The Interdependence of Rules and Civic Values in Commons Management

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Abstract

This paper examines how the interaction between rules restricting resource use and civic values promoting cooperation affect the successful provisions of commons. Rules help maintain cooperation by upholding the beliefs of cooperators that others will not defect on their contribution. In return, the successful enforcement of these rules hinges upon costly enforcement by cooperators. Using the context of forest commons management in Ethiopia, I show that groups with both rules and civic values produce best forest outcomes than groups in which these two factors operate in isolation. Falsification tests based on detailed forest ecology suggest that these findings are not due to omitted variables. The effects arise because in groups with rules, cooperators spend much more time monitoring their forest, expect free riders to be punished, hold optimistic beliefs about the cooperation of others, and also contribute more than cooperators from groups without rules. These findings highlight the interdependence of rules and civic values in the management of commons.

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Keywords: Grazing bylaws, conditional cooperation, commons management, public goods game, Ethiopia

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I. Introduction

Common property management requires cooperation, which is difficult to achieve due to the free rider problem: individuals who do not cooperate cannot be excluded easily from using the commons. A large number of studies have underscored the importance of rules restricting resource extraction by individual users in mitigating the free rider problem (see Ostrom 1990, Tang 1991, Balland and Platteau 1996, Bardhan 2000, Dayton-Johnson 2000, Agrawal 2001, Persha et al. 2011). Another set of studies highlight the role of civic values that emphasizes cooperation provided others do the same in alleviating the free rider problem (see Coleman 1990, Putnam et al. 1993, Fukuyama 1995, Fehr and Schmidt 1999, Fischbacher and Gaechter 2010, Rustagi et al. 2010, Kosfeld and Rustagi 2015). However, the empirical evidence thus far is largely based on studying the effect of rules and civic values in isolation. This is despite the fact that theory predicts these two forces to interact with each other, resulting in multiple stable equilibria (Fehr and Schmidt 1999, Tabellini 2008, Kosfeld et al. 2009). In this paper, I attempt to fill this gap by examining how the interaction between rules restricting resource use and civic values such as conditional cooperation affects the successful management of forest commons.[1]

There are strong theoretical reasons to expect the interdependence of conditional cooperation and rules regulating resource use. The presence of conditional cooperators changes the cooperation dilemma into a coordination problem. The equilibrium selection depends on the beliefs that conditional cooperators hold about the behavior of others. If the beliefs are optimistic then cooperation is the likely outcome, but if they are pessimistic then defection is the plausible outcome. Because most groups are heterogeneous, conditional cooperators may contribute initially due to optimistic beliefs, but as they figure out the presence of free riders, they form pessimistic beliefs and start defecting as well, resulting gradually in the breakdown of cooperation (Fehr and Schmidt 1999). Given the difficulty in sustaining voluntary cooperation, rules specifying clearly the acceptable level of resource extraction and punishment of violations therefrom are considered important in upholding the beliefs of conditional cooperators about others' contribution. Since rules are often decentrally enforced in the context of commons management, there is second order free rider problem: it is individually costly to enforce rules but generates benefits for the entire group. Theory suggests that because conditional cooperators experience strong disutility from disadvantageous inequality if others defect on their contribution, they are willing to undertake costly punishment to discipline free riders (Fehr and Gaechter 2000). Thus, the successful implementation of rules hinges upon costly enforcement by conditional cooperators.

Specifically, four insights emerge: (a) groups without conditional cooperation and rules are expected to perform poorly; (b) groups with conditional cooperators alone but without any rules are unlikely to produce superior outcomes because in such groups conditional cooperators are likely to hold pessimistic beliefs about the behavior of others; (c) groups with rules alone but without conditional cooperation are also unlikely to witness superior outcomes because in these groups rules are unlikely to be enforced; (d) groups with both conditional cooperation and rules are expected to have superior outcomes because in these groups rules are enforced and

[1] Conditional cooperation is the individual propensity to cooperate provided others do the same. Sometimes, it is also referred to as positive reciprocity and trustworthiness (see for instance Fehr and Schmidt 1999 and Fehr 2009).

conditional cooperators hold optimistic beliefs about the behavior of others.

I test these insights in the context of forest commons management program in Ethiopia, which was launched in 2000 by the Oromia Government and German Organization for International Cooperation (GIZ). The purpose of the program was to mitigate high deforestation from unregulated livestock grazing that led to the absence of young trees considered vital for healthy forest growth (Kubsa and Tadesse 2002). Under the program, 56 pre-existing groups of Arsi Oromo people were offered secure property rights to manage their forest as a common property. The performance of each group in managing its commons was assessed using the count of young trees per hectare. The first assessment was conducted in 2005 and it shows large variation in outcomes: while some groups have only 13 young trees per hectare, others have over 165 young trees (mean = 66.81, s.d. 34.96). The performance data was used by the program agency to decide on group level fine. These two program features (property rights and punishment) were expected to generate incentives for groups to manage their forests successfully. However, because punishment is targeted at the entire group and not the individuals who free ride, it is unlikely to resolve the free rider problem that groups experience while managing their forest.

