Appendix 1. Theoretical Solution

A1. Resource uncertainty

In this section, we propose a formal model of common-pool resources and examine the impact of shocks on harvesting. In each group, n individuals i decide simultaneously how much resources to harvest from the common-pool resource R_t. Individuals are allowed to harvest up to $x_{it} < R_t / n$, where x_i are harvests by individual i. The duration of the game is determined endogenously by collective decisions. In particular, the game ends in case resources become exhausted.

Total harvests X_t is defined as a sum of harvests by n individuals: $X_t = \sum_i x_{it} \leq R_t$. Each period, a shock can diminish a fraction of resources $0 < \theta_t < 1$. A shock z_t is drawn from the uniform distribution $U(\alpha_1\ \alpha_2)$ with some probability, which implies that $\theta_t = z_t / R_t$. We consider only negative shocks, which diminish resources. This is because of the fact that in the presence of positive events, resource conservation is not necessary to prevent group collapse.

Resource dynamics follow the logistic curve:

$$R_{t+1} = (1-\theta)(R_t + \dot{R}_t) - X_t = (1-\theta)(R_t + rR_t(1 - R_t / K)) - X_t, \qquad (1)$$

where $0<r<1$ is the intrinsic growth rate of resources; K is its carrying capacity; and $\dot{R}_t = rR_t(1 - R_t / K)$ captures the natural growth or regeneration of resources. If a group runs out of resources ($R_t<1$), subjects lose all their payoffs accumulated up to the moment of resource exhaustion. This creates a strong incentive to conserve resources. We use the condition ($R_t<1$) instead of ($R_t<0$) to avoid a situation when resources become negative as a result of a shock alone (regardless of harvesting decisions), i.e. in case resources are already close to exhaustion.

The utility of individual i at time t depends on his/her harvests:

$$u_{it} = \ln(x_{it}) \qquad (2).$$

Subjects maximize the cumulative payoffs over time (see Antoniadou et al., 2013):

$$V(R_t) = \max_{x, R_{t+1}} \sum_{t=0}^{\infty} \beta^t \ln(x_{it}), \qquad (3a)$$

$$\text{s.t. } R_{t+1} = (1-\theta_t)(R_t + \dot{R}_t) - X_t, \qquad (3b)$$

given the initial level of resources R_0, where parameter β is the discount rate.

Equation 3a can be written as the Bellman equation with the state variable R_t, and the control variable x_{it}:

$$V(R_t) = u_{it} + p_t(\theta_t, R_t, X_t)\beta E[V(R_{t+1})], \qquad (4)$$

s.t. $R_{t+1} = (1-\theta_t)(R_t + \dot{R}_t) - X_t$,

where $p_t(\theta_t, R_t, X_t)$ is the probability that the game will continue to the next period (resources will not fall below 1).

The first order condition with respect to R_{t+1} gives:

$$-u_{it}'(x_{it}) + \beta p_t E[\frac{\partial V(R_{t+1}, \theta_{t+1})}{\partial R_{t+1}}] = 0 . \tag{5}$$

By Envelope Theorem differentiating $V(R_{t+1}, \theta_{t+1})$ with respect to R_t gives:

$$V'(R_t) = u_{it}'(x_{it})(1-\theta)\frac{\partial(R_t + \dot{R}_t)}{\partial R_t} . \tag{6}$$

We take one step forward for (6) and apply it into (5), to derive:

$$u_{it}'(x_{it}) = (1-\theta)\beta p_t E[u_{it+1}'(x_{it+1})\frac{\partial(R_{t+1} + \dot{R}_{t+1})}{\partial R_{t+1}}] , \tag{7}$$

which leads to:

$$1/x_{it} = \beta(1-\theta)p_t(1 + r - 2r\frac{R_{t+1}}{K})(1/x_{it+1}) . \tag{8}$$

