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NO. 114

Discoordination and Miscoordination Caused by Sunspots in the Laboratory

WORKING PAPERS

WORKING PAPERS
ON EAST ASIAN STUDIES

JUNE 2017

UNIVERSITÄT
DUISBURG
ESSEN

Offen im Denken

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ISSN: 1865-8571 (Printed version) / 1865-858X (Internet version)
Download: https://www.uni-due.de/in-east/news/green_series.php

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WORKING PAPERS ON EAST ASIAN STUDIES, NO. 114, DUISBURG 2017

Abstract

This paper[1] combines two strands of the experimental sunspot literature. It extends the rare literature that focuses experimentally on the coordination problems caused by sunspot variables. It also extends the literature that focuses on coordination games that have a payoff-dominant and a divergent risk-dominant equilibrium. To achieve this, we use a repeated three-player stag hunt game with fixed groups. In our experiment, a sunspot variable points randomly at the risk-dominant or the payoff-dominant choice. We find out-of-equilibrium behavior (discoordination) caused by the sunspot variable in the short run. In the long run, the sunspot variable can lead to coordination of the payoff-dominated equilibrium (miscoordination).[2] If the sunspot-generating process points more frequently to the risk-dominant choice, some groups converge to the sunspot equilibrium.[3]

Keywords

Sunspot, Coordination

JEL Classification

C92, C72, D81, E40, J52

1 We thank Jeannette Brosig-Koch, Michael Roos, and Christoph Helbach as well as seminar participants at the University of Duisburg-Essen for their helpful comments and suggestions. We also thank the Ruhr Graduate School in Economics for the generous funding.

2 We use the terms "discoordination" and "miscoordination" like Beugnot et al. (2012).

3 That is to say, all players repeatedly correlate their decision perfectly with the sunspot variable.

1 INTRODUCTION

The selection of one out of many available equilibria is of importance on the macroeconomic level. Whether a random, irrelevant, and public device can play a role in this selection is therefore an important question not only for game theory but also for macroeconomics. For example, the question of whether incorrect credit ratings can have a destabilizing effect on the economy is of relevance to economics not only since the financial crisis of 2007–2008. In a broader sense, a wrong credit rating can be interpreted as a random, irrelevant, and public device or a sunspot variable.[4] The coordination effects of sunspot variables are widely analyzed in theory and in experiments. However, to our knowledge, there is just one experimental paper that focuses on the coordination *problems* caused by sunspot variables, namely that by Beugnot, Gürgüç, Øvlisen, and Roos (2012). They use a three-player 2 × 2 × 2 game, in which the payoff-dominant equilibrium is also the risk-dominant equilibrium. They find frequent discoordination caused by sunspot variables. However, situations like the financial crisis are characterized not only by discoordination (e.g. the phase of great uncertainty after the onset of the crisis) but also by miscoordination (e.g. the convention of buying mortgage-backed securities before the onset of the crisis). Therefore, we run an experiment to analyze the influence of a sunspot variable in a coordination game with a payoff-dominant equilibrium and a divergent risk-dominant equilibrium. In contrast to Beugnot et al. (2012), miscoordination (the coordination of the payoff-dominated equilibrium) is more achievable in our experiment.

We use a three-player stag hunt game. It has a payoff-dominant equilibrium, in which all the players use the cooperative choice, and a divergent risk-dominant equilibrium, in which all the players choose the secure choice. The sunspot variable points randomly at one of the two choices. We vary the random sunspot-generating process to change the risk and the payoff related to the coordination of the sunspot variable. In the control treatment, there is no sunspot variable. In the so-called neutral treatment, the sunspot variable points with an equal probability to the payoff-dominant strategy or the risk-dominant strategy. In the negative treatment, the sunspot variable points with a higher probability to the risk-dominant strategy than to the payoff-dominant strategy.

The remainder of this study is structured as follows. Section 2 summarizes the previous literature. Section 3 describes our experimental design and provides details about the variation of the treatment parameters. Section 4 gives the game theoretical solution to the base game. Section 5 discusses the results. Section 6 analyzes the results and puts them into the context of previous research.

2 THE PREVIOUS LITERATURE

"Sunspot" is short for "the extrinsic random variable" on which agents coordinate their decisions (Shell 2008). The term "sunspot" can be traced back to Jevons (1878), because he mistakenly believed that solar activity drives the business cycle. In modern macroeconomic parlance, a sunspot variable is any random variable that is unrelated to fundamental factors (Farmer 1999). Sunspot variables have been seen as a source of extrinsic uncertainty, which

4 This is the case if the informative value of the rating is zero, which therefore can be seen as a random draw, and this is common knowledge.

triggers the volatility of market outcomes such as the price level, stock market prices, unemployment rates, interest rates, and exchange rates (Cass and Shell 1983). An explanation for the effectiveness of sunspot variables could be the focal point theory of Schelling (1980). It sees the sunspot variable as coordination assistance. Aumann (1987) shows that it can be advantageous for players to coordinate their actions on an extrinsic variable. Cass and Shell (1983) provide early, specific theoretical research on sunspot variables. They suggest that sunspot models are complete, rational expectations, general equilibrium models, which offer an explanation for excess volatility. Beside these initial works on sunspot variable modeling, there is a vast literature on this topic. Farmer (1999) and Shell (2008) survey the macroeconomic ideas. Shell (2008) concludes that the heterogeneity of (probability) beliefs is only one source of sunspot equilibria. He concludes that other possible sources are natural restrictions on participation in the securities markets, which can be shown in some infinite overlapping generation models (OLG). It is difficult to verify the existence or the effectiveness of sunspot variables empirically. Therefore, running a laboratory experiment to investigate a sunspot variable and its influence is an ideal method. In the laboratory a perfect sunspot variable – irrelevant and random – can be generated. Additionally, due to the controllable laboratory environment, a causal effect of the sunspot variable on decision making and its economic consequences can be identified. Marimon et al. (1993) were the first to run a laboratory experiment to investigate sunspot equilibria. In their experiment an overlapping generation design with a stationary equilibrium and a cyclic equilibrium is used. Blinking squares with red and yellow colors are shown on the computer screen. Marimon et al. (1993) find that without training subjects ignore the sunspot variable. In training periods they artificially correlate the occurrence of some real shocks with the colors. After training periods the real shocks are removed. The price fluctuations persist without a tendency of convergence to the cyclic equilibrium. Although they find some sunspot-influenced behavior in the laboratory, no sunspot equilibrium is generated.