As mentioned before, the primary reasons behind the absence of young trees was unregulated livestock grazing, which resulted in the disappearance of young trees from browsing. The successful management of the forest thus requires groups to formulate policies that restrict the impact of livestock grazing in the forest (Amente 2005). However, only 46 percent of the groups have grazing bylaws that put restrictions on grazing inside the forest and on the same spot. I use the number of months grazing is forbidden inside the forest as a measure of grazing bylaws (mean = 1.5 months, s.d. 1.70).

Measuring conditional cooperation is challenging because such data are not readily available for groups engaged in commons management. Moreover, simple observational measures might be confounded with reputation formation, repeated interaction, and beliefs about the behavior of others. To overcome these concerns, I follow Fischbacher et al. (2001) and use a one-shot anonymous public goods game in the strategy method. In the experiment, two players are randomly assigned to an experimental group. Each player takes two contribution decisions: unconditional and conditional. In the former, players decide simultaneously on their contribution to the public good in which beliefs play a role. In the latter, the strategy method is used, whereby each player decides her contribution conditional on all possible contribution decisions of the other player (making beliefs redundant). A free rider contributes zero in all the decisions regardless of what the other player contributes, whereas a conditional cooperator increases her contribution in the contribution of the other player. Following Fischbacher et al. (2001), I use the Spearman correlation between self and other players' contribution in the conditional decision as a revealed measure of conditional cooperation (mean 0.51, s.d. 0.28). I find that all groups in the sample are heterogeneous in their type composition, comprising largely of free riders and conditional cooperators.

I regress young tree count on conditional cooperation, grazing bylaws, and an interaction term between these two variables. Identifying the effect of the interaction term on forest management outcome is very difficult. It is likely that groups with higher levels of conditional cooperation and grazing bylaws differ from other groups in observable and unobservable dimensions, resulting in selection bias. I attempt to mitigate this concern as follows. First, the study takes place in a highly contained setting where groups are homogeneous with respect to ethnicity, religion, organizational structure, and origin. Moreover, none of the groups were created, split, or merged under the program, but existed long before the program was launched. Second, I show that there is no association of pre-program forest condition with conditional cooperation, grazing bylaws, and their interaction term. I also use clan fixed effects to account for differences in clan specific characteristics. Groups are located within villages, so I also account for village fixed effects to absorb differences in village specific characteristics. Together, these steps help in alleviating the scope of pre-existing differences from driving the results. Third, I control for several important variables discussed in the literature on common property management including proxies of geography, economic heterogeneity, social heterogeneity, duration of being under the program, group size, and leader type. Fourth, I conduct a number of novel sensitivity analyses and falsification tests which increase the confidence that the main results are unlikely to be arising from omitted variables.

The results show that when considered alone neither conditional cooperation nor grazing bylaws matter for forest management success. It is rather the interaction term which enters with a large positive and significant coefficient. The marginal effect of one standard deviation increase in the interaction term is between 29 more young trees per hectare, which is large relative to a mean of 67 young trees. When a dummy variables approach is considered to account for non-linearity, the marginal effect of the interaction term turns out to be 25 more young trees and is also highly significant. Estimates from quantile regression are also similar to the OLS estimates. These results persist in magnitude and significance when I use the outcome from second forest assessment (2012-13), which is available for slightly over one-half of the groups. I proceed by conducting novel sensitivity analyses and falsification tests to alleviate further the scope of omitted variables. For this purpose, I use species specific data on the distribution of young and mature trees per hectare. Ecological evidence suggests that browsing affects the frequency of young broadleaf trees, but it has little bearing on young coniferous trees which are unpalatable to livestock. I first start by showing that the interaction term has no effect on the frequency of mature trees of either type. This is reassuring because livestock cannot browse away such trees. Second, in line with ecological studies, I show that withing the young trees the effect of the interaction term matters only for broadleaf tree species, but not for coniferous tree species. Third, within young broadleaf tree species, I show that the marginal effect of the interaction term is very large for *Hagenia abyssinica*, which is palatable to livestock and thus prone to severe browsing (Amente 2005). Again, no effect is observed for mature Hagenia trees. For these findings to be spurious, omitted variables must be specifically correlated with the frequency of young Hagenia trees, which seem highly unlikely. Overall, the results confirm the importance of the interaction between conditional cooperation and grazing bylaws for the successful management of forest commons.

