Monitoring and management of common property resources: empirical evidence from forest user groups in Ethiopia

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ONLINE APPENDIX

Appendix A. Extra tables

Table A1. Sample size per experimental arm

Treatments	Number of forest user groups	Total members	Members sampled
Control group	34	933	320
Monitoring intervention	98	2,665	895
TOTAL	132	3,598	1,215

Table A2. Descriptive statistics

	Baseline data			
Variables	Control	Treatment	Diff	P-value
Monitoring				
Monitoring committee (0/1)	0.383	.296	.087	.355
Leader ability				
Education[a]	3.220	2.706	.514	.045
Years of schooling (years)	4.860	3.607	1.252	.077
Business experience (0/1)	0.212	.093	.12	.072
Leader effort				
Forest patrolling (days)	41.084	43.334	–2.25	.533
Forest benefits				
Forest income (ETB)	1781.100	2144.394	–363.295	.488
Leader characteristics				
Age (years)	45.960	45.086	.875	.738
Gender (1 if male)	0.980	.972	.009	.802
Income (ETB)	35596.580	50611.037	–15014.457	.200
Livestock holding (number of livestock)	29.271	25.207	4.064	.271
Household size (number of household members)	11.820	10.144	1.676	.065
Duration in power (years)	6.240	5.162	1.079	.120
Prosocial motivation (0/1)	0.344	.424	–.080	.430
Group characteristics				
Altitude	2.264	2.215	.051	.703
Year of establishment	2005.677	2005.612	.064	.926
Group size	27.500	27.194	.306	.732
Share of female members	0.208	.205	.004	.875
Average age	48.572	47.712	.859	.487
Average education	0.462	.509	–.047	.292
Average household size	9.053	9.293	–.241	.462
Average income	27400.396	36388.366	–8987.970	.033
Average livestock holding	23.063	21.607	1.457	.313
Share of trusting members	0.168	.118	.050	.227
Number of potential crop trees (per hectare)	45.064	45.425	–.360	.954
Value of standing trees[b]	2.819	2.712	.106	.793
Distance to market[c]	2.768	5.221	–2.453	.449
Distance to asphalt road[c]	0.148	.197	–.049	.191
Average outside income opportunity (0/1)	0.328	.349	–.022	.354
Income heterogeneity (Gini coefficient)	0.257	.302	–.045	.129
Land heterogeneity (Gini coefficient)	0.502	.494	.007	.871
Clan fractionalization index	0.093	.158	–.064	.067
Members prosocial motivation	0.851	.792	.059	.183
Members' forest patrolling (days)	39.639	42.967	–3.329	.218
	End-line data			
Leader characteristics				
Education[a]	2.867	2.453	.414	.022
Years of schooling	4.387	3.693	.695	.116
Business experience (0/1)	0.344	.114	.230	0
Forest patrolling (days)	62.569	76.021	–13.452	.189
Group characteristics				
Average forest income (ETB)	4056.445	6339.1	–2282.655	.085
Average outside income opportunity (0/1)	0.144	.180	–.036	.149

[a] Education is a categorical variable that ranges from 1 (no education) to 6 (university diploma or degree).
[b] Value of standing trees is measured as the forest stock weighted by distance to market.
[c] Distance indicators are measured in hours of walking. Land holding measured in *timad* (a local measure): one timad is approximately 0.25 hectares.
Notes: ETB: Ethiopian Birr. Altitude ranges from 1 (2,200–2,700 m above sea level) to 3 (3,000–500m above sea level).

Table A3. Determinants of monitoring committee

	Full sample of leaders	Less pro-socially motivated	More pro-socially motivated
OIO	–0.000	0.084	–0.041
	(0.227)	(0.349)	(0.303)
Altitude	–0.347	–0.189	0.117
	(0.202)	(0.573)	(0.283)
Year of establishment	–0.021	–0.052	0.086
	(0.014)	(0.038)	(0.038)
Group size	–0.005	–0.004	0.014
	(0.005)	(0.007)	(0.010)
Share of female members	–0.248	–0.057	0.219
	(0.357)	(0.465)	(0.473)
Average age	–0.007	–0.017	0.012
	(0.010)	(0.010)	(0.011)
Average education	–0.059	–0.077	–0.367
	(0.156)	(0.243)	(0.263)
Land heterogeneity	0.007	0.226	–0.328
	(0.113)	(0.336)	(0.349)
Clan fractionalization index	0.073	0.123	–0.334
	(0.124)	(0.207)	(0.362)
Distance to market	–0.002	0.001	0.005
	(0.013)	(0.034)	(0.013)
Potential crop trees	–0.000	–0.002	0.003
	(0.001)	(0.003)	(0.003)
Village fixed effects	Yes	Yes	Yes
Constant	44.011	106.968	–172.734
	(27.642)	(77.457)	(76.516)
R^2	0.552	0.694	0.711
Observations[a]	117	65	46

