**Democracy and cooperation in commons management: experimental evidence of representative and direct democracy from community forests in Ethiopia[[1]](#footnote-1)\***

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# **ONLINE APPENDIX**

This appendix includes theoretical predictions (Appendices A and B), further data analysis (Appendix C) and the experimental protocol (Appendix D).

**Appendix A**

**Selfish equilibrium**

Assuming individuals to be selfish and myopic, the individual gain from their harvest level can be written as:

 (A1)

where is the price per tree harvested, is round specific harvest level and is the payoff of individual in period .

Since individuals are assumed to be rational and myopic, they contribute zero to the group gain and expect others to do the same as the objective is to maximize their short term gain. Consequently, in an open access scenario, purely self-interested individuals would maximize their gain at the point where they use their full capacity. Therefore, the payoff function in equation (A1) monotonically increases with and reaches its maximum at the point where individual harvest equals the maximum capacity limit .

Mathematically, purely myopic individuals maximize their round level gain as:

Maximize

subject to

So, the Lagrangian function is given as:

 . (A2)

This function reaches its maximum when the following first-order conditions are satisfied:

 (A3)

 (A4)

This means individuals would maximize own gain by harvesting the maximum allowed in all rounds. Thus, the myopic equilibrium would be

This implies that purely self-interested individuals maximize their payoff by harvesting the maximum in all rounds. Assuming that individuals are identical (and have the same incentive and preferences), at individual gain maximization equilibrium, the group gain would be reached at:

 (A5)

 .

Therefore, at purely selfish equilibrium, the group harvest would be:

 .

**Appendix B**

**Social optimum**

To drive the social optimum, we need to construct group payoff function,[[2]](#footnote-2) which would be given as:

 , (A6)

where is the group gain obtained at the end of the game and is the amount of trees that remain at the end of the game; i.e. in round .

To drive the formula for the end stock , we use forward induction method as follows:

Let the initial stock be and be the group total harvest at round Then the forest stock at the end of round 1 would be:

where is the group total harvest in round 1.

For the second round, the stock that remained at the end of the first round has to re-grow by the rate of ; which is given as:

 .

Therefore, the stock at the end of round 2 would be:

 .

Similarly, the stock that remains at the end of round 3 would be:

 .

Following similar pattern, the stock remaining at the end of round 4 would be:

 .

Similarly, the stock at the end of the game would be:[[3]](#footnote-3)

 (A7)

where is the re-growth rate at which the forest at the end of a certain round () grows for the next round () and is the initial stock of trees with which the groups start playing the game.

Then, substituting equation (A7) in place of in equation (A6), we get:[[4]](#footnote-4)

 (A8)

It’s noteworthy that equation (A8) represents the situation of a standard CPR extraction problem where the round level harvest effort has two contradicting effects on the cumulative group gain. On the one hand, it increases the group gain through an increase in round level gain. On the other hand, it reduces the group gain through reduction in the end stock. The latter part represents the negative externality that arises from round level harvest effort.

Note also that at each round the resource growth is limited by the holding capacity constraint of the common plot. To emulate this, our experiment is designed in such a way that round level stock cannot grow more than the initial stock; i.e. the initial stock is the maximum that the common plot holds. To compute the capacity constraint of the common plot in round *t*, we proceed as follows.

Let the initial endowment of the group be . Then, the amount of trees at the beginning of the first round is given as:

Round 1: (A9)

The stock at the beginning of the second round is:

Round 2:

⇒ (A10)

Round 3:

 ⇒

Substituting equation (A10) in place of , we get

 ⇒

⇒ (A11)

Round 4:

 ⇒

 ⇒

Substituting in place of

 ⇒

 ⇒ (A12)

Following the same procedure, we obtain the beginning stock (A) in round as:

Round t: (A13)

From equation (A9) we know that

Hence, equation (A13) can be written as:

 (A14)

where j=1,2,3,…., 9.

In summary, the group gain in equation (A8) would be maximized subject to:

* The group capacity constraint given as
* The holding capacity constraint of the common plot

To compute the cooperative maximum, we need to form a Lagrangian function given as:

 (A15)

where are Lagrangian multipliers that respectively define the amount by which the maximum value of the group gain changes if the group harvest capacity constraint and the common plot holding capacity constraint are relaxed by 1 unit each.

Note that according to our experimental set up, the parameters used were

 .

Consequently, by maximizing equation 20, we get . Then, assuming identical individuals as we did earlier, we get the individual harvest level that coincides with the social optimum as:

 where in our case.

In the second game, the selfish and social optimum may change only in the case of groups that played the second game with sanction depending of the strength of the sanction. In all other treatments, the two optimums remain the same. Individual payoff for groups with sanctioning rule can be given as:

, where is the amount of punishment per tree harvested above the amount required for social optimum (i.e., 2 trees).