Theory suggests that the successful effect of the interaction term is due to better enforcement of grazing bylaws by conditional cooperators, which in return cause conditional cooperators to hold optimistic beliefs about the behavior of others. I shed light on these mechanisms using data from individual level survey and behavioral experiment. I restrict the analyses to individuals who are classified as conditional cooperators, that is, for whom the Spearman correlation is $p - value < 0.05$ (see Fischbacher et al. 2001). Holding the behavioral type fixed, I show that conditional cooperators from groups with grazing bylaws are 100 percentage points more likely to report fewer grazing violations that conditional cooperators from groups without grazing bylaws. Moreover, data on beliefs from the unconditional decision in the public goods game also confirm this result – conditional cooperators from groups with grazing bylaws hold much more optimistic beliefs about contribution by others than conditional cooperators from groups without grazing bylaws. For these gap in beliefs to arise, grazing bylaws must be enforced. So, I show that conditional cooperators from groups with grazing bylaws spent twice as much time monitoring their forest than conditional cooperators from groups without grazing bylaws. Furthermore, in groups with grazing bylaws, conditional cooperators expect free riders to be punished with nearly 100 percent likelihood. Lastly, I show that there is a strong positive association between beliefs and contribution in the unconditional decision of the public goods game. Together, these patterns clearly suggest that enforcement leads to optimistic beliefs which then translate into higher cooperation and better forest management outcomes.

This paper contributes to the growing literature on understanding the determinants of successful provision of public goods and common property resources both in the lab and in the field. Thus far, the focus of field studies on commons management has been on the importance of civic values and policies when considered in isolation (see for instance Tang 1991, Balland and Platteau 1996, Bardhan 2000, Dayton-Johnson 2000, Agrawal 2001, Persha et al. 2011). This paper adds to the literature by studying the effect of civic values, grazing bylaws, and their interaction term. In this sense, it complements laboratory findings on the interaction between conditional cooperation and rules by taking into consideration a richer context and policy environment (Gaechter and Thoeni 2005, Gunnthorsdottir et al. 2007, Ones and Putterman 2007).

Two closely related papers are by Rustagi et al. (2010) and Kosfeld and Rustagi (2015). In these papers, the authors show a positive effect of conditional cooperation and leader punishment behavior on forest management outcomes. However, these papers (as well as the literature in general), ignore the effect of grazing bylaws as well as their interaction with conditional cooperation on forest management outcomes. The findings from this paper actually show that conditional cooperation alone has no implications for forest management success and that the entire effect comes from its interaction with grazing bylaws. As a result, previous studies might be overestimating the importance of conditional cooperation by assigning to it the effect of the interaction term. This paper therefore fills a major gap in the literature. It also uses new data made available by the program agency on the species specific distribution of young and mature trees to study carefully the effect of the interaction between conditional cooperation and grazing bylaws. In addition, the paper also highlights the importance of channels via which the interaction effects may arise using a combination of survey and experimental data not discussed before.

The paper is structured as follows: Section II describes the field setting, Section III describes data used in this study, Section IV discusses the empirical specification and strategy. Section V presents results on the association of the forest management outcome with conditional cooperation, grazing bylaws and their interaction term. Section VI discusses the channels, and Section VII offers concluding remarks.

II. Field Setting

The study takes place in the largest forest commons management program in Ethiopia. The program was launched in 2000 by German Organization for International Cooperation (GIZ) and the Oromia state government to conserve the Adaba-Dodola forest protection area. Before the program launch, the browsing of young trees by a large number of livestock led to severe forest degradation characterized by: a) high deforestation rate of 3 percent per year (Kubsa and Tadesse 2002) and, b) very low forest growth of just 1m3/hectare/year in the pre-program period (Trainer 1996).

During the program period, 56 groups located inside the forest were made direct beneficiaries of the program. The entire forest area was sub-divided into blocks and each block was placed under the management of a group. Negotiations were held across neighboring groups to reach a consensus on block boundaries. These boundaries are located deep inside the forest away from the settlements, so the negotiations did not introduce any selection at the margin via the reassignment of members to one or the other group. Each group was given formal property rights to manage its forest block as a common property. For logistical reasons, the program was rolled out over time. The program features and implementation authorities were the same in each stage.[2] Under the program, group members are allowed to graze livestock, harvest timber and non-timber forest products for self-consumption and sale, and maintain existing homesteads and farms inside the forest. In return for these benefits, the groups are required to maintain existing forest cover, restrict further expansion of agriculture and settlement inside the forest, and prevent outsiders from accessing the forest.

The performance of each group in managing its forest is to be assessed every five years by the local forest administration. During the assessment, the program agency collects data on the number of young and mature trees per hectare (see section III). The young tree count is used to determine rent that each group must pay annually to the administration. The rent is progressive and groups with lower young tree count pay a higher rent; this is expected to provide incentives for groups to manage their forest better. The first assessment was conducted in 2005. The second assessment was conducted in 2012-13 and this data are available for only some groups.

