Nudging with heterogeneity in environmental sensitivity : a public goods experiment in networks*

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April 10, 2017

Abstract

We propose an experimental test of the theoretical predictions obtained in Ouvrard and Stenger (2017), namely that the reaction to a nudge implemented in a network depends on the network structure, and on individuals' sensitivity to the environment. They obtain that the most sensitive individuals in a circle network should contribute more under nudge implementation coordinating their actions (*i.e.* strategic uncertainty is reduced). In the star network, the result depends on the content of the nudge. Indeed, it is necessary for the regulator to know each individual position in the network, in order to propose a nudge for which the content is adequate to their position. In the experiment we first elicited the subjects' sensitivity to environmental matters. We then determined subjects' inequity aversion (Blanco *et al.* 2010, Teyssier 2012). Finally, the subjects played a twice ten period public goods game in network (circle or star), similar to the one proposed in Rosenkranz and Weitzel (2012). The first ten periods served as a baseline. Then, a nudge (announcement of the socially optimal level of contribution) was implemented both under complete information (the content of the nudge takes into account individuals' position) and under incomplete information (the nudge cannot rely on individuals' position and targets one individual). We show that nudge implementation does not

*We would particularly like to thank Giuseppe Attanasi, Urs Fischbacher and Mathieu Lefebvre for their helpful comments on the protocol of this experiment, as well as Kene Boun My for programming the experiment. We are also grateful to the participants at the French German Workshop on Experimental Economics (Konstanz, 2016).

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induce an increase in the level of contributions (both for less and highly sensitive subjects, and in both networks). However, it induces a higher coordination on the social optimum in the circle for the most sensitive subjects. In the star network, the targeted nudge induces a decrease in the level of contribution for the least sensitive subjects. Econometric estimations corroborate these different results.

Key Words : inequity aversion; networks; nudge; environmental sensitivity; public goods experiment.

JEL Codes : C72, C91, H41, Q50.

1 Introduction

Whether a network is formal or not (club, association, neighborhood, etc.), our individual decisions are somehow and partly influenced by others' own decisions. The influence of an individual's network has obtained an increasing focus in the literature, in particular concerning cooperation among individuals to contribute to local public goods (Allouch 2015, Bloch and Zenginobuz 2007, Bramoullé and Kranton 2007, Bramoullé *et al.* 2014, Sanditov and Arora 2016).

In this paper we are concerned with local environmental quality, and how the influence of an individual's network determine its level. Indeed, the fact to belong to a network may facilitate the observation of the behavior adopted by peers. Empirical evidence highlight that an individual's network does influence pro-environmental decisions. Welsch and Kühling (2009) study the determinants for adopting pro-environmental behaviors. Among different factors (economic, cognitive, own consumption in the past), the authors focus in particular on the impact of "reference persons" (peers, neighbors, etc.). They show that the behavior of reference persons positively influence individuals' purchase of organic food and green electricity. In another study, Cavalcanti *et al.* (2013) provide evidence that the more fishermen are integrated in their social network, the more they participate in the development of environmental programs. The intuition is that when fishermen are highly integrated in a social network, they do not want to harm their peers. Finally, Primmer *et al.* (2014) focus on the determinants to contract with payments for ecosytem services among Finnish forest owners. They show that perceived benefits on local members (neighbors, peer forest owners, etc.) increase the probability to contract in the future. In sum, these articles highlight that economic agents are influenced by the behavior of their neighbors, and this influence may be the result of mimetism or of a strategic answer to maintain cooperation.

Notwithstanding, even if agents participate to the provision of local public goods when being in networks, they contribute less than the socially optimal level (Bramoullé and Kranton 2007, Bramoullé *et al.* 2014). The intuition is that agents do not consider the impact of their contributions in the benefit of their neighbors in the network.

To deal with this issue, Ouvrard and Stenger (2017) proposed a theoretical model in which they considered nudge implementation (announcement of the socially optimal level of contribution). A nudge presents the advantage of being a simple, costless and noncoercive action with the objective to influence agents' decisions in a given direction (Thaler and Sunstein 2009). Researchers obtained encouraging results in the field with nudge implementation, in particular when dealing with environmental concerns: energy savings (Allcott 2011, Costa and Kahn 2013, Ferraro and Price 2013), paper usage (Egebark and Ekström 2016), adoption of new practices (Kuhfuss *et al.* 2016), etc.

The objective of this paper is to test the theoretical predictions obtained in Ouvrard and Stenger (2017), namely that the efficiency of a nudge implemented to increase the total level of contributions for environmental quality, with individuals in networks, depends: (i) on individuals' sensitivity to environmental matters and, (ii) on the structure of the network. Even if the present paper focus on environmental concerns, the same framework could be applied to more general questions considering, for instance, individuals' interest in the public good which is provided instead of environmental sensitivity.

We thus propose a laboratory experiment, with similarities to Rosenkranz and Weitzel (2012)'s experiment. These authors wanted to test the theoretical predictions obtained by Bramoullé and Kranton (2007) on the Nash equilibria in different networks (complete, circle, star, line). However, contrary to these authors, we first elicited the subjects' environmental sensitivity in order to construct networks with subjects sharing the same sensitivity to environmental matters, and to be able to test the theoretical predictions obtained in Ouvrard and Stenger (2017). Besides, contrary to Rosenkranz and Weitzel who focused on the study on Nash equilibria, we allowed the subjects to contribute the socially optimal contribution[1]. Moreover, our subjects played with one structure only (circle or star network) to avoid learning. Finally, our protocol differs from Rosenkranz and Weitzel (2012)'s one because our subjects first played a series of ten period without external incentives, and then another series of ten periods under nudge implementation.

Our results highlight that nudge implementation seems to be most suited for circle networks as predicted in Ouvrard and Stenger (2017), even if we do not observe a significant increase in the level of contributions. However, for the most sensitive subjects to environmental matters we find more coordination on the socially optimal outcome. In the star network, we observe a significant decrease of the level of contributions at the level of the network for the least sensitive subjects. When estimating the probability to

[1]In Rosenkranz and Weitzel (2012), the subjects' contribution could not exceed the Nash equilibrium level.

coordinate on the Nash equilibrium, we find that the subjects' environmental sensitivity negatively explain the probability to coordinate on this level (*i.e.* they coordinate more on the socially optimal profile of contributions).

The rest of the paper is organized as follows. We consider the related papers in Section 2. Then, we briefly state the hypotheses we want to test in Section 3, establishing a link with the theoretical model presented in Ouvrard and Stenger (2017). In Section 4, we detail the protocol of the experiment. The results are presented in Section 5. In Section 6, we focus on the determinants of the probability to coordinate on the Nash equilibrium. Finally, Section 7 gives a discussion and concludes.

2 Related literature

In this section, we present the different strands of research related to our question in this paper.

First, our experiment may be related to those focusing on cooperation in networks due to the nature of the game we study (voluntary contributions to a local public good). Choi *et al.* (2008) propose an experiment in which individuals form groups of three, and each subject can observe the actions of his/her neighbors at the end of each period (complete network). The authors also consider different values of the public good (high and low). They show that, for a given time period, the provision rate of the public good is significantly higher when the value of the public good is high compared to the case when it is low. Moreover, the provision rate of the public good is higher in dynamic games[2] than in one-shot games. In another experiment, Choi *et al.* (2011) compare different forms of networks (empty, line, star, one link) with the complete network studied in Choi *et al.* (2008). Moreover, they study directed and non-directed networks.[3] They show that the level of cooperation is highly dependent on the form of the network. The lowest rate of cooperation is observed in the empty network, while the highest rate of cooperation is observed in the star network.[4] They also make the distinction between two kinds of

[2]In dynamic games, the game was played during 3 periods.

[3]A network is said to be directed if the links between individuals work in one direction. For instance, individual A can observe individual B, but individual B cannot observe individual A.

