firms, to the global level, e.g. standardization of recording technologies. Recently, a similar argument has developed when considering the global development of carbon-free energy sources, as opposed to continued dependence on fossil fuels (Acemoglu et al. 2012). Green innovation is believed to benefit from a coordinated and coherent transition. There are increasing returns to scale as innovation builds on existing knowledge, and infrastructure and energy sources develop in tandem. The spillovers suggest the need for a coordinated global policy, to transform the world economy from one based on fossil fuel energy, to one based on renewables.

We design a novel dynamic game, which we believe includes some key elements of major transition processes. Specifically, our game satisfies Katz and Shapiro's (1986) definition of a network externality that "the utility that a user derives from consumption of the good increases with the number of other agents consuming the good." The game is a type of dynamic three-player stag-hunt game. It combines features of a coordination game, and has a flavor of a public good game (such as free-rider incentives). We study how people behave in this game in a laboratory experiment. In our experiment, we specifically consider the effect of green framing; the game captures elements of a transition to a green economy, which we accentuate in one of the treatments. We refer to our game as the 'green transition game', but the game without framing describes more generally the transition in a network economy.

In the game, which consists of multiple rounds, group members have to choose whether they want to transit from the benchmark (initial) state to an alternative state, where states in the game are determined by chips that can take two different colors. Initially (in the first round), all group members have three chips of the same color (purple in the reference treatment, brown in the green framing treatment), and the benchmark state is a stable Nash equilibrium. In each of the following rounds of the game, individuals can change the color of one of their chips, at most one per round, and in both directions. The network externality arises as only chips that match the color group majority are paid. If five group chips are changed into the other color (blue in the reference treatment, green in the framing treatment), the majority has changed, and the stable Nash strategy becomes for all members to transit as quickly as possible to the alternative state, in which all group members have chips of the same (but other) color. The transition is slow, and the payoffs depend on the own choices interacting with the choices made by the collective within a group, that is, on the composition of the chips in the group at the beginning of a round. The alternative equilibrium, where all chips have changed color, has higher payoff. To have a consistent green framing treatment, we give chips of the other (non-initial) color (blue or green) a public good character. Blue (green) chips yield payoffs not only to the individual who owns them, but to all group members. The core features of our game are the following. The alternative state (with all blue or green chips) offers a higher potential payoff for all group members. The transition from the initial state to the alternative state is costly. Costs are so high, that the transition is only profitable

when the group transits coherently. For an individual player, choices are risky. This simple set up defines a coordination problem: only when the majority of the group transit, does it pay off for the individual to go along. The transition dynamics produce a 'valley of death': during the transition, all players have lower payoffs, but frontrunners pay most. If in a game individuals start a transition to the alternative state, but find no support by their group members, they suffer substantial losses and may rather turn back. Stated reversely, this feature resembles a free-rider problem. An individual that lags one round behind the other group members during the transition benefits most.[1]

As the game is novel it is difficult to predict how individuals behave in the experiment. However, under the above conditions, we believed that it is difficult for groups to coordinate on a transition, even though groups that succeed have significantly higher payoffs. Individuals have to form beliefs about the choices of their peer group members, and when too many individuals choose to delay the transition for their own gain, the transformation fails and losses cumulate. Most costs are allocated to those individuals that supported the transition, while the conservative or opportunistic members do not pay the price, or even gain, from their lack of support.

The first aim of this paper is to see what decision subjects make in this game. Do they manage to transit or not? To enable groups to learn to coordinate over time, the same game was played five times, with constant but anonymous group members (partner matching).

Secondly, we are interested in the effect of framing in this type of dynamic coordination games. It has been widely documented that even though the information provided and the choices to be made are the same over treatments, beliefs and choices are affected by the way the problem is framed (e.g. Dufwenberg et al. 2011). In our context, framing can enhance the transition, for example as it provides an understanding of a common benefit. But the opposite is also possible, as framing anchors beliefs and as such reduces the flexibility of subjects' strategies. We investigate framing effects by adding a treatment in which we add meaningful environmental context to the instructions. That is, whereas the baseline treatment uses neutral language as much as possible, the framing treatment uses language that is environmentally loaded. Apart from the framing the two treatments are identical in terms of subjects, experimental procedure, payoffs, and all other design issues. In particular, also in the framing treatment the same game was repeated five times with partner matching.

We choose green framing. The global interest in and concerns about climate change and media attention provides a meaningful context (IPCC 2014). For some experiment subjects, the framing induces support for the transition; they may reflect on a better world not addicted to fossil fuel energy. But the framing also provides potential anchoring into the present state. Climate sceptics warn for huge costs involved when the world economy built on richly available cheap fossil fuel energy has to transform into one that drives on – mostly intermittent – renewable energy sources. The technology of the game presumes that the transition is beneficial, the equivalent of an optimist perspective where green growth is feasible – various studies point to economic benefits of a clean

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[1] As an example, consider the case of climate policy. If the world moves away from fossil-fuels, prices will drop, and it becomes increasingly beneficial for individual countries to defect a climate treaty and enjoy cheap energy for a little longer.

environment – even though the transition towards such an economy where clean technologies are favored over dirty technologies will be a costly endeavor (Acemoglu et al. 2012), not in the least because of the enormous infrastructural investments required to support a renewable energy structure (IEA 2011).

The paper makes several contributions to the literature. The multi-person dynamic game we have developed is simple but has interesting features, both from a theoretical and an experimental point of view. In addition, we believe that key elements of the game, such as the coordination problem, the role of beliefs, and the dynamics are representative of many situations in real life, where it may take time to move from a particular state to another, potentially better state. The experimental results show robust learning over the five games. In the first game coordination appears to be very difficult, but payoffs increase as the number of unsuccessful transitions decreases with gained experience over the games. Nevertheless, only a small minority of groups in the baseline treatment learn to make the transition.

We also contribute to the literature on framing. As will be detailed in the next section, the impact of the way in which a problem is described is rather ambiguous. It often depends on the type of game, the exact wording and kind of framing or labeling, and other aspects of the experimental design. In particular, we introduce environmental framing as treatment variable in our experiment. Our findings suggest that simply adding environmental context significantly increases the number of profitable transactions, but it also inhibits learning from past experiences and reduces coherence of strategies. Consequently, average payoffs in both treatments are very similar, even though the framing condition results in twice as many green technologies. Our results thus suggest general support for 'going green' but also more anchoring of beliefs: proponents and opponents stick more closely to their initial choices.

2   Related literature

Our paper is related to several strands of literature, both from experimental economics and environmental economics. The green transition game can be described as a dynamic stag hunt game, and is thus a special type of a coordination game which involves strategic uncertainty. Standard (static) coordination games typically have multiple Nash equilibria, where one is preferred (in terms of payoffs) to the other(s). For example, in a minimum effort game, the situation in which all players exert minimum effort is a Nash equilibrium. Although there are potentially great gains from coordinating on a high(er) effort level, the decision to exert (more) effort is risky. Many studies have examined the question which equilibrium will be selected, both theoretically and experimentally, but there is no clear answer. Theoretical arguments have been provided both supporting the selection of the risky, cooperative, pay-off dominant equilibrium (for sample, Harsanyi and Selten, 1988) as well as the safe, defecting, risk-dominant one (for example Carlsson and Van Damme, 1993). Experimental findings in these games are also mixed and report coordination on both equilibria (Van Huyk et al. 1990, Cooper et al. 1990).

Experimental evidence also suggests that the way in which players make decisions in these games, and thus the way in which equilibria are selected, depends on parameters of the experimental setting, like number of players, pay-

off structure, riskiness of strategies, history of play etc., and numerous experiments have examined which factors, mechanisms or institutions may reduce the frequency of coordination failures.[2] For instance, Battalio et al. (2001) documents that subjects' behavior in three stag hunt games is affected by the optimization premium, the expected payoff difference between an individual's best and inferior response to a particular strategy, in particular in the longer run. Another robust finding in these experiments is the considerable variation in behavior of groups. Actions in the first few repetitions of a game have a large impact on how groups behave in later repetitions (see e.g. Charness 2000). Groups that choose the pay-off dominant action in the first rounds typically maintain high levels of coordination across time, whereas groups that start with few cooperative decisions tend to converge to the risk dominant (pay-off dominated) outcome. Whether and how these findings translate to our experiment is ambiguous due to the many differences between these games and our game. Unlike most of the other stag hunt/coordination game experiments the green transition game is inherently dynamic in nature, has groups consisting of more than two players, and coordination on the good outcome cannot be realized immediately but takes time (multiple periods).

Our paper is also related to a strand of literature that uses experiments to examine environmental problems, and which games are typically more dynamic in nature (like our game). For example, a series of papers studies so-called collective-risk social dilemmas, also called climate protection game (Milinski et al. 2008, Tavoni et al. 2011, Barrett and Dannenberg 2012). This type of social dilemma is basically a threshold public good game, where people can contribute individually to a collective public good, and everyone suffers if the group fails to reach the target (because of dangerous climate change, for example). In all these studies groups have an incentive to avoid a loss, but the target may be certain or less certain, the consequences of crossing the threshold and the probability of crossing vary, etc. The basic version of this climate protection game is as follows (Milinski et al. 2008). Subjects participate in groups of six. At the beginning of the experiment subjects are endowed with €40 each. In each of 10 rounds they must decide whether to invest €0, €2, or €4 in a so-called climate account. If after 10 rounds the total contributions of the group are at least €120 - so if on average subjects have contributed half of their endowment - every subject keeps the remainder of the endowment (i.e. the amounts not invested in the climate account). If the target level of €120 is not reached, a disaster may occur in which all group members lose their savings with a known, fixed probability of 90%, 50%, or 10%.[3] Beliefs play a very important role in this game, like in our game. Subjects

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[2] Several studies have linked these coordination failures to macroeconomic phenomena such as why economies are stalled in low-productivity states or end up in a poverty trap (Bryant 1983, Cooper and John, 1998, Capra et al. 2009). Capra et al. (2009) is most related to our paper. They study the impact of simple communication and voting in a dynamic experimental macroeconomic environment with poverty traps and find that absent any institutions most economies (groups) converge to the poverty trap. With communication or voting some groups manage to reduce coordination failures, but only when these two institutions are combined the economies reliably escape the poverty trap in the longer run. They do not examine the effect of framing, however.

[3] Note that the experiment is based on a dynamic game, like the experiment of this paper. An important difference between this experiment and ours is that their payoffs are based on the

have a strong incentive to avoid the disaster and thus should invest if they believe that sufficient others will contribute, in particular in the 90% treatment. Nevertheless, Milinski et al. (2008) find that only five out of 10 groups managed to avoid the disaster by reaching the target in the 90% treatment whereas only one (no) group reached the target in the 50% (10%) treatment. This basic design has been extended to examine factors that may influence performance. For example, announcements (making a pledge) appear to increase the success rate (Tavoni et al. 2011)[4] whereas introducing uncertainty about the level of the threshold yields even many more catastrophes (Barrett and Dannenberg 2012).[5] In all these papers, the ultimate outcome is most crucial, i.e. the fundamental issue, which largely determines the payoffs, is whether the threshold is reached or not. An important contribution of our paper is that the transition process itself is also very important. Even groups that end up in the state with clean technologies may realize low total earnings if they coordinate badly and thus attain low per period payoffs during the game. Furthermore, as far as we know, none of these studies looks at the effect of framing.