While managing their forest as a common property, group members face a free rider problem. Though there is punishment for poor performance in the form of a rent, it is targeted at the group and not the individuals who free ride. Thus, for resolving this within group free rider problem formulation and enforcement of rules regulating forest use is considered crucial to create an enabling environment for conditional cooperators. However, because rule enforcement in decentralized contexts is prone to second order free rider problem, the support of conditional cooperators is warranted for success.

[2] Group level characteristics are uncorrelated with the program stage.

III. Data

The paper uses five data sources. The data on group performance in forest management were obtained from program offices in Adaba and Dodola, and were subsequently verified using data obtained independently from the main program office in Addis Ababa. This data includes number of young and mature trees per hectare of group managed forest and is averaged over all relevant tree species. The data on grazing bylaws were obtained using in-depth community and household level surveys with group members. The data on conditional cooperation were obtained through a behavioral experiment with group members. In addition to these three sources, I also consider two new data sources. One of these is species specific number of young and mature trees per forest hectare. The other is survey and experimental data on channels via which the interaction of policies and conditional cooperation affect forest management outcomes. I describe the first three data sets below, while the remaining two are discusses in section V and VI respectively. Of the 56 groups in the study area, the paper covers 51 groups because data on outcomes was not available for two groups and a pilot was conducted in three groups which are excluded from the study.

III.A. Group Performance in Forest Management

The performance of groups in managing their forest in the program period is assessed as the number of young trees per hectare. A tree is defined as young if is two meters tall and (depending on the species) has a diameter at breast height of $\leq$40 cm or$\leq$ 25 cm. According to forestry studies, the young tree count is a robust measure of group performance in the program period because excessive browsing by livestock in the pre-program period resulted in their disappearance from the forest. Left with only mature trees, the forest would have died in a few decades. Thus, the natural regeneration of a forest depends in part on the number of young trees with a potential to form a long-term mature stand (Trainer 1996, Amente 2005).

Data on the number of young trees is available from two assessments. The first assessment was conducted in 2005 and covers all 51 groups in the sample. The second assessment was conducted in 2012 and covers only 27 of the 51 groups in the sample. I use data from the first assessment to report the main results, whereas data from the second assessment are used to show persistence in results over time. Panel A, Table 1 shows that the average number of young trees is 66.79 (s.d. 34.61) in 2005 and 62.78 (s.d. 38.79) in 2012-13. There is a strong positive correlation between the two assessments ($r = 0.78$, p-value ¡ 0.000), suggesting that the groups that performed well in 2005 also performed well in 2012-13.

In addition to the data on young trees, the program office also collected data on mature trees in 2005, as well as 2012-13. Since mature trees must have been young in the past, I consider the variation in their survival in 2005 as reflecting group performance in the pre-program period. Panel A, Table 1 shows that the average number of mature trees in 2005 is 54.88 (s.d. 19.89).

III.B. Grazing Bylaws

In the period preceding the program, browsing of young trees by high livestock numbers led to severe forest degradation. This is reflected in a large number of cattle heads estimated to be

480,000 and very low forest growth of just $1m^3$ per hectare per year in the pre-program period (Trainer 1996, Kubsa and Tadesse 2002). Consequently, bylaws regulating grazing inside the forest are considered critical for natural forest regeneration (Amente 2005).

Panel B in Table 1 shows that 46 percent of the groups have grazing bylaws. In these groups, grazing inside the forest and on the same spot is forbidden for 2-5 months in a year (the modal response is three months). The average for the full sample is 1.47 months in a year (s.d. 1.70), but 3.26 months (0.689) for the sample of groups with grazing bylaws.

The restrictions on grazing are put in place during the rainy season when tree seeds germinate. The violation of bylaws is subject to graduated sanctioning: first violation is let off with a warning, second and third violations are slapped with monetary fines per cattle, whereas fourth violation may even lead to expulsion from the group. Since forest commons involve decentralized governance, their enforcement is prone to second order free rider problem: individual group members are better off if others pay the cost to enforce the bylaws.

III.C. Conditional Cooperation

Measuring conditional cooperation in the field is challenging due to confounding motivations accruing from repeated interactions and reputation formation. In addition, it is very difficult to infer the absence of conditional cooperation from groups in which little cooperation is observed because of multiple equilibria arising from differences in beliefs about the behavior of others: conditional cooperators with optimistic beliefs are expected to cooperate, whereas those with pessimistic beliefs are expected to defect. Thus, it is plausible that groups with similar degrees of conditional cooperation are classified differently, resulting in a large measurement error. To circumvent these concerns, I follow Fischbacher et al. (2001) and Fischbacher and Gächter (2010) and elicit conditional cooperation in a one-shot anonymous public goods game. The game is implemented in the strategy method, which allows me to reliably measure conditional cooperation by making beliefs redundant, but without inducing any bias (Brandts and Charness 2011, Fischbacher et al. 2012). The instruction and procedures are listed in Rustagi et al. (2010).