The following sunspot experiments can be grouped roughly into the following four categories: first, experiments in which the sunspot equilibrium is payoff-indifferent to the other equilibria; second, experiments in which the sunspot variable points at the payoff-dominant equilibrium; third, the sunspot variable points at a payoff-dominated equilibrium; fourth, the sunspot variable switches between payoff-rankable equilibria. An experiment that compares these categories is reported by Duffy and Feltovich (2010). They search for the circumstances under which a sunspot equilibrium is achieved and find that a sunspot equilibrium can be reached even if it is not a Nash equilibrium (NE). It is necessary for the sunspot equilibrium to be Pareto-efficient. Similarly, Bone et al. (2013) conclude that the sunspot equilibrium prevails if it is Pareto-efficient in a game with an asymmetric payoff function.

Examples of the first category – the sunspot equilibrium is payoff-indifferent to the other equilibria – are provided by Duffy and Fisher (2005) and Fehr et al. (2012). Duffy and Fisher (2005) use market games with two equilibria, which are not Pareto-ranked. They observe that coordination could easily be established by sunspot variables. Their first important finding is that sunspot equilibria are sensitive to the flow of information. That means that, in a call market, which delivers limited information from buy and sell sites, participants coordinate more frequently based on sunspot variables. In contrast, in a double-auction market, in which there is more information, participants coordinate less frequently on sunspot variables. The second finding is that the semantics of the sunspot variable matter. That is to say, sunspot variables have to be related semantically to the experimental environment. Fehr et al. (2012) conduct a two-person coordination game, in which agents have to pick a number from zero to one hundred. Players are punished according to the deviation from each other. Each combination of two equal numbers constitutes an NE. In this game fifty is the risk-dominant NE. A semantically salient message in the form of an extrinsic public/private signal is used as the sunspot variable. They find that extraneous public signals lead to almost perfect coordination on the sunspot equilibrium. However, with not publicly observed signals, the risk-dominant equilibrium predominates. Sunspot-influenced behavior can still be observed for highly correlated private signals.

Examples of the second category – the sunspot variable points at the payoff-dominant equilibrium – are provided by Cason and Sharma (2007), Devetag et al. (2013), and Arifovic et al. (2016). Cason and Sharma (2007) demonstrate that missing knowledge of others' expectations can inhibit the sunspot equilibrium, even though it is a payoff-dominant equilibrium. To demonstrate this, they let participants play against robots with straightforward and known decision rules. Arifovic et al. (2016) formulate a model that describes how people learn to coordinate on a Pareto-efficient sunspot equilibrium. An example of the third category – the sunspot variable points to a payoff-dominated equilibrium – is given by Bosch-Domenech and Vriend (2013), who observe that people coordinate on the only payoff-dominated equilibrium, which makes it simultaneously to a focal point.

Examples of the fourth category – the sunspot variable points to switching payoff-rankable equilibria – are presented by Beugnot et al. (2012), Arifovic et al. (2013), Arifovic and Jiang (2014), and Shurchkov (2016). Arifovic et al. (2013, 17) find "that subjects can indeed coordinate on extraneous announcements (a 'sunspot' equilibrium)." Arifovic and Jiang (2014) investigate the influence of the sunspot variable in a bank run game. They vary the risk of the payoff-dominant alternative. They find that the sunspots are just relevant if the sunspot equilibrium lies somewhere in the middle between the risk-dominant alternative and the payoff-dominant alternative.

3 THE EXPERIMENTAL DESIGN

3.1 PROCEDURES

The experiment is computer-based and takes place at the "Essen Laboratory for Experimental Economics" (elfe) at the University of Duisburg-Essen in December 2010 and June 2011. The participants are recruited via ORSEE (Greiner 2004). To program the experiment, z-Tree (Fischbacher 2007) is used. A total of 6 sessions with 87 participants are conducted. The participants are mainly undergraduate students from the University of Duisburg-Essen with an average age of 24.15 years. The sessions last at most 60 minutes. The average payoff for the participants is 12.66 Euros with a minimum payoff of 3.00 Euros and a maximum payoff of 15.00 Euros.

3.2 THE STRUCTURE

The experiment uses 3-person groups. The groups play a repeated stag hunt game over 40 periods. The groups are randomly matched and stay together over all 40 periods. A between-subject design is employed, in which each subject only participates in 1 of the treatments. The detailed course of events in the experiment is as follows. On entering the laboratory, the subjects are randomly allocated to different workstations. They receive instructions (see Appendices C, D, and E for the translated instructions) and have the opportunity to ask questions, which are answered privately by the experimenter. When all the subjects have indicated that they understand the instructions, they have to answer a set of 4 or

6 control questions,[5] which are mainly concerned with the general set-up of the experiment and the payoff rules. Subjects who have problems answering the questions can ask the experimenters for help. After all the subjects have answered the questions correctly, the experiment starts. In the first stage, subjects in the same group receive an identical announcement. The announcement is either "strategy A will be chosen by the majority" or "strategy B will be chosen by the majority." These announcements are random, since they are determined by the throw of a dice.[6] The experimenter throws the dice in front of all the participants, and the participants see the number on the dice via video transmission. The subjects have to fill in the number that they see in a dialog box on their computer screen. The participants receive one of the two announcements under different conditions according to the different treatments. Appendix A shows a (translated) screenshot. In the second stage, the subjects play a standard stag hunt game with three players. A participant has to choose between alternative "A" and alternative "B." Appendix B shows a (translated) screenshot of the decision screen. The participants' payment is based on their decisions and the decisions of the other players in the group. All the groups in this experiment receive the same payoff table.[7] In this table the rows indicate the participants' decision of "A" or "B," and the columns show the decisions of the other players in the group. Each cell indicates what a participant will receive depending on her decision and the decisions of the others in her group. For example, if the participant chooses "A" and if any of the other members of her group choose "B," the participant receives 0 Euros, whereas, if the participant chooses "A" and if both of the other players also choose "A," the participant receives 12 Euros. Table 1 shows the payoff.