Using equations 1 and 8, the model can be reduced to the system of equations :

$$X_{t+1} = X_t \beta(1-\theta)p_t(1 + r - 2r\frac{R_{t+1}}{K}) , \tag{9a}$$

$$R_{t+1} = (1-\theta)(R_t + rR_t(1 - R_t/K)) - X_t . \tag{9b}$$

The equilibrium of the above system can be derived, using conditions $R_{t+1} = R_t$, $X_{t+1} = X_t$, and assuming that p_t=p, as:

$$X^* = \frac{K(-1 + 2\beta p - \beta^2 p^2(1+r)(1-\theta)(1 - r(1-\theta) + \theta)}{4\beta^2(1-\theta)p^2 r} ,$$

$$R^* = \frac{K(\beta p(1-\theta)(1+r) - 1)}{2\beta(1-\theta)pr} . \tag{10}$$

In two other solutions, subjects harvest nothing in the equilibrium $(X^* = 0)$. Solution (10) implies that the share of resources harvested in the equilibrium:

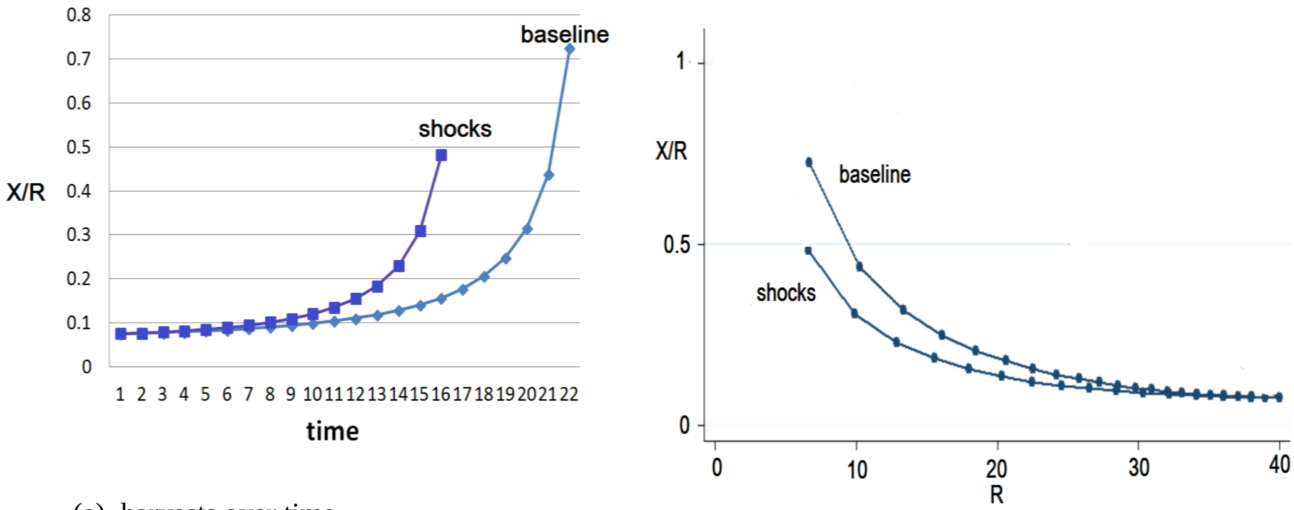
$$X^*/R^*_{shocks} = \frac{1 - \beta p(1 - r + r\theta + \theta)}{2\beta p} . \tag{11}$$

Increasing θ decreases the fraction of harvested resources in (11). Thus, we expect that shocks promote resource conservation in the equilibrium:

$$(X^*/R^*)_{baseline} = \frac{1-\beta p(1-r)}{2\beta p} > (X^*/R^*)_{shocks} = \frac{1-\beta p(1-r+r\theta+\theta)}{2\beta p}. \quad (12)$$

In the absence of shocks, we expect subjects to harvest the fraction of resources $(X^*/R^*)_{baseline} = \frac{1-\beta p(1-r)}{2\beta p} = \frac{1-0.99(1-0.1)}{2*0.99} = 0.055$, assuming p=1 and β=0.99. This is more than the social optimum, which requires that resources remain at their half capacity *K/2*, while group members consume the renewal rate of resource ($X^*_t = rK/4$). This in turn implies the socially optimal fraction of harvested resources is equal to (2/3)/40=0.02<0.055. If resources are below the maximum sustainable growth (for instance because of shocks), it would be beneficial for individuals to reduce their harvests so as to give the resource time to renew itself and reach the optimal level.