[4]The star network allows the middle player to observe the behavior of the peripheric players.

behaviors: strategic commitement and strategic delay.[5] They show that the first kind of behavior is more likely to be observed in directed networks with uninformed subjects (some can observe the behavior of others, but those who are observed cannot observe the behavior of the observer). Symmetrically, the second kind of behavior is more likely to be observed with informed subjects. Finally, Rosenkranz and Weitzel (2012) provide an experimental test of the theoretical model proposed by Bramoullé *et al.* (2007). In particular, they show that individuals may coordinate on Nash equilibria, but it depends on the shape of the networks. They obtain a higher rate of coordination both in the complete and the star networks. The complete network is characterized by a low centrality (no subject concentrates the number of links) and a high density (each subject has a high number of direct neighbors). The star network is defined by the opposite properties: a high centrality (one individual concentrates the whole neighborhood) and a low density.

Second, our experiment may also be related to those on agglomeration bonus scheme (a bonus given to forest or agricultural landowners conditional on the adoption of conservation activities by their neighbors and themselves). In a laboratory experiment, Banerjee *et al.* (2012) study spatial coordination of landowners, varying the size of the group (six or twelve players). They focus on groups located on a circle network.[6] The authors show that subjects succeeded to coordinate more often on the socially optimal outcome when the group size is small compared with a larger group size. In a similar experiment (still focusing on the circle network), Banerjee *et al.* (2014) study the effect of information provision about the behavior of their direct and indirect neighbors on the performance of the agglomeration bonus scheme. They obtain that providing the subjects with such information increase the emergence of socially optimal outcomes. However, it is worth noticing that the authors also highlight that, over time, information provision is not efficient anymore since the subjects turn to risk-dominant outcomes. Finally, Banerjee *et al.* (2017), still with a similar experiment, vary the transaction costs (high and low), and allow for communication between neighbors (circle network). The authors obtain that less coordination on the socially optimal outcome is observed when the transaction costs are

[5]The first behavior characterizes the "tendency for subjects in certain network positions to make contributions early in the game in order to encourage others to contribute". The second behavior charaterizes the "tendency for subjects in certain network positions to delay their decisions until they have observed a contribution by a subject in another position".

[6]Each player had two direct neighbors: one on the right and one on the left.

high. However, even in the case of low transaction costs, full coordination at the level of network is seldom observed. Instead, the authors observe local coordination. Moreover, Banerjee *et al.* show that (costly) communication between neighbors significantly improve the performance of the agglomeration bonus scheme. Our experiment differs from these ones as we do not vary the size of the network, and our subjects were not allowed to communicate. Moreover, contrary to these experiments, we also considered the star network.

Finally, our experiment differs from those focusing on network formation (Corbae and Duffy 2008, Goeree *et al.* 2009, Corten and Buskens 2010)[7], because we consider that the network is exogenous. Indeed, in our setting, groups of individuals (neighborhood, professional networks) are already formed. We are not interested in their formation. We want to capture the effect of nudges and their diffusion inside these groups. Our experiment also differs from coordination games (Keser *et al.* 1998, Berninghaus *et al.* 2002, Cassar 2007), because coordination games require subjects to coordinate on an efficient strategy. Subjects has no incentive to free-ride and to choose another action. It would lower their profit. However, cooperation games require subjects to cooperate to achieve a common objective. In that case, subjects have incentives to free-ride.

3 Theoretical predictions for local public goods in networks under nudge implementation

Before turning to the design of our experiment, we describe the main results obtained in Ouvrard and Stenger (2017), and formulate the hypotheses we test in this paper.[8]

We consider an economy with n agents in a fixed network involved in the supply of a local public good. In this paper, we focus on the circle and the star networks (see Fig. 1). Indeed, for the complete network, Ouvrard and Stenger (2017) obtain the same results than for the circle network given that both structures are regular graphs (the number of direct neighbors is the same for each agent). In both the line and star networks, some agents in the networks should contribute if the socially optimal profile of contributions is

[7]Overall, these authors show that subjects create new links with other subjects (and thus create a network) when the others tend to act in a similar way.

[8]The model is based on the one proposed by Bramoullé and Kranton (2007).

implemented, while others should not contribute at all. However, the authors show that in the line network, more information is needed concerning agents' position to implement the nudge we consider (announcement of the socially optimal level of contribution). Thus, we decided to consider the star network only to assess if the experimental results corroborates the intuitions of the theoretical model.

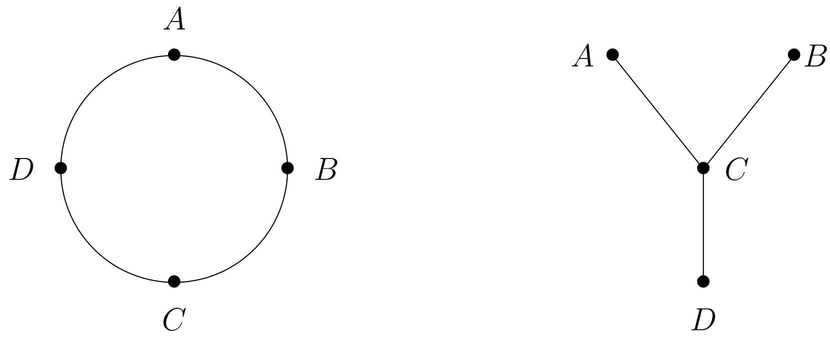

Figure 1: Circle and star networks.

Agents can voluntarily contribute to a local public good, at a constant marginal cost c. Agent i's level of contribution is denoted as x_i, $x_i \in \mathbb{R}^+$. In the network, agents i and j are direct neighbors if a link exists between them: $g_{ij} = 1$. In that case, agent j benefits from the contributions made by agent i, and conversely.[9] Notice that agent i benefits from his/her own contributions: $g_{ii} = 1$. If agent j is not a direct neighbor of agent i, then $g_{ij} = 0$, and agent j cannot benefit from the contributions made by agent i. The set of agent i's direct neighbors is N_i, where $N_i = \{j \in N \setminus i : g_{ij} = 1\}$, and his/her total number of direct numbers is given by k_i, the cardinal of the set N_i.

The voluntary contributions benefit the agents according to the concave benefit function $f(X)$, where $X = \sum_{i=1}^{N_i} x_i$. Knowing that the Nash equilibrium level of contributions is lower than the socially optimal one, Ouvrard and Stenger (2017) consider the implementation of a nudge consisting of the announcement of the socially optimal level of contribution for a given agent, denoted as $\hat{x}_i$.[10] Moreover, it may be difficult for agents to coordinate on one equilibrium due to the multiplicity of Nash equilibria. Thus, the second objective of the nudge is to reduce strategic uncertainty (Van Huyck *et al.* 1990).

[9]We consider non directed links: $g_{ij} = g_{ji}$.

[10]Agents undercontribute since they do not take into account the impact of their contribution on the benefit of their direct neighbors when solving their private program.

The intuition of this moral cost function is that as long as agents depart from the value which is announced by the regulator, they will incur a moral cost given by the function $g(x_i - \hat{x}_i)$, with $g'(.) \lesseqqgtr 0$ if $x_i - \hat{x}_i \lesseqqgtr 0$, and $g''(.) > 0$. This modelisation share similarities with the moral cost function proposed in Brekke *et al.* (2003, 2010), Bruvoll and Nyborg (2004), Czajkowski *et al.* (2017), Figuières *et al.* (2013) and Nyborg (2011). In these models, economic agents suffer from a moral cost as long as their depart from their morally ideal effort.[11] Agents' total utility is thus:

$$U_i(x_i) = f\left(x_i + \sum_{i \in N_i} x_j\right) - cx_i - g(x_i - \hat{x}_i) \tag{1}$$

The authors consider nudge implementation both under complete and incomplete information. Under complete information, the content of the nudge depends on agents' position in the network. On the contrary, under incomplete information it is not possible to make the content of the nudge dependent on agents' position, because the regulator only knows the structure of the network (circle or star) and does not know their exact position inside the network. Thus, the regulator implements the same nudge for everyone (the content is the same), that targets some individuals in the networks.