Finally, our paper is linked to the literature on framing effects. Tversky and Kahneman (1981) use decision frame "to refer to the decision-maker's conception of the acts, outcomes, and contingencies associated with a particular choice". They add "the frame that a decision-maker adopts is controlled partly by the formulation of the problem and partly by the norms, habits, and personal characteristics of the decision-maker". This type of framing, sometimes called label framing, applies adequately to our design, and all changes we implement between the two treatments are purely textual. The game and choice options are exactly the same, but the formulation of the problem is different, and this may or may not affect the frame that subjects adopt as well as their behavior. Dufwenberg et al. (2011) stress the role of beliefs: "frames may influence a player's beliefs, which influence his motivation *as well as* his beliefs of other's choices and all of this influence his behavior." Many experiments have been conducted to examine the effects of framing, both in individual decision-making situations (e.g. Tversky and Kahneman 1981, Bateman et al. 1997) and in decision-making in groups (Andreoni 1995, Cookson 2000). Here we focus on a few studies that use alternative wording in environmental problems. [6]

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realized situation at the end of the 10 rounds, whereas the payoff in our experiment is based on all rounds.

[4] The success rate of 50% in Tavoni et al. (2011) is much higher than the 10% in the corresponding treatment in Milinski et al. (2008). Barrett (2011) argues that this difference is due to the act that in Tavoni et al. (2011) the investments in the first three rounds are not made by the players themselves but by a computer. We would like to add that all findings are based on relatively few observations (groups).

[5] In the two treatments without (with) threshold uncertainty the catastrophe occurred two (16) out of 20 times. Note that before subjects in this experiment made their actual decisions, groups played five practice rounds where group membership was reshuffled. Therefore, the statistical results as reported by Barrett and Dannenberg (2012) should be interpreted with care as they are not based on independent observations.

[6] We do not discuss studies that look at valence framing, that is whether information is presented in a positive or negative light (e.g. give or take games). Also many studies have compared behavior between essentially the same games but with different names like the Community Game or the Wall Street Game. Typically, a community frame has a rather strong cooperation enhancing effect in prisoner's dilemma games but a much weaker effect in public good games (see e.g. Ellingsen et al. 2012, Rege and Telle 2004).

Pevnitskaya and Ryvkin (2013) examine to what extent environmental context helps (pro-environmental) behavior and cooperation in a two-player dynamic public bad experiment. They argue that framing may affect behavior for at least two reasons. First of all, adding meaningful context to an otherwise abstract situation may make the situation more concrete and so help subjects to better understand the complex game setting (e.g. Cooper and Kagel, 2003, 2009). Secondly, framing may create additional noise/unobserved heterogeneity by invoking subjects' (home-grown) preferences and experiences from outside the lab that are not directly linked to the situation in the lab. In the dynamic game of Pevnitskaya and Ryvkin (2013), subjects have to choose their production levels, which generate private revenues and emissions (the public bad). To allow for learning subject play 20 periods, and after a restart, another 20 periods of the same game. With inexperienced subjects, they find that in the treatment with environmental context (which uses pollution and cost of environmental damage) subjects choose significantly lower production levels than in the neutral setting (which uses common stock and common stock maintenance costs). However, after the restart, the effect of environmental context is weaker and treatment differences in the level of the public bad are no longer statistically significant. While this experiment has several properties in common with the experiment in this paper (i.e. it is one of the few dynamic public bad games, the environmental context), there are also some notable differences such as the number of subjects (two versus three), and the number of games/repetitions, but the most important differences is probably the type of game. Compared to their game, our game is more about coordination and is particularly suited to study transition processes.

Cason and Raymond (2011) study framing effects in an emissions trading experiment with voluntary compliance. They hypothesized that subjects would find it more (morally) problematic to lie about 'pollution levels' than about simple 'numbers', such that compliance was expected to be higher in the treatment with environmental context than in the control treatment with neutral context. Contrary to their hypothesis, however, they find that environmental framing increases noncompliance significantly with subjects reporting levels of pollution below the actual levels. They argue that subjects comply less honestly with environmental context because they want to avoid the negative connotation of pollution that may be provoked when subjects honestly report high actual pollution levels (and not when they report just a high number). Although their results are hard to compare to ours, as the experiments differ in many dimensions, their findings clearly indicate that the effects of environmental framing are not always positive.

3 Game and model specification

The experiment is based on a simple three-player game, which may be considered to be a dynamic variant of a stag hunt game. A stag hunt game typically has two pure strategy Nash equilibria, a risk-dominant one and a payoff-dominant one. Our game is inherently dynamic as choices available to subjects in a round and payoffs per round also depend on decisions taken in earlier rounds. Note that unlike the stag hunt game our game only has one Nash equilibrium in pure strategies; the outcome that maximizes payoffs is not a pure strategy equilibrium.

Here we describe the game by defining a formal model; the next section will explain the details of the game and the experimental design and procedure. For convenience of notation and analysis, we describe an infinite horizon autonomous game. The infinite game enables us to present in a relatively simple format some equilibria supported by consistent strategies and beliefs, to demonstrate that one unique pure-strategy Nash equilibrium exists and multiple mixed-strategy equilibria. One should keep in mind that the first aim of our experiment is to study if in this game groups are able to escape from the bad equilibrium of the initial state and transit to a better state with higher payoffs. Secondly, we want to examine whether adding meaningful environmental context could help groups make this transition easier and/or achieve higher payoffs, for instance because of improved coordination on a particular outcome. So, we do not intend to specify a full-fledged model including all equilibrium strategies or to compare outcomes with specific equilibria. When assessing the experiment outcomes, we rather test whether outcomes suggest multiplicity of equilibria among groups, and whether the outcomes are different for the two treatments. The analysis in this section sketches the theoretical background needed for these tests.

In our game, let i be the index for the subject $i \in \{1,2,3\}$, t the round, and $b_i(t) \in \{0,1,2,3\}$ the number of blue chips subject i has at the beginning of round t.[7] The current state is described by the vector $\mathbf{b}(t)=(b_1(t), b_2(t), b_3(t))$, and the total number of blue chips in the group is $B(t)=b_1(t)+b_2(t)+b_3(t)$. In the first round, subjects are endowed with three purple chips and zero blue chips, so $b_i(1)=0 \; \forall \; i$ and $\mathbf{b}(1) = (0, 0, 0)$. During each round, subjects have to decide whether or not they want to change the color of their chips; $b_i(t+1) \in \{0,1,2,3\}$ denotes the number of blue chips subject i has at the beginning of round $t+1$, which is equal to the number of blue chips the subject has at the end of round t (i.e. after the change). In each round, subjects can change the color of at most one chip, and they cannot have less than zero or more than three chips of each color. Profits materialize at the end of a round and $v_i(\mathbf{b}(t+1))$ indicates the immediate payoff subject i receives at the end of round t. As payoff $v_i(\mathbf{b}(t+1))$ is symmetric for all subjects in a group, we only define the payoff in round $t+1$ for player 1, which depends on $\mathbf{b}(t+1)$ and $\mathbf{b}(t)$ as follows:

(1) $\quad v_1\big(\mathbf{b}(t + 1)\big) = 10\big(3 - b_1(t + 1)\big) + B(t + 1)$ if $B(t) < 5$

(2) $\quad v_1\big(\mathbf{b}(t + 1)\big) = 10 b_1(t + 1) + B(t + 1)$ if $B(t) > 4$

Note that the state in round t determines the so-called payoff scheme in round $t+1$, that is which color of chips are paid. The first part of the immediate payoff function gives the value of coordination, and presents the positive reinforcement of equal colored chips among the subjects. If the majority of chips are purple, as is the case in equation (1) since $B(t) < 5$, then each purple chip a subject has at the end of the round pays ten units. If the majority of chips are blue, as is the case in equation (2) since $B(t) > 4$, then each blue chip a subject has at the end of the round pays ten units. The second part of the immediate payoff function provides the public-good dimension of the game. That is, blue chips not only pay to their

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[7] In the analysis, we describe the game for the treatment with neutral framing, i.e. we only talk about purple and blue chips (and not about brown and green chips).

owners, but to the whole group. Each blue chip a group has at the end of round t yields 1 to every group member. Consequently, the initial state, when stationary, pays $v_1(0, 0, 0) = 30$, while the maximal payoff is reached for the `bliss' stationary state $v_1(3, 3, 3) = 39$.

The cumulative future payoff at the beginning of round t for subject i, $\pi_i(\mathbf{b}(t))$, is given recursively by expectations, where we subtract a bliss-point or reference payoff $\bar{v}$ to ensure convergence:

(3) $$\pi_i(\mathbf{b}(t)) = \mathbb{E}[v_i(\mathbf{b}(t+1)) - \bar{v} + \pi_i(\mathbf{b}(t+1))|\mathbf{b}(t)]$$

It is easy to verify that the following simple pure strategy is individually rational. All subjects increase their number of blue chips (if possible, that is, if $b_i(t)$ < 3) when $B(t) > 4$ and decrease their number of blue chips (if possible, that is, if $b_i(t) > 0$) when $B(t) < 5$. Given this pure strategy, the game will quickly converge to the closest extreme steady state, $\mathbf{b} = (0, 0, 0)$ or $\mathbf{b} = (3, 3, 3)$. When the game starts at zero, it remains there indefinitely. As the initial state is a Nash equilibrium, we can expect that many groups will stay in this equilibrium. However, there may be other, more attractive equilibria and individuals could try to reach these. In particular there may be multiple equilibria in mixed strategies.

Mixed strategies are described through the functions $p_i(\mathbf{b})$ and $q_i(\mathbf{b})$, which present the probability that subject i adds or drops a blue chip, respectively. We restrict the attention to symmetric strategies, consistent for permutations of $\mathbf{b}$. Mixed strategies must satisfy the rationality condition that if $p_i(\mathbf{b}) > 0$, then expected payoffs after switching a purple chip for a blue chip must not decrease, and if $q_i(\mathbf{b}) > 0$, then expected payoffs after switching a blue chip for a purple chip must not decrease.

Mixed strategies can become very complicated, with different kinds of inbuilt threats. In Appendix A we provide an example, where the expected payoffs are calculated relative to the bliss payoff of 39 (so that expected payoffs are negative and finite, because the game converges to the bliss outcome with probability 1). The example supports a full transition, but not immediate. Starting from $\mathbf{b} = (0, 0, 0)$, all subjects play a mixed strategy in which they choose to switch a purple chip for a blue one with 65% probability. In 72% of the cases, at least two subjects will have one blue chip, and the transition continues in pure strategies. In 28% of the cases, one or no subject has a blue chip, and the same mixed strategy is repeated. It takes in most cases more than the minimal two rounds to converge to the bliss point. The expected transition costs are 43 units, while a fully coordinated (but not individually rational) transition would cost 39 units.[8] The free-rider incentive, which makes the pure transition strategy individually irrational, increases costs by 4 units.

4 Experiment

Here we present some more information about the game, and the experimental design and procedure. We will also formulate hypotheses, which

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[8] Here we define transition costs to be the expected decrease in cumulative payoffs relative to the bliss-point payoff 39. The costs mentioned are costs for individual members.

will be tested in Section 5. The instructions used in the experiment can be found in Appendix B.