**Appendix C**

Table C1*. The number of groups by treatments in the second game*

|  |  |
| --- | --- |
|  | Leader |
| Yes | No |
| Election | Yes | Representative democracy (5 groups, 4 chose sanction) | Direct democracy (4 groups, 3 chose sanction) |
| No | Appointed leader (3 groups, 3 chose sanction) | Imposed rule (5 groups, 3 imposed sanction) |

Table C2. *Comparison of resource stocks over rounds under selfish and social optimum predictions. Results are obtained by maximizing the individual and group payoff functions*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Round | Selfish equilibrium prediction | As % of the initial stock | Social optimum prediction | As % of the initial stock |
| 1 | 101 | 100 | 101 | 100 |
| 2 | 56 | 55.44 | 100 | 99 |
| 3 | 6 | 5.94 | 99 | 98 |
| 4 | 1 | 0.9 | 98 | 97 |
| 5 | - | - | 97 | 96 |
| 6 | - | - | 96 | 95 |
| 7 | - | - | 94 | 93 |
| 8 | - | - | 92 | 92 |
| 9 | - | - | 91 | 90 |
| 10 | - | - | 89 | 88 |

Table C3. *One-way ANOVA result of the basic characteristics of the participants by treatment*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Elected Leadership | Imposed Leadership | Elected rule | Imposed rule | F-test  |
| Household size | 5.64 | 5.93 | 6.65 | 6.72 | 1.29 (0.28) |
| Age (in years) | 43.56 | 49.2 | 47.25 | 43.28 | 1.25 (0.3) |
| Gender (1=male) | 0.88 | 0.87 | 0.81 | 0.92 | 0.93 (0.43) |
| Education (years completed) | 3.44 | 2.8 | 3.7 | 3.2 | 0.12 (0.89) |
| Livestock (Tropical livestock unit) | 5.32 | 4.07 | 4.09 | 4.6 | 1.32 (0.11) |
| Trust | 0.56 | 0.53 | 0.7 | 0.6 | 1.84 (0.16) |
| Illegal harvest  | 0.56 | 0.53 | 0.68 | 0.56 | 0.33 (0.72) |
| Forest dependence | 0.37 | 0.44 | 0.44 | 0.4 | 1.49 (0.23) |

 *\*Values in parentheses are p-values.*

Most of the participants reported trusting the other members of their forest user groups. Almost 60% of the participants replied “yes” to the direct question of whether they trust the other members of their forest user groups. About 39% of the members have complained that there is still illegal harvesting from the block of their community forest. None of these variables vary significantly across the treatment groups in our experiment, which was mainly assured by the random assignment of participants to the treatments.

Table C4. *Comparison of gains under selfish and social optimum predictions*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Equilibrium solution | Individual gain (in ETB) | End stock | Group gain (in ETB) | Efficiency level (a) |
| Selfish  | 10.2 |  1 | 51 |  56.5% |
| Social optimum |  18 | 89 | 90 | 100% |

Notes (a): Efficiencies achieved by groups are obtained by dividing the actual amount they have earned by the amount they could have earned had they been as cooperative as predicted under social optimum.

Table C5. *Average absolute harvest level of groups and their round beginning stock*

 *by treatments in game 2*

|  |  |  |  |
| --- | --- | --- | --- |
| Round | Elected leadership | Imposed leadership | No leadership |
|  | Absolute Harvest level | Round beginning stock | Absolute Harvest level | Round beginning stock | Absolute Harvest level | Round beginning stock |
| 1 | 4.48 | 101 | 4.47 | 101 | 4.32 | 101 |
| 2 | 5.24 | 86.9 | 5.47 | 86.53 | 3.72 | 87.34 |
| 3 | 3.72 | 68.53 | 4.13 | 65.12 | 3.6 | 76.61 |
| 4 | 2.96 | 55.14 | 3.33 | 48.9 | 3.16 | 63.38 |
| 5 | 2.55 | 42.62 | 2.27 | 35.46 | 2.6 | 52.33 |
| 6 | 1.92 | 33.9 | 1.73 | 26.53 | 2.08 | 43.27 |
| 7 | 1.71 | 25.85 | 1.4 | 18.92 | 1.69 | 36.15 |
| 8 | 1.44 | 19.63 | 2.1 | 18.27 | 1.84 | 30.53 |
| 9 | 1.17 | 14.83 | 1.4 | 13.37 | 1.64 | 23.46 |
| 10 | 0.9 | 10.26 | 0.8 | 7.03 | 1.95 | 20.38 |
|  |  |  |  |  |  |  |
| 11 | 2.56 | 101 | 5.2 | 101 | 5.2 | 101 |
| 12 | 2.16 | 96.98 | 5.87 | 82.5 | 4.16 | 82.5 |
| 13 | 2.64 | 94.1 | 4.93 | 58.48 | 3.96 | 67.87 |
| 14 | 2.76 | 88.73 | 3.6 | 37.2 | 3.12 | 52.88 |
| 15 | 2.34 | 83.48 | 2.33 | 21.12 | 3.24 | 41.00 |
| 16 | 1.92 | 78.15 | 1.07 | 10.4 | 2.2 | 27.07 |
| 17 | 2.22 | 76.92 | 0.8 | 6.38 | 1.24 | 17.67 |
| 18 | 1.9 | 72.26 | - | - | 1.2 | 14.79 |
| 19 | 1.75 | 65.1 | - | - | 1.2 | 16.22 |
| 20 | 1.9 | 61.33 | - | - | 2 | 18.07 |