The impact of shocks in the equilibrium on model dynamics can differ from their impact outside the equilibrium. Figure A1.1 illustrates dynamics of the dynamical system described in (9), using parameter values as in the experiment. In the figure, we compare model predictions in the baseline and shock scenarios. We assume that initial harvests are equal to 3 in the numerical analysis. Increasing this value fosters resource depletion. Figure A1.1(a) illustrates that groups are expected to harvest a larger fraction of resources, the more severe the shocks are. However, this result is driven by the fact that resources are diminished by shocks under resource uncertainty. In fact, from equation 9(a) it follows that larger θ implies that subjects harvests less resources for the same size of the resource. This is supported by Figure A1.1(b), which depicts the fraction of harvested resources over time for different values of the resource.



(a) harvests over time

Figure A1.1 The fraction of resources harvested over time. Parameter values used in the figure: K=80, r=0.1, R_0=45, β=0.99 correspond to parameters used in the experiment. We assume shocks to be equal to the expected value of shocks in the experiment: z_t=1 in the shock treatment; and z_t=0 in the baseline.

A2.Intergroup sharing

In the sharing treatment, after harvesting decisions, subjects can decide whether to send some of their harvests to augment resources of the partner group. Let's assume that subjects share a fraction of their harvests in anticipation that members of the partner group would do the same. In the presence of intergroup sharing, the utility of individual *i* equals:

$$u_{it} = \ln(x_{it}(1-c)), \qquad (13).$$

where *c* is the fraction of his/her harvest shared with the outgroup members.

Subjects maximize the cumulative payoffs over time:

$$V(R_t) = \max_{x,R_{t+1}} \sum_{t=0}^{\infty} \beta^t \ln(x_{it}(1-c)), \qquad (14)$$

$$\text{s.t. } R_{t+1} = R_t + \dot{R}_{jt} - X_t + cY_t, \qquad (15)$$

where Y_t is the total harvest in the partner group.

The system can be described by equations (derived analogously to equations 9a and b):

$$(1-c)X_{t+1} = (1-c)X_t \beta p_t (1 + r - 2r\frac{R_{t+1}}{K}),$$

$$R_{t+1} = R_t + rR_t(1 - R_t / K) - X_t + cY_t. \qquad (16)$$

A3. Collective versus individual donations to the outgroup

We compare the frequency of individual versus collective contributions to the outgroup. By individual contributions we refer to the situation where only one participant shared her harvests with the outgroup at time *t*. In turn, collective contributions describe the situation, when more than one individual donated resources. Figure A1.2 compares the frequency of collective contributions and the total number of periods, during which at least one subject donated harvests to the outgroup. The figure illustrates that the more often groups share resources, the higher the percentage of collective contributions is.