Ouvrard and Stenger show that under complete information, nudge implementation may lead to an increase in the level of contributions.

Hypothesis 1: Under complete information, the total level of contributions increases following nudge implementation in both types of networks.

Under incomplete information, Ouvrard and Stenger show that in the star network the total level of contributions may increase if the individual in the center is targeted (the nudge suggests to this individual to contribute the socially optimal contribution). However, if the individuals on the periphery are targeted (the nudge suggests to them to not contribute), then the network may coordinate on the Nash equilibirum profile of contributions. Note that the loss of information in the circle network is not an issue since everyone has the same number of direct neighbors. Indeed, the social optimal profile of contributions depends on the configuration of the network. In the case of a regular

[11] In these papers, the target to be reached is fixed by agents themselves, while in Ouvrard and Stenger (2017) and in this paper, it is the regulator who sets it.

network (everyone has the same number of direct neighbors), then the socially optimal profile of contributions is symetric.

Hypothesis 2: Under incomplete information, the total level of contributions increases in the star network following nudge implementation if the individual in the center is targeted.

Based on the previous hypothesis, and on the theoretical predictions in Ouvrard and Stenger (2017), if the nudge is efficient, in particular in the circle network, then we should also observe more coordination.

Hypothesis 3: The nudge induces more coordination in the circle network than in the star network.

The intuition is that the content of the nudge is the same for all subjects in the circle network, while it differs across subjects in the star network (suggesting the individual in the center to contribute his/her 10 tokens, while those in the periphery should not contribute). On the basis of the results of Keser and van Winden (2000) and Fischbacher *et al.* (2001), who showed that subjects are (imperfect) conditional cooperators in public goods game, we may indeed expect that the fact to suggest to some individuals to contribute more than others may reduce the willingness to contribute if others do not.

Finally, the different models proposed so far on voluntary contributions for a local public goods in network (Bramoullé and Kranton 2007, Bramoullé *et al.* 2014, Ouvrard and Stenger 2017) do not integrate psychological dimensions that can explain the agents' behavior. More precisely, Bramoullé and Kranton (2007) and Bramoullé *et al.* (2014) focus on the study of Nash equilibria (what they expect to observe). However, agents are not necessarily the perfect utility maximizers we generally expect to be. Inequity aversion (Fehr and Schmidt 1999, Teyssier 2012) may also be a determinant explaining why the subjects do not necessarily free ride when contributing to public goods, and thus explaining why it may be difficult for the subjects to coordinate on one equilibrium.

Hypothesis 4: Inequity aversion is a determinant of subjects' decision to contribute for the public good.

We test these different hypotheses in the experiment we propose in the next section.

4 Experimental design

The experiment was conducted in February 2017 in the Laboratory of Experimental Economics of Strasbourg (LEES).[12] On average, sessions were completed in seventy minutes.

Below, we detail the different stages of this experiment. The order of this protocol was chosen so that the most difficult tasks from a cognitive point of view were played last.

4.1 First stage: General Ecological Behavior (GEB) scale

At the beginning of the experiment, the subjects randomly picked a number in order to assign them to a computer. Then, the instructions were read aloud, informing the subjects that they would participate in an economic experiment with five independent stages, and with final earnings being the sum of their earnings in each stage. Before the end of the experiment, the subjects did not receive any feedback on their earnings: everything was determined at the end of the fifth stage. In case subjects had questions, an experimenter came to answer them privately.

To determine subjects' environmental sensitivity, we first implemented the General Ecological Behavior (GEB) scale (Davis *et al.* 2009, 2011), similarly to Boun My and Ouvrard (2017). The subjects had to complete a questionnaire of 28 items (detailed in the appendix). There were five possible answers: "never", "seldom", "sometimes", "often" and "always", recoded from 1 for "never" to 5 for "always".[13]

The mean score of the first session (M=103) was used for the other sessions to determine whether the subjects were few or highly sensitive to the environment. The subjects with a score higher than the mean were the most sensitive to environmental matters, and conversely for those below the mean. For the analysis of this experiment, those being the least sensitive to environmental matters were considered as A players, while the most sensitive were considered as B players. We asked them to answer honestly, and paid them 3 euros for this stage. The subjects did not know that their answers to this questionnaire would help us to construct networks with subjects sharing the same environmental sensitivity in the fourth stage.

[12] The program of this experiment was designed by Kene Boun My with the web platform EconPlay (www.econplay.fr).

[13] The opposite code was implemented for the 11 unecological items.

4.2 Second stage: Advantageous inequity aversion

We implemented a modified dictator game to elicit the subjects' advantageous inequity aversion, following Blanco *et al.* (2011) and Teyssier (2012). The subjects played successively the role of a *receiver* and of a *dictator*, without knowing which role the computer would randomly allocate them at the end of the experiment.

As a receiver, the subjects first choose whether to opt out of the game and to receive immediately 5 points, or to play the game. As a dictator, they had to determine a repartition between the receiver and herself. More precisely, they had 21 decisions to make between two options (presented as lists). In the left option, the repartition was always 18 points for herself and 2 points for the receiver, denoted as (18;2). In the right option, a menu of equal repartitions was presented in an increasing order. In the first line, the repartition was 0 point each (denoted as (0;0)), while in the last line it was 20 points each (denoted as (20;20)).

At the end of the experiment, each dictator was randomly matched with a receiver, and they received the corresponding payoff. The conversion rate was 1 point = 0.25 euro.

4.3 Third stage: Disadvantageous inequity aversion

In the third stage, we determined the subjects' disadvantageous inequity aversion with an ultimatum game (Blanco *et al.* 2011; Teyssier 2012).

The subjects played this game as an *X player* (sender), and then as a *Y player* (responder). Similarly to the previous stage, they knew that they would play these two roles, and that the computer would randomly determine their role at the end of the experiment. Once their role was determined, they were matched with a corresponding partner: if they were an X player, they were matched with a Y player (and conversely).

As an X player, the subjects had to determine how to share an amount of 20 points between the Y player and themselves. Then, as a Y player, the subjects faced a list of 21 repartitions between the X player and themselves, starting from (20;0) - *i.e.* 20 points for the X player and 0 for themselves - to (0;20) - *i.e.* the opposite repartition. For each repartition, the subjects had to choose to "Accept" (left option) or to "Reject" (right option) the proposition. Obviously, they did not know the proposition made by the X player. Moreover, they knew that if they chose to "Reject" the proposition made by the X player, then both of them would earn nothing for this task. The rate of conversion was the same than for the previous stage (1 point = 0.25 euro).[14]

4.4 Fourth stage: Local public goods game

For this stage, subjects were randomly assigned to fixed groups of four individuals. Depending on the results to the GEB scale, we formed groups of A players only, and groups of B players only to directly compare groups with a different environmental sensitivity (with a random repartition of the subjects). Note that the subjects were not aware of the way we formed the groups.[15]

The subjects played a 10 periods public goods game in one structure only (circle or star network). They were endowed with a fixed amount of 10 tokens that could be invested in an environmental account to improve environmental quality. We explained in the instructions that tokens invested in the environmental account would benefit the subjects and their direct neighbors only. Using examples (with visual illustrations following Fig. 1), we emphasized that invested tokens in this account would not necessary benefit the entire group (in particular in the circle network). The subjects knew that the non invested tokens would be lost at the end of each period.

Subjects' earnings were given by the following payoff function:

$$\pi_i = 3 + 4ln\left(1 + x_i + \sum_{N_i} x_j\right) - x_i \tag{2}$$

with x_i being subject i's contribution, and $\sum_{N_i} x_j$ the sum of the contributions made by his/her direct neighbors.

The Nash equilibrium is $X^{NE} = 3$ tokens. In the circle network, the socially optimal profile of contributions is such that each subject should contribute $x^* = 4$ tokens. In the star network, it is such that the individual in the center should contribute $x^* = 10$ tokens, while the individuals in the periphery should not contribute. We gave the subjects a table for their payoff (expressed in ECU), depending on their level of contribution and the one of their direct neighbors. The rate of conversion was 1 ECU = 0.50 euro.[16]

[14] We kept the same wording than for the previous stage, and talked about "points" to be shared.