4.1 The game

The experiment is based on the formal game described in the previous section, but with a finite horizon. In particular, each experimental game consists of seven rounds. In every round a subject has exactly three chips, which may be purple or blue, and subjects have to decide simultaneously whether or not they want to change the color of one of their chips. In the first round, subjects are endowed with three purple chips and zero blue chips each. Depending on the pay-off scheme that is implemented, each chip is either worth 10 tokens or nothing. There are two possible pay-off schemes: (1) pay-off scheme purple: each purple chip a subject has at the end of a round yields 10 tokens to the subject (whereas blue chips yield nothing); (2) pay-off scheme blue: each blue chip a subject has at the end of a round yields 10 tokens to the subject (whereas purple chips yield nothing). Which payoff scheme is implemented for a group in a round is determined automatically by a simple majority rule: if at the *start* of a round the majority of chips in a group are purple (blue) the purple (blue) pay-off scheme is realized (see equations (1) and (2)). Subjects know which pay-off scheme will be implemented in a round before choosing whether they want to change the color of one of their chips or not.

The chips a subject has thus generate (private) pay-offs for the subject, which depend on the color of the chips and the pay-off scheme that is implemented in that round. On top of this, blue chips have a public-good type of feature: every blue chip a group member has generates a pay-off of one to *all* group members, irrespective of the applied pay-off scheme.

If all group members keep their purple chips in every round, pay-off scheme purple is implemented during the entire game, and a benchmark (status quo) pay-off of 210 tokens per subject is reached in the game. In contrast, immediate and full transition by all group members results in a total of 18 blue chips and a pay-off of 234 tokens per person over all rounds of a game.[9]

Some remarks are in order. First of all, it should be noticed that, by design, pay-off scheme blue can only be implemented ($B(t) > 4$) if at least two subjects have changed (some of) their chips, so a single individual cannot bring about a transition. Second, the gains from a successful, symmetric and simultaneous transition are relatively modest (234 versus 210) but equal for all subjects. An important feature of our dynamic game is that the transition is costly in the sense that in Rounds 1 and 2, subjects' payoffs are lower – namely 16 and 23, respectively – than in the status quo situation of the bad equilibrium where no

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[9] The benchmark (status quo) payoff of 210 tokens per game per subject follows from 3 purple chips × 10 tokens × 7 rounds. For the group it would be much better if all group members transited immediately and fully to the blue chips. Summing the blue chips a subject has at the end of each round then gives 1 + 2 + 3 + 3 + 3 + 3 + 3 = 18 blue chips over the game. As the group's majority color of the chips at the *beginning* of a round determines which payoff scheme is implemented, payoff scheme purple will be implemented in rounds 1 and 2, and payoff scheme blue from round 3 onwards. The payoffs resulting from immediate, full transition are 23 tokens in round 1 (2×10 tokens + 3×1 token), 16 tokens in round 2 (1×10 tokens + 6×1 token), and 39 tokens in rounds 3 to 7 (3×10 tokens + 9×1 token), for a total of 234 tokens per subject.

changes are made. Third, immediate and full transition does not give the highest payoffs, neither at the individual level, nor at the group level. Consider the following situation. Two group members start changing their chips in Round 1, whereas one group member lags behind one round, i.e. he keeps all purple chips in Round 1, and only starts changing chips from Round 2 onwards. This strategy increases total group payoffs from 702 (= 3 × 234) to 703 tokens.[10] Although the average individual gains from this strategy are very small (234.33 versus 234), the benefits are unequally divided: the two 'leading' subjects realize 231 tokens each whereas the 'laggard' earns 241 tokens. Hence, one characteristic of the game is that full immediate transition is no equilibrium as it may be attractive for an individual to choose a strategy of lagging behind one round. Indeed, a subject following this strategy can guarantee that he earns the most of all group members. We believe that the possibility of profitable deviations, which resembles somewhat a dynamic type of free-riding in a standard public good game, is an appealing and realistic feature of the green transition game.

4.2 Experimental design and procedures

In total 78 subjects participated in the experiment reported in this paper, in 26 groups of three subjects. The subjects participated in (only) one out of four sessions, run in the CentERlab at Tilburg University. The experimental design is summarized in Table 1. There are two experimental treatments, called *baseline* (BSL), and *framing* (FRM), which differ only slightly; details are provided below. For each treatment we conducted two sessions, and a session lasted on average about one hour.

In each session, subjects were randomly allocated to computers and to groups, and subjects could not identify who was in their group. The same experimenter distributed instructions (included in Appendix B) and read them aloud to establish common knowledge. The experiment was programmed in Z-tree (Fischbacher, 2007). Group composition stayed the same for all rounds and games in the experiment (partner matching), which resulted in 13 independent observations (groups) per treatment.

TABLE 1: Experimental design

Treatment	Name	# groups	# subjects	# games
Baseline	BSL	13	39	65
Framing	FRM	13	39	65

The baseline treatment consisted of five repetitions of the seven-round game described in the previous subsection. The subjects were told that each round

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[10] The number of blue chips the group has at the end of the rounds is 2, 5, 8, 9, 9, 9, 9, which gives an average of 17 blue chips per individual. As with immediate full transition, payoff scheme purple will be implemented in rounds 1 and 2, and payoff scheme blue from round 3 onwards. The payoffs for the two 'leading' group members are 22 tokens in round 1 (2×10 tokens + 2×1 token), 15 tokens in round 2 (1×10 tokens + 5×1 token), 38 tokens in round 3 (3×10 tokens + 8×1 token), and 39 tokens in rounds 4 to 7 (3×10 tokens + 9×1 token), for a total of 231 tokens. The payoffs of the 'laggard' are 32 tokens in round 1 (3×10 tokens + 2×1 token), 25 tokens in round 2 (2×10 tokens + 5×1 token), 28 tokens in round 3 (2×10 tokens + 8×1 token), and 39 tokens in rounds 4 to 7 (3×10 tokens + 9×1 token), for a total of 241 tokens. If two or more subjects follow this strategy, total group payoffs go down.

consisted of the following three stages. In Stage 1, subjects were informed about the number of purple and blue chips they had and the number of purple and blue chips their group had at the start of that round. Then subjects were informed about the two possible payoff schemes and the payoff scheme that would be implemented in the round: if the majority of chips in a group were purple (blue), payoff scheme purple (blue) was employed. In Stage 2, subjects indicated privately and simultaneously whether they wanted to change one purple into one blue chip, one blue chip into one purple chip, or did not want to make a change by clicking a radio button. At most one chip could be changed in every round. The total number of chips a subject had was always three, as was the maximum number of chips of a particular color. Negative numbers of chips were not allowed. Finally, in Stage 3, subjects were informed about the number of purple and blue chips they had (after the change), the number of purple and blue chips their group had (after the change) and their personal payoffs for the round. Remember that in addition to the payoff resulting from a subject's own chips and the payoff scheme, each blue chip the group had in Stage 3 yielded one token to each group member. Both types of payoffs were shown to the subjects. After Stage 3, the round was over and subjects continued with the next round of the game. During a round, subjects could see the information of all previous stages of that round.

The only difference between the baseline treatment and the framing treatment are the instructions. Instead of using neutral language, the instructions in treatment FRM included environmentally loaded context (green framing) with references to clean and dirty technologies and to subsidies. The text stated that subjects started with three brown chips (instead of purple as in treatment BSL) which could be changed for green chips (instead of blue chips). In addition, it said "The brown chips represent dirty technologies that use exhaustible resources like fossil fuels and that contribute to climate change. The green chips represent clean technologies, using renewable resources like solar and wind energy. In the game you play, you invest in fossil fuels or in renewable energy by deciding on the chips". No such connection to technologies was made in treatment BSL. Finally whereas in treatment BSL the public good feature of the blue chips was described as "On top of that, and irrespective of the payoff scheme, each *blue* chip your group has at the end of the round yields 1 token to each of the group members", in treatment FRM it read "In addition to the payoffs that are determined by the dominant technology, we <u>*subsidize*</u> green chips. Each *green* chip your group has at the end of the round yields 1 token to each of the group members (irrespective of the infrastructure)" (italics and underlining in original text). Apart from these differences in the instructions (see Appendix B for the full texts), the procedure in the two experimental conditions was exactly the same, so also treatment FRM had five games of seven rounds, etc. Therefore in what follows we will use the language of the baseline treatment, and talk about purple and blue chips. In both treatments we had 13 three-person groups.

After the last round of a game, subjects received information about their total payoffs in that game, and then they continued with the first round of a new game. After all five games, one game was randomly selected by the computer to be paid, and subjects were informed about their earnings in the selected game. After the experiment, subjects were paid their earnings in cash, with an exchange rate of 100 tokens = €5.00. Subjects earned on average €10.50.

4.3 Hypotheses

Before formulating the hypotheses we first summarize the boundaries of the possible outcomes of the game. On the one end, subjects can preserve the status quo with only purple chips. We consider this outcome the benchmark. There is no transition, the number of blue chips is 0, and game payoffs are 210 for each subject. On the other end, subjects can implement the fastest possible transition. Each subject adds one blue chip each round, so that after two rounds the transition is made and the total number of blue chips that any subject has collected over the game amounts to 18. The individual payoffs are 234. As explained in the previous subsection, the average payoff can be further increased if one subject delays the transition one round. That strategy decreases the average total number of blue chips in the game by one but increases total group payoffs by one. Hence, average subject payoff increases by one-third to 234.3. When describing the results, we will also use the variable transition speed, which gives the pace at which the transition is made (minimum value is 0 in case of no transition, maximum speed is 6 if number of blue chips is at least 5 at the end of round 2).

We formulate a series of hypotheses that we test with the experimental data. Broadly speaking the order of the hypotheses is such that they move from more general, aggregate behavior to more specific, individual behavior. The approach is to formulate a series of explicit null hypotheses, which basically state the neutral effect of no change. Then, for each hypothesis we speculate about reasonable alternatives/expected outcomes and include these in the text.

As explained above, there is only one pure Nash strategy, upholding the benchmark. As the game is complex, only after the experience of some games will groups probably understand the properties of the game and learn to coordinate. The first null hypothesis is that subjects do not learn and therefore behavior does not change across games. We split the hypothesis in three parts, one for the number of blue chips, one for profits, and one for transition speed because (lack of) coordination may affect these measures differently.

An even stricter version of this hypothesis is that the status quo situation will be sustained in every round and every game, resulting in zero blue chips, average game payoffs of 210, and zero transition speed. Alternatively, one may expect that over the games, groups improve their performance. We therefore speculate that the number of blue chips, the profits, and the transition speed increase over games. Furthermore, we conjecture that after sufficient experience (e.g. in later games) profits exceed the benchmark payoff of 210.

HYPOTHESIS 1A. (*Learning – Blues*) Number of blue chips is constant over games.
HYPOTHESIS 1B. (*Learning – Profits*) Profits are constant over games.
HYPOTHESIS 1C. (*Learning – Transition speed*) Transition speed is constant over games.