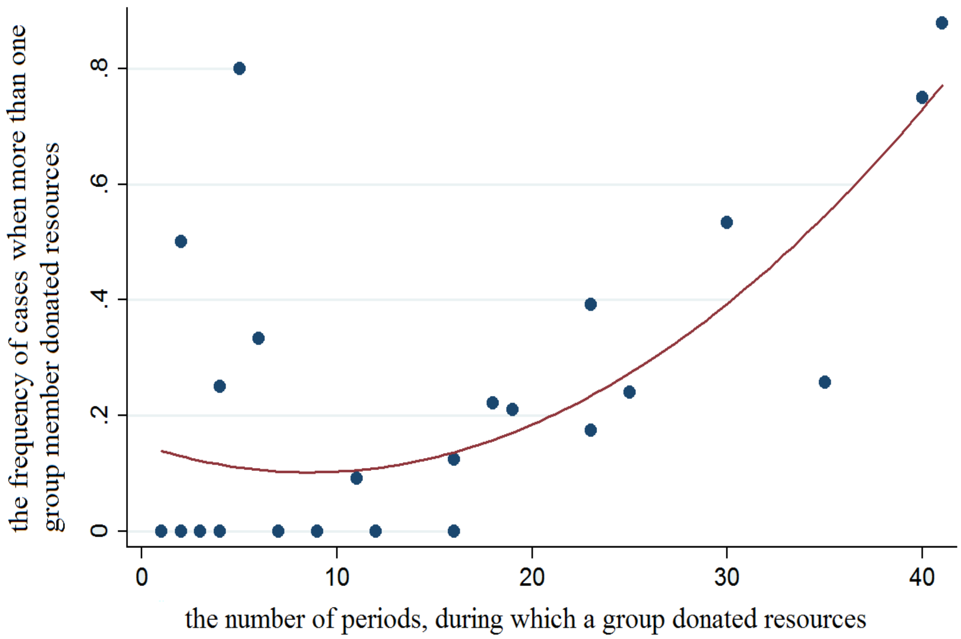
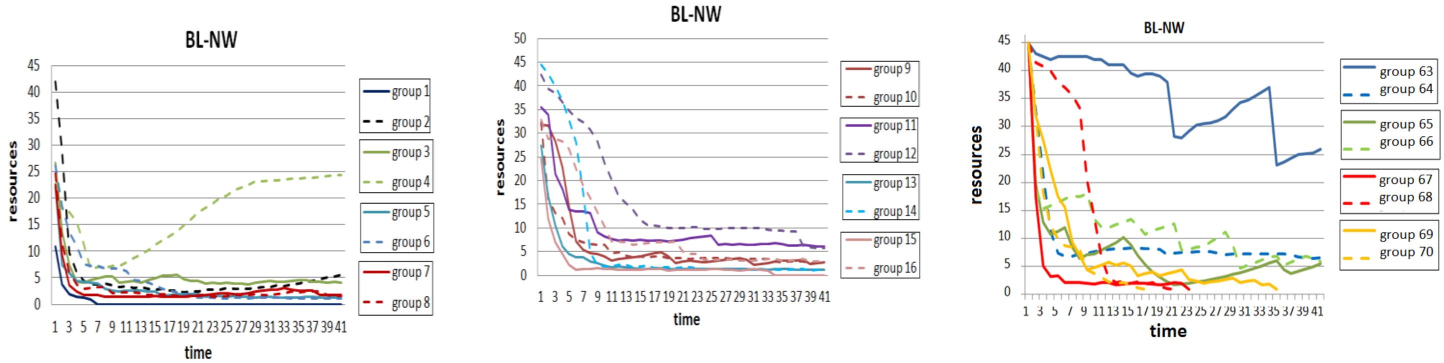
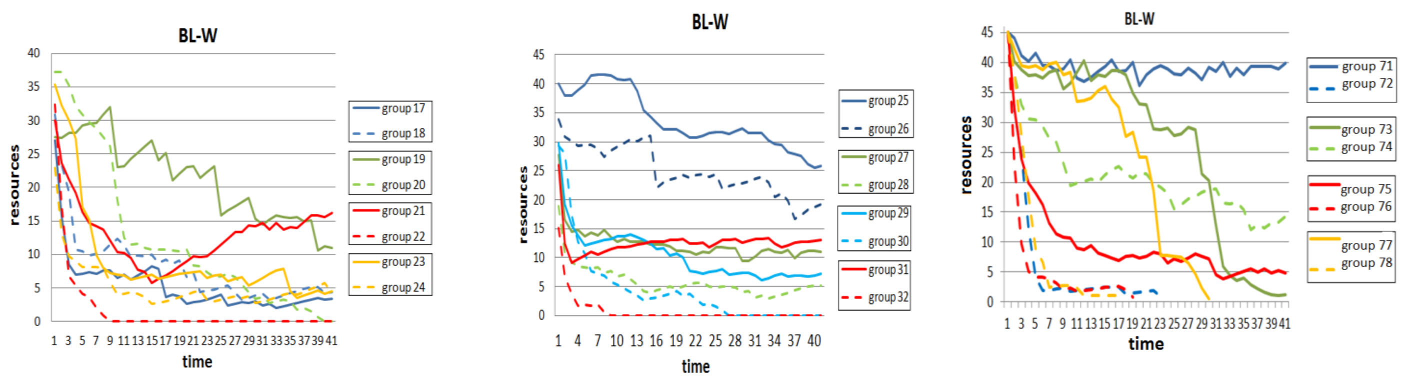


Figure A1.2 The frequency of intergroup sharing versus collective donations.