The Experiment. – During the game, two players were randomly assigned to an experimental group. Each player received an endowment of six bills of one Ethiopian Birr (the daily wage) and had to decide how many bills to keep in his pocket and how many to contribute to a public good called "project". Any amount in the project was multiplied by 1.5 and then distributed equally between the two players, regardless of their contribution. Because the marginal per capita return from contributing one Birr to the project is 0.75, it is always in the material self-interest of a player to contribute nothing. Yet, if both players contributed their entire endowment, each player's earnings increased from 6 to 9 Birr; this created a cooperation dilemma similar to what members experience while managing their commons.

Each player took an unconditional and a conditional decision in the game. In the unconditional decision, players contributed simultaneously and stated their beliefs about the contribution of the other player. In the conditional decision, the strategy method was used, wherein players were visualized one-by-one the seven possible contribution decisions of the other player and then asked to state their own contribution for each of these, making beliefs redundant. The payoff of player i is given by:

$$\pi_i = 6 – C_i + 0.75(C_1 + C_2), \tag{1}$$

where $i = (1, 2)$, C_i denotes contribution of player i to the project, 0.75 is the marginal per capita return from investing into the public good, and $(C_1 + C_2)$ is the total value of the public good. To ensure incentive compatibility, both decisions were made payoff relevant. A die was rolled to determine for which player the unconditional decision is taken; this was matched with the other player's conditional decision to calculate payoffs.

The experiment and the first round of household and community survey were conducted from March-May in 2008. This was the first time ever that individuals took part in an experiment. Each session lasted about three hours including instructions (see Appendix C). Of the 1349 members residing in 51 groups, 709 members took part in the experiment, implying a response rate of 53 percent. On average, each player earned 7.5 Birr, which is slightly over one day's wage in 2008 in the largest town in study area.

Measuring conditional cooperation. – Following Fischbacher et al. (2001) and Fischbacher and Gächter (2010), I calculate for each player the Spearman correlation between self and other player's contribution in the conditional decision. The higher the Spearman ρ the higher is the propensity to cooperate conditionally. I then aggregate the Spearman ρ over individuals from a group to obtain group specific averages. If a group comprises chiefly of conditional cooperators, the average Spearman ρ will be close to 1, but zero if it is dominated by free riders. Though, the Spearman ρ is also zero for altruists and other types of flat contributions, the share of these two types in the sample is negligible (< 2 percent each). The average propensity to cooperate conditionally in the sample is 0.495 (s.d. 0.276, Table 1, Panel B).

III.D. Descriptive Statistics

Figure 1 shows the raw association of young trees per hectare with conditional cooperation, grazing bylaws and an interaction between the two. It is based on indicator variables for conditional cooperation whereby '1' means conditional cooperators are in majority (average Spearman *rho* = 0.72), otherwise '0' (average Spearman *rho* = 0.27) and grazing bylaws whereby '1' means grazing bylaws are present, otherwise '0'.

(i) Category 0 includes groups with conditional cooperators = 0 and grazing bylaws = 0
(ii) Category 1 includes groups with conditional cooperators = 1, but grazing bylaws = 0
(iii) Category 2 includes groups with conditional cooperators = 0 but grazing bylaws = 1
(iv) Category 3 includes groups with conditional cooperators = 1 and grazing bylaws = 1