The second hypothesis considers the aggregate treatment effect of green framing. The null hypothesis, as formulated in HYPOTHESIS 2, is that the number of blue chips, the profits, and the transition speed are equal in the two treatments. After all, the game subjects play – including the equilibrium predictions – is exactly the same in both treatments and pro-environmental behavior in the lab has no real environmental impact outside the lab. Alternatively, as also has been argued in the literature (e.g. Pevnitskaya and Ryvkin 2013), adding meaningful context

(including subsidies) may affect behavior. In particular, we speculate that green framing affects all relevant measures such that the number of blue chips, the profit, and the transition speed are higher in treatment FRM than in treatment BSL, both in the short run (in Game 1) and when subjects have gained more experience (in Game 5).

HYPOTHESIS 2. (*Aggregate Treatment Effect*) The number of blue chips (A), profits (B), and the transition speed (C) are the same in both treatments, both in the short run (Game 1) and in the long run (Game 5).

The two hypotheses about aggregate behavior can be tested by comparing the three measures across games and across treatments.

The next hypotheses are about group and individual behavior. Although HYPOTHESIS 2 predicts no differences between the two treatments, several studies have shown that framing may have an effect. If this is the case, one would like to get an idea why. At least two possible mechanisms have been put forward in the literature. First of all, adding meaningful context to an otherwise abstract situation may make the situation more concrete and so help subjects to better understand the complex game setting (e.g. Cooper and Kagel, 2009). Secondly, framing may create additional noise/unobserved heterogeneity by invoking subjects' (home-grown) preferences and experiences from outside the lab that are not directly linked to the situation in the lab. The joint effect of these forces is not clear ex ante and what the outcome will be is basically an empirical question. For example, context may or may not help to form similar beliefs and to coordinate.

By formulating and testing HYPOTHESIS 3 and HYPOTHESIS 4 we hope to be able to say something about the underlying mechanisms. We formulate the hypotheses based on the arguments mentioned above. First, we hypothesize that behavior within a group is not coordinated. In particular, the null hypothesis, as formulated in HYPOTHESIS 3 is that within a group individual decisions are made independently. Alternatively, we speculate that subjects learn to coordinate their decisions such that choices in the first round of a later game are more coherent/coordinated than in the first round of the first game(s). For each game and treatment we can test whether the observed shares of coherent groups (i.e. groups with all-purple or all-blue chips at the end of Round 1) in the experiment are equal to the expected share following from the null hypothesis. We speculate that as the subjects accumulate experience with each game, the share of groups with the same choices in Round 1 rises.

HYPOTHESIS 3. (*Independent Round 1 strategies*) Within groups, individual choices in Round 1 are independent.

Regarding the effect of environmental context the null hypothesis is that Round 1 decisions are independent of the framing, both in Game 1 (HYPOTHESIS 4A) and in later games (HYPOTHESIS 4B). Alternatively, we speculate that framing has an effect on the decisions subjects make in Round 1, but we do not know whether the effect will be positive or negative. If meaningful context helps subjects to better understand the complex game, this improved comprehension may induce them to make different choices, and it may make coordination easier and coherence higher. On the other hand, as mentioned above, adding environmental

context may invoke subjects' preferences, and create unobserved heterogeneity which may lead to fragmented decisions. Both effects may already come about in Round 1 of Game 1, or in later games, or both. That is, already in the very first round the context may influence decision making, and lead to divergent preferences/beliefs about what the group should do. Differences in later games may be caused by the fact that framing may induce subjects to adjust their behavior less to experiences in previous games because of entrenched positions or may make them base their choices more on their own principles and their own past choices rather than on others' choices (anchoring).

HYPOTHESIS 4A. (*Short-run treatment effect in Round 1*) Decisions in Round 1 of
      Game 1 are the same in both treatments.
HYPOTHESIS 4B. (*Longer-run treatment effect in Round 1*) Decisions in Round 1 of
      Games 2 – 5 are the same in both treatments.

Although it may be difficult to disentangle these and other possible motives, we can test whether first round decisions and coherence are the same in both treatments or not, both in Game 1 and in later games.

The last hypotheses are about changes in behavior within a game and between games. As said, differences between the two treatments – if any – may arise from distinct choices already in the very first round of the experiment or come from divergent decisions and reactions during the game(s). The first null hypothesis, formulated as HYPOTHESIS 5, states that the decisions an individual makes in a subsequent round do not depend on the choices of the group members in earlier rounds of that game, such that there is no coordination within a game. Alternatively, we speculate that a subject's decision in a round is influenced by the choices the other group members have made in the previous round, such that coordination is expected to take place.

HYPOTHESIS 5. (*Coordination within games*) Individual choices are independent of
      earlier group behavior in a game.

HYPOTHESIS 6 extends HYPOTHESIS 5 to consider the effect of environmental context. The null hypothesis is that the relationship between an individual's decisions and earlier decisions of the group members does not depend on the framing and hence is the same in the two treatments. Alternatively, we speculate that framing affects the way individuals react to group experience. In particular, we conjecture that framing weakens this relationship, mainly because environmental context may induce people to anchor more on their own preferences. Accordingly, subsequent-round choices depend less on same game group experience and more on individual past round behavior. For example, a person who cares deeply about environmental issues (outside the lab) may be prepared to invest in green technologies, even if the other group members have not done so (yet). On the other hand, someone may argue that if clean technologies need subsidies they are not really financially sound, and this person may choose to stick to dirty technologies. Although these divergent views and interpretations of the game may also exist in the baseline treatment, it seems reasonable to expect that framing reinforces such beliefs.

HYPOTHESIS 6. (*Framing and coordination within games*) Framing has no effect on the relation between individual choices and earlier group behavior in a game.

The last two hypotheses are very similar to HYPOTHESIS 5 and HYPOTHESIS 6, but instead of comparing decisions in two ensuing rounds of the same game, they examine whether decisions in a particular round of two subsequent games are related. The null hypothesis is that the choice an individual makes in a particular round of a particular game is not related to choices made by the group members in the preceding game. Consequently, as formulated in HYPOTHESIS 7, decisions between games are not coordinated. Alternatively, we speculate that over the games, individuals learn to coordinate such that an individual's choice in a round does depend on choices of other group members in the same round of the previous game.

HYPOTHESIS 7. (*Coordination between games*) Individual choices are independent of group behavior in the preceding game.

The last hypothesis relates to the effect of environmental context. The null hypothesis, as formulated in HYPOTHESIS 8, is that the relationship between an individual's decisions and decisions of the group members in the preceding game does not depend on the framing and hence is the same in the two treatments. Alternatively, and for similar reasons as stated above, we speculate that framing makes individuals react less to group experience from earlier games. For example, we expect that in treatment FRM an individual's choice in Round 1 of Game 2 depends less on the decisions of the other group members in Round 1 of Game 1 than in treatment BSL.

HYPOTHESIS 8. (*Framing and coordination between games*) Framing has no effect on the relation between individual choices and group behavior in the preceding game.

In Section 5 we will test all eight hypotheses. The first four hypotheses will be tested by means of non-parametric tests, the last four in a regression.

5 Results

In this section we present the results of the experiment. Before testing the hypotheses we first discuss some general results in section 5.1. Then, in sections 5.2 and 5.3 we test the hypotheses that relate to behavior at the aggregate and the group or individual level, respectively.

5.1 General results

We first present an impression of the data and the results at the aggregate level. The full set of outcomes, at the group level, is provided in the Appendix C, in FIGURE 3 and FIGURE 4. TABLE 2 gives average summary statics of some key variables for each game, aggregated over groups and rounds, for both treatments. Total blue chips is the total number of blue chips an individual has accumulated in a game (maximum 18); profits indicate the individual payoff over an entire game; and transition speed gives the speed at which the transition is made (minimum value

0 in case of no transition, maximum speed is 6 if number of blue chips is at least 5 at the end of Round 2). FIGURE 1 shows for both treatments and across all rounds the average number of blue chips per individual (bottom lines, left axis) and the average individual payoffs (top lines, right axis) per round.

TABLE 2: Blue chips, profits and transition speed per game and treatment

Game	Total blue chips		Profits		Transition speed	
	BSL	FRM	BSL	FRM	BSL	FRM
1	4.2	11.3***	197	194	1.0	3.8***
2	6.1	11.2*	204	209	1.6	3.9**
3	4.6	11.1*	208	212	1.3	3.9**
4	5.6	10.6	212	212	1.8	3.5
5	4.0	10.6*	213	216	1.3	3.5*
Average	4.9	10.9**	207	209	1.4	3.7**

* FRM significantly different from BSL at 10%, ** significant at 5%, *** significant at 1% (Mann-Whitney U-tests; groups as units of observations).
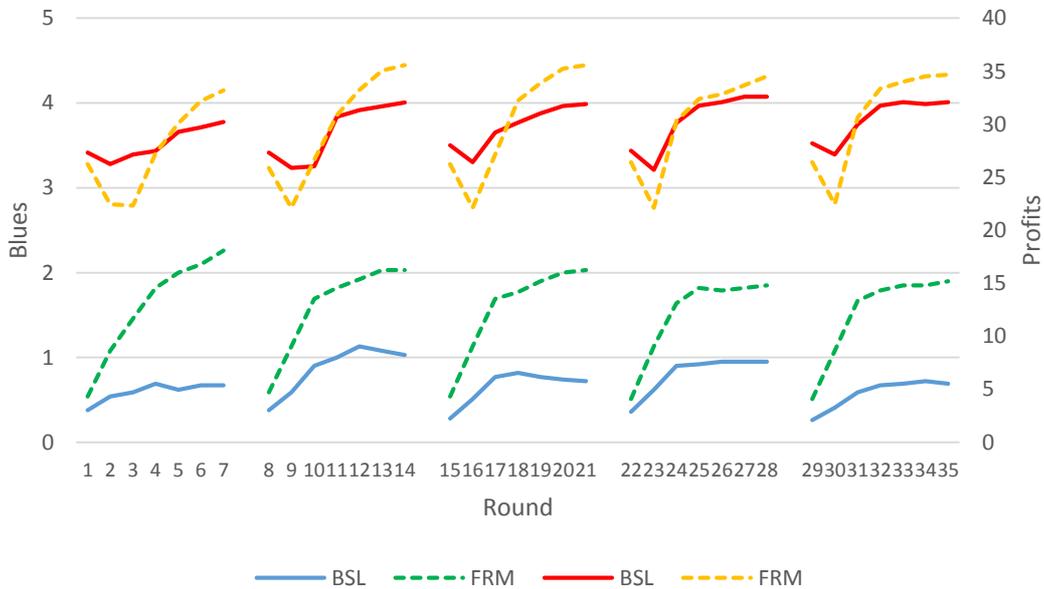
FIGURE 1. Blue chips and payoffs, per game and treatment
Per individual, averaged over subjects; bottom lines show blue chips (left vertical axis), top lines profits (right vertical axis)

Inspection of TABLE 2 and FIGURE 1 suggests some first observations. Firstly, although the average total number of blue chips is positive, it is much lower than the maximum possible sum of 18, even in treatment FRM where the number of blue chips is about twice as high as in treatment BSL. FIGURE 1 reveals that subjects in treatment BSL rarely have more than one blue chip on average, whereas in later rounds of treatment FRM subjects basically have two blue chips on average. Secondly, the results indicate a substantial coordination problem: in both treatments the average payoff per individual in Games 1 and 2 (and the average over five games) is below the status quo payoff of 210 (and profits below 30 in most rounds). Thirdly, there is some evidence of learning; payoffs in later games (4, 5) exceed those in early games (1, 2), also in the baseline treatment, although very little variation in the outcomes over games is visible in FIGURE 1, at least

within a treatment and at the aggregate level. Finally, whereas for all games the number of blue chips and the transition speed vary markedly between the two treatments, the total payoffs are remarkably close. The difference in patterns of profits per round in FIGURE 1, however, suggests that these payoffs are not realized in similar ways.