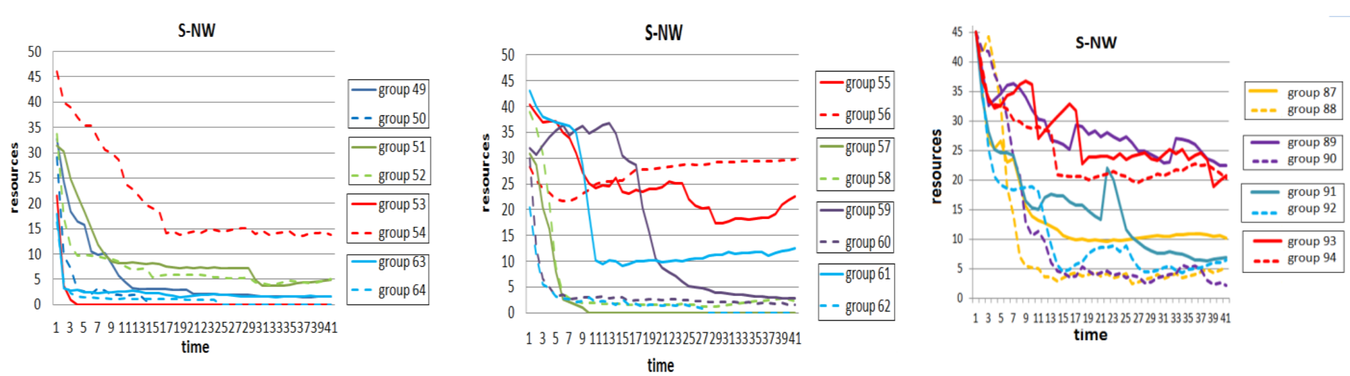
Appendix B



(a) The baseline treatment



(b) The shock treatment



(c) The sharing treatment

Figure B1.1 Availability of resources at a given period. Boxes indicate interacting groups, i.e. partners. To increase visibility we depict 4 partner groups per figure. Figures on the right show results from the sample of subjects from the University of Vienna.

Appendix B. Instructions

All

Welcome

You are now taking part in a decision-making experiment. Depending on your decisions and decisions made by others, you may be able to earn a substantial amount of money.

The experiment consists of three parts. In the first part, we will ask you to answer questions which will appear on your screen. Once everybody has answered them, we will distribute a set of instructions. Afterwards, the second part of the experiment will start, during which you can learn dynamics of the game. The third part - of the actual experiment - will follow afterwards with some additional elements. This part will last much longer than the second part. We will distribute instructions for this part prior to its beginning.

All

Part 2

During this part of the experiment, you will have a chance to learn dynamics of the game. You will be matched with 2 other participants to collect tokens from the common pool of tokens. Your group starts with the common pool of 45 tokens.

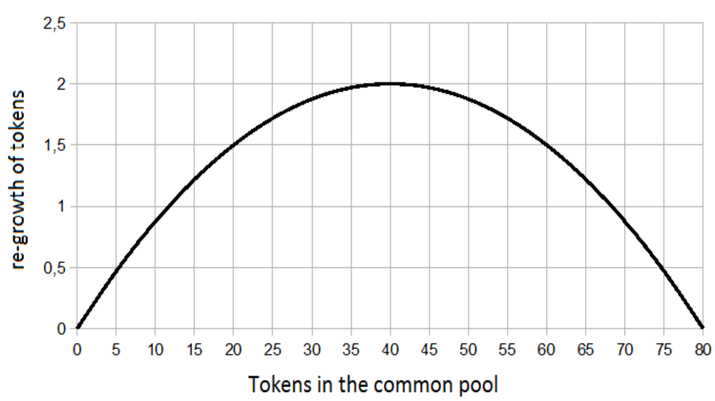
You will not know who is who in your group during or after the experiment. Every member of your group, including you, will decide simultaneously on the number of tokens to collect. The number of tokens collected by each person cannot exceed 33% of all tokens available to the group. You will be informed about how many tokens were collected by others in your group. The decisions of group members will be displayed in a random order every period - it will not be possible to determine who collected how many tokens.