Table C6. *Random effect Tobit regression: the effect of democracy on HR*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Model 1 | Model 2 | Model 3 | Model 4 |
|  | Between-subjects effect of democracy (Game II) | Between-subjects effect of amount of sanction(Game II for sessions with sanction) | Between-subjects effect of agreeing with rule or leader(Game II for sessions with election) | Within-subjects effect of democracy(Game I&II) |
| Representative democracya | -0.345\*\*\* | -0.418\*\*\* | -0.0989 | -0.229\*\*\* |
|  | (-6.25) | (-6.29) | (-1.46) | (-5.16) |
| Direct democracy | -0.259\*\*\* | -0.350\*\*\* | n.a | -0.234\*\*\* |
|  | (-4.36) | (-4.12) |  | (-5.08) |
| Imposed leadership  | -0.0611 | -0.195\*\* | n.a | 0.0988\* |
|  | (-0.79) | (-2.09) |  | (1.93) |
| Imposed ruleb | n.a | n.a | n.a | 0.110\*\* |
|  |  |  |  | (2.53) |
| Agree (1=agreed, 0=otherwise) | n.a | n.a | -0.108\* | n.a |
|  |  |  | (-1.73) |  |
| Number votes | n.a | n.a | 0.0408 | n.a |
|  |  |  | (0.67) |  |
| Sanction (1=sanction, 0=no sanction) | 0.0952 |  | 0.0425 | 0.0128 |
|  | (1.46) |  | (0.40) | (0.31) |
| Amount of sanction (t-1) | n.a | -0.00990 |  | n.a |
|  |  | (-1.57) |  |  |
| Round | n.a |  |  | 0.00415 |
|  |  |  |  | (1.21) |
| First Round HR (Game 1) | -0.0449 | -0.155 | -0.0339 | 0.275\*\*\* |
|  | (-0.51) | (-1.49) | (-0.34) | (4.48) |
| Average HR (Game 1)  | 0.401\*\* | 0.530\*\*\* | 0.606\*\*\* |  |
|  | (2.57) | (2.93) | (4.03) |  |
| Collapse (1=Collapsed before10th round) | 0.175\*\* | 0.313\*\*\* | 0.283\*\*\* |  |
|  | (2.76) | (3.74) | (2.99) |  |
| End of game (1=last round, 0=otherwise) | 0.101\*\* | 0.0532 | 0.0636 | 0.174\*\*\* |
|  | (2.31) | (0.92) | (1.73) | (4.64) |
| Trust (1=yes, 0=no) | 0.0663 | 0.0969\* | 0.00909 | -0.0370 |
|  | (1.37) | (1.82) | (0.16) | (-0.97) |
| Illegal harvest (1=no, 0=yes) | -0.0846 | -0.0725 | -0.0203 | -0.0569 |
|  | (-1.84) | (-1.22) | (-0.34) | (-1.54) |
| Forest dependence (% of annual income) | -0.0504 | 0.0271 | -0.101 | 0.0658 |
|  | (-0.37) | (0.16) | (-0.63) | (0.59) |
| Gender (1=male; 0=female) | 0.0559 | 0.129\* | 0.00142 | 0.0376 |
|  | (0.92) | (1.87) | (0.02) | (0.73) |
| Age (years) | -0.00244 | -0.00163 | -0.00190 | 0.000962 |
|  | (-1.34) | (-0.79) | (-0.95) | (0.64) |
| Livestock (TLU) | -0.000703 | 0.00206 | -0.00620 | -0.00913 |
|  | (-0.09) | (0.16) | (-0.68) | (-1.44) |
| Education level (years completed) | 0.00541 | 0.00695 | 0.00368 | 0.00784\* |
|  | (1.00) | (1.15) | (0.49) | (1.75) |
| Constant | 0.355\*\* | 0.331\*\* | 0.0295 | 0.207\* |
|  | (2.56) | (2.20) | (0.07) | (1.80) |
| Session fixed effect | n.a | n.a | n.a | Yes |
| Round fixed effect | Yes | Yes | Yes | n.a |
| Left censored observations | 108 | 87 | 85 | 223 |
| Uncensored observation | 585 | 395 | 350 | 1195 |
| Right censored observation | 59 | 51 | 7 | 136 |
| *N* | 752 | 533 | 442 | 1554 |

z statistics in parentheses; \* *p* < 0.05, \*\* *p* < 0.01, \*\*\* *p* < 0.001; a For model 3 “Representative democracy” is a dummy that assumes 1 for groups with representative democracy and 0 for direct democracy. bThis is a reference category for Models 1&2, but inModel 4 it assumes 1 for sessions with imposed rule and if the game is 2 and it assumes 0 otherwise.

Table C7. *Random effects Tobit regression results without socio-demographic variables*

|  |  |  |
| --- | --- | --- |
|  | Model (1) | Model (2) |
|  |  |  |
|  | Between-subjects effect of leadership | Within-subjects effect of leadership |
|  |  |  |
| Representative democracy | -0.298\*\*\* | -0.231\*\*\* |
|  | (-5.31) | (-5.20) |
| Direct democracy | -0.322\*\*\* | -0.238\*\*\* |
|  | (-5.43) | (-5.17) |
| Imposed leadership | 0.0284 | 0.103 |
|  | (0.40) | (1.402) |
| Imposed rulea | n.a | 0.113\*\* |
|  |  | (2.59) |
| Sanction (1 if sanction; 0 no sanction) | 0.0274 | 0.0366 |
|  | (0.53) | (0.88) |
| Round  | n.a | 0.290\*\*\* |
|  |  | (4.57) |
| First round HR (Game 1) | 0.0277 | 0.173\*\*\* |
|  | (0.30) | (4.60) |
| Average HR (Game 1) | 0.381\*\* | 0.00410 |
|  |  (2.35) | (1.20) |
| End game  | 0.0994\*\* | 0.212\*\*\* |
|  | (2.26) | (4.17) |
| Constant | 0.362\*\*\* | -0.231\*\*\* |
|  | (5.17) | (-5.20) |
| Session fixed effect | n.a | Yes  |
| Round fixed effect | Yes  | n.a |
| *N* | 752 | 1554 |

t statistics in parentheses; \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01; a reference category for Model 1.