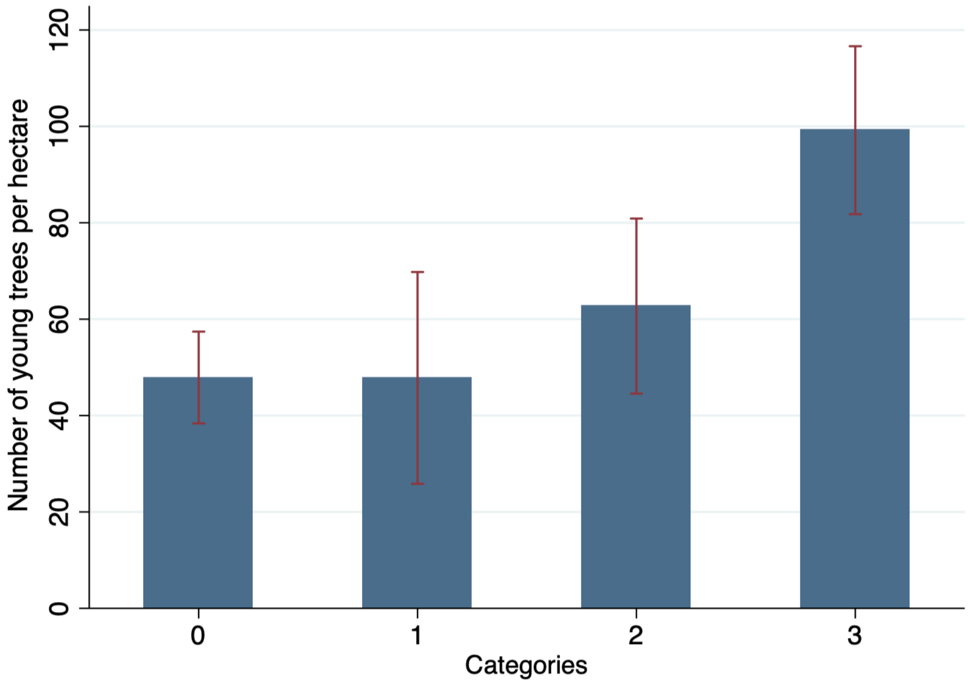

Figure 1: Association of young trees with conditional cooperation, grazing bylaws and their interaction term

Notes: The categories are based on indicator variables for conditional cooperators are in majority (1=majority, 0=otherwise) and the presence of grazing bylaws (1=Present, and 0=Absent). In category 0, conditional cooperation = 0 and grazing bylaws = 0; in category 1, conditional cooperation = 1, grazing bylaws = 0; in category 2, conditional cooperation = 0, grazing bylaws = 1; and in category 3, conditional cooperation = 1, grazing bylaws = 1. Category 3 shows the total effect of the interaction term, which is highly significantly different from zero. The marginal effect of the category 3 is also statistically significant.

The average forest management outcome in groups from the baseline category is 48 young trees per hectare. The performance of groups from category 1 is indistinguishable from the performance of groups in category 0 (marginal effect = -0.09 young trees), suggesting that having conditional cooperators in majority alone does not lead to better forest outcomes. Although, the performance of groups in category 2 is slightly higher than in groups from category 0 (marginal effect = 14.81 young trees), the difference is not statistically significant (p-value > 0.30); this suggests that having grazing bylaws alone also does not lead to better forest outcomes either. However, the performance in groups from category 3 wherein conditional cooperators are in majority and grazing bylaws are present witness much better forest outcomes (marginal effect = 35 young trees) and the difference is also statistically significant (p-value < 0.05).

IV. Empirical Specification and Strategy

To estimate the effect of conditional cooperation, grazing bylaws, and their interaction on commons management success, an ideal experiment is the one in which the researcher a) sorts individuals by types (conditional cooperators or free riders) to form groups exogenously, such that some groups comprise primarily of conditional cooperators, some both conditional cooperators and free riders, and others primarily of free riders; b) stratifies groups by the share of conditional cooperators and randomly assigns grazing bylaws to one-half of the groups within each stratum. A key advantage of this approach is that random assignment ensures conditional cooperation, grazing bylaws, and their interaction is uncorrelated with covariates.

However, such clean experimental data may be difficult to obtain because it is impossible to form groups exogenously and then randomly assign bylaws to some but not the others outside the lab. Thus, researchers often have to deal with observational data which is prone to omitted variables bias – groups with higher levels of conditional cooperation and grazing bylaws differ from the rest in many observable and unobservable dimensions. One way to alleviate this concern is to use instrumental variables strategy. However finding instruments that affect only conditional cooperation and not grazing bylaws and vice versa is very difficult as the exclusion restrictions are unlikely to hold, inducing even more bias.

In the face of these limitations, I combine a number of identification strategies to mitigate this concern. I model the association of forest management outcomes with conditional cooperation, grazing bylaws, and their interaction term using the following OLS specification which is in the spirit of differences-in-difference estimation:

$$y_{icv} = \alpha_0 + \alpha_1 y_{icv0} + \beta CC_{icv} + \gamma GB_{icv} + \delta(CC * GB)_{icv} + \mathbf{X}_{icv}\lambda + \theta_c + \eta_v + \epsilon_{icv} \qquad (2)$$

where y_{icv} is the average number of young trees per hectare in group i with dominant clan c, and village v. y_0 is the pre-program forest management outcome. CC is the average propensity to cooperate conditionally, GB is number of months grazing inside the forest is forbidden, and $CC * GB$ is the interaction term. $\mathbf{X}$ is a vector of control variables that are hypothesized in the literature to matter for commons management success. θ_c and η_v are fixed effects for the dominant clan in the group and the village in which the group is situated. ϵ_{icv} is an idiosyncratic error term. The coefficients of interest are β, γ, and δ, which capture respectively the effect of conditional cooperation alone, grazing bylaws alone, and the marginal effect of the interaction term between conditional cooperation and grazing bylaws on forest management outcome. To the extent the groups comprise of both free riders and conditional cooperators, β and γ are not expected to be significantly different from zero. In contrast, δ is expected to be positive and $>$ 0.