The total number of tokens collected by the group will be subtracted from the common pool of tokens. Then, depending on the number of tokens left in the common pool, there will be a re-growth in the number of tokens (RG), according to:

$$RG=0.1*TC*(1-TC/80),$$

where TC is the number of tokens in the pool, and 80 is the maximum carrying capacity of the pool of tokens, i.e. beyond which the number of tokens will not increase further.

The graph below illustrates an increase in the number of tokens (RG) in the common pool, depending on the number of tokens in the common pool (TC):



For instance, if the number of tokens in the common pool is 40, then the expected re-growth of tokens is 2, and there will be 42 tokens available to your group in the next period.

You will be asked to collect tokens for some periods. However, this part of the experiment may also end if the number of tokens in the common pool of tokens goes below 1 [one]. In this case, everyone is your group looses all their tokens.

Your Earnings:

The aim of this part of the experiment is to give you the opportunity to learn dynamics of the game. You will not earn money.

Timing:

There is another important note. You will have a limited but a sufficient amount of time (some seconds) to decide how many tokens to collect. If you exceed this time, the decision will be taken for you.

Before starting:

In order to check if you understand these instructions, please answer questions which will appear on your screen.

The baseline treatment

Part 3

In this part of the experiment, you will be asked to collect tokens for many periods - just as you did before. You will be randomly matched with 2 new participants, thus you will interact with different players than in part 2 of the experiment.

Your Earnings:

Your earnings will be equal to the number of tokens, which you collected. Each token is worth 0.5[1]Euro.

There is, nevertheless, an exception: if the number of tokens in the common pool goes below 1 [one], everyone in your group will lose all their tokens. In this case, your earnings will be zero in this part of the experiment.

[1]During the experiment conducted at the University of Warsaw, each token was worth 1.5 złotych.

The shock treatment

Part 3

In this part of the experiment, you will be asked to collect tokens for many periods - just as you did before. You will be randomly matched with 2 new participants, thus you will interact with different players than in part 2 of the experiment. In addition, there is the possibility of a random event occurring, which can be thought of as a shock destroying tokens in the common pool.

The random event:

In this part of the experiment, there is 33% of chances that your group will lose between 0.5 and 1.5 tokens due to a random event.

Your Earnings:

Your earnings will be equal to the number of tokens, which you collected. Each token is worth 0.5 Euro.

There is, nevertheless, an exception: if the number of tokens in the common pool goes below 1 [one], everyone in your group will lose all their tokens. In this case, your earnings will be zero in this part of the experiment.

The sharing treatment

Part 3

During this (last) part of the experiment, you will be asked to collect tokens for many periods - just as you did before. You will be randomly matched with 2 new participants, thus you will interact with different players than in part 2 of the experiment.

In this part of the experiment, your group will be matched with another group in the room. We will refer to this group as a “partner group”. During the experiment, you can observe choices made by others in your group and also choices made by others in the partner group. Members of the partner group will collect tokens from their own common pool of tokens.

After collecting decisions take place, you can decide whether you want your group to share some tokens from your total tokens (tokens which you collected up to this time) with the partner group.

Sharing

After everyone has decided how many tokens to collect, you will be asked to indicate how many tokens you would like to share with the partner group.

Precisely, you will be asked to indicate how many tokens from your total tokens you would like to send to the partner group. If you do not wish to share tokens write 0. The amount of tokens taken from you will be added to the pool of tokens of the partner group. These tokens will be subtracted from your total tokens.

Members of the partner group will be also asked whether they would like to share some of their tokens with your group.

Your Earnings:

Your earnings will be equal to the number of tokens, which you collected. Each token is worth 0.5 Euro.
There is, nevertheless, an exception: if the number of tokens in the common pool goes below 1 [one], everyone in your group will lose all their tokens. In this case, your earnings will be zero in this part of the experiment.

If the number of tokens in the common pool of the partner groups goes below 1 [one], members of this group will lose all their tokens. They will not participate in the experiment any longer. Afterwards, there will be no voting decisions in your group.

Sharing + Shocks

Part 3

During this (last) part of the experiment, you will be asked to collect tokens for many periods - just as you did before. You will be randomly matched with 2 new participants, thus you will interact with different players than in part 2 of the experiment.