[15] For instance, in groups of A players, the subjects did not know that they were part of a group with a low sensitivity to environmental matters.

[16] Contrary to the two previous stages, we did not use the term "point" but "ECU" since the rate of conversion was not the same.

In Rosenkranz and Weitzel (2012), the subjects could contribute between 0 and 1, with two decimals. Contrary to them, we do not focus on Nash equilibria but on the social optimum. This is why we allowed the subjects to contribute up to 10 tokens.

At the end of each period, the subjects received feedback on the total level of contribution of their direct neighbors, as well as their gain for the period. To give enough incentive, they knew that one period over the ten would be randomly selected at the end of the experiment to determine their earnings for this stage.

4.5 Fith stage: Local public goods game with nudge implementation

For the last stage, we informed the subjects that they would play the same game than in the previous one (with the same rate of conversion), except that a piece of information would be disclosed on their screen at the beginning of each period (before they took their decision). To limit demand effects (Zizzo 2010), we reminded the subjects that their decisions would be anonymous. Moreover, each sessions were conducted by an expertimenter who was not a professor of the University.

In the circle network, the subjects could read the follwoing message on their screen:

" *If each subject participates investing 4 tokens in the environmental account, then the whole group may benefit from the highest environmental quality* "

In the star network, we implemented two different messages in order to test the first and the second hypotheses of the previous section (corresponding to two different treatments).[17] We first considered a non-targeted (N.T) message, *i.e.* the content was the same for everyone:

" *If the player C participates investing 10 tokens in the environmental account, then the whole group may benefit from the highest environmental quality* "

with the Player C being the player in the center of the star network (Fig. 1). This message was implemented to mimick a situation of incomplete information from the regulator's point of view (he has no knowledge on individuals' exact position in the network).

[17]The subjects played in one treatment only.

Second, we considered targeted (T.) messages, corresponding to messages for which the content varied depending on individuals' position in the network (to mimick a situation of complete information from the regulator's point of view). Individuals in the periphery (players A, B and D) could read the following message on their screen:

" *If you choose to not participate to the environmental account, then the whole group may benefit from the highest environmental quality. Indeed, your contribution would be redundant with the one of player C.* "

while player C could read:

" *If you participate investing 10 tokens in the environmental account, then the whole group may benefit from the highest environmental quality* "

A summary of the different steps of this public goods game is presented in Table 1.

Table 1: Summary of the public goods game.

	Circle		Star		
	1-10	11-20	1-10	11-20	11-20
Groups A	baseline	nudge	baseline	non-targeted nudge	targeted nudge
	4 groups		**11 groups**	**5 groups**	**6 groups**
Groups B	baseline	nudge	baseline	non-targeted nudge	targeted nudge
	6 groups		**9 groups**	**5 groups**	**4 groups**

5 Results

In this section, we describe the results we obtained. A total of 144 subjects participated in the six sessions that were conducted (with 54.86% being females, and 63.89% being students in economics). On average, the subjects earned 16.37 euros (with a standard deviation of 3.06 euros). We obtained six groups of subjects differing in their environmental sensitivity (*i.e.* groups composed of A and B players) that we do not take into account in the analysis below. Thus, we consider a total of 120 subjects.

5.1 Environmental sensitivity and Inequity aversion

We first focus on the study of subjects' environmental sensitivity and inequity aversion (both advantageous and disadvantageous). Then, we compare the results we obtained with other studies in which these tests have been implemented.

Environmental sensitivity

Concerning the measurement of environmental sensitivity, the mean score per item (on the 28 ones) was 3.61 (SD = 0.72). The GEB scale was found to be acceptable (α = 0.73). With the same scale, internal reliability in other studies was 0.76 in Davis *et al.* (2009), 0.75 in Davis *et al.* (2011) and 0.74 in Boun My and Ouvrard (2017). As a consequence, we cannot reject the hypothesis that this questionnaire measured only one dimension (environmental sensitivity).

Inequity aversion

In Fehr and Schmidt (1999), agents' utility function is defined as:

$$U_i\left(x_i, x_j\right) = \begin{cases} x_i - \alpha_i\left(x_j - x_i\right) & \text{if } x_i \leq x_j \\ x_i - \beta_i\left(x_i - x_j\right) & \text{if } x_i > x_j \end{cases} \tag{3}$$

where x_i and x_j are, respectively, the monetary payoffs of agents i and j.

The coefficient of advantageous inequity aversion β_i is determined according to the subjects' decision as a dictator. Let us assume that a subject switches from the repartition (18;2) to the egalitarian repartition $(\omega_i;\omega_i)$. Thus, this subjects prefers the repartition $(\omega_i;\omega_i)$ over (18;2), but prefers the repartition (18;2) over $(\omega_i - 1;\omega_i - 1)$. Following Blanco *et al.* (2011) and Teyssier (2012), we obtain that $u_i(\tilde{\omega_i};\tilde{\omega_i}) = u_i(18;2)$, with $\tilde{\omega_i} \in [\omega_i - 1;\omega_i]$, $\omega_i \in \{0, ..., 20\}$, and $u_i(.)$ corresponding to Eq. (3). Setting $\tilde{\omega_i} = \omega_i - 0.5$ and rearranging, we get that:

$$\beta_i = \frac{18.5 - \omega_i}{16} \tag{4}$$

The coefficient for disadvantageous inequity aversion α_i is determined according to the subjects' decision as an X player (sender) in the third task. Following Blanco *et al.* (2011) and Teyssier (2012), let us assume that r_i is the decision number, minus one, of the first decision in which a Y player (responder) accepts the repartition proposed by an X player (sender). In that case, $r_i - 1$ is the decision number, minus one, of the last decision such that the Y player rejects the repartition proposed by the X player. Thus, the Y player is indifferent between accepting a repartition $\tilde{d_i} \in \{d_i - 1; d_i\}$, with $d_i \in \{0, ..., 20\}$, and rejecting the repartition and earning nothing. Similarly to the advantageous inequity aversion, we get that for this agent $u_i(\tilde{d}_i; 21 - \tilde{d}_i) = u_i(0; 0)$. Setting $\tilde{d}_i = d_i - 0.5$ and rearranging according to Eq. (3), we obtain:

$$\alpha_i = \frac{d_i - 0.5}{21 - 2d_i} \tag{5}$$

The distribution of the coefficients α and β is displayed in Fig. 2. On the basis of a Spearman correlation test, the coefficients α and β are not significantly correlated ($\rho = -0.071$, $p - value$=0.440).[18]

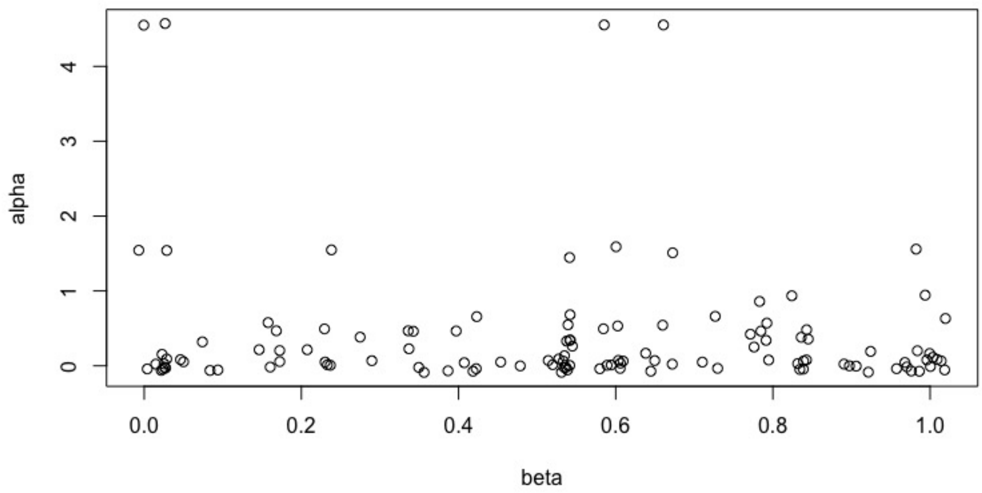

Figure 2: Joint distribution of the values of the coefficients alpha and beta (inequity aversion).