[a] The number of observations dropped from 132 to 117 because we have data on “potential crop trees” for only 117 FUGs.
Note: Clustered (at village level) standard errors in parentheses.

Table A4. Monitoring, leader ability and leader effort (observational data with imputation)

	Education	Years of schooling	Business experience	Days patrolling
	(1)	(2)	(3)	(4)
Monitoring	0.516	1.393	–0.066	13.998
	(0.424)	(1.208)	(0.120)	(7.806)
OIO	1.288	1.800	0.630	–9.254
	(1.035)	(2.948)	(0.300)	(21.675)
Monitoring ×	–3.566	–8.432	–0.626	2.449
OIO	(1.393)	(3.967)	(0.405)	(16.202)
Controls	Yes	Yes	Yes	Yes
Village F.E.	Yes	Yes	Yes	Yes
Constant	15.175	–63.997	41.282	5048.477
	(154.074)	(438.769)	(45.366)	(1688.384)
R^2	0.471	0.439	0.449	0.611
Observation	125	125	130	124

Notes: F.E.: fixed effects. Clustered (at village level) standard errors in parentheses. Included explanatory variables: age of the leader, income of the leader, livestock holding of the leader, clan of the leader, household size of the leader, altitude, year of establishment, group size, share of female members, average age of members, share of members who can read and write, average household size of members, share of trusting members, share of members who have non-farm income (employment and business), income heterogeneity, land heterogeneity, clan fractionalization index, average distance to market, average distance to asphalt road, value of standing timber stock, and number of potential crop trees per ha.

Table A5. Monitoring, resource rents, and leader ability (observational data, alternative measures of resource rent)

	Forest stock weighted by distance to market			Forest stock multiplied by timber price			Forest stock multiplied by timber price and weighted by distance to market		
	Education	Years of schooling	Business experience	Education	Years of schooling	Business experience	Education	Years of schooling	Business experience
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Monitoring	1.415	3.901	0.065	1.120	3.112	–0.026	0.616	1.910	–0.077
	(0.386)	(1.136)	(0.193)	(0.429)	(0.874)	(0.145)	(0.544)	(1.131)	(0.146)
Monitoring × *VT*	–0.024	–0.049	–0.002	0.000	0.000	–0.000	0.000	0.001	0.000
	(0.021)	(0.075)	(0.011)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
VT	0.019	0.086	0.003	0.240	0.912	–0.066	0.278	1.044	–0.031
	(0.013)	(0.036)	(0.004)	(0.099)	(0.364)	(0.048)	(0.120)	(0.417)	(0.036)
OIO	2.709	6.476	1.318	2.600	6.711	0.673	2.883	6.157	0.812
	(1.823)	(5.064)	(0.956)	(2.134)	(4.867)	(0.766)	(2.125)	(4.391)	(0.623)
VT × *OIO*	0.008	0.048	–0.037	0.000	–0.000	–0.000	–0.000	–0.000	–0.000
	(0.072)	(0.192)	(0.029)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)
Monitoring × *OIO*	–5.570	–12.853	–1.336	–2.886	–5.203	–1.420	–3.207	–6.056	–1.616
	(2.052)	(4.974)	(0.882)	(2.652)	(6.355)	(0.962)	(2.651)	(6.573)	(0.885)
Monitoring × *OIO* × *VT*	–0.001	–0.002	0.000	–0.001	–0.004	0.000	–0.002	–0.006	0.000
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.003)	(0.000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Village fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	192.040	480.248	15.747	232.795	702.684	39.950	199.561	550.980	23.711
	(189.001)	(480.951)	(41.630)	(156.100)	(468.157)	(44.935)	(144.798)	(413.223)	(42.682)
R^2	0.498	0.490	0.472	0.545	0.527	0.453	0.550	0.535	0.458
Observations	101	101	101	101	101	101	101	101	101