In order to take a somewhat closer look at the general results we classify game outcomes into three categories. First, those games where on a group level four or fewer blue chips (on average, 1.3 per individual) were chosen are labeled as 'coordinated on purple' or 'no transition'. For these games (with $B(t) < 5$), we find that purple is always the majority color, and thus the purple payment scheme is implemented. Therefore each blue chip decreases the individual payoff by 10 token, while it increases the group payoff by 3 token, so that the total group payoff decreases by 7 token. Per person, the payoff thus decreases with 7/3 per additional blue chip. Second, we consider those games where more than four chips are blue, over the full game (so with $B(t) > 4$), and where payoffs at least equal the benchmark payoff. These games are labeled 'coordination on blue' or 'profitable transition'; they present a successful transition to blue. The third category of games consists of those where more than four blue chips were chosen, but where payoffs fell short of the benchmark payoff. These games are labeled 'no coordination' or 'costly transition'. We note that in all costly transition games the blue payment scheme remained after the first round in which it was implemented (so after $B(t) > 4$). That is, no group went back to purple once blue was implemented.

FIGURE 2 shows the game outcomes, per treatment, per game, by outcome classification. It reveals several clearly observable patterns. Firstly, in both treatments the number of games classified as 'costly transition' (grey bars) decreases over the games. So subjects learn to avoid this costly outcome, in particular in treatment FRM where in the very first game many groups experienced a costly transition. Secondly, in treatment BSL subjects realize very few profitable transactions (blue bars), and in later games coordination seems to focus on 'no transition' (purple bars). In treatment FRM, on the other hand, the share of profitable transitions increases across games. Moreover, with framing in every game more groups experience a profitable transition than no transition, whereas no transition is always the modal outcome in the baseline treatment.

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each panel one treatment; horizontal axis: 5 games; vertical axis: shares
bars: dark blue=coordinated on profitable transition to blue, gray=costly transition, purple=no transition
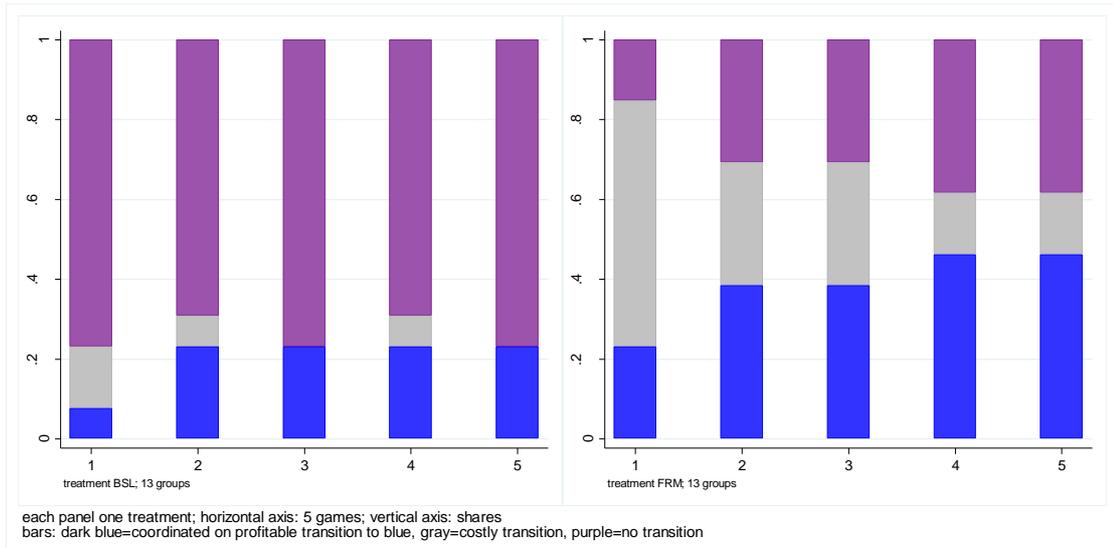
FIGURE 2. Game coordination outcome types per game and treatment

5.2   Testing aggregate behavior (hypotheses 1-2)

We examine first whether groups learn over games or not, as stated in
HYPOTHESIS 1. We use the data of TABLE 2 to see if the number of blue chips, the
profits and the transition speed increase from one game to the next one (short-
run effect) and to compare the averages between Games 5 and 1 (long-run effect).
As TABLE 2 shows, in most of the cases, the total number of blue chips does not
change much over games and the difference between one game and the next is
never bigger than two. For both treatments, HYPOTHESIS 1A that the number of blue
chips does not change across games cannot be rejected; both the short-run and
the longer-run effects on the number of blue chips are not significant (two-sided
Wilcoxon matched-pairs signed-ranks with groups as units of observation, n = 13,
all $p > 0.21$) apart from the change from Games 4 to 5 in the baseline treatment ($p
= 0.03$, n = 13). The results for the payoffs are slightly different. The change in
profits from Game 1 to Game 2 is significant in both treatments (n = 13, $p = 0.10$,
and $p = 0.03$ for treatments BSL and FRM, respectively), but none of the other
short-run effects are. The long-run effect on profits is also significant (n = 13, $p \leq
0.01$ for both treatments). So the hypothesis of no change in profits (HYPOTHESIS
1B) can partly be rejected in favor of the alternative speculation. However, we find
no evidence that after sufficient experience profits exceed the benchmark profit
level of 210. To the contrary, for both treatments we cannot reject the hypothesis
that profits in Games 2 to 5 are equal to 210 (two-sided Wilcoxon signed-ranks
test, n=13, all $p > 0.10$) whereas profits in Game 1 appear to significantly *lower*
than the benchmark payoff ($p < 0.02$ for both treatments). Hence the rise in
payoffs over the games seems more due to the fact that groups learn to avoid the
very low profits of Game 1 rather than successfully realizing profits that exceed
the status quo level. The results for the transition speed are very similar to those
for the blue chips. HYPOTHESIS 1C, which states that the transition speed is constant
over games cannot be rejected for any treatment (two-sided Wilcoxon matched-
pairs signed-ranks gives $p > 0.11$, n= 13 for all comparisons in treatment BSL and
$p > 0.72$, n= 13 for all comparisons in treatment FRM). In all, outcomes are very

stable and – at least at the aggregate level – not much learning seems to be going on, in particular not after Game 2.

Next we use the data in TABLE 2 to examine the treatment effect at the aggregate level, as formulated in HYPOTHESIS 2. The stars in the columns of TABLE 2 indicate the outcomes of a two-sided Mann-Whitney U test with groups as units of observation when testing whether the two values in the two columns to the left are significantly different or not (n_1 = 13, n_2 = 13 for all comparisons). The results depend very much on the variable under consideration. Both the total number of blue chips accumulated in a game and the transition speed are significantly different in treatment FRM in all games except Game 4, and often so at high levels of significance. In contrast, profits are much more similar in the two treatments and do not differ significantly in any of the games (all p > 0.49) – as was also suggested by FIGURE 1. Consequently, the support for HYPOTHESIS 2 is mixed: whereas the null hypothesis of no treatment effect can be rejected for the number of blue chips and the transition speed, there is no evidence that framing affects profits in the short or in the long run.

5.3   Testing group level and individual behavior (hypotheses 3-8)

In order to find out more about the mechanisms behind these results we now focus on group and individual behavior. As argued in section 4.3, treatment differences may already arise in the very first round of a game, for example because context creates differences in beliefs, or they may develop when beliefs and strategies evolve within a game or across games. In some groups, subjects may play consistently blue, in other groups subjects may play consistently purple, while in still other groups subjects' behavior may be not be coordinated at all. The null hypothesis (HYPOTHESIS 3) is that all subjects decide on their first-round choice independently. We expect, however, that subjects learn that it is beneficial to coordinate their actions within their group, such that decisions by group members are correlated. In addition, HYPOTHESIS 4 states the null hypotheses that framing has no effect on first-round coordination, neither in the short run (HYPOTHESIS 4A) or in the longer run (HYPOTHESIS 4B).

TABLE 3 presents the information needed to test HYPOTHESIS 3 and HYPOTHESIS 4. The left panel of TABLE 3 shows the average share of blue chips individuals have in the first round of a game (g) for each treatment (x) separately (p_{xg}). The data indicate, for instance, that in all games of treatment FRM slightly more than 50% of the subjects switch one purple chip for a blue one in Round 1. The right panel of TABLE 3 shows the observed share of coherent groups, i.e. the share of groups that have all-purple chips or all-blue chips in the first round of a game in a treatment (os_{xg}). It shows for example that in treatment FRM at the end of Round 1 of Game 1 in only two out of 13 groups (=0.15) all three group members have the same color chips, whereas this is ten out of 13 (0.77) in Round 1 of Game 4 in treatment BSL.

TABLE 3. Share of blue chips and observed share of coherent groups in first round, per game and treatment

	Share (p_{xg})		Coherence (os_{xg})	
Game	BSL	FRM	BSL	FRM
1	.38	.54	.31	.15
2	.38	.59	.54*	.15
3	.28	.54	.62*	.38
4	.36	.51	.77***	.38
5	.26	.51	.69*	.54**

Stars denote differences between expected and observed shares; *significant at 10%, ** significant at 5%, *** significant at 1% (binomial tests).

Under the null hypothesis of independent decisions, if a share p of subjects chooses blue in a round, the expected share es of all-blue groups plus all-purple groups is $p^3 + (1-p)^3$. For each game (g) and treatment (x) we can test whether the observed share os_{xg} in the experiment, as shown in the right panel of the table, is equal to the expected share es_{xg} where

$$(4) \qquad\qquad es_{xg} = p_{xg}{}^3 + (1 - p_{xg})^3$$

with the values of p_{xg} taken from the left panel of TABLE 3.[11]

We see from TABLE 3 that the observed share of coherent groups varies considerably, both within treatments as across treatments, and much more than the share of blue chips. In the very first round of the experiment, coherence is very low and the observed share of coherent groups is not significantly different from the expected share. In both treatments coherence tends to increase over games, although the rise is clearly larger and faster in the baseline treatment. Using two-sided binomial tests, we are able to reject the null hypothesis of independent strategies within a group (HYPOTHESIS 3) for all games after Game 1 for the baseline treatment. With framing, on the other hand, the observed share of coherent groups does not differ significantly from the expected share with the exception of the final game. Given that the shares of blue chips are remarkably stable across games, we can conclude that the increase in coherence is largely unrelated to the development of the shares of blue chips.

Regarding potential treatments differences (HYPOTHESIS 4), TABLE 3 – and the different starting points of the lines in the lower part of FIGURE 1 – indicates that the average number of blue chips per individual in Rounds 1 is consistently higher in treatment FRM than in treatment BSL. Formally testing HYPOTHESIS 4 gives mixed support though. For Round 1 of Game 1 we cannot reject the first part of the null hypothesis (HYPOTHESIS 4A) that the shares are the same in both treatments (Fisher exact test with all individual decisions, $n_1 = 39$, $n_2 = 39$, $p > 0.25$), whereas we can reject HYPOTHESIS 4B as the average fractions over Games 2-5 are significantly different (Mann-Whitney U test, one average fraction per group, $n_1 = 13$, $n_2 = 13$, $p = 0.06$). So, although there seems to be an immediate effect of environmental context, resulting in more blue chips in the first rounds of a game, the treatment effect becomes only significant in the somewhat longer run.