5.2 Do subjects increase their level of contribution under nudge implementation?

The level of contribution, per network, is presented in Table 2. Groups of B players systematically contribute more than groups of A players, regardless of the network and the sequence of the public goods game.

[18]This result is in line with those obtained in Teyssier (2012), but not with those in Blanco *et al.* (2011).

Table 2: Mean contribution per network and per treatment (standard deviation in parenthesis).

	Circle		Star		
	1-10	11-20	1-10	11-20 (N.T.)	11-20 (T.)
Groups A	7.88	7.98	8.32	8.26	7.50
	(2.67)	(3.98)	(4.27)	(2.71)	(4.31)
	4 groups		**11 groups**	**5 groups**	**6 groups**
			(5 gr. N.T. + 6 gr. T.)		
Groups B	11.48	10.87	9.39	10.32	8.45
	(4.87)	(3.92)	(3.53)	(5.10)	(3.37)
	6 groups		**9 groups**	**5 groups**	**4 groups**
			(5 gr. N.T. + 4 gr. T.)		

Non-parametric tests on the mean contributions at the level of the network are conducted. We start with the circle network. For each type of players, we do not find significant differences in the level of contributions between periods 1-10 and 11-20 (Wilcoxon signed rank test, *p-value* = 1.00 for A players, and *p-value* = 0.313 for B players). Thus, it seems that the nudge does not induce higher contributions from the subjects. However, both before and during nudge implementation, groups of B players significantly contribute more than groups of A players (Mann-Whitney Wilcoxon rank sum test, *p-value* = 0.043 during periods 1-10, and *p-value* = 0.087 during periods 11-20).

Considering the star network, the only significant effect we find is a decrease of the level of contributions for groups of A players following targeted nudge implementation (Wilcoxon signed rank test, *p-value* = 0.063 for A players, and *p-value* = 1.00 for B players). Non targeted nudge implementation has no significant effect by comparison with the baseline for both types of players (Wilcoxon signed rank test, *p-value* = 0.625 for A players, and *p-value* = 1.00 for B players). In the baseline, we do not find any significant difference between groups of A and B players (Mann-Whitney Wilcoxon rank sum test, *p-value* = 0.159). This result is not changed under nudge implementation, since there is no significant differences between groups of A and B players both under targeted and non targeted nudge implementation (Mann-Whitney Wilcoxon rank sum test, *p-value* = 0.241 with the targeted nudge, and *p-value* = 0.209 with the non targeted one).

Finally, we compare the levels of contributions between the circle and star networks. In the baseline, there is no significant difference between structures (Mann-Whitney Wilcoxon rank sulm test, *p-value* = 0.896 for A players, and *p-value* = 0.175 for B players). Turning to periods 11-20, the only significant difference is between the circle and the star with B players under targeted nudge implementation (Mann-Whitney Wilcoxon rank sum test, *p-value* = 0.043). [19]

These observations lead to the following result:

Result 1: (a) Nudge implementation seems to be most suited for circle networks since a decrease of the level of contributions is observed with the targeted nudge in the star network (A players).

(b) Nudge implementation does not lead to an increase of the level of contributions.

Point (a) seems to corroborate the theoretical predictions obtained in Ouvrard and Stenger (2017), namely that our nudge is most adapted to circle networks. However, contrary to their predictions, an increase in the level of contributions is not observed (Point (b)). Notwithstanding, for B players this result is not surprising as we noticed that they contributed at higher levels than A players.

Even if the level of contributions does not vary under nudge implementation, we may observe a change in the profile of contributions. We analyze this possibility in the next subsection.

5.3 Does nudge implementation lead to more coordination?

Following Rosenkranz and Weitzel (2012), we now study local coordination. We start with local coordination on the Nash equilibrium, and then turn to local coordination on the social optimum.

5.3.1 Local coordination on the Nash equilibrium

On the basis of the predictions from the function chosen for the monetary payoffs, a subject is said to be in a local equilibrium if the sum of his/her contribution and of the contributions of his/her direct neighbors is equal to 3, or if he/she does not contribute and the sum of his/her direct neighbors is larger or equal to 3.

The mean number of local coordination around the Nash equilibrium per type of group and per treatment is given in Table 3.

[19] For A players (circle vs star): *p-value* = 0.748 (targeted nudge) and *p-value* = 0.902 (non targeted nudge). For B players: *p-value* = 0.583 (non targeted nudge).

Table 3: Mean number of local coordination on the Nash equilibrium per network and per treatment.

	Circle		Star		
	1-10	11-20	1-10	11-20 (N.T.)	11-20 (T.)
Groups A	0.725	0.875	1.136	1.82	1.40
Groups B	0.767	0.583	1.20	1.36	1.25

In the circle network, we observe two opposite dynamics: A players seem to coordinate their actions on the Nash equilibrium under nudge implementation, and the contrary for B players. However, these are not significant differences (Wilcoxon signed rank test, *p-value* = 0.423 for A players, and *p-value* = 0.361 for B players). Moreover, we do not observe any significant difference between the two types of groups (Mann-Whitney Wilcoxon rank sum test, *p-value* = 0.915 for periods 1-10, and *p-value* = 0.387 for periods 11-20).

Turning to the star network, it seems that nudge implementation increases the number of local equilibria on the Nash equilibrium. However, only the targeted nudge induces a significant increase with A players by comparison with the baseline (Wilcoxon signed rank test, *p-value* = 0.063 with targeted nudge, and *p-value* = 0.125 with non targeted nudge). We do not observe any significant differences with B players (Wilcoxon signed rank test, *p-value* = 0.875 with targeted nudge, and *p-value* = 0.201 with non targeted nudge). Note that both before and during nudge implementation there are no significant differences between groups of A and B players (Mann-Whitney Wilcoxon rank sum test, *p-value* = 0.879 for periods 1-10, *p-value* = 0.593 with targeted nudge, and *p-value* = 0.599 with non targeted nudge).

Finally, we can compare between structures. Surprisingly, there are no significant differences in the number of local coordination on the Nash equilibrium between the circle and the star networks during the baseline (Mann-Whitney Wilcoxon rank sum test, *p-value* = 0.238 for A players, and *p-value* = 0.214 for B players). Similarly, non targeted nudge does not induce significant differences between these two structures (Mann-Whitney Wilcoxon rank sum test, *p-value* = 0.138 for A players, and *p-value* = 0.117 for B players). However, targeted nudge implementation does induce such a significant difference (Mann-Whitney Wilcoxon rank sum test, *p-value* = 0.037 for A players, and *p-value* = 0.087 for B players).

Result 2: The targeted nudge (star network) is the only nudge leading to more coordination on the Nash equilibrium for A players, by comparison with the baseline.

Again, this result seems to corroborate the theoretical predictions obtained in Ouvrard and Stenger (2017). As discussed in Section 7, it seems to indicate that such a nudge is most suited for the circle network. Moreover, this observation is in line with the previous result: the subjects did not increse their level of contributions in the star network because they coordinate more on the Nash equilibrium.

5.3.2 Local coordination on the social optimum

Contrary to Rosenkranz and Weitzel (2012), we also focus on local coordination on the social optimum. In a circle network, individuals are in a local equilibrium on the social optimum if their two direct neighbors and themselves contribute four tokens each. In a star network, such a local coordination is considered if, for individuals in the periphery, they do not contribute while the individual in the center contributes 10 tokens. For the individual in the center, all individuals in the periphery should not contribute while he/she contributes 10 tokens.