Notes: Clustered (at forest user group level for DID and village level for OLS) standard errors in parentheses. Included explanatory variables: age of the leader, education of the leader, income of the leader, livestock holding of the leader, clan of the leader, household size of the leader, altitude, year of establishment, group size, share of female members, average age of members, share of members who can read and write, average household size of members, share of trusting members, share of members who have non-farm income (employment and business), income heterogeneity, land heterogeneity, clan fractionalization index, average distance to market, average distance to asphalt road, value of standing timber stock, and number of potential crop trees per ha.

Table A6. Monitoring, ability and effort (experimental data, ANCOVA model)

	Ability		**Effort**
	Education	Years of schooling	Days patrolling
Monitoring intervention	0.104	0.399	–14.059
	(0.304)	(0.848)	(16.079)
OIO	1.624	3.985	–144.694
	(0.874)	(2.600)	(47.392)
Monitoring intervention ×	–2.645	–5.147	154.197
OIO	(1.157)	(3.500)	(53.925)
Controls	Yes	Yes	Yes
Village fixed effects	Yes	Yes	Yes
Constant	139.503	122.672	–19709.298
	(126.874)	(327.962)	(13306.648)
R^2	0.414	0.367	0.452
Observations	101	101	101

Notes: Clustered (at forest user group level for DID and village level for OLS) standard errors in parentheses. Included explanatory variables: age of the leader, education of the leader, income of the leader, livestock holding of the leader, clan of the leader, household size of the leader, altitude, year of establishment, group size, share of female members, average age of members, share of members who can read and write, average household size of members, share of trusting members, share of members who have non-farm income (employment and business), income heterogeneity, land heterogeneity, clan fractionalization index, average distance to market, average distance to asphalt road, value of standing timber stock, and number of potential crop trees per ha.

Table A7. Monitoring, ability and effort (experimental data, distinguishing the three monitoring interventions)

	Ability			Effort
	Education	Years of schooling	Business experience	Days patrolling
	(1)	(2)	(3)	(4)
Top-down monitoring	–1.053	–2.363	–0.233	–14.975
	(0.377)	(1.129)	(0.141)	(9.864)
Reward	–0.673	–2.079	–0.087	–14.026
	(0.405)	(1.132)	(0.159)	(8.857)
Bottom-up monitoring	–0.772	–2.127	–0.069	–9.899
	(0.449)	(1.169)	(0.201)	(9.057)
OIO	–1.692	–4.199	1.023	12.030
	(1.142)	(3.153)	(0.462)	(29.507)
Top down monitoring × OIO	1.558	3.250	–1.365	
	(1.359)	(3.829)	(0.545)	
Reward × OIO	1.710	2.492	–1.119	
	(1.555)	(4.321)	(0.658)	
Bottom-up monitoring × OIO	1.121	1.698	–1.154	
	(1.674)	(4.289)	(0.746)	
Year	–1.210	–2.645		33.198
	(0.369)	(0.820)		(14.665)
Top-down monitoring × Year	0.749	2.578		55.662
	(0.511)	(1.103)		(23.868)
Reward x Year	1.261	3.081		62.781
	(0.507)	(1.055)		(25.156)
Bottom-up monitoring × Year	0.665	2.839		–0.306
	(0.504)	(1.044)		(22.855)
OIO × Year	3.927	9.309		
	(1.642)	(4.036)		
Top-down monitoring × OIO × Year	–2.415	–5.883		
	(2.319)	(5.313)		
Reward x OIO × Year	–4.637	–8.048		
	(2.369)	(4.995)		
Bottom-up monitoring × OIO × Year	–4.074	–8.596		
	(2.388)	(5.104)		
Controls				
Village fixed effects				
Model				
Constant	219.486	331.456	–21.947	–2089.830
	(164.220)	(404.782)	(61.357)	(5920.951)
R^2	0.346	0.284	0.409	0.417
Observations	211	211	107	210

Notes: Clustered (at forest user group level for DID and village level for OLS) standard errors in parentheses. Included explanatory variables: age of the leader, education of the leader, income of the leader, livestock holding of the leader, clan of the leader, household size of the leader, altitude, year of establishment, group size, share of female members, average age of members, share of members who can read and write, average household size of members, share of trusting members, share of members who have non-farm income (employment and business), income heterogeneity, land heterogeneity, clan fractionalization index, average distance to market, average distance to asphalt road, value of standing timber stock, and number of potential crop trees per ha.