At the end of each period, the participant is informed about her current decision, the current decisions of her group members, and her payment from that period. Moreover, in each period the participant can see the information from the previous periods (her decisions, the announcements, the decisions of the others, and her payments). Table 2 shows an empty history table as an example. These pieces of information are meant to facilitate learning from one period to the next and thereby convergence to an equilib-

Table 1: The Normal-Form Game of a Three-Player Stag Hunt Game

	Other players' decisions in your group		
Your decision	If ***BOTH*** of the other participants choose A	If ***ONE*** of the other participants chooses A and the other chooses B	If ***BOTH*** of the other participants choose B
A	12	0	0
B	7	7	7

Table 2: History Table

Period	Announcement	Your decision	Decisions of the other players in your group	Your payment in period
...	...	...	...	...

5 All the participants have to answer four questions; the participants in sessions with sunspot treatments have to answer two additional questions regarding the sunspot variables.

6 In the pilot that we run in December 2010, we throw the dice. To keep the sequence of realizations of the sunspot variable the same in July 2011 as in the pilot, we let the subjects see the video of throwing the dice in December 2010. Note that the sequence of dice results for the neutral treatment and for the negative treatment are the same, because we run the two treatments at the same time in the pilot.

7 The subjects see the table in the instructions.

rium. For the final payoff, 1 period is randomly chosen from the 40 periods. The participants receive their earnings in that period plus a show-up fee of 3 Euros, as mentioned at the beginning of the experiment. At the end of the experiment, a questionnaire is filled out by the participants, asking for demographics (like sex, age, and study subject) and school grades (final grade, last math grade, and last German grade).

3.3 TREATMENTS

We want to know how a sunspot variable influences coordination problems if a payoff-dominant and a divergent risk-dominant outcome are available.

Two kinds of random sunspot-generating processes are taken into account, a neutral and a negative random sunspot-generating process. As a benchmark, we are also interested in the game without a sunspot variable. Therefore, we run a control treatment without sunspots, a treatment with a neutral sunspot-generating process, and another treatment with a negative sunspot-generating process. The sessions with sunspot treatments consist of two stages, while the sessions with the control treatment only contain the second stage. In all the sessions with sunspot variables, the participants receive an announcement in each period before they make a decision. The announcement is either "strategy A will be chosen by the majority" (A-sunspot; the payoff-dominant strategy) or "strategy B will be chosen by the majority" (B-sunspot; the risk-dominant strategy). The announcement is decided by a dice and thus is totally random and irrelevant of the fundamentals. Therefore, it could be seen as a sunspot variable. In sessions with the neutral random sunspot-generating process (neutral treatment), the subjects see both announcements with the probability of 1/2. The participants in that treatment receive the announcement "strategy A will be chosen by the majority" if the dice is 1, 2, or 3 and "strategy B will be chosen by the majority" otherwise. In sessions with the negative random sunspot-generating process (negative treatment), the subjects see the B-sunspot with the probability of 5/6. Accordingly, the A-sunspot is shown with a probability of 1/6 in that treatment. The participants in that treatment receive the announcement "strategy A will be chosen by the majority" if the dice is 1 and "strategy B will be chosen by the majority" otherwise.[8] The rules are common knowledge to the subjects.

Table 3: Treatment Overview

Treatment	Number of participants	Number of groups
Control	21	7
Neutral	30	10
Negative	36	12
Total	87	29

8 We also run a session with a positive random sunspot-generating process (A-sunspot with probability 5/6; B-sunspot with probability 1/6). While we obtain interesting findings in sessions with neutral treatment and with negative treatment, we do not see any effect in the positive treatment. Therefore, we decide not to run further sessions of the treatment with the positive random sunspot-generating process. The participants in that session are excluded from the analyses.

4 THEORETICAL CONSIDERATIONS

4.1 THE BASE GAME

The base game of our experiment is a stag hunt game, which describes a conflict between safety and social cooperation. This game can be traced back to Jean-Jacques Rousseau, who described a situation in which two individuals go out on a hunt. Each can individually choose to hunt a stag or to hunt a hare. Each player must choose an action without knowing the choice of the other. If an individual hunts a stag, he must have the cooperation of his partner to succeed. An individual can gain a hare by himself, but a hare is worth less than a stag. This is taken to be an important analogy for social cooperation. In the experiment there is an analogous setting with three players. If a subject chooses "A," the cooperative strategy, and if – and only if – both of the other players also choose "A," the subject receives 12 Euros. Otherwise, the subject gains nothing. However, if the subject chooses "B" – no matter what the other members of her group choose – she always receives 7 Euros. In this game there are two pure strategy NEs, one that is risk-dominant and another that is payoff-dominant. The payoff-dominant equilibrium is realized if all three group members choose the cooperative strategy, A. In this case all the players receive the maximal payoff of 12 Euros, whereas the risk-dominant equilibrium is realized if all three group members choose the non-cooperative strategy, B. In that case all the players obtain the payoff of 7 Euros.