Table C8. *Between-subjects regression by using random effects Tobit and GLS models*

|  |  |  |  |
| --- | --- | --- | --- |
|  | Model (1) | Model (2) | Model (3) |
|  | Random effect Tobit regression | Random effects GLS regression (S.E. clustered at group level) | Random effects GLS regression (S.E. clustered at individual level) |
|  |  |  |  |
| Representative democracy  | -0.298\*\*\* | -0.242\*\*\* | -0.242\*\*\* |
|  | (-5.31) | (-3.60) | (-5.07) |
| Direct democracy  | -0.322\*\*\* | -0.260\*\*\* | -0.260\*\*\* |
|  | (-5.43) | (-6.03) | (-6.50) |
| Imposed leadership | 0.0284 | 0.0465 | 0.0465 |
|  | (0.40) | (1.25) | (0.80) |
| Imposed rulea |  |  |  |
|  |  |  |  |
| Sanction (=1 if sanction, 0=no sanction) | 0.0274 | 0.0261 | 0.0261 |
|  | (0.53) | (0.50) | (0.64) |
| First Round HR (Game 1) | 0.0277 | 0.00720 | 0.00720 |
|  | (0.30) | (0.11) | (0.10) |
| Average HR (Game 1)  | 0.381\*\* | 0.198\*\* | 0.198\* |
|  | (2.35) | (2.28) | (1.83) |
| End game effect  | 0.0994\*\* | 0.0781\*\* | 0.0781\*\* |
|  | (2.26) | (2.43) | (2.29) |
| Constant | 0.362\*\*\* | 0.409\*\*\* | 0.409\*\*\* |
|  | (5.17) | (6.87) | (7.69) |
| Round fixed effect | Yes  | Yes  | Yes |
| *N* | 752 | 752 | 752 |

t statistics in parentheses; \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01; a reference category.

Table C9. *Average socio-economic characteristics of leaders and members*

|  |  |  |
| --- | --- | --- |
|  | **Exogenous leader** | **Endogenous leader** |
|  | **Leaders (n=3)** | **Members (n=12)** | **Leaders (n=5)** | **Members (n=20)** |
| Household size  | 3.67 | 6.5 | 5.4 | 5.7 |
| Age | 42.87 | 48.83 | 43.8 | 43.37 |
| Gender  | 0.67 | 0.92 | 1 | 0.85 |
| Education | 0 | 3.5 | 3.6 | 3.4 |
| Livestock (TLU) | 3.17 | 4.05 | 8.84 | 4.44 |
| Trust (1=trust, 0 = not trust) | 0.67 | 0.5 | 0.6 | 0.55 |
| Perception of illegal harvest (1=no, 0=yes) | 1 | 0.42 | 0.6 | 0.56 |
| Forest dependence in % (a)  | 0.37 | 0.46 | 0.32 | 0.38 |

Note: (a) Forest dependence is measured as the proportion of total annual household income derived from forest commons.

Table C10. *Behavioral changes between game 1 and game 2 for leaders*

*and other group members*

|  |  |  |  |
| --- | --- | --- | --- |
| Group | Number of votes in election | Leader | Rest of group |
| Change in average HR  | Change in HR in round 1  | Change in average HR  | Change in HR in round 1  |
| Game 1 | Game 2 | Game 1 | Game 2 | Game 1 | Game 2 | Game 1 | Game 2 |
| 1 | 3 | 0.36 | 0.07 | 0.4 | 0.1 | 0.35 | 0.24 | 0.33 | 0.20 |
| 2 | 4 | 0.31 | 0.08 | 0.3 | 0.1 | 0.4 | 0.09 | 0.43 | 0.10 |
| 3 | 4 | 0.23 | 0.04 | 0.3 | 0.2 | 0.44 | 0.37 | 0.50 | 0.43 |
| 4 | 4 | 0.18 | 0.17 | 0 | 0.1 | 0.51 | 0.28 | 0.53 | 0.30 |
| 5 | 4 | 0.22 | 0.48 | 0.4 | 0.3 | 0.58 | 0.5 | 0.68 | 0.38 |
| 6 | - | 0.59 | 0.22 | 0.7 | 0.2 | 0.41 | 0.67 | 0.23 | 0.68 |
| 7 | - | 0.39 | 0.43 | 0.4 | 0.2 | 0.65 | 0.61 | 0.63 | 0.43 |
| 8 | - | 0.72 | 0.34 | 0.9 | 0.3 | 0.39 | 0.64 | 0.33 | 0.68 |

Notes: Groups 1-5 with endogenous leader and 6-8 with exogenous leader. Group 3 is the only group where the leader chose not to implement sanctions.

Table C11. *The average HR of the members and leaders before and after the leadership treatment*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Leader | Follower 1 | Follower 2 | Follower 3 | Follower 4 |
|  | before | after | before | after | before | after | before | after | before | after |
|  | Av. HR game1 | Av. HR game2 | Av. HR game1 | Av. HR game2 | Av. HR game1 | Av. HR game2 | Av. HR game1 | Av. HR game2 | Av. HR game1 | Av. HR game2 |
| Group 1 | 0.36 | 0.07 | 0.45 | 0.28 | 0.3 | 0.28 | 0.33 | 0.27 | 0.33 | 0.11 |
| Group 2 | 0.31 | 0.08 | 0.8 | 0.18 | 0.06 | 0.01 | 0.55 | 0.14 | 0.17 | 0.03 |
| Group 3 | 0.23 | 0.04 | 0.52 | 0.45 | 0.55 | 0.47 | 0.24 | 0.28 | 0.45 | 0.29 |
| Group 4 | 0.18 | 0.17 | 0.49 | 0.23 | 0.6 | 0.48 | 0.51 | 0.17 | 0.45 | 0.24 |
| Group 5 | 0.22 | 0.48 | 0.53 | 0.35 | 0.45 | 0.53 | 0.78 | 0.33 | 0.56 | 0.8 |
| Group 6 | 0.59 | 0.22 | 0.32 | 0.73 | 0.5 | 0.7 | 0.49 | 0.73 | 0.34 | 0.53 |
| Group 7 | 0.39 | 0.43 | 0.6 | 0.7 | 0.75 | 0.59 | 0.57 | 0.8 | 0.68 | 0.34 |
| Group 8 | 0.72 | 0.34 | 0.38 | 0.54 | 0.22 | 0.71 | 0.41 | 0.67 | 0.53 | 0.62 |

Note: Yellow cells indicate an increase in harvest; blue cells a decrease in harvest.