Coefficient stability

We probe the robustness of our main result, the effect of monitoring on ability of the leader in the presence of outside income opportunities, using the coefficient stability approach (see Altonji *et al*., 2005; González and Miguel, 2015; Oster, 2017). We calculate adjusted coefficients, using the following equation:

$$\hat{\hat{\beta}} = \hat{\beta}^* - \left(\hat{\beta} - \hat{\beta}^*\right) * \frac{(R^{max} - R^*)}{(R^* - R)}, \quad \text{(A1)}$$

where $\hat{\hat{\beta}}$ is the adjusted coefficient; $\hat{\beta}^*$ and R^* are estimated coefficient and R^2 from a model with observables, respectively; and $\hat{\beta}$ and R are estimated coefficient and R^2 from a model without controls respectively. R^{max} is R^2 from a regression of the dependent variable on all relevant controls (both observables and unobservables). Since we do not have information on unobservable covariates, we do not know the value of R^{max}. We follow the previous literature: (1) González and Miguel (2015) assume that R^{max} is a survey–resurvey reliability ratio of an outcome variable, usually a pairwise correlation in time-invariant variables between two survey rounds; (2) Bellows and Miguel (2009) assume that $R^{max} = 2R^* - R$; (3) Oster (2017) assumes that $R^{max} = min\{2.2R^*, 1\}$; and the most conservative case, (4), is based on the assumption that $R^{max} = 1$. The results are presented in Table A8. As is evident, including observables does not make our key coefficients insignificant, which suggests that the effect of monitoring on leader's ability and effort is unlikely to be driven by unobserved variables.

Table A8. Monitoring and leaders: Coefficient stability approach

			González and Miguel (2015)	González and Miguel (2015)	Bellows and Miguel (2009)	Oster (2017)	Most conservative case
Monitoring and leader's ability in the presence of outside income opportunities (categorical education)	–3.284	–5.63					
	(1.217)	(1.521)					
R^2	0.208	0.497					
R^{max}			0.500	0.800	0.933	1	1
Adjusted coefficients			–5,657	–8,096	–7,982	–9,721	–9,721
Monitoring and leader's ability in the presence of outside income opportunities (Years of schooling)	–7.874	–12.59					
	(3.522)	(4.26)					
R^2	0.155	0.49					
R^{max}			0.500	0.800	0.921	1	1
Adjusted coefficients			–12,740	–16,972	–17,296	–19,793	–19,793
Monitoring and leader's effort	15.991	18.71					
	(6.999)	(9.12)					
R^2	0.329	0.647					
R^{max}			0.500	0.800	1.212	1	1
Adjusted coefficients			17,455	20,024	21,437	21,737	21,737
Controls	No	Yes					
Village fixed effects	Yes	Yes					
Observations	125	99					

Note: Robust standard errors in parentheses.