4.2 THE SUNSPOT VARIABLES

In the sessions with sunspot variables, subjects in the same group receive an identical announcement, either "strategy A will be chosen by the majority" or "strategy B will be chosen by the majority" depending on the result of a dice. Those announcements have nothing to do with fundamentals, for example preferences, endowments, or payoff functions. However, following the sunspot variable is an NE. There could be convergence to the payoff-dominant outcome (A-convergence), convergence to the risk-dominant outcome (B-convergence), or no convergence in the control treatment. In the treatments with sunspot variables, there is an additional possibility: convergence to the sunspot equilibrium. In that case all the subjects in a group choose the strategy of the sunspot variable points (sunspot-convergence). Figure 1 shows examples of the different types of convergence observed in our experiment.[9]

The three possible convergence types are rankable according to their expected payoff. A-convergence will lead to an expected payoff of 12 Euros. B-convergence will lead to an expected payoff of 7 Euros. Convergence to the sunspot variable will lead to an expected payoff of $p_A \cdot 12 + (1 - p_A) \cdot 7$ Euros, where p_A is the probability of an A-sunspot.

This leads to the following expected payoff-related hierarchy: payoff (A-convergence) > payoff (sunspot-convergence) > payoff (B-convergence).

5 RESULTS

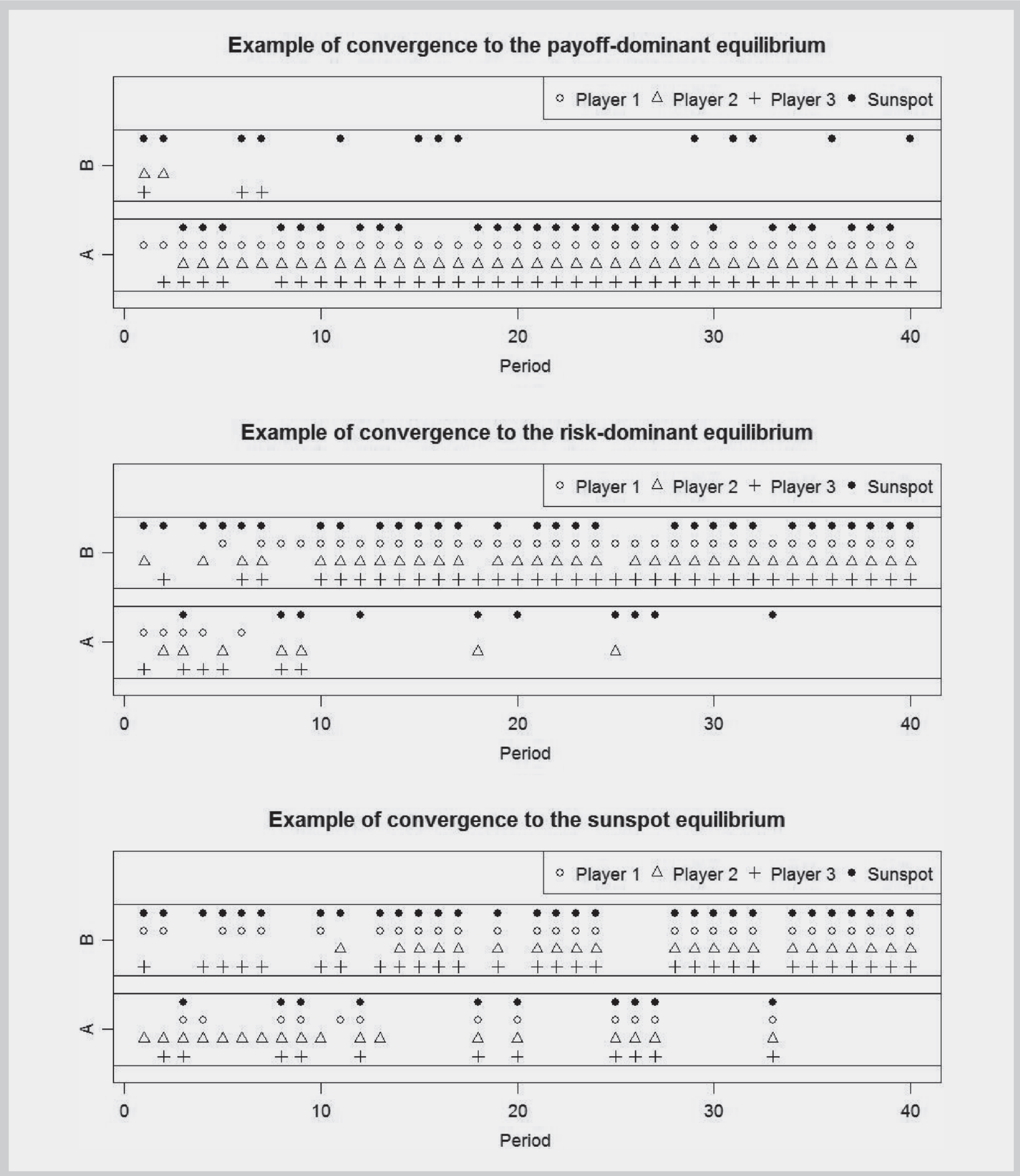
Section 5 is organized as follows. In Section 5.1 we discuss just the decisions and the equilibria of the first period. In Section 5.2 we consider the decisions, equilibria, and earnings of the whole game. We analyze the convergence types in Section 5.3.

5.1 THE FIRST PERIOD

In this subsection we examine the decisions in the first period. Of the 21 participants in the control treatment, 16 (76.19 %) choose alternative A. Of the 30 participants in the neutral treatment, 11 (36.67 %) choose alternative A. Of the 36 participants in the negative treatment, 19 (52.78 %) choose alternative A. Both sunspot treatments differ (slightly) significantly from the control

9 We define convergence as follows: convergence is achieved if all the participants choose the same alternative in each of the last ten periods. If these decisions are always A (always B), we refer to "A-convergence" ("B-convergence"). If these decisions always follow the sunspot variable, we refer to "sunspot-convergence." If there is at least one deviation of one participant in the last ten periods, we refer to "no convergence."