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[11] Given the shares of blues presented in TABLE 3, the values of the expected shares es_{xg} range from 0.25 when $p_{xg} = 0.51$ to 0.43 when $p_{xg} = 0.26$.

At the same time, as we have seen, framing does not lead to more coherence. On the contrary, whereas groups in the baseline treatment learn to coordinate their decisions in the first round of later games, behavior of groups in treatment FRM is and remains much less harmonized. Only in the very last game a reasonable number of groups manage to coordinate their decisions from the start of the game, which explains the relatively low level of payoffs in this treatment.

The last hypotheses are about changes in behavior *within* a game (HYPOTHESIS 5 and HYPOTHESIS 6) and *between* games (HYPOTHESIS 7 and HYPOTHESIS 8). As said, differences between the two treatments – if any – may arise from distinct choices already in the very first round of a game or come from divergent decisions and reactions later in the game. As we not only want to consider the decisions of the other group members, but also want to control for a subject's own decision, we test these hypotheses by means of regression, using several specifications. In all specifications the number of blue chips a subject has in a round is regressed on the subject's own number of blue chips and the average number of blue chips of the other group members. Specifications (1)–(3) include the variables of the previous round of the same game as explanatory variables, and specifications (4)–(6) use variables of the same round of the previous game (see TABLE 4, G refers to game, R to round). To take into account that choices within a group are not independent, all errors are clustered within groups.

TABLE 4. OLS regressions for first-round choices

	Within games			Across games		
	(1)	(2)	(3)	(4)	(5)	(6)
	Own	Own	Own	Own	Own	Own
	Blue	Blue	Blue	Blue	Blue	Blue
	G1R2	G1R2	G1R2	G2R1	G2R1	G2R1
VARIABLES	BSL	FRM	Both	BSL	FRM	Both
Own Blue G1R1	0.520**	0.979***	0.520***	0.339*	0.127	0.339**
	(0.187)	(0.156)	(0.184)	(0.158)	(0.126)	(0.156)
Own Blue G1R1×T			0.460*			-0.211
			(0.240)			(0.199)
Av. Blue others G1R1	0.347***	0.236***	0.347***	0.455**	-0.291	0.455**
	(0.0694)	(0.0615)	(0.0684)	(0.177)	(0.215)	(0.174)
Av. Blue others G1R1×T			-0.111			-0.746**
			(0.0914)			(0.275)
Constant	-0.0756	0.0403	-0.0756	0.0794	0.678***	0.0794
	(0.0754)	(0.128)	(0.0744)	(0.117)	(0.138)	(0.115)
Treatment Dummy (T)			0.116			0.598***
			(0.147)			(0.179)
N	39	39	78	39	39	78
R-squared	0.464	0.561	0.573	0.228	0.064	0.182

Robust standard errors in parentheses; * significant at 10%, ** significant at 5%, *** significant at 1%.

We first test HYPOTHESIS 5, which states that the decisions individuals make in a subsequent round do not depend on the choices of the group members in earlier rounds of that game, such that there is no coordination within a game. Alternatively, we predict that a subject's decision in a round is influenced by the

choices the other group members have made in the previous round. We test the hypothesis using data of the first two rounds in the first game, as this sample gives the cleanest test. Specifications (1) and (2) show that in both treatments both the subject's own blue chips and the average number of blue chips of the other group members in Round 1 of Game 1 have a positive and significant effect on the blue chips an individual has in Round 2 of Game 1.[12] Therefore we can reject the hypothesis that choices are independent of group behavior earlier in the game in favor of the alternative hypothesis that a subject's decision in a round is influenced by the choices the other group members have made in the previous round of the same game.

Specification (3) shows the estimation results for both treatments together, with a treatment dummy for treatment FRM (T) and interaction terms between the explanatory variables and the treatment dummy. The results indicate that the coefficient of the subject's own choice of Round 1 is significantly higher in treatment FRM than in treatment BSL, but the reaction to the other group members' previous choices does not differ significantly between the two treatments. Hence, we cannot reject HYPOTHESIS 6 that framing has no effect on the relationship between individual choices and earlier group behavior within a game.

The last three specifications show the results of a similar exercise, but here the dependent variable is the number of blue chips a subject has in Round 1 of Game 2. The regression results for the baseline treatment, shown in specification (4), illustrate that a subject's decision in the first round of Game 2 depends significantly on the subject's own decision and on the average group decision in Round 1 of Game 1. For treatment FRM, however, both coefficients are not significantly different from zero such that the number of blue chips the group had in the first game does not influence whether an individual changes the color of a chip in the first round of Game 2 (see specification (5)). Actually, given that only the constant is high and very significant, the group's history (including the subject's own decision) in Game 1 does not seem to play a role at all in treatment FRM. The evidence for HYPOTHESIS 7 about coordination between games is thus mixed: for treatment BSL we can reject the null hypothesis that a subject's decision in Round 1 of Game 2 does not depend on the other group members' decision in Round 1 of Game 1, while for treatment FRM we cannot reject the no-coordination hypothesis.

Finally, possible treatments differences (HYPOTHESIS 8) can be detected more directly from specification (6). The results show that the estimated coefficients of the subject's own previous game first-round choice are similar for both treatments, but that the effect of the previous game decisions of the other group members is very different. In particular, we can reject HYPOTHESIS 8 in favor of the alternative hypothesis that the relation between individual choices and group behavior is influenced by framing.

Taken together, the regression results suggest that environmental context affects individual choices in (at least) two ways. Within a game, framing induces individuals to stick more closely to their initial choices, whereas across games framing makes subjects follow less closely the initial choices of their group

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[12] It may be worth noting that the estimated coefficients of own blue G1R1 are smaller than 1. This means that if the other group members do not have any blue chips in the first round, a subject has on average less than one blue chip in Round 2, even if she had one in Round 1. This (negative) effect is stronger in the baseline treatment.

members. Although the two reactions are related, the mechanisms behind them are not the same and we find that framing has a strong impact on the dynamics, as can be seen from the following numerical demonstration. Consider a group where one group member changes a purple chip into a blue one in Round 1 of Game 1. Using the estimates from TABLE 4, the expected numbers of blue chips the group has in Round 2 of Game 1 are 0.64 and 1.34 for treatments BSL and FRM, respectively. With framing, the number is not only twice as high, it is also above one. This indicates that the number of blue chips goes up on average in treatment FRM whereas it goes down in the baseline treatment. The same holds when the group has initially two blue chips: the expected numbers of blue chips in Round 2 is 1.51 (2.55) without (with) framing and this is below (above) 2.

6 Conclusion

We have designed a novel dynamic game, the green transition game, which combines features of a coordination game with features of a public good game (including free-rider incentives). The game is a type of dynamic three-player stag-hunt game, and captures some elements of a transition of a transition from an economy using dirty technologies to a green economy. In the game, which consists of multiple rounds, group members have to choose each round whether they want to change the color of one the three chips they have. They start with only purple chips. If sufficiently many chips are changed, the group transits from a benchmark stable Nash equilibrium (only purple chips) to an alternative state (only blue chips) with higher payoffs, but the transition is slow and costly. Coordination is required to implement the transition while minimizing costs: only when the majority of the group transit, does it pay off for the individual to go along. The transition dynamics produce a 'valley of death': when individuals start a transition to the alternative state, but are not supported by their group members, they suffer substantial losses and turn back. To further complicate the transition, we have added a free-rider problem. An individual that lags one round behind the other group members during the transition rounds benefits most. However, when too many individuals choose to delay the transition for their own gain, the transformation fails and losses cumulate. Most costs are allocated to those individuals that supported the transition, while the conservative or opportunistic members do not pay the price, or even gain, from their lack of support.

To enable groups to learn to coordinate over time, the same game was repeated five times, using partner matching. We have run two treatments: one baseline treatment with neutral wording and one framing treatment, in which the instructions included meaningful environmental context. We find robust learning over the five games. In the first game coordination is very difficult, but payoffs increase as the number of unsuccessful transitions decreases with gained experience over the games. Nevertheless, only a small minority of groups in the baseline treatment learn to make the transition. Adding environmental context significantly increases the number of profitable transactions, but also in the first game of the framing treatment payoffs are lower than the benchmark payoffs. Furthermore, the environmental context seems to inhibit learning from past experiences, in particular across games, and the coherence of strategies is weaker than with neutral language. Consequently, average payoffs in both treatments are very similar, even though the framing condition results in twice as many green

technologies. Our results thus suggest some general support for 'going green' but also for more anchoring of beliefs: proponents and opponents stick more closely to their initial choices and seem less inclined adjust their decisions based on the group's history.

This paper reports the results of the first experiment with this new, three-player dynamic stag-hunt game. We believe this game has some interesting features, and corresponds rather well to coordination problems individuals, teams, firms, or countries may experience in real life when considering a change away from the stable status quo situation to a potentially better state. Changes in networks with externalities (standards for appliances, fax machines, fuel infrastructure) provide examples of such dynamic coordination games. The game introduced here seems to offer a rather balanced tradeoff between costs and benefits, also given the fact that the groups' performances are rather mixed. We think this basic framework is appealing and could be extended and tested in several directions. For example, one could look at different group sizes or allow for various forms of asymmetry, such as unequal number of chips, reflecting asymmetric technological capacities. Another natural extension would be to study the effect of (policy) instruments, which could help improve coordination in this game. We are currently working on experiments that examine some specific interventions, such as communication and leadership.

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Appendix A: Strategies for the infinite horizon game

We compute the following individually rational strategies for the infinite horizon game. First, consider the two pure strategies that converge quickly to the extremes of full purple or full blue. If the group number of blue chips equals at least 5, all members try to get 3 blue chips as quickly as they can (strategy 1). Otherwise, if the number of group blue chips is less than 5, all group members switch to full purple (strategy 2). As the group starts with no blue chips, it is stuck in the all purple equilibrium, which is a stable equilibrium. Payoffs are normalized relative to the payoff of the equilibrium to which they converge. The table that specifies the strategies and payoffs is given below.