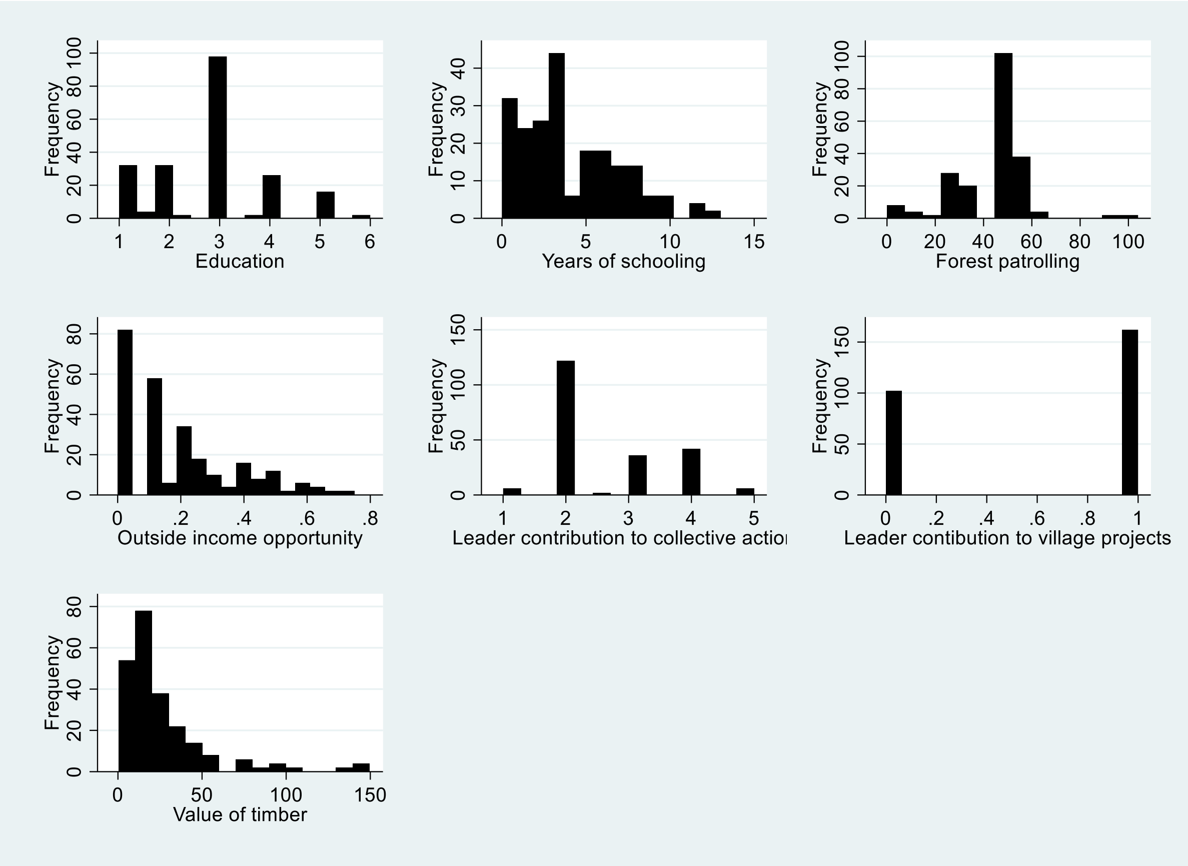

Figure A1. Distribution of key variables.

Appendix B. The Adaba-Dodola Participatory Forest Management (PFM) program

The Adaba-Dodola forest is located on the northern slopes of the Bale Mountains. Before PFM, the forest was under state control but access was open to anyone. Expansion of agricultural land, livestock grazing, and uncontrolled forest extraction decreased the area of Ababa-Dodola forest from 140,000 ha in the 1980s to 53,000 ha in recent years (Kubsa *et al.*, 2003). Currently, about 50,000 hectares of this forest are managed by 132 forest user groups (FUGs) under the PFM program. As a result, deforestation rates have substantially decreased (Ameha *et al.*, 2016).

Membership: Jointly with community representatives, the Oromia Forest and Wildlife Enterprise (OFWE) developed membership criteria based on settlement proximity to the forest, permanent residence in the village, and customary use rights. These criteria were subsequently approved by majority vote in each village and used to establish FUGs.

Rights and responsibilities: Established FUGs negotiate contracts with the Oromia Rural Land and Natural Resources Administration Authority (ORLNRAA) specifying rights and duties of the group, and conditions of contract termination. FUGs are allowed to use forest products for consumption and sales, and maintain existing farm plots inside the forest. In return, they should manage the forest in a sustainable manner, restrict further settlement and agricultural expansion, and pay an annual rent. This rental agreement remains valid for an indefinite period, unless forest utilization exceeds the maximum extraction level set by the government (the so-called "allowable cut") by more than 10 per cent. Each FUG is allocated a demarcated forest block, which is managed jointly by group members. The size of the forest block depends on the size of the group, with a carrying capacity assumption of 12 ha per member (so 360 ha for the maximum group size). Forests play a significant role in the livelihood of group members, and we estimate that the value of forest-based products accounts for about 25 per cent of annual income. Other key income sources are agriculture and livestock production.