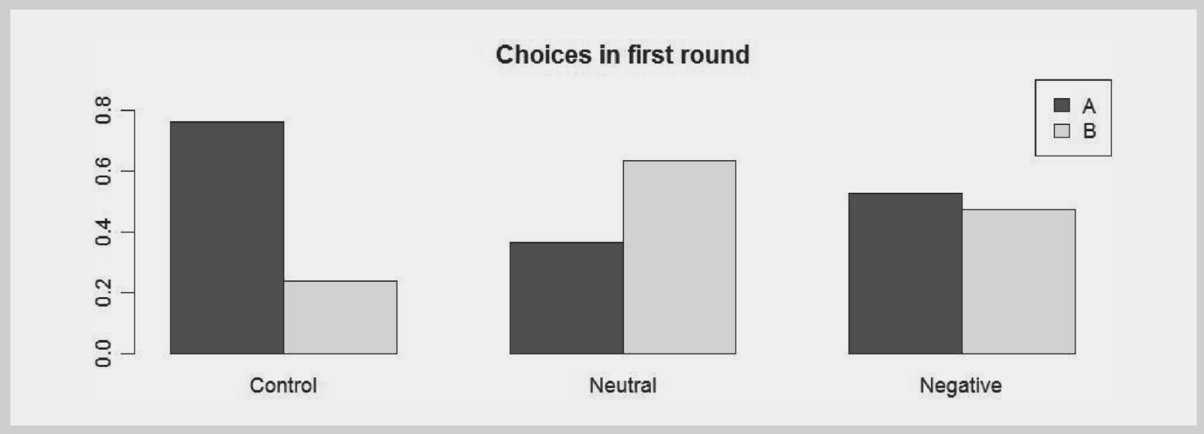
Figure 1: Types of Possible Convergences



treatment. A Fisher test is performed (control vs. neutral $p = 0.01$; control vs. negative $p < 0.10$). Note that the participants in both treatments see a B-sunspot in the first period.

We also compare the equilibria reached in the first period. In the control treatment, 3 of 7 (42.86 %) groups are in equilibrium. In the neutral treatment, 4 of 10 (40.00 %) groups are in equilibrium. In the negative treatment, all 12 groups fail to reach an equilibrium. The Fisher tests reveal significant differences between the negative and the control treatment ($p = 0.04$) as well as between the negative and the neutral treatment ($p = 0.03$). However, the neutral treatment and the control treatment do not differ significantly ($p = 1$). To conclude the observations in the first period, the sunspot variable dissuades

Figure 2: Shares of the Participants Choosing A in the First Period



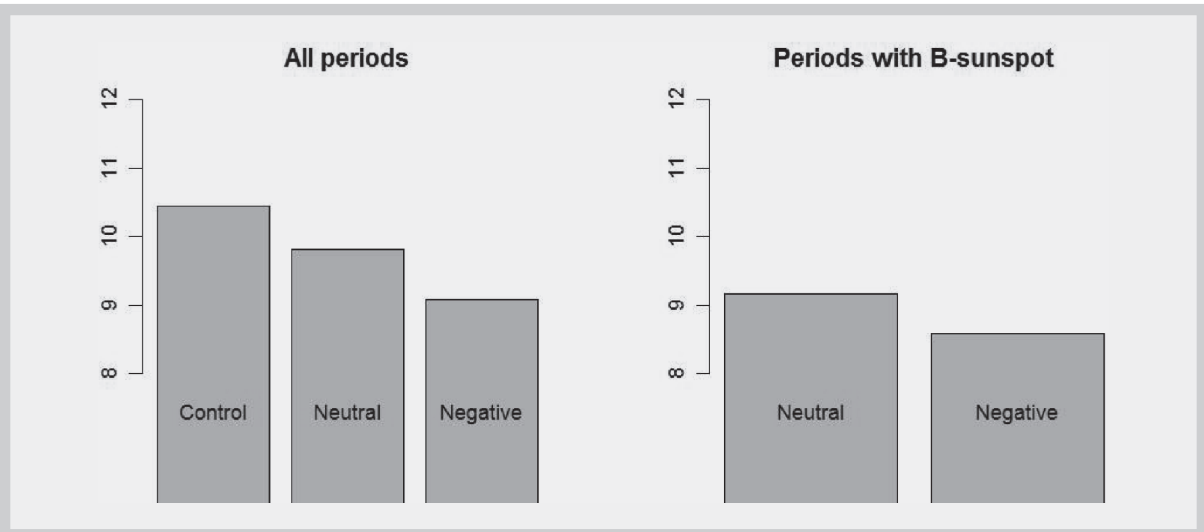
people from the payoff-dominant outcome. Additionally, the negative sunspot-generating process leads to an increase in discoordination.

5.2 ALL PERIODS

Now we consider the whole game. In the control groups, the payoff-dominant equilibrium is reached in 76.07 % of the periods. In the neutral treatment, the payoff-dominant equilibrium is reached in 63.50 % of the periods. The groups in the negative treatment choose the payoff-dominant equilibrium in 54.17 % of the cases. However, a two-sided Mann-Whitney U test reveals no significant differences (neutral vs. control $p = 0.26$; negative vs. control $p = 0.15$; negative vs. neutral $p = 0.95$). The results for the average payoff over all the periods are similar. The expected payoffs are higher in the control group (10.45 Euros on average) than in the neutral treatment (9.82 Euros) or in the negative treatment (9.08 Euros). However, the differences are not significant (neutral vs. control $p = 0.22$; negative vs. control $p = 0.12$; negative vs. neutral $p = 0.76$).