The mean number of local coordination on the social optimum per type of group and per treatment is given in Table 4.

Table 4: Mean number of local coordination on the social optimum per network and per treatment.

	Circle		Star		
	1-10	11-20	1-10	11-20 (N.T.)	11-20 (T.)
Groups A	0.000	0.025	0.036	0.060	0.150
Groups B	0.033	0.750	0.022	0.040	0.050

Again, two different dynamics are observed in the circle network: A players do not seem to coordinate much on the social optimum under nudge implementation, while B players do so. For B players, this increase is a significant one (Wilcoxon signed rank test, *p-value* = 0.036, and *p-value* = 1.00 for A players). Moreover, before nudge implementation, A and B players do not significantly differ while they do during periods 11-20 (Mann-Whitney Wilcoxon test, *p-value* = 0.540 for periods 1-10, and *p-value* = 0.017 for periods 11-20).

As expected from the previous analysis, no significant differences are observed in the star network following targeted (Wilcoxon signed rank test, *p-value* = 0.588 for A players, and *p-value* = 1.00 for B players) and non targeted nudge implementations (Wilcoxon signed rank test, *p-value* = 1.00 for A players, and *p-value* = 1.00 for B players). Moreover, the dynamics for A and B players do not differ (Mann-Whitney Wilcoxon test, *p-value* = 1.00 for periods 1-10, *p-value* = 0.180 with targeted nudge, and *p-value* = 1.00 with non targeted nudge).

Finally, the dynamics between structures (circle and star) are also exarcerbated both for A players (Mann-Whitney Wilcoxon test, *p-value* = 0.074 with targeted nudge, and *p-value* = 1.00 with non targeted nudge) and B players (Mann-Whitney Wilcoxon test, *p-value* = 0.023 with targeted nudge, and *p-value* = 0.011 with non targeted nudge). They are not exarcerbated during periods 1 to 10 (Mann-Whitney Wilcoxon test, *p-value* = 0.651 for A players, and *p-value* = 0.842 for B players).

Result 3: In the circle network, nudge implementation leads to more coordination on the social optimum for B players.

Thus, even if we do not observe an increase in the level of contributions for the most sensitive subjects (B players), we cannot reject the hypothesis that their contributions are made in a more efficient way because they coordinate more on the social optimum.

5.4 Individual contributions

Following Rosenkranz et Weitzel (2012), we analyze individual decisions concerning contributions with Tobit regressions, separating them for the circle and the star networks. The results are reported in Table 5.

The explanatory variables are: $Neighbors_{t-1}$, capturing the total level of contributions of an individual's direct neighbors in the previous period; $Period$, to capture the trend in time; $Nb.Neighbors$, for the number of direct neighbors (only for the star network); $T2$ a dummy for the treatment with non targeted nudge.

The following psychological variables are also included: α, corresponding to disadvantageous inequity aversion; β, for advantageous inequity aversion, and $Sensitivity$, a dummy for subjects' environmental sensitivity.[20]

[20]We include the two variables for inequity aversion because we found that they were not significantly correlated.

Finally, socio-economic variables are included in addition to a variable for subjects' *Gender* (not reported here since the corresponding coefficients are not significant): *Age*; a dummy *Background* to capture whether subjects are studying economics; $Conf.friends$ and $Conf.work$ to capture, respectively, subjects' confidence towards their friends and their work colleagues (this last variable is not reported since the corresponding coefficient is never significant); *Activity*, which is a dummy which takes the value 1 is the subject is a member of an association (charitable, sportive, religious, political); and $Influence$ which is a dummy taking the value 1 is the subject is influenced in his/her daily life by the values of the association.

Except for the star network under nudge implementation, subjects' environmental sensitivity is always a positive and significant determinant of their decisions (as emphasized in the previous subsections). In their environmental public goods experiment, Boun My and Ouvrard (2017) obtained a similar result. This may be explained by the fact that subjects have a higher interest in the environment. In the circle network, students' background is also a positive and significant determinant of their contributions (both before and during nudge implementation). Surprisingly, subjects' age is also a positive and significant determinant of their decision to contribute in the circle network during periods 1-10. During periods 11-20, both the period and subjects' confidence towards their friends negatively and significantly explain their level of contribution. Such a negative trend is generally observed in public goods game (Ledyard 1995, Chaudhuri 2011). The negative coefficient associated with the variable capturing subjects' confidence towards their friends is more suprising, and suggests that under nudge implementation subjects may be tempted to contribute less when relying on their partners in the network. Finally, the variables capturing inequity aversion do not explain subjects' decisions in the circle network.

However, in the star network advantageous inequity aversion significantly explain them. An interpretation may be that an individual discovering that he/she contributes less than his/her direct neighbors increase his/her contribution, because he/she does not like inequity. Both during periods 1-10 and periods 11-20, the period also negatively explain decisions. During periods 1-10 in the star network, decisions are positively explained by subjects' confidence towards their friends and by the fact of being part of an association, two variables that may indeed explain cooperation. Finally, in periods 11-20,

Table 5: Tobit estimation of individual contributions.

	Circle		Star	
	(1-10)	(11-20)	(1-10)	(11-20)
Variable	Coeff.	Coeff.	Coeff.	Coeff.
	(S.E)	(S.E)	(S.E)	(S.E)
Neighbors_{t-1}	-0.031	0.001	-0.053	-0.055
	(0.123)	(0.052)	(0.107)	(0.057)
Period	-0.111	-0.140*	-0.158***	-0.208***
	(0.092)	(0.074)	(0.054)	(0.057)
Nb. Neighbors	-	-	0.271	-0.649**
			(0.359)	(0.317)
T2	-	-	-	0.475
				(0.442)
α	-0.476	-0.136	-0.295	-0.198
	(0.122)	(0.229)	(0.229)	(0.192)
β	-0.283	-0.121	1.620*	-0.281
	(0.952)	(0.640)	(0.927)	(0.782)
Sensitivity	1.364**	1.599***	0.849**	0.382
	(0.641)	(0.552)	(0.327)	(0.460)
Age	0.370*	0.194	-0.058	0.109
	(0.192)	(0.143)	(0.157)	(0.155)
Background	1.317**	1.555***	0.307	-1.029**
	(0.506)	(0.573)	(0.359)	(0.473)
Conf. friends	-1.651	-1.504**	0.983**	0.510
	(1.135)	(0.746)	(0.496)	(0.488)
Activity	-0.332	-0.041	1.654***	0.118
	(0.599)	(0.970)	(0.337)	(0.524)
Influence	-0.916	-0.295	-0.772*	-0.664
	(0.776)	(0.654)	(0.430)	(0.613)
Constant	-3.459	-0.242	-0.329	3.954
	(3.867)	(3.747)	(3.388)	(3.373)
Log-likelihood	-412.878	-386.179	-930.769	-924.918
Number of individuals	24	24	54	54
Number of observations	216	216	486	486

Standard errors (in parenthesis) are clustered by groups

Significance level: 1% (***), 5% (**) et 10% (*)

the number of neighbors and subjects' background negatively explain their decision. The intuition may be that under nudge implementation subjects expect their neighbors to contribute more, and in particular students in economics.

Result 4: Inequity aversion is not a determinant of subjects' decision, except advantageous inequity aversion in the star network. Under nudge implementation, inequity aversion is not a determinant of subjects' decisions in both types of networks.

6 Study of the determinants of the emergence of local equilibria on the Nash equilibrium

Contrary to Rosenkranz and Weitzel (2012), we propose to study the determinants favoring the emergence of local equilibria on the Nash equilibrium. Estimating a model in which the lag of the dependent variable is an explanatory variable may lead to an endogeneity bias. We thus estimate a dynamic probit model following Wooldridge (2005). The results are reported in Table 6.

In addition to the explanatory variables used in the previous regressions to explain local coordination on the Nash equilibrium, we also consider the variable *Local eq. 1st period* which is a dummy taking the value 1 if a local equilibrium on the Nash solution is implemented for individual i in the first period (following Wooldridge 2005); and *Local* $eq._{t-1}$, which is the lag of our dependent variable.