Appendix C. The formal model

Stage 3. Optimal effort by group members

We first solve for the effort level that each group member would choose if she were elected as the leader. Individual group members can be ranked in terms of ability: $A_i \in (0, \hat{A})$. The first order condition of (1) with respect to effort e_l for individual *i* is:

$$\frac{\partial Y_i}{\partial e_i} = -\alpha I_{e_l}(A_i, 1 - e_i) + (1 - \alpha)(1 + \beta)P_{e_l}(A_i, e_i, R) - C_{e_i}(m, e_i) = 0. \quad \text{(B1)}$$

Using the implicit function theorem, we immediately obtain:

$$\frac{de_l^*}{dm} = -\left[\frac{-C_{e_l m}(m, e_l)}{\alpha I_{e_l e_l}(A_l, 1 - e_l) + (1 - \alpha)(1 + \beta)P_{e_l e_l}(A_l, e_l, R) - C_{e_l e_l}(m, e_l)}\right]. \quad \text{(B2)}$$

Assuming $C_{e_l m} < 0$, $C_{e_l e_l} = 0$, $I_{e_l e_l} < 0$, and $P_{e_l e_l} < 0$, we obtain the intuitive result that $\frac{de_l^*}{dm} > 0$. If supplying effort reduces the monitoring costs for leaders (due to, say, less onerous inspections if group members are more satisfied), then leaders will optimally increase their effort toward the production of the public good.

How do outside opportunities affect the leader's effort? We readily obtain:

$$\frac{de_l^*}{d\alpha} = -\left[\frac{-I_{e_l}(A_l, 1 - e_l) - (1 + \beta)P_{e_l}(A_l, e_l, R)}{\alpha I_{e_l e_l}(A_l, 1 - e_l) + (1 - \alpha)(1 + \beta)P_{e_l e_l}(A_l, e_l, R) - C_{e_l e_l}(m, e_l)}\right] < 0. \quad \text{(B3)}$$

Greater opportunity costs will, at the margin, reduce effort allocated to production of the public good. From (B2) and (B3) we find how prosocial motivation affects effort. Specifically:

$$\frac{d\left(\frac{de_l^*}{dm}\right)}{d\beta} < 0, \text{ and} \quad \text{(B4)}$$

$$\frac{d\left(\frac{de_l^*}{d\alpha}\right)}{d\beta} > 0 \qquad \text{if } \alpha P_{e_l} I_{e_l e_l} > (1 - \alpha) I_{e_l} P_{e_l e_l}. \quad \text{(B5)}$$

If leaders have stronger prosocial preferences, the change in their optimal effort level as a result of either extra monitoring or improved outside opportunities will be attenuated ("dampened").

Stage 2. Selection of the leader

Members use predicted effort levels to elect the candidate that will provide the highest level of the public good, given the set of candidates (to be determined below). Grossman and Hanlon (2014) make the simplifying assumption that the public good value produced in equilibrium is increasing in the ability of the leader: $\frac{dP}{dA_i}>0$, or that the direct effect of ability is greater than any indirect effect via reduced effort levels chosen by more able leaders. Stage 2 therefore reduces to a simple step: select the most able candidate from the pool of volunteers. If there are no candidates, no leader is elected and no public good is provided.

Stage 1. Candidacy choice

Group members will compare their expected utility as a "normal group member" and as the leader. The most able candidate will be elected, so each member has to evaluate her payoffs as the leader in terms of the public good that will be provided as well as in terms of candidacy and monitoring cost (φ and $C(m,e_i)$) and the opportunity cost of effort, e_i. The Nash equilibrium solution of this game, where members simultaneously decide whether to run or not, is complex as multiple equilibria might emerge (observe that group members have to form expectations about whether their peers are prepared to run or not, which will depend on the expectations of these peers, and so on).

Grossman and Hanlon (2014) discuss the following conditions as necessary and sufficient for the existence of an equilibrium in pure strategies: (i) at most one individual will choose to run; (ii) if a member chooses to run, the net payoff (payoff from being a leader minus payoff without leader) is greater than or equal to zero; (iii) if a member chooses to run, no other member who could produce a higher public good has a positive payoff from running; and (iv) if no member chooses to run, it must be because the net payoff (payoff from running minus payoff from no one running) is not positive.