Following seminal studies on commons management (Ostrom 1990, Balland and Platteau 1996, Bardhan 2000, and Agrawal 2001), I control for a variety of important variables. These include pre-program group performance, proxies of geography (elevation, forest type, border with non-forest areas), proxies of economic heterogeneity (market distance, Gini of cattle ownership), social heterogeneity (share of female members, clan heterogeneity, settlement fragmentation), duration of being under the program (months), and group size. In addition, while conducting robustness checks, I further control for leader type (Koseld and Rustagi 2015) and Gini of land ownership.

A key concern in identifying the effect of the interaction term on forest management outcome is the selection bias. As the thought experiment described above lays out, for these effects to be interpreted as causal, we need exogenous formation of groups and random assignment of grazing bylaws. Historical records by eminent historians concur that the Arsi Oromo formed clan-based settlements in the historical past (Pankhurst 1998). From the survey data on the clan of each household in the study area, I see that 85 percent of the people still reside in their ancestral clan homeland. Therefore, I can use clan fixed effects to absorb pre-existing clan specific differences. In addition, the groups today are part of a larger administrative unit called *kebele*, which is synonymous with a village. To ensure that the interaction term is not picking up village specific differences, I also include village fixed effects. Thus, the combination of clan and village fixed effects allows me to mitigate the concern over omitted variables bias from non-random formation of groups.

It is plausible that groups with different levels of conditional cooperation and grazing bylaws differ in their pre-program forest outcomes. I show in Table 2 that this is not the case. The mature tree count is uncorrelated with conditional cooperation, grazing bylaws, as well as their interaction term. The coefficients are not only very small in magnitude but are also individually as well as jointly statistically insignificant. Moreover, since the specification in equation 2 controls for the mature tree count, the omitted variables bias must come from sources that affect young tree count independently of mature trees. To gauge the scope of some of these factors, I show in Table 2 that other proxies of forest condition, such as forest area per person, forest area per cattle, and the importance of forest in the livelihood of group members is uncorrelated with conditional cooperation, grazing bylaws, and their interaction term.

Another possibility is that groups with higher levels of conditional cooperation and grazing bylaws experienced in the assessment year favourable weather conditions resulting in better forest outcomes. I doubt that this was the case, as the groups cover a small geographical area and experience very similar weather shocks. Nonetheless, to alleviate this concern, I use data from the second assessment to test whether the results still persist over time.

Finally, I conduct novel sensitivity analyses and falsification tests which tighten the scope of omitted variables. Studies in ecology suggest that livestock grazing affects primarily the frequency of young broadleaf trees, but it has no consequences for young coniferous trees as these are unpalatable to livestock (Regassa 2003, Tesfaye et al. 2002). Therefore, I expect the interaction term to have a bearing only on the count of young broadleaf trees but not young coniferous trees. In addition, since livestock browsing cannot take mature broadleaf and mature coniferous trees from the forest, the interaction term should have no bearing on the count of mature trees of either type. Finally, ecological studies find that one particular tree species called *Hagenia abbysinica* is particularly prone to livestock browsing because of the nutritive value of its leaves (Amente 2005). Consequently, I test whether the interaction term matters for the survival of young trees of this species, without affecting the mature ones. Together, for these effects to be driven by bias, the omitted variables must be correlated with factors affecting specifically the count of young Hagenia trees, which besides the grazing ban, seem very unlikely.

V. Results

Table 3 presents the main results. Since conditional cooperation, grazing bylaws and their interaction term are measured on different scales, I standardize these variables using z-scores to make the coefficients comparable. Column 1 is without any controls and shows that the coefficients on conditional cooperation (CC) and bylaws alone (GB) are small in magnitude and also individually as well as jointly statistically insignificant (see p-value = 0.35). However, the coefficient on the interaction term (CC*GB) is large in magnitude and statistically significant at the 5-percent level. According to this estimate, one standard deviation increase in the interaction term increases marginally young tree count by 21 trees, which is a large economic effect. Moreover, the three variables explain 50 percent of the variation in the outcome.

In column 2, I account for the pre-program outcome, measured as the number of mature trees per hectare. It enters with a positive and statistically significant coefficient. Nonetheless, the coefficient on the interaction term remains stable in magnitude and significance. This is expected, for in Table 2 we saw that the interaction term is uncorrelated with the mature tree count. In column 3, I introduce control variables including proxies of geography, economic heterogeneity, social heterogeneity, and the timing of program launch. This does not lead to any major changes in the coefficient on the interaction term, which is now significant at the 1-percent level. In column 4, when I additionally introduce a vector of clan and village fixed effects, the coefficient on the interaction term rises in magnitude to 29 trees and remains significant at the 1-percent level.