There are few similarities between the two types of networks concerning the variables explaining the probability for a subject to coordinate on the Nash equilibrium. On the circle network during periods 1-10, the probability to coordinate on the Nash equilibrium is positively explained by subjects' confidence towards their friends, and negatively by the existence of a Nash equilibrium in the previous period and by subjects' confidence towards work colleagues. This may signal that the nature of the network (friends or work colleagues) is of matter when explaining cooperation. During periods 11-20, the probability to coordinate on the Nash equilibrium is now positively explained by a constant, and negatively by subjects' sensitivity and background. The negative coefficient associated to environmental sensitivity corroborates the results of the non parametric tests concerning coordination on the social optimum in the previous section. Indeed, as emphasized in the previous section, even if for the most sensitive subjects the number of local equilibria on the Nash equilibrium is not reduced, we highlighted that they coordinate significantly more on the social optimum. Concerning subjects' background, we showed in the previous section with the Tobit regressions that students in economics contributed significantly more to the local public good. Our result is this section if thus in adequation to our past observations.

Turning to the star network, both during periods 1-10 and 11-20, the probability to coordinate on the Nash equilibrium is positively affected by the emergence of a Nash equilibrium in the first period of the game, the number of neighbors and the period. Note also that subjects' background positively explains the emergence of a local Nash equilibrium. The results thus suggest that subjects learn over time how to coordinate on the Nash equilibrium, and that the emergence of a local Nash equilibrium in the first period may be a factor explaining a form of inertia on the Nash equilibrium. Finally, having a central position in the network is also a key determinant.

Result 5: Environmental sensitivity explains the probability to coordinate on the Nash equilibirum in the circle network. However, inequity aversion is not a determinant, in both structures.

7 Discussion and conclusion

In this paper, we proposed a laboratory experiment to test the theoretical predictions obtained in Ouvrard and Stenger (2017). We decided to focus on two networks (circle and star), that are not necessarily representative of all the situations we could conceive in reality. However, the results we obtained may still provide the policymakers with some keys regarding nudge implementation.

As in Boun My and Ouvrard (2017), the efficiency of the nudge we proposed differs depending on individuals' sensitivity to environmental matters. Even if we do not observe an increase in the level of contributions (at the level of the network), we still observe more coordination on the socially optimal profile of contributions for the most sensitive individuals. This result seems to go in the same direction than those obtained in Banerjee *et al.* (2014): information provision (on the behaviors of neighbors in Banerjee *et al.* 2014, or on the socially optimal contribution in this paper) is an efficient incentive. However, our result also seems to suggest, as emphasized by Sunstein (2013), that nudge implementation should take into account individuals' heterogeneity or, put differently, that nudge

Table 6: Dynamic probit estimation.

	Circle		Star	
	(1-10)	(11-20)	(1-10)	(11-20)
Variable	Coeff.	Coeff.	Coeff.	Coeff.
	(S.E)	(S.E)	(S.E)	(S.E)
Local eq. 1st period	-0.648	-2.261	1.210***	0.775**
	(1.471)	(3.204)	(0.293)	(0.338)
Local eq.$_{t-1}$	-1.018**	0.331	0.054	0.085
	(0.469)	(0.329)	(0.186)	(0.180)
Decision$_{t-1}$	-0.116	-0.022	0.041	0.021
	(0.093)	(0.084)	(0.039)	(0.037)
Nb. Neighbors	-	-	0.369***	0.600***
			(0.129)	(0.190)
T2	-	-	-	0.101
				(0.256)
Period	0.049	0.020	0.085***	0.093***
	(0.048)	(0.045)	(0.026)	(0.028)
α	0.530	0.573	0.059	0.012
	(0.357)	(0.694)	(0.139)	(0.201)
β	-0.799	-0.008	-0.197	-0.479
	(1.185)	(0.467)	(0.356)	(0.496)
Sensitivity	-0.190	-0.966**	-0.134	-0.236
	(0.721)	(0.391)	(0.197)	(0.274)
Age	-0.058	-0.292**	-0.087	0.024
	(0.210)	(0.116)	(0.078)	(0.104)
Background	-0.522	-1.677***	0.146	0.764**
	(0.819)	(0.459)	(0.218)	(0.321)
Conf. friends	1.835**	0.793	-0.202	-0.020
	(0.883)	(0.467)	(0.269)	(0.370)
Conf. work	-1.383**	-0.216	0.143	0.231
	(0.697)	(0.364)	(0.215)	(0.299)
Constant	0.589	4.374*	0.225	-2.648
	(4.179)	(2.425)	(1.732)	(2.358)
Log-likelihood	-77.579	-78.437	-258.425	-259.014
Number of individuals	24	24	54	54
Number of observations	216	216	486	486

Significance level: 1% (***), 5% (**) et 10% (*)

implementation should target some individuals. Moreover, our results seems to highlight a better suitability of our nudge for circle networks, rather than for star networks.

Our results also suggest that in star networks there is a form of inertia in the emergence of local Nash equilibria, that the nudge cannot control for. Indeed, we found in the previous section that the emergence of a local Nash equilibrium in the first period positively and significantly explain the probability that subjects coordinate on a Nash equilibrium. In the circle network, on the contrary, this probability is negatively and significantly explained by subjects' sensitivity to environmental matters, age and background (under nudge implementation). Thus, this result reinforce the idea that nudge implementation needs to be considered for specific structures.

Finally, we obtain clear policy implications: even if the nudge we considered may be an efficient tool for given structures and individuals, as predicted in Ouvrard and Stenger (2017), it still has some limits that should be considered by policymakers. In particular, the apparent simplicity of the method (provision of a piece of information) may be offset by the necessity to know agents' intrinsic characteristics (such as environmental sensitivity, interest in the public good, etc.) and their network's structure for the nudge to be efficient.

In sum, this paper participates to the knowledge on nudge implementation proposing an experimental test of the predictions obtained in Ouvrard and Stenger (2017). Future research, both theoretical and experimental, may try to investigate how the diffusion of pro-environmental behaviors occurs in networks. In particular, do individuals adopt such behaviors by imitation or because of strategic motivations?

References

[1] Allcott, H., 2011. "Social Norms and Energy Conservation." *Journal of Public Economics*, 95: 1082–1095.

[2] Banerjee, S., T.N. Cason, F.P. de Vries and N. Hanley, 2017. "Transaction costs, communication and spatial coordination in Payment for Ecosystem Services Schemes." *Journal of Environmental Economics and Management*, 83: 68–89.

[3] Banerjee, S., A.M. Kwasnica and J.S. Shortle, 2012. "Agglomeration bonus in small and large local networks: A laboratory examination of spatial coordination." *Ecological Economics*, 84: 142–152.

[4] Banerjee, S., F.P. de Vries, N. Hanley and D.P. van Soest, 2014. "The Impact of Information Provision on Agglomeration Bonus Performance: An Experimental Study on Local Networks." *American Journal of Agricultural Economics*, 96: 1009–1029.

[5] Berninghaus, S.K., K-L. Ehrhart and C. Keser, 2002. "Conventions and Local Interaction Structures: Experimental Evidence." *Games and Economic Behavior*, 39: 177–205.

[6] Blanco, M., D. Engelmann and H.T. Normann, 2011. "A within-subject analysis of other-regarding preferences." *Games and Economic Behavior*, 72: 321–338.

[7] Boun My, K. and B. Ouvrard, 2017. "Nudge and tax in an environmental public goods experiment: does environmental sensitivity matter?" BETA Working Paper 2017-06.

[8] Bramoullé, Y. and R. Kranton, 2007. "Public goods in networks." *Journal of Economic Theory*, 135: 478–494.

[9] Bramoullé, Y., R. Kranton and M. D'Amours, 2014. "Strategic Interaction and Networks." *American Economic Review*, 104: 898–930.