The picture changes if we focus on the periods in which the sunspot variable points to the risk-dominant choice (B-sunspot). In these periods the groups of the neutral treatment reach the payoff-dominant equilibrium in 50.77 % of the cases. The groups in the negative treatment reach the payoff-dominant equilibrium in 45.00 % of the periods. If we compare those with the control treatment using a two-sided Mann-Whitney

Figure 3: The Average Expected Payoffs per Treatment in Euros



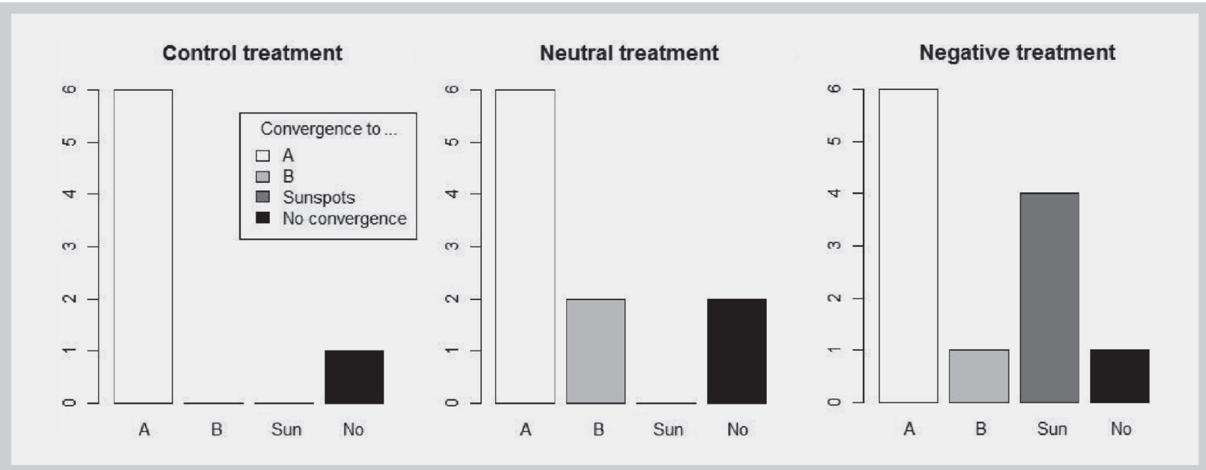
U test, we find slightly significant differences (neutral vs. control $p = 0.08$; negative vs. control $p = 0.06$; negative vs. neutral $p = 0.83$).[10] This has an effect on the earnings. The expected payoffs are on average 9.16 Euros for the neutral treatment and 8.58 Euros for the negative treatment in the specific periods. A two-sided Mann-Whitney U test reveals significant differences in the payoffs (neutral vs. control $p = 0.13$; negative vs. control $p < 0.05$; negative vs. neutral $p = 0.47$).[11] Figure 3 shows the average payoff per treatment over all the periods and over the periods with a B-sunspot. To conclude, (B-)sunspots dissuade people from the payoff-dominant choice, as we have already seen in the first period. This has a negative influence on the payoff. However, the differences in the payoffs are stronger in periods with a B-sunspot than over the whole game.

5.3 CONVERGENCES

Figure 4 shows the differences in convergence types across the treatments. In the control treatment, 6 groups reach A-convergence (85.71 %), while 1 group reaches no convergence (14.28 %). In the neutral treatment, 6 groups (60.00 %) reach A-convergence, while 2 groups (20.00 %) reach B-convergence and 2 groups (20.00 %) reach no convergence. In the negative treatment, 6 groups (50.00 %) reach A-convergence, 1 group (8.33 %) reaches B-convergence, 4 groups (33.33 %) reach sunspot-convergence, and 1 group (8.33 %) reaches no convergence. A Fisher test shows that the neutral treatment compared with the control treatment has a slight effect on A- or B-convergence ($p = 0.05$). The same is true for the negative treatment. A Fisher test shows that B-convergence is reached slightly more often than A-convergence in the negative treatment than in the control treatment ($p = 0.05$). A Fisher test also shows that the negative treatment compared with the neutral treatment makes the sunspot equilibrium slightly significantly more likely than A-convergence ($p = 0.08$).

The differences in the convergence speed are also interesting. This is the number of periods needed to achieve accord (the last period of a deviation in a group plus one). The convergence is achieved slightly significantly faster in the control treatment than in the neutral treatment (two-sided Mann-Whitney U test $p = 0.09$) and then in the negative treatment ($p = 0.07$). There is no significant difference in the convergence

Figure 4: The Composition of Different Convergence Types among Treatments



10 We compare the average number of periods in which the payoff-dominant equilibrium is reached per group. In the treatments with sunspot variables, we use only the periods with a B-sunspot. For the control treatment, we use all the periods.

11 We compare the average payoff per group over all the periods with a B-sunspot. For the control treatment, we use all the periods.

speed between the neutral treatment and the negative treatment (p = 0.94).

To conclude, nearly all the groups converge in the long run. Although there is coordination in nearly all the groups, the groups with sunspot variables coordinate significantly more often on the payoff-dominated equilibria. Only some groups in the negative treatment use the sunspot variable as a (mis)coordination device. They coordinate on the (payoff-dominated) sunspot equilibrium. Additionally, the groups with sunspot variables need more periods to converge. We can say – again – that sunspot variables lead to discoordination in the short run and miscoordination in the long run.

6 CONCLUSION

We study how a sunspot variable can lead to coordination problems using a three-player stag hunt game. It has a payoff-dominant and a divergent risk-dominant equilibrium. The sunspot variable points to one of these two choices.

We find that sunspot variables dissuade people from the payoff-dominant outcome. In the short run, we observe a discoordination effect of sunspot variables. However, sunspot variables have a miscoordination effect in the long run. The effects of the sunspot variable are more pronounced if the random sunspot-generating process points more often to the risk-dominant choice. In more detail, first, we find that people facing a B-sunspot are more prone to choose the risk-dominant alternative. This leads to a lower payoff after B-sunspots. Second, sunspot variables delay the convergence to one equilibrium. Third, convergence to the payoff-dominant equilibrium is more often achieved without sunspot variables. Fourth, the negative sunspot-generating process is more likely to be a (mis)coordination device than the neutral sunspot-generating process.

This paper complements two strands of the experimental sunspot literature. First, it extends the rare literature that focuses experimentally on the coordination failure effects of sunspot variables. Second, it expands the coordination experiments with a payoff-dominant and a divergent risk-dominant equilibrium.