Table C12. *HR in the 1st and 11th round of the members and leaders before and after the leadership treatment*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Leader | Follower 1 | Follower 2 | Follower 3 | Follower 4 |
|  | before | after | before | after | before | after | before | after | before | after |
|  | HR in round 1 Game 1 | HR in round 1 Game 2 | HR in round 1 Game 1 | HR in round 1 Game 2 | HR in round 1 Game 1 | HR in round 1 Game 2 | HR in round 1 Game 1 | HR in round 1 Game 2 | HR in round 1 Game 1 | HR in round 1 Game 2 |
| Group 1 | 0.4 | 0.1 | 0.2 | 0.3 | 0.2 | 0.3 | 0.5 | 0.2 | 0.4 | 0 |
| Group 2 | 0.3 | 0.1 | 0.7 | 0.2 | 0 | 0.1 | 0.8 | 0.1 | 0.2 | 0 |
| Group 3 | 0.3 | 0.2 | 0.7 | 0.3 | 0.4 | 0.2 | 0.5 | 0.8 | 0.4 | 0.4 |
| Group 4 | 0 | 0.1 | 0.5 | 0.1 | 0.7 | 0.8 | 0.3 | 0.1 | 0.6 | 0.2 |
| Group 5 | 0.4 | 0.3 | 0.5 | 0.3 | 0.5 | 0.2 | 1 | 0.2 | 0.7 | 0.8 |
| Group 6 | 0.7 | 0.2 | 0 | 0.7 | 0.6 | 0.6 | 0.3 | 0.8 | 0 | 0.6 |
| Group 7 | 0.4 | 0.2 | 0.5 | 0.3 | 0.6 | 0.3 | 0.4 | 0.8 | 1 | 0.3 |
| Group 8 | 0.9 | 0.3 | 0.4 | 0.5 | 0.2 | 0.7 | 0.1 | 0.8 | 0.6 | 0.7 |

Note: Orange cells indicate an increase in harvest; green cells a decrease in harvest.

Table C13. *Random effects Tobit regression for Game II excluding the least cooperative participants and group in baseline game (robustness check)*

|  |  |  |
| --- | --- | --- |
|  | Model (1) | Model (2) |
|  | Between-subjects effect of democracy (Game II) (excluding the two least cooperative participants) | Between-subjects effect of democracy (Game II) (excluding the least cooperative group) |
|  |  |  |
| Representative democracy | -0.355\*\*\* | -0.348\*\*\* |
|  | (-6.57) | (-6.26) |
| Direct democracy | -0.0303 | -0.0402 |
|  | (-0.39) | (-0.49) |
| Imposed leadership  | -0.253\*\*\* | -0.262\*\*\* |
|  | (-4.36) | (-4.38) |
| Imposed rule |  |  |
| Sanction (=1 if sanction, 0=no sanction) | 0.111 | 0.102 |
|  | (1.07) | (1.46) |
| First Round HR (Game 1) | -0.0274 | -0.0208 |
|  | (-0.32) | (-0.23) |
| Average HR (Game 1)  | 0.462\*\*\* | 0.391\*\* |
|  | (2.96) | (2.46) |
| Collapse (1=Game I collapsed before10th round, 0=otherwise) | 0.193\*\*\* | 0.182\*\* |
|  | (3.10) | (2.80) |
| End of game (1=last round, 0=otherwise) | 0.101\*\* | 0.102\*\* |
|  | (2.32) | (2.38) |
| Trust (1=yes, 0=no) | 0.0599 | 0.0657 |
|  | (1.27) | (1.31) |
| Illegal harvest (1=no, 0=yes) | -0.0730 | -0.0704 |
|  | (-1.61) | (-1.48) |
| Forest dependence (in % of annual income) | -0.109 | -0.0831 |
|  | (-0.82) | (-0.60) |
| Gender (1=male; 0=female) | 0.0571 | 0.0606 |
|  | (0.96) | (0.99) |
| Age (years) | -0.00386\*\* | -0.00175 |
|  | (-2.05) | (-0.90) |
| Livestock (TLU) | 0.00115 | -0.000338 |
|  | (0.15) | (-0.04) |
| Education level (years completed) | 0.00222 | 0.00383 |
|  | (0.41) | (0.68) |
| Constant | 0.395\*\* | 0.317\*\* |
|  | (2.88) | (2.22) |
| *N* | 739 | 722 |

z statistics in parentheses; \* *p* < 0.1, \*\* *p* < 0.05, \*\*\* *p* < 0.011.

Figure C1. *Average harvest ratio (HR) and beginning stock over rounds (baseline game)*

The bars represent 95% confidence interval.

Figure C2. *The average harvest ratio of leaders and members for*

*sessions with elected leaders*

Figure C3. *The average harvest ratio of leaders and members for*

 *groups with imposed leadership*

Note: The graphs in figures C2 and C3 give the average harvest rate of leaders and their group members in both game 1 and game 2. On the other hand, the harvest rates in table C11 are the unconditional harvest behaviors of each member of the groups at the beginning of the two games in relation to their group leader.