TABLE 5. Conservative Strategies*

Stra-tegy	Subject's blue chips at start of round			Subject's blue chips at end of round			Immediate payoff			Next round payoff			Total payoff at start of round		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
In equilibrium strategies															
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Out of equilibrium strategies to purple															
2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	2	0	0	1	1	1	-9	0	0	0	1	1	-9
2	0	0	3	0	0	2	2	2	-18	1	1	-9	3	3	-27
2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	1	2	0	0	1	1	1	-9	0	0	0	1	1	-9
2	0	1	3	0	0	2	2	2	-18	1	1	-9	3	3	-27
2	0	2	2	0	1	1	2	-8	-8	0	0	0	2	-8	-8
2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
2	1	1	2	0	0	1	1	1	-9	0	0	0	1	1	-9
Out of equilibrium strategies to blue															
1	0	2	3	1	3	3	-22	-2	-2	-11	-1	-1	-33	-3	-3
1	0	3	3	1	3	3	-22	-2	-2	-11	-1	-1	-33	-3	-3
1	1	1	3	2	2	3	-12	-12	-2	0	0	0	-12	-12	-2
1	1	2	2	2	3	3	-11	-1	-1	0	0	0	-11	-1	-1
1	1	2	3	2	3	3	-11	-1	-1	0	0	0	-11	-1	-1
1	1	3	3	2	3	3	-11	-1	-1	0	0	0	-11	-1	-1
1	2	2	2	3	3	3	0	0	0	0	0	0	0	0	0
1	2	2	3	3	3	3	0	0	0	0	0	0	0	0	0
1	2	3	3	3	3	3	0	0	0	0	0	0	0	0	0
1	3	3	3	3	3	3	0	0	0	0	0	0	0	0	0

* For each variable, columns correspond to the separate members in each group. Payoffs are relative to payoffs of the stationary state (all purple chips, or all blue chips) to which they converge.

Next we consider a more sophisticated strategy, which always converges to the full blue stable equilibrium (see TABLE 6). The interpretation of the strategies is as follows.

1. If the total group number of blue chips at the start of a round is at least equal to 5, then for each subject payoffs are maximal when it increases its number of blue chips as quickly as possible.
2. When the total number of blue chips at the start of a round equals 2, then all group members invest in blue and make the transition as quickly as possible.
3. When the total number of blue chips at the start of a round is 3 or 4, and at most one subject has no blue chip, then each member will ensure it has 2 blue chips at the end of the round, or 1 if it started with none. The intuition is that individual payoffs are maximized when the group has at least 5 chips at the end of the current round = start of the next round (to secure the transition); but each individual prefers to have 2 blue chips at the end of the round, as the individual payoff with 2 blue chips exceeds or is at least equal to the individual payoff with 1 or 3 blue chips. The reason is that having only 1 blue chip increases the current round payoff by 9 units, but comparing the future payoffs when starting with (1,2,2,) or (2,2,2), it appears that the former state decreases the future payoffs by 11 units for the first subject. Thus ending the round with (2,2,2) is strictly preferred over (1,2,2,) for the first subject. Similarly, (2,2,2) is strictly preferred over (3,2,2) for the first subject.
4. When two members have no blue chip, and the third member has 2 or 3 blue chips, then individual payoffs are maximized when the group has at least 5 chips at the end of the current round = start of the next round (to secure the transition); so that the group has (1,1,3) at the end of the round.
5. If the number of blue chips in the group is 0 or 1, then all subjects follow a symmetric mixed strategy with a probability α to have 1 blue chip at the end of the round, and probability $(1-\alpha)$ to have no blue chip at the end of the round. The mixed strategy details are presented in TABLE 7. For $\alpha=0.654$, we find that the mixed strategy is rational, in the sense that the expected payoff with one blue chip at the end of the round is the same as the expected payoff without a blue chip (in both cases: $E[\pi]=-43$). If the subject has only purple chips at the end of the round, the individual expected payoff for that round is $E[v_i]=-7.7$, but the probability of repeating to the same state in the next round is $1-\alpha^2=0.57$; only if both other subjects choose blue will the game move out of the initial state. If the subject himself has one blue chip at the end of the round, then the individual expected payoff for that round is lower ($E[v_i]=-16.7$), but the probability of starting the transition has increased to 0.88. Finally, if the subject has one blue chip and the other subjects have none, it does not pay off for the subject to add one blue chip, as such a strategy decreases the expected immediate payoff by 9 units and it does not increase the next round expected payoff substantially – or at least not sufficiently.

Note, if the mixed strategy for 0 or 1 blue chips is based on a different level of α, then the outcome is not an equilibrium. Consider, for example, the case that $\alpha=0.5$. In that case, when starting without blue chips, not changing the color of a chip will result in an expected payoff of -57.0 (not in the table). Changing one chip to become blue increases the expected payoff to -49.5 (not in the table). The

symmetric mixed strategy for α=0.5 is thus not an equilibrium: when the other group members have a 'too' small probability to acquire a blue chip, it is always profitable (in expectations) to acquire a blue chip oneself. On the other hand, when α = 0.9 for all subjects, then the expected payoff for keeping only purple chips equals -33.9 (not in the table), while the expected payoff for converting a purple chip into a blue chip is -39.7 (not in the table). It is thus profitable to keep purple. If other group members have a 'too high' probability to transit to blue, it is profitable (in expectations) to lag behind. As a result, the symmetric mixed equilibrium strategy is stable, in the sense that deviations from some participants will induce compensating strategies from the other group members.

TABLE 6. Transition Strategies 1-5[*]

Stra-tegy	Subject's blue chips at start of round			Subject's blue chips at end of round			Immediate payoff			Next round payoff			Total payoff at start of round		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
In equilibrium strategies															
5	0	0	0	Mixed			−13.6			−29.4			−43		
5	0	0	1	Mixed			−13.6			−29.4			−43		
2	0	1	1	1	2	2	-14	-24	-24	-11	-1	-1	-25	-25	-25
3	1	1	1	2	2	2	-23	-23	-23	0	0	0	-23	-23	-23
1	1	2	2	2	3	3	-11	-1	-1	0	0	0	-11	-1	-1
1	2	2	2	3	3	3	0	0	0	0	0	0	0	0	0
1	2	3	3	3	3	3	0	0	0	0	0	0	0	0	0
1	3	3	3	3	3	3	0	0	0	0	0	0	0	0	0
Out of equilibrium strategies															
2	0	0	2	1	1	3	-14	-14	-34	-12	-12	-2	-26	-26	-36
4	0	0	3	1	1	3	-14	-14	-34	-12	-12	-2	-26	-26	-36
3	0	1	2	1	2	2	-14	-24	-24	-11	-1	-1	-25	-25	-25
3	0	1	3	1	2	2	-14	-24	-24	-11	-1	-1	-25	-25	-25
3	0	2	2	1	2	2	-14	-24	-24	-11	-1	-1	-25	-25	-25
1	0	2	3	1	3	3	-22	-2	-2	-11	-1	-1	-33	-3	-3
1	0	3	3	1	3	3	-22	-2	-2	-11	-1	-1	-33	-3	-3
3	1	1	2	2	2	2	-23	-23	-23	0	0	0	-23	-23	-23
1	1	1	3	2	2	3	-12	-12	-2	0	0	0	-12	-12	-2
1	1	2	3	2	3	3	-11	-1	-1	0	0	0	-11	-1	-1
1	1	3	3	2	3	3	-11	-1	-1	0	0	0	-11	-1	-1
1	2	2	3	3	3	3	0	0	0	0	0	0	0	0	0

* For each variable, columns correspond to the separate members in each group. Payoffs are relative to payoffs of the stationary state with all blue chips.

TABLE 7. Mixed Strategy 5, details[*]

Subject's blue chips at end of round			Immediate payoff, subject 1	Next round payoff, subject 1	Total payoff at start of round, subject 1
1	2	3			probability, $\alpha=0.654$
Strategy subject 1: full purple					
			−7.7	−35.3	−43.0
0	0	0	-9	$E[\pi]=-43.0$	$(1-\alpha)^2=0.120$
0	0	1	-8	$E[\pi]=-43.0$	$\alpha(1-\alpha)=0.226$
0	1	0	-8	$E[\pi]=-43.0$	$\alpha(1-\alpha)=0.226$
0	1	1	-7	-25	$\alpha^2=0.428$
Strategy subject 1: one blue					
			−16.7	−26.3	−43.0
1	0	0	-18	$E[\pi]=-43.0$	$(1-\alpha)^2=0.120$
1	0	1	-17	-25	$\alpha(1-\alpha)=0.226$
1	1	0	-17	-25	$\alpha(1-\alpha)=0.226$
1	1	1	-16	-23	$\alpha^2=0.428$
Strategy subject 1: two blue					
			−25.7	−25.5	−51.2
2	0	0	-27	-36	$(1-\alpha)^2=0.120$
2	0	1	-26	-25	$\alpha(1-\alpha)=0.226$
2	1	0	-26	-25	$\alpha(1-\alpha)=0.226$
2	1	1	-25	-23	$\alpha^2=0.428$

* Payoffs are relative to payoffs of the stationary state with all blue chips.

Appendix B: Instructions

Baseline treatment

Welcome and thanks for participating in this experiment. Please read these instructions carefully, as you can earn a considerable amount of money.

During the experiment, amounts will be denoted by tokens. Tokens are converted to Euros at the following exchange rate: 1 token = € 0.05, so 100 tokens = € 5.00. At the end of this experiment you will be paid your earnings from the experiment.

It is strictly forbidden to communicate with the other participants during the experiment. If you have any questions or concerns, please raise your hand. We will answer your questions individually. It is very important that you follow this rule. Otherwise we must exclude you from the experiment and from all payments.

Detailed information on the experiment

The experiment consists of five games of 7 rounds each, in which you will interact with two other participants. The three of you form a group that will remain the same in all 7 rounds and in all games. You will never know the identity of the other participants in your group. The group composition is secret for every participant. Interaction only takes place via the computer.

What you have to do

At the beginning of a game, in round 1, you as well as your group members receive 3 purple chips and 0 blue chips each. In each round you have to make one decision on changing chips.

Before you decide on the chips, the pay-off scheme for that round is determined. There are two pay-off schemes, called pay-off schemes PURPLE and BLUE. In pay-off scheme PURPLE, each *purple* chip you have at the end of the round yields 10 tokens whereas in pay-off scheme BLUE each *blue* chip you have at the end of the round yields 10 tokens. On top of that, and irrespective of the payoff scheme, each *blue* chip your group has at the end of the round yields 1 token to each of the group members.

Which scheme is implemented for your group in a round is determined by the majority of chips your group has at the *beginning* of the round. That is, if your group has more purple chips than blue chips at the beginning of the round, pay-off scheme PURPLE will be implemented; if your group has more blue chips than purple chips at the beginning of the round, pay-off scheme BLUE will be implemented.

Regarding the decision on changing chips you have to choose whether you want to change one purple chip into one blue chip, whether you want to change one blue chip into one purple chip, or whether you want to make no change. Note that you are not allowed to have a negative number of chips of a particular colour, so in order to be able to change a chip you need to have at least one chip of that colour.

How you make your decisions and interact with your group members in each round

Each round consists of the following three stages:

1. **Information about chips and pay-off scheme.**
   You are informed about the number of purple and blue chips you have and about the number of purple and blue chips your group has. You are also informed about the two pay-off schemes:
   o Pay-off scheme PURPLE: Each purple chip you have in Stage 3 yields 10 tokens.
   o Pay-off scheme BLUE: Each blue chip you have in Stage 3 yields 10 tokens.
      Which scheme is implemented for your group is determined by the majority of chips your group has.
      Recall that *in addition* to the scheme that is implemented, each blue chip your group has in Stage 3 yields 1 token to each group member.

2. **Decision on changing chips.**
   You have to indicate whether or not you want to change one of your chips. That is, you have to decide between:
   o no change
   o change one purple chip into one blue chip
   o change one blue chip into one purple chip
      Note that depending on the number of purple and blue chips you have, not all options may be possible in a particular round.

3. **Resulting pay-offs.**
   You are informed about the number of purple and blue chips you have (after the change) and about the number of purple and blue chips your group has (after the change).