Model predictions with respect to leader ability

Next, turn to the impact of monitoring on ability of the leader. The net payoff from running as a candidate is given by:

$$\pi_i = \alpha I(A_i, 1 - e_i^*) + (1-\alpha)(1+\beta)P(A_i, e_i^*, R) - C(m, e_i^*) - \phi - \alpha I(A_i, 1). \quad \text{(B6)}$$

Observe that the following holds:

$$\frac{d\pi_i}{dA_i} = \alpha I_{A_i}(A_i, 1 - e_i^*) + (1-\alpha)(1+\beta)P_{A_i}(A_i, e_i^*, R) - \alpha I_{A_i}(A_i, 1). \quad \text{(B7)}$$

Following Grossman and Hanlon, we focus on the case where $\frac{d\pi_i}{dA_i} < 0$, or the case where high-ability group members have less incentive to be the leader than low-ability members (see below).

Increasing the intensity of monitoring, *m*, raises the additional compliance or sanctioning costs of being the leader: $C_m > 0$. This reduces utility for the incumbent leader, and hence reduces the probability for candidate leaders that "running for office" is the optimal strategy. For the marginal candidate, the expected utility from being the leader may now fall below the expected utility from not being the leader. For each member, there is a threshold monitoring level, $\bar{m}_i$, where she is indifferent between being the leader and having no group leader (and for monitoring intensities greater than this personal threshold level she will prefer not to run).

Assuming $\frac{d\pi_i}{dA_i} < 0$, it can be shown that $\bar{m}_i > \bar{m}_j$ for $A_i < A_j$. In other words, for high-ability candidates the threshold monitoring level is higher than for low-ability candidates, and there exists a range of monitoring levels for which high-ability candidates decide not to run, while it is optimal for low-ability candidates to run for leadership.

But when does the condition $\frac{d\pi_i}{dA_i} < 0$ hold? To address this question, Grossman and Hanlon first show that $\frac{d\pi_i}{dA_i}$ is decreasing in outside opportunity parameter α. It follows that:

$$\frac{d^2\pi_i}{dA_i d\alpha} = \left[I_{A_i}(A_i, 1-e_i^*) - \alpha I_{A_i}(A_i, 1)\right] + \left[\alpha I_{e_i A_i}(A_i, 1-e_i^*) + (1-\alpha)(1+\beta)P_{e_i A_i}(A_i, e_i^*, R)\right]\frac{de_i^*}{d\alpha}. \quad \text{(B8)}$$

Now it can be shown, upon rearranging terms and applying a linear approximation, that:

$$\frac{d^2\pi_i}{dA_i d\alpha} < 0. \quad \text{(B9)}$$

Next, Grossman and Hanlon show that there exists a cut-off level of α above which $\frac{d\pi_i}{dA_i} < 0$, for all values of *m*. Using (B7), this cut-off level is given by:

$$\bar{\alpha} = \frac{(1+\beta)P_{A_i}(A_i, 1, R)}{I_{Ai}(A_i, 1) + (1+\beta)P_{A_i}(A_i, 1, R)} < 1. \quad \text{(B10)}$$

For all $\alpha > \bar{\alpha}$, we therefore know that $\frac{d\pi_i}{dA_i} < 0$. In other words, for "sufficiently high" opportunity costs – defined by (B10) – high-ability members will choose not to run for the leadership position at a lower level of monitoring than low-ability leaders. The highest-ability group member will first opt out of the pool of candidates as monitoring intensity increases.

From (B10) it also follows directly that $\frac{d\bar{\alpha}}{d\beta} > 0$, or that the critical level of outside income opportunity is higher for pro-socially motivated leaders. This means that group members with a stronger prosocial motivation exit out of candidacy later – the critical level of individual ability where members decide "not to run" occurs at a higher level of ability as members are more prosocial. From (B10) it also follows that $\frac{d\bar{\alpha}}{dR} > 0$, or that more able members are willing to run for the leadership for greater value of the resource stock. This follows from the assumption of complementarity between ability and resource wealth in producing the public good: $\frac{\partial^2 P}{\partial A_i \partial R} > 0$.

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