**Selection of leaders in a representative democracy**

In previous sections we have already established that elected leaders promote cooperation in commons dilemma compared to both imposed and open access scenarios. Now an intriguing question is: Who is more likely to be elected as a leader? Comparing the socio-economic characteristics of the leaders and the members shows that in groups where participants are allowed to choose their leaders, the leaders are wealthier (measured by the livestock ownership) than other group members (see table C9). In rural Oromia in general, and in the study area in particular, livestock ownership is one of the major indicators of wealth. A non-parametric (Mann-Whitney) test shows that democratically elected leaders own significantly more livestock than other members of their group (n=25; z=-3.061; p=0.0022). On the other hand, there is no significant difference in livestock ownership between randomly selected leaders (imposed leaders) and other members of their groups (n=15; z=0.375; p=0.7078). The selection of leaders in our experiment is consistent with the leadership selection culture of Oromo, according to which wealthy men in the age bracket of 40-48 years (traditionally called Luba age grade) are supposed to be the decision makers for the society (Melbaa, 1988). It is in this class that Oromo men attain full status as men and assume the leadership position in their society. In our experiment, in all five groups with representative democracy only men were chosen as leaders. Another interesting observation is that two participants in our experiment who are members of the executive committee of the forest user groups were also re-elected as leaders in the experiment (groups 3 and 4). Only one of eight leaders decided not to implement the sanctioning rule (group 3) and he is the wealthiest elected leader (TLU of 11) and the most cooperative leader in the second game after being elected as a leader (see tables C10 and C11 and figure C2).

**Appendix D**

**EXPERIMENTAL PROTOCOL**

First of all we would like to thank you for accepting our invitation, and for coming to participate in this experiment.

In this experiment today you can earn a considerable amount of money that you are permitted to keep and take home. You must understand that this is not our private money but given to us by our university for research. If you listen to the following instructions carefully, you can, depending on your decisions and the decisions of the other participants in your group, earn a considerable amount of money. This, therefore, requires you to follow the instructions very attentively. The objective of the experiment is to generate data for our research project. It does not have any political objective; neither religious objectives. We are interested in your decision during the experiment. However, there is no “right” or “wrong” answer.

During the experiment we will not speak in terms of Ethiopian Birr (ETB), but in points. Hence, your entire earnings will be calculated in points. At the end of the experiment the total amount of points you have earned will be converted to ETB at the rate of 1 Point = 0.5 ETB. You will be paid 5 ETB for just participating in the experiment (as an appearance fee) plus the additional earnings that you have kept during the experiment. Further, you will be paid the share of the trees that remain at the end of the game. The experiment is composed of two games; each with 10 rounds. You can earn money in each round depending on amount of trees you decide to harvest. Your total earning finally paid out is the amount of money earned in either of the two games; which will be determined by tossing a coin. Your earnings will be paid out to you in private such that nobody will know your decisions in the experiment.

**Some important remarks before we can start:**

1. The experiment will take about two hours, including waiting time. If you find that this experiment is something that you do not wish to participate in for any reason, **or you already know that you will not be able to stay for the two hours,** please let us know immediately so that we can replace you with somebody else.
2. You are not allowed to communicate with each other throughout the game. Your harvest decisions are private and hence nobody should make any attempt to see the harvest decisions of others.
3. **It is very important that you understand the game**. Therefore we will check your understanding by asking each of you “test questions” about the procedures of the game. If you do not understand the rules you may always ask the assistants to explain them. **But if you cannot answer the test questions after explaining them again, we will have to exclude you from the experiment.**
4. If you have questions, always raise your hand and wait until the assistant comes to you. Then you can ask your question and the assistant will answer it. You are not allowed to talk to other participants during the experiment. You are not allowed to leave the room without permission.

**Before we start explaining the procedures to be followed in the experiment, you will pick a number from the basket that comes to you, and remember that this number will be your identification number throughout the experiment.**

(Theparticipants will be made to pick their identification number).

**Game I (Baseline Game): This is the first part of the experiment.**

In this experiment you are making decisions about the management of a forest from which you and 4 other people can extract trees. You can earn points by extracting trees but the more trees you and the other 4 participants in your group extract, the smaller the size of the forest becomes and the less you will be able to harvest in the remaining rounds. In addition to this, you will also be paid in group the amount of trees that remain standing at the end of the game. Hence, if you cut more trees in each round you will have small number of trees that remain standing at the end. At the beginning of each round you will be informed of the number of trees available for harvest and the maximum number of trees you will be allowed to harvest. Then, at each round you will individually decide how much trees to take away. Furthermore, the forest available in one round will regenerate naturally at the growth rate of 10% for the next round. For instance, this implies that if your common plot has 85 trees in a specific round, there will be 9 additional trees for the next round. Similarly, if you have 72 trees at the beginning of a certain round, you can have 7 additional trees for the next round due to the natural growth rate. But the trees in any round cannot grow more than 101.

*[The assistant will explain this in local language and by using visual aid. To visualize standing trees at the beginning of every round, we use small equal pieces of green cloth with stickers, where a piece represents a standing tree. For example, at the beginning of the experiment, the pieces will be arranged in 10 rows and 10 columns; 9 rows with 10 small pieces of clothes and 1 row with 11 trees to represent a forest plot with 101 standing trees.]*

As your forest plot has 101 trees at the beginning of the experiment, you will be allowed to harvest maximum of 10 trees in the first round, and this will stay same in the subsequent rounds till the forest size declines to 50 trees. However, starting from the round at the beginning of which the available stock is 50 or less, the maximum number of trees to be harvested would be less than 10 as shown in the following table. The rounds in this game are supposed to imply different tree harvesting seasons.