[10] Brekke, K.A., G. Kipperberg and K. Nyborg, 2010. "Social Interaction in Responsability Ascription: The Case of Household Recycling." *Land Economics*, 86: 766–784.

[11] Brekke, K.A., S. Kverndokk and K. Nyborg, 2003. "An economic model of moral motivation." *Journal of Public Economics*, 87: 1967–1983.

[12] Bruvoll, A. and K. Nyborg, 2004. “The Cold Shiver of Not Giving Enough: On the Social Cost of Recycling Campaigns.” *Land Economics*, 80: 539–549.

[13] Cassar, A., 2007. “Coordination and cooperation in local, random and small world networks: Experimental evidence.” *Games and Economic Behavior*, 58: 209–230.

[14] Cavalcanti, C., S. Engel and A. Leibbrandt, 2013. “Social integration, participation, and community resource management.” *Journal of Environmental Economics and Management*, 65: 262–276.

[15] Chaudhuri, A., 2011. ”Sustaining cooperation in laboratory public goods experiments: a selective survey of the literature.” *Experimental Economics*, 14: 47–83.

[16] Choi, S., D. Gale and S. Kariv, 2008. “Sequential equilibrium in monotone games: A theory-based analysis of experimental data.” *Journal of Economic Theory*, 143: 302–330.

[17] Choi, S., D. Gale, S. Kariv and T. Palfrey, 2011. “Network architecture, salience and coordination.” *Games and Economic Behavior*, 73: 76–90.

[18] Corbae, D. and J. Duffy, 2008. “Experiments with network formation.” *Games and Economic Behavior*, 64: 81–120.

[19] Corten, R. and V. Buskens, 2010. “Co-evolution of conventions and networks: An experimental study.” *Social Networks*, 32: 4–15.

[20] Costa, D.L. and M.E. Kahn, 2013. “Energy conservation ”nudges” and environmentalist ideology: evidence from a randomized electricity field experiment.” *Journal of the European Economic Association*, 11: 680–702.

[21] Czajkowski, M., N. Hanley and K. Nyborg, 2017. “Social Norms, Morals and Self-interest as Determinants of Pro-environment Behaviours: The Case of Household Recycling.” *Environmental and Resource Economics*, 66: 647–670.

[22] Davis, J., J.D. Green and A. Reed, 2009. “Interdependence with the environment: Commitment, interconnectedness, and environmental behavior.” *Journal of Environmental Psychology*, 29: 173–180.

[23] Davis, J., B. Le and A.E. Coy, 2011. “Building a model of commitment to the natural environment to predict ecological behavior and willingness to sacrifice.” *Journal of Environmental Psychology*, 31: 257–365.

[24] Egebark, J. and M. Ekström, 2016. “Can indifference make the world greener?” *Journal of Environmental Economics and Management*, 76: 1–13.

[25] Fehr, E. and K.M. Schmidt, 1999. “A theory of fairness, competition and cooperation.” *Quarterly Journal of Economics*, 114: 817–868.

[26] Ferraro, P. and M.K. Price, 2013. “Using Non-Pecuniary Strategies to Influence Behavior: Evidence from a Large Scale Field Experiment.” *The Review of Economics and Statistics*, 95: 64–73.

[27] Figuières, C., D. Masclet and M. Willinger, 2013. “Weak Moral Motivation Leads to the Decline of Voluntary Contributions.” *Journal of Public Economic Theory*, 15: 745–772.

[28] Fischbacher, U., S. Gaächter and E. Fehr, 2001. “Are people conditionally cooperative? Evidence from a Public Goods Experiment.” *Economics Letters*, 71: 397–404.

[29] Goeree, J.K, A. Riedl and A. Ule, 2009. “In search of stars: Network formation among heterogeneous agents” *Games and Economic Behavior*, 67: 445–466.

[30] Keser, C., K-M. Ehrhart and S.K. Berninghaus, 1998. “Coordination and local interaction: experimental evidence” *Economics Letters*, 58: 269–275.

[31] Keser, C. et F. van Winden, 2000. ”Conditional Cooperation and Voluntary Contributions to Public Goods.” *The Scandinavian Journal of Economics*, 102: 23–39.

[32] Kuhfuss, L., R. Préget, S. Thoyer and N. Hanley, 2016. ”Nudging farmers to enroll land into agri-environmental schemes: the role of a collective bonus.” *European Review of Agricultural Economics*, 43: 609–636.

[33] Ledyard, J., 1995. “Public Goods: A Survey of Experimental Research. In J. H. Kagel and A. E. Roth(eds.).” *The Handbook of Experimental Economics*, 111–194, Princeton, NJ: Princeton University Press.

[34] Nyborg, K., 2011. "I don't want to hear about it: Rational ignorance among duty-oriented consumers." *Journal of Economic Behavior and Organization*, 79: 263–274.

[35] Ouvrard, B. and S. Stenger, 2017. "Nudge in networks" Cahier du LEF 2017-02.

[36] Primmer, E., R. Paloniemi, J. Similä and A. Tainio, 2014. "Forest owner perceptions of institutions and voluntary contracting for biodiversity conservation: Not crowding out but staying out." *Ecological Economics*, 103: 1–10.

[37] Rosenkranz, S. and U. Weitzel, 2012. "Network structure and strategic investments: An experimental analysis." *Games and Economic Behavior*, 75: 898–920.

[38] Sunstein, C.R., 2013. "The Storrs Lectures : Behavioral Economics and Paternalism." *Yale Law Journal*, 122: 1826–1899.

[39] Teyssier, S., 2012. "Inequity and risk aversion in sequential public good games." *Public Choice*, 151: 91–119.

[40] Thaler, R. H. and Sunstein C. R., 2009. *Nudge: Improving Decisions about Health, Wealth, and Happiness*. Penguin Books.

[41] Van Huyck, J.B., R.C. Battalio and R.O. Beil, 1990. "Tacit Coordination Games, Strategic Uncertainty, and Coordination Failure." *American Economic Review*, 80: 234–248.

[42] Welsch, H. and J. Kühling, 2009. "Determinants of pro-environmental consumption: The role of reference groups and routine behavior." *Ecological Economics*, 69: 166–176.

[43] Wooldridge, J.M., 2005. "Simple Solutions to the Initial Conditions Problem in Dynamic, Nonlinear Panel Data Models with Unobserved Heterogeneity." *Journal of Applied Econometrics*, 20: 39–54.

[44] Zizzo, D.J., 2010. "Experimenter demand effects in economic experiments." *Experimental Economics*, 13: 75–98.

GEB questionnaire

1) I use energy-efficient bulbs.

2) If I am offered a plastic bag in a store, I take it.

3) I kill insects with a chemical insecticide.

4) I collect and recycle used paper.

5) When I do outdoor sports/activities, I stay within the allowed areas.

6) I wait until I have a full load before doing my laundry.

7) I use a cleaner made especially for bathrooms, rather than an all-purpose cleaner.

8) I wash dirty clothes without prewashing.

9) I reuse my shopping bags.

10) I use rechargeable batteries.

11) In the winter, I keep the heat on so that I do not have to wear a sweater.

12) I buy beverages in cans.

13) I bring empty bottles to a recycling bin.

14) In the winter, I leave the windows open for long periods of time to let in fresh air.

15) For longer journeys (more than 6h), I take an airplane.

16) The heater in my house is shut off late at night.

17) I buy products in refillable packages.

18) In winter, I turn down the heat when I leave my house for more than 4 hours.

19) In nearby areas, I use public transportation, ride a bike, or walk.

20) I buy clothing made from all-natural fabrics (e.g. silk, cotton, wool, or linen).

21) I prefer to shower rather than to take a bath.

22) I ride a bicycle, take public transportation, or walk to work or other.

23) I let water run until it is at the right temperature.

24) I put dead batteries in the garbage.

25) I turn the light off when I leave a room.

26) I leave the water on while brushing my teeth.

27) I turn off my computer when Im not using it.

28) I shower/bathe more than once a day.