   You are also informed about the earnings resulting from your chips and the pay-off scheme, the earnings resulting from the blue chips your group has, and your total earnings for the round.

   The experiment then continues with the next round of the game, or if it was the last round of a game, with the first round of a new game.

   The information you receive
   During each round, you see the information of all previous stages of that round.
   After the last round of a game, you will receive information about your total earnings in that game.

   Final earnings
   At the end of the experiment you are informed about your earnings in all five games. One of the five games will be randomly selected by the computer to be paid. You are informed about your earnings in the game that is selected for payment.

   Possible change after Game 2
   After Game 2 is finished, the game may be changed slightly. You will be informed about this on your screen. After this brief interruption, the experiment

will continue with Game 3. In all games you will be in a group with the same participants.

You get a couple of minutes to look at the instructions. If you have any questions, please raise your hand. Please remain seated quietly until the experiment starts.

When the experiment is finished, also please remain seated quietly. We will call you one by one to receive your earnings.

Framing treatment

Welcome and thanks for participating in this experiment. Please read these instructions carefully, as you can earn a considerable amount of money.

During the experiment, amounts will be denoted by tokens. Tokens are converted to Euros at the following exchange rate: 1 token = € 0.05, so 100 tokens = € 5.00. At the end of this experiment you will be paid your earnings from the experiment.

It is strictly forbidden to communicate with the other participants during the experiment. If you have any questions or concerns, please raise your hand. We will answer your questions individually. It is very important that you follow this rule. Otherwise we must exclude you from the experiment and from all payments.

Detailed information on the experiment

The experiment consists of five games of 7 rounds each, in which you will interact with two other participants. The three of you form a group that will remain the same in all 7 rounds and in all games. You will never know the identity of the other participants in your group. The group composition is secret for every participant. Interaction only takes place via the computer.

What you have to do

At the beginning of a game, in round 1, you as well as your group members receive 3 brown chips and 0 green chips each. In each round you have to make one decision on changing chips. The brown chips represent dirty technologies that use exhaustible resources like fossil fuels and that contribute to climate change. The green chips represent clean technologies, using renewable resources like solar and wind energy. In the game you play, you invest in fossil fuels or in renewable energy by deciding on the chips.

We assume that there is a supporting infrastructure that can facilitate only one technology at a time. The infrastructure is determined by the dominant technology, that is, the majority of chips in your group at the start of the round. A BROWN infrastructure means brown technologies make profits: each *brown* chip you have at the end of the round yields 10 tokens. A GREEN infrastructure means green technologies make profits: each *green* chip you have at the end of the round yields 10 tokens.

In addition to the payoffs that are determined by the dominant technology, we <u>subsidize</u> green chips. Each *green* chip your group has at the end of the round yields 1 token to each of the group members (irrespective of the infrastructure).

Which infrastructure is implemented for your group in a round is determined by the majority of chips your group has at the *beginning* of the round. That is, if your group has more brown chips than green chips at the beginning of the round, infrastructure BROWN will be implemented; if your group has more green chips than brown chips at the beginning of the round, infrastructure GREEN will be implemented.

Regarding the decision on changing chips you have to choose whether you want to change one brown chip into one green chip, whether you want to change one green chip into one brown chip, or whether you want to make no change. Note that you are not allowed to have a negative number of chips of a particular colour,

so in order to be able to change a chip you need to have at least one chip of that colour.

How you make your decisions and interact with your group members in each round
Each round consists of the following three stages:

1. **Information about chips and infrastructure.**
   You are informed about the number of brown and green chips you have and about the number of brown and green chips your group has. You are also informed about the two infrastructures:
   o BROWN infrastructure: Each brown chip you have in Stage 3 yields 10 tokens.
   o GREEN infrastructure: Each green chip you have in Stage 3 yields 10 tokens.
   Which infrastructure is implemented for your group is determined by the majority of chips your group has.
   Recall that *in addition* to the infrastructure that is implemented, we <u>subsidize</u> green investments, and therefore each green chip your group has in Stage 3 yields 1 token to each group member.

2. **Decision on changing chips.**
   You have to indicate whether or not you want to change one of your chips. That is, you have to decide between:
   o no change
   o change one brown chip into one green chip
   o change one green chip into one brown chip
   Note that depending on the number of brown and green chips you have, not all options may be possible in a particular round.

3. **Resulting pay-offs.**
   You are informed about the number of brown and green chips you have (after the change) and about the number of brown and green chips your group has (after the change).
   You are also informed about the earnings resulting from your chips and the infrastructure, the earnings resulting from the green chips your group has, and your total earnings for the round.

The experiment then continues with the next round of the game, or if it was the last round of a game, with the first round of a new game.

The information you receive
During each round, you see the information of all previous stages of that round. After the last round of a game, you will receive information about your total earnings in that game.

Final earnings

At the end of the experiment you are informed about your earnings in all five games. One of the five games will be randomly selected by the computer to be paid. You are informed about your earnings in the game that is selected for payment.

Possible change after Game 2

After Game 2 is finished, the game may be changed slightly. You will be informed about this on your screen. After this brief interruption, the experiment will continue with Game 3. In all games you will be in a group with the same participants.

You get a couple of minutes to look at the instructions. If you have any questions, please raise your hand. Please remain seated quietly until the experiment starts.

When the experiment is finished, also please remain seated quietly. We will call you one by one to receive your earnings.

Appendix C: Extra figures (group level)
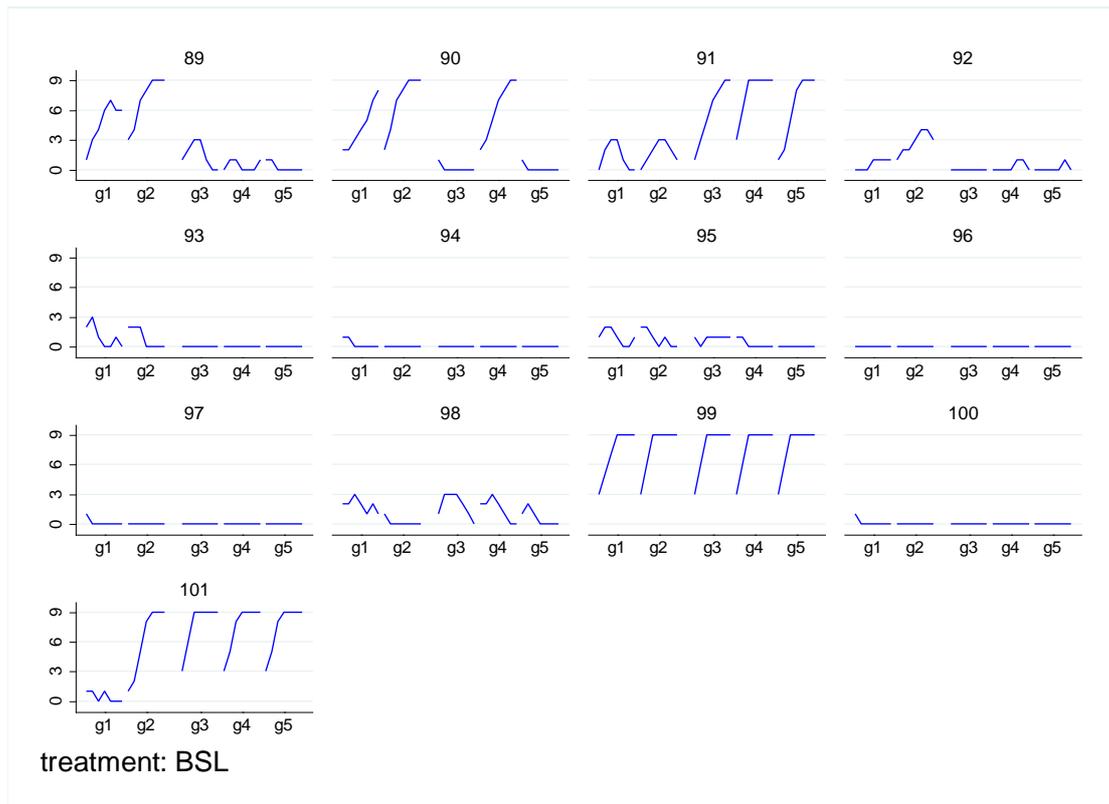
FIGURE 3. Blue chips over games and rounds, per group, treatment BSL
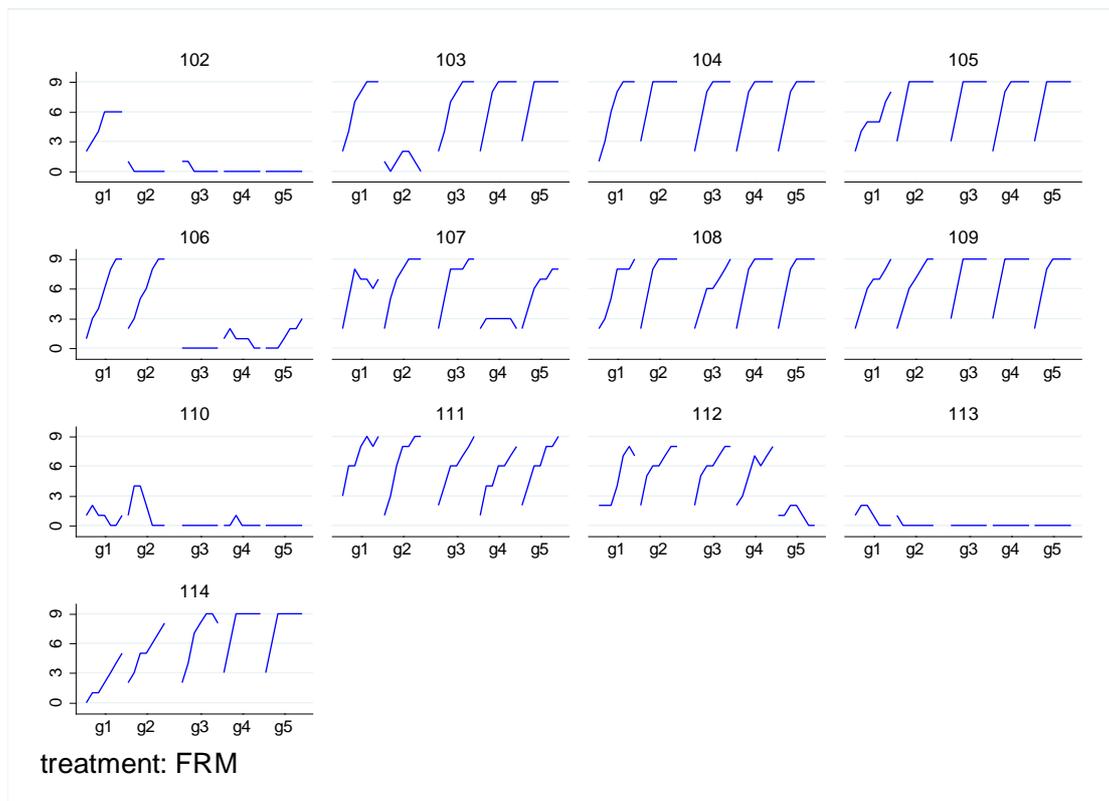
FIGURE 4. Blue chips over games and rounds, per group, treatment FRM.