Table. *The maximum number of trees allowed to harvest at each round*

|  |  |
| --- | --- |
| The number of trees at the beginning of the round | Maximum number of trees each participant is allowed to harvest |
| 51-101 | 10 |
| 45-50 | 9 |
| 40-44 | 8 |
| 35-39 | 7 |
| 30-34 | 6 |
| 25-29 | 5 |
| 20-24 | 4 |
| 15-19 | 3 |
| 10-14 | 2 |
| 5-9 | 1 |
| 0-4 | 0 |

Now we will distribute the table in which you are going to write your harvest decision in each round to keep track of your earnings.

Table: *Harvest decisions of the participants*

|  |
| --- |
| **Participant ID Number:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** |
| 1 | 2 | 3 | 4 | 5 | 6 |
| Rounds of the game | Total group harvest in the previous round | Natural Re-growth | Size of the forest at the beginning of the round | Maximum allowed | Your harvest decision |
| Practice 1 |  | - | 101 | 10 |  |
| Practice 2 |  |  |  |  |  |
| Practice 3 |  |  |  |  |  |
| 1 |  | - | 101 | 10 |  |
| 2 |  |  |  |  |  |
| 3 |  |  |  |  |  |
| 4 |  |  |  |  |  |
| 5 |  |  |  |  |  |
| 6 |  |  |  |  |  |
| 7 |  |  |  |  |  |
| 8 |  |  |  |  |  |
| 9 |  |  |  |  |  |
| 10 |  |  |  |  |  |

The first column (Column 1) gives you the current round at which you are going to make your decisions. In the fourth column (Column 4) you will be given the number of trees available at the beginning of that specific round. In the fifth column (Column 5) you will have the maximum number of trees you and each of the other participants are allowed to harvest in that particular round. The grey shaded area for the first four columns means that we will give you this information in each round. You are only required to fill in column 6. The sixth column is where you write your harvest decision depending on the stock of trees available for that round and the maximum number of trees you are allowed to harvest. This decision is your private decision and no one else in the group will know what you choose. Neither will you know what a particular person in your group chooses. You will only know the total tree that all 5 players harvest.

At the beginning of every round you will be informed about the size of forest in your plot as a group and the maximum number of trees you will be allowed to harvest. Then you will write your harvest level in the 5th column. Then we will collect your “Table of harvest decision” and calculate the first 4 columns of your table in the next round to enable you make your personal harvest decision.

*For example, let’s assume that at the beginning of the third round your group has 40 trees and you harvest 3 trees and others harvest 4, 2, 4 and 2. Then, you will write 3 in the 5th column for the 3rd round. It means that your group as a whole harvests 15 (3+4+2+4+2=15) trees, leaving 25 (40-15) standing trees on your forest plot. Due to the natural growth rate, the 25 standing trees will add 3 more trees for the 4th round. Hence you will have 28 (25+3) standing trees at the beginning of the next round. Thus, from Table 1 we know that the maximum number of trees you will be allowed to take away in the 4th round will be 5 as the number of standing trees is between 25-29. Then, in the first 4 columns (Columns 1, 2 3 and 4) of the 4th round, these pieces of information will be filled in your table and the table will be given back to you so that you will make your harvest decision in the 4th round; and fill that in the 5th column for the 4th round.*

[continue with more examples]

At the end of the game you will be paid the amount of money in Ethiopian Birr equal to:

* the amount of trees you harvest in all rounds plus
* your share from the number of trees standing/conserved at the end of the game
* the appearance fee

Note that the trees are translated into monetary value in such a way that the value of every tree you harvest in each round and the amount of trees that remain standing at the end of the game is 0.5 ETB.

Now you are going to practice the game before you start the main game, but the trees you harvest in these practice rounds will not be counted in your total earning at the end of the experiment.

*Before we start the practice, if you have any problem in understanding the game, writing or reading, please raise your hand and ask us.*

*(Practice of the game continues)*

**Game II. Treatments to the experiment**

**Election of leader**

As in the first ten rounds, you and all the others will make your private harvest decisions. Before we proceed with the game for the next 10 rounds you will be able to make some changes in the procedures.

Before we proceed with the game for the next 10 rounds you are going to choose a person who will be responsible to decide on a specific rule for the coming 10 rounds. Then, in the coming 10 rounds you will play the game with the rule that your leader chooses. We will now distribute the voting cards. You are not allowed to talk to others about your vote. It is your private choice whom you want to become the leader of your group. The person that gets at least 3 votes will be the leader of the next game. On the other hand, if you don’t want to vote for any of the persons, you can also abstain from voting and your vote will not be counted. However, in case of unanimity we will toss a coin among the alternatives with highest votes to decide who will become a leader.

[count votes and announce leader]

The leader can choose whether he/she wants to continue to play this game with “sanctions” or “without sanctions”. According to the sanction rule, no one should harvest more than 2 forest units per round in order to make the best profit as a group. In the sanction rule, it is forbidden to cut more than 2 trees. The fine, if the regulation is violated, is that you will lose twice whatever you harvest more than 2 trees in that particular round and the sum will be subtracted from whatever you earned so far. However, if you are not caught you will go with all trees you harvest and it will be counted in your final score. The probability with which you will be monitored and punished is 1/5. To determine who is being monitored, at the end of every round we will draw a number from the basket with the players’ number and the player whose number comes out of the basket will be considered as being monitored and will be punished according to the rule if he/she has harvested more than 1 tree.