In this part of the experiment, your group will be matched with another group in the room. We will refer to this group as a "partner group". During the experiment, you can observe choices made by others in your group and also choices made by others in the partner group. Members of the partner group will collect tokens from their own common pool of tokens.

Every period after collecting decisions take place, you can decide whether you want to share some tokens from your total tokens (i.e. tokens which you collected up to the time of sharing decision) with the partner group.

In addition, after collecting and sharing decisions, there is also the possibility of a random event occurring, which can be thought of as a shock destroying tokens in the common pool.

Sharing

After everyone has decided how many tokens to collect, you will be asked to indicate how many tokens you would like to share with the partner group.

Precisely, you will be asked to indicate how many tokens from your total collected tokens you would like to send to the partner group. If you do not wish to share tokens write 0. The amount of tokens taken from you will be added to the pool of tokens of the partner group. These tokens will be subtracted from your total collected tokens.

Members of the partner group will be also asked whether they would like to share some of their tokens with your group.

The random event:

In this part of the experiment, there are 33% of chances that your group will lose between 0.5 and 1.5 tokens due to a random event. The partner group faces the same probability of a random event occurring.

Your Earnings:

Your earnings will be equal to the number of tokens which you collected minus the tokens you shared with the other group. Each token is worth 0,5 Euro.

There is, nevertheless, an exception: if the number of tokens in the common pool goes below 1 [one], everyone in your group will lose all their tokens. In this case, your earnings will be zero in this part of the experiment.

If the number of tokens in the common pool of the partner groups goes below 1 [one], members of this group will lose all their tokens. They will not participate in the experiment any longer. Afterwards, there will be no voting decisions in your group.

Appendix C. Measurements of other-regarding preferences, IQ and risk aversion

PRE-EXPERIMENT QUESTIONS

DICTATOR GAME

You are matched with a person in this room. You have 1 Euro.

How many cents would you like to share with this person?

TRUST GAME

You are matched with another (different) person. You have 1 Euro. How many cents would you like to send him/her? For every cent you send, the person will receive a double value of this amount. He or She will be asked to send you some money back (as he or she wishes), keeping the rest for himself.

TRUSTWORTHINESS

A person (different from the preview two) in this room sends you x cents. You can send back between 0 and x cents. How many cents would you like to send back?

RISK-LOVING

You have 1 Euro. You have the possibility of investing some cents in a project. The project has 40% of probabilities of being successful. If the project is successful, you will receive the invested amount multiplied by 3. You will also keep cents which you have invested. If the project fails, you only keep cents, which you have not invested. How many cents would you like to invest in the project?

COGNITIVE SKILLS (IQ)

You have 20 seconds to respond to the following questions. For each correct answer you earn 25 cents.

a) Which number comes next?

3, 5, 8, 13, 21, …

b) Which number is missing?

1	4	3
5	9	4
4	5	…

c) Which number comes next?

4, 54, 654, …

b) Which number is missing?

17	8	5	4
13	7	5	4
10	6	4	...

POST-EXPERIMENT QUESTIONNAIRE

1. Are you: (Male /Female)
2. Nationality
3. Are you a undergraduate student or a master student
4. In you are an undergraduate student, in which year of study are you currently? (1, 2, 3, 4, 5)
5. Which is your major: (Economics / Business, Management / A Social Science / Natural Science, Mathematics, etc, / Art, Language, Humanities / Others)
6. How would you describe the income of your parents from 1 to 7 where 1 = low and 7 = high
7. How much money do you spend every month (apartment, food, clothes...)?
8. How would you describe your political preferences from 1 to 7 where 1 = very right-wing and 7 = very left-wing?
9. Before the experiment, how long did you expect that the experiment would last?

Additional questions: Only after treatments with sharing:

How much do you agree with the following statements?

10. Before the experiment, I expected that the partner group would share some resources with us in case we had few tokens in our pool because of my group collecting too many tokens: 0 completely disagree – 4 completely agree
11. Before the experiment, I expected that the partner group would share some resources with us in case shocks destroyed tokens in our pool: 0 completely disagree – 4 completely agree