To our knowledge, Beugnot et al. (2012) are the only authors to focus on the coordination failure effects of sunspot variables. In contrast to Beugnot et al. (2012), in our experiment the risk-dominant equilibrium is divergent from the payoff-dominant equilibrium. That should make coordination on the payoff-dominant equilibrium more difficult than in the experiment conducted by Beugnot et al. (2012). On the other hand, we use constant groups. Previous experimental results suggest that this should simplify coordination on an equilibrium. Beugnot et al. (2012) find frequent discoordination caused by sunspot variables. Our results partially support their findings. In fact, we find a discoordination effect caused by sunspot variables in the short run. In the long run, we find more evidence for miscoordination caused by sunspot variables. The divergent payoff-dominant and risk-dominant equilibria together with the fixed groups seem to help the coordination but not necessarily on the payoff-dominant equilibrium. Coming back to the coordination failure power of an incorrect credit rating, we conclude that, if the informational value of a credit rating is like a random draw and there are divergent risk-dominant and payoff-dominant choices, the following is true. A wrong credit market rating has the power to lead not only to discoordination but also to miscoordination.

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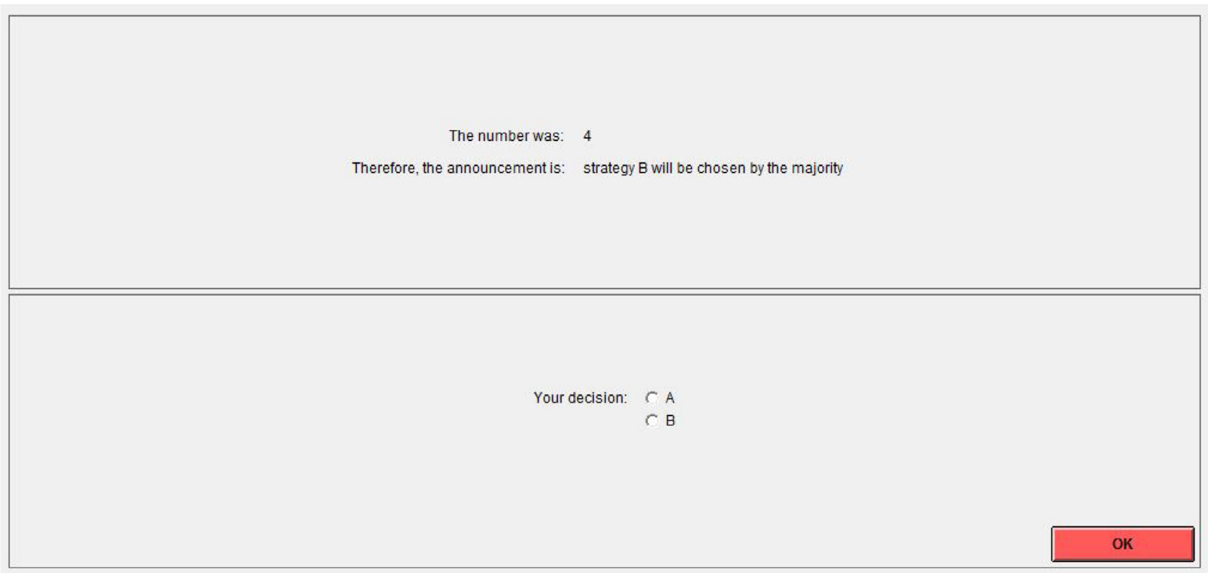
APPENDIX

A A SCREENSHOT OF THE DICE IN THE EXPERIMENT

B THE DECISION SCREEN



C INSTRUCTIONS OF THE CONTROL TREATMENT

INSTRUCTIONS (CONTROL):

Preliminary Note

You are participating in a study of decision-making behavior in the context of experimental economics. During the study you and the other participants will be asked to make decisions. Throughout and after the experiment, no participant will receive information about the other participants' decisions.

Please read the following instructions. After you have read the instructions, we will come to you to answer the open questions. When all the questions have been answered, the experiment will start. Should you have questions during the experiment, you can give a sign at any point to ask for help from us. No communication among participants is allowed during the experiment.

At the end of the experiment, you will receive the payoff from the experiment and a show-up fee of 3 Euros **in cash.**

Decision Situation

This experiment consists of 40 rounds. At the beginning of the first round you will be randomly paired with two other participants to form a group of three. Notice that **the members of your group will be the same** in each round. All groups in the experiment consist of three people.

In each round, you and the other members of your group will decide whether to **"A"** or **"B".**

Your payment will base on **your decisions and the decisions of the other players in your group.** All groups in this experiment receive the same payoff table which is explained below.

In this table, rows indicate your decision of **"A"** or **"B"**, and columns show the decisions of the other players. Each cell indicates the payoff in Euro you will receive depending on your decision and the decisions of the others in your group. For example, if you choose **"A"**; and if both of the other members of your group choose **"B"** you receive **0 Euros**; whereas, if you choose **"A"**, and if both of the other players choose **"A"**, you receive **12 Euros.**

Information

After you make your decision, you will be informed about your current decision, the current decisions of your group members and your payment from that round. Moreover, in each round, you can see the information from previous periods (your decisions, the decisions of the others and your payments).

In the table each row gives information about each previous round. Your previous decisions will be in the second column and the previous decisions of the other members of your group will be in the third column. The last column will display your previous payments from previous rounds. The screen you will see in each round will be similar to one of the following:

Round	Your decision	Decisions of the other players in your group	Your payment in round
....	....	....	....

Your Payment

At the end of the experimental session, **one round** is chosen from the 40 rounds. You will be paid your payment in that round. Moreover, you will receive a show-up fee of 3 Euros.

	Other players' decisions in your group		
Your decision	If **BOTH** of the other participants choose A	If **ONE** of the other participants chooses A and the other chooses B	If **BOTH** of the other participants choose B
A	12	0	0
B	7	7	7

D INSTRUCTIONS OF THE NEUTRAL TREATMENT

INSTRUCTIONS (NEUTRAL SUNSPOTS):

Preliminary Note

You are participating in a study of decision-making behavior in the context of experimental economics. During the study you and the other participants will be asked to make decisions. Throughout and after the experiment, no participant will receive information about the other participants' decisions.