On the other hand, if the leader chooses “no sanction”, there is no sanction that punishes those who harvest more than 2 trees. In other words, even if somebody harvests more than 2 trees, he/she will not be punished.

*Ask: Did everybody understand the rules?*

[ask leader which rule he wants and remind participants again on the rule]

**Imposed random leader**

As in the first ten rounds, you and all the others will make your private harvest decisions. Before we proceed with the game for the next 10 rounds you will be able to make some changes in the procedures.

Before we proceed with the game for the next 10 rounds we are going to choose a person who will be responsible to decide on a specific rule for the coming 10 rounds. Then, in the coming 10 rounds you will play the game with the rule that your leader chooses. We will randomly choose the leader by drawing one of the player numbers from this basket.

[show that all 5 numbers are in the basket and make random draw and announce leader]

The leader can choose whether he/she wants to continue to play this game with “sanctions” or “without sanctions”. According to the sanction rule, no one should harvest more than 2 forest units per round in order to make the best profit as a group. In the sanction rule, it is forbidden to cut more than 2 trees. The fine, if the regulation is violated, is that you will lose twice whatever you harvest above 1 tree in that particular round and the sum will be subtracted from whatever you earned so far. However, if you are not caught you will go with all trees you harvest and it will be counted in your final score. The probability with which you will be monitored and punished is 1/5. To determine who is being monitored, at the end of every round we will draw a number from the basket with the players’ number and the player whose number comes out of the basket will be considered as being monitored and will be punished according to the rule if he/she has harvested more than 1 tree.

On the other hand, if the leader chooses “no sanction”, there is no sanction that punishes those who harvest more than 2 trees. In other words, even if somebody harvests more than 2 trees, he/she will not be punished.

*Ask: Did everybody understand the rules?*

[ask leader which rule he wants and remind participants again on the rule]

**Election of a sanctioning rule**

As in the first ten rounds, you and all the others will make your private harvest decisions. The forest size will again start with 101 trees. Before we proceed with the game for the next 10 rounds you will be able to make some changes in the procedures. You can choose whether you want to continue to play this game with “sanctions” or “without sanctions”. According to the sanction rule, no one should harvest more than 2 trees per round in order to make the best profit as a group. The fine, if the regulation is violated, is that you will lose twice whatever you harvest above 2 trees in that particular round and the sum will be subtracted from whatever you earned so far. However, if you are not caught you will go with all trees you harvest and it will be counted in your final score. The probability with which you will be monitored and sanctioned is 1/5. To determine who is being monitored, at the end of every round we will draw a number from the basket with the players’ number and the player whose number comes out of the basket would be considered as being monitored and will be punished according to the rule if he/she has harvested more than 2 trees.

On the other hand, if you choose “no sanction”, there is no sanction that punishes those who harvest more than 2 trees. In other words, even if somebody harvests more than 2 trees, he/she will not be punished. In this game, harvesting more than 2 trees will increase personal profit, but it decreases the size of the resource in the subsequent rounds and the profit you get from the number of trees standing at the end of the game as the group. Nonetheless, it is your private decision to decide the amount of trees to harvest in each round.

*Ask: Did everybody understand the rules?*

We will now distribute the voting cards. You are not allowed to talk to others about your vote. It is your private choice whether you want to continue with sanction rule or the one without sanction. The rule that gets at least 3 votes will be implemented in the following 10 rounds of the next game. On the other hand, if you don’t want to vote for any of the rules, you can also abstain from voting and your vote will not be counted. However, in case of unanimity we will toss a coin to decide which of the rules should be implemented.

Now the participants will be made to vote between the two rules by writing either 1, 2 or 3 to imply the rule they favor, where 1 is sanction, 2 is without sanction and 3 is abstain.

**Randomly assigned sanctions**

As in the first ten rounds, you and all the others will make your private harvest decision. The forest size will again start with 101 trees. Now you are going to play the game for the coming ten rounds with a "sanction rule". According to the sanction rule, no one should harvest more than 2 forest units per round in order to make the best profit as a group. The fine, if the regulation is violated, is that you will lose twice whatever you harvest above 2 trees in that particular round and the sum will be subtracted from whatever you earned so far. However, if you are not caught you will go with all trees you harvest and it will be counted in your final score. The probability with which you will be monitored and punished is 1/5. To determine who is being monitored, at the end of every round we will draw a number from the basket with the players’ number and the player whose number comes out of the basket will be considered as being monitored and will be punished according to the rule if he/she has harvested more than 2 trees.

*Ask: Did everybody understand the rule?*

**Randomly assigned no sanctions**

As in the first ten rounds, you and all the others will make your private harvest decision. The forest size will again start with 101 trees. If you want to make a maximum gain at group level no one has to harvest more than 2 trees. But as it was in the first game your personal gain increases with the number of trees you harvest. It is your personal decision to decide how much to harvest in any given round.

*Ask: Did everybody understand the rules?*

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2. Note that the group gain is computed only at the end of the game following our experimental setup. [↑](#footnote-ref-2)
3. The advantage of including $A\_{T}$ in our model is that it enables us to capture the effect of externalities associated with individual harvest from the commons and it represents the real life social dilemma between individual and group interests. [↑](#footnote-ref-3)
4. In our model we have not accounted for the interest rate that the participants may earn by postponing their harvest from period$ t$ to future periods. This is because we assumed that the re-growth rate would play the role of interest by increasing the availability of the forest products in future periods. Moreover, it is not customary for the rural households in our study area to express benefits of postponing today’s consumption in terms of bank interest rate as they are not accustomed with the banking system. They are less likely to save their money (if any) in banks to earn interest on their savings. [↑](#footnote-ref-4)