Please read the following instructions. After you have read the instructions, we will come to you to answer the open questions. When all the questions have been answered, the experiment will start. Should you have questions during the experiment, you can give a sign at any point to ask for help from us. No communication among participants is allowed during the experiment.

At the end of the experiment, you will receive the payoff from the experiment and a show-up fee of 3 Euros **in cash.**

Decision Situation

This experiment consists of 40 rounds. At the beginning of the first round you will be randomly paired with two other participants to form a group of three. Notice that **the members of your group will be the same** in each round. All groups in the experiment consist of three people.

In each round, you and the other members of your group will decide whether to **"A"** or **"B".**

Announcement

You and the other members of your group will receive an announcement at the beginning of each period. The announcement will be either **strategy A will be chosen by the majority** or **strategy B will be chosen by the majority,** and it will be the ***same*** for all the participants in this experiment, hence for all the members of your group.

These **announcements are random** since they are determined by the throw of a dice. The experimenter will throw the dice in front of all the participants and you have the opportunity to see the number on the dice via video transmission. You will receive the announcement **"strategy A will be chosen by the majority"** if the dice is 1, 2 or 3, and **"strategy B will be chosen by the majority"** if the dice is 4, 5 or 6.

Your payment will base on **your decisions and the decisions of the other players in your group.** All groups in this experiment receive the same payoff table which is explained below.

	Other players' decisions in your group		
Your decision	If **BOTH** of the other participants choose A	If **ONE** of the other participants chooses A and the other chooses B	If **BOTH** of the other participants choose B
A	12	0	0
B	7	7	7

In this table, rows indicate your decision of **"A"** or **"B"**, and columns show the decisions of the other players. Each cell indicates the payoff in Euro you will receive depending on your decision and the decisions of the others in your group. For example, if you choose **"A"**; and if both of the other members of your group choose **"B"** you receive **0 Euros**; whereas, if you choose **"A"**, and if both of the other players choose **"A"**, you receive **12 Euros.**

Information

After you make your decision, you will be informed about your current decision, the current decisions of your group members and your payment from that round. Moreover, in each round, you can see the information from previous periods (your decisions, the announcement, the decisions of the others and your payments).

Each row will give information about each round. The announcement given in that period will be in the second column. Your previous decisions will be in the third column and the previous decisions of the other members of your group will be in the fourth column. The last column will display your previous payments from previous rounds. The screen you will see in each round will be similar to one of the following:

Round	Announcement	Your decision	Decisions of the other players in your group	Your points in round
....	....	....	....	....

Your Payment

At the end of the experimental session, **one round** is chosen from the 40 rounds. You will be paid your payment in that round. Moreover, you will receive a show-up fee of 3 Euros.

E INSTRUCTIONS OF THE NEGATIVE TREATMENT

INSTRUCTIONS (NEGATIVE SUNSPOTS):

Preliminary Note

You are participating in a study of decision-making behavior in the context of experimental economics. During the study you and the other participants will be asked to make decisions. Throughout and after the experiment, no participant will receive information about the other participants' decisions.

Please read the following instructions. After you have read the instructions, we will come to you to answer the open questions. When all the questions have been answered, the experiment will start. Should you have questions during the experiment, you can give a sign at any point to ask for help from us. No communication among participants is allowed during the experiment.

At the end of the experiment, you will receive the payoff from the experiment and a show-up fee of 3 Euros **in cash.**

Decision Situation

This experiment consists of 40 rounds. At the beginning of the first round you will be randomly paired with two other participants to form a group of three. Notice that **the members of your group will be the same** in each round. All groups in the experiment consist of three people.

In each round, you and the other members of your group will decide whether to **"A"** or **"B"**.

Announcement

You and the other members of your group will receive an announcement at the beginning of each period. The announcement will be either **strategy A will be chosen by the majority** or **strategy B will be chosen by the majority,** and it will be the ***same*** for all the participants in this experiment, hence for all the members of your group.

These **announcements are random** since they are determined by the throw of a dice. The experimenter will throw the dice in front of all the participants and you have the opportunity to see the number on the dice via video transmission. You will receive the announcement **"strategy A will be chosen by the majority"** if the dice is 1 and **"strategy B will be chosen by the majority"** if the dice is 2, 3, 4, 5 or 6.

Your payment will base on **your decisions and the decisions of the other players in your group.** All groups in this experiment receive the same payoff table which is explained below.

	Other players' decisions in your group		
Your decision	If **BOTH** of the other participants choose A	If **ONE** of the other participants chooses A and the other chooses B	If **BOTH** of the other participants choose B
A	12	0	0
B	7	7	7

In this table, rows indicate your decision of **"A"** or **"B"**, and columns show the decisions of the other players. Each cell indicates the payoff in Euro you will receive depending on your decision and the decisions of the others in your group. For example, if you choose **"A"**; and if both of the other members of your group choose **"B"** you receive **0 Euros**; whereas, if you choose **"A"**, and if both of the other players choose **"A"**, you receive **12 Euros.**

Information

After you make your decision, you will be informed about your current decision, the current decisions of your group members and your payment from that round. Moreover, in each round, you can see the information from previous periods (your decisions, the announcement, the decisions of the others and your payments).

Each row will give information about each round. The announcement given in that period will be in the second column. Your previous decisions will be in the third column and the previous decisions of the other members of your group will be in the fourth column. The last column will display your previous payments from previous rounds. The screen you will see in each round will be similar to one of the following:

Round	Announcement	Your decision	Decisions of the other players in your group	Your points in round
....	....	....	....	....

Your Payment

At the end of the experimental session, one round is chosen from the 40 rounds. You will be paid your payment in that round. Moreover, you will receive a show-up fee of 3 Euros.

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