One concern could be that these estimates do not account for non-linearity, so I also report estimates using the interaction between indicators variables for conditional cooperation and grazing bylaws (see section III. D) in column 5. The coefficient on the interaction term is positive and statistically significant at the 1-percent level. Its magnitude is similar to previous estimates and suggest that in groups with both higher levels of conditional cooperation and grazing bylaws, the young trees count is higher by 25 trees, which is economically very large.[3]

The results from quantile regressions are very similar to their OLS counterparts and fall within the confidence interval of the OLS estimates. This could be because in most groups conditional cooperation does not exceed 0.8, and the mean and the median are also very similar.

Another concern discussed above is that these effects are due to some weather shocks that positively impacted groups with higher conditional cooperation and grazing bylaws, but negatively the remaining groups. To counteract this concern, I show in columns 6-7 that these effects hold even when I consider the second forest management outcome which is available only for slightly over one-half of the groups in the sample. Moreover, the magnitude of the coefficients obtained either using the continuous measures of conditional cooperation and grazing bylaws (column 6) or indicator variables (column 7) leads to estimates that are similar to those obtained from the first assessment.

In contrast the coefficient on conditional cooperation alone and grazing bylaws alone are mostly negative, small in magnitude, and statistically insignificant. One reason behind the negative coefficient on grazing bylaws is that when such bylaws exist but are not enforced it might lead to more frustration than otherwise, resulting in even more negative outcomes.

[3] These estimates are robust to dropping one group at a time and controlling for other variables, such as Gini of land and leader type (results available upon request).

V.A. Sensitivity Analysis and Falsification Tests

The above results suggest a robust effect of the interaction term between conditional cooperation and grazing bylaws on forest management outcome. Nonetheless, it is plausible that these effects are capturing the effect of some omitted variables. To mitigate this concern, I combine sensitivity analysis with falsification tests to ensure that these effects are not spurious and that they arise due to the interaction of conditional cooperation and grazing bylaws.

For this purpose, I use a new dataset obtained from the forest commons management program office for 38 of the 51 groups.[4] The dataset contains the distribution of young and mature trees in the forest from 12 different species. These species are classified into two divisions based on the diameter that can be attained at maturity.

Division I tree species. – are those that attain a diameter at breast height (DBH) of < 40 cm at maturity. This includes seven species *Juniperus excelsa, Podocarpus falcatus Hagenia abyssinica, Ekebergia capensis, Scheffleria abyssinica, Olea europea africana, and Mytenus species.* These species are further organized into two sub-divisions, those that are "very young" (DBH of < 20 cm) and those that are intermediate (20<DBH<40).

Division II tree Species. – are those that attain a DBH of < 25 cm at maturity. This includes five tree species *Hypericum lanceolatum, Rapanea melanphloeos, Nuxia congesta, Buddleya polystachia, Erica arborea, Pittosporum viridiflorum, and others.* The trees from this division are not organized into further sub-divisions.

Altogether, there are 19 observations per group on the average frequency of trees per forest hectare: 14 from Division I species (seven each from the two sub-divisions) and 5 from Division II species.

To conduct sensitivity analysis and falsification tests, I use the following OLS specification:

$$y_{idgv} = \alpha_0 + \beta CC_{idgv} + \gamma GB_{idgv} + \delta(CC * GB)_{idgv} + \mathbf{X}_{idgv}\lambda + \omega_d + \theta_c + \eta_v + \epsilon_{idgv}, \quad (3)$$

where y_{icg} is number of young trees of species i, from division d, in forest common managed by group g, located in village v. As before, CC is the average propensity to cooperate conditionally in a group, GB is the number of months grazing is forbidden inside the forest, and $CC * GB$ is the interaction between the two. X is a vector of control variables listed in equation 1. ω_d is a fixed effect for the tree division, θ_c is a fixed effect for the dominant clan in the group, η_v is a fixed effect for the village in which the group is located, and ϵ_v is an error term.

In the Afromontane ecosystem of the Bale Mountains, the forest comprises of broadleaf and coniferous trees. Since cattle browse on young broadleaf tree species, it can have severe consequences on their abundance in the forest. Thus in groups with both higher levels of conditional cooperation and grazing bylaws, the frequency of young broadleaf tree species is expected to be higher. In contrast, there should not be any effect on the count of young

[4] I verify that the main results hold when I use a sample of these 38 groups. In this case, the coefficient on the interaction term is 27.128, s.e. 11.234.

coniferous tree species, as these are not susceptible to browsing by cattle. Furthermore, since cattle cannot damage mature trees from browsing, there should be no effect of the interaction term on mature trees of either the broadleaf or the coniferous types.

Figure 2 displays these patterns after controlling for altitude only, which is crucial for specific specific distribution of trees. It is evident from the figure that the interaction term has no effect on mature broadleaf trees, mature coniferous trees, and young coniferous trees. However, it has a positive effect only on the distribution of young broadleaf trees, which is also significant at the 5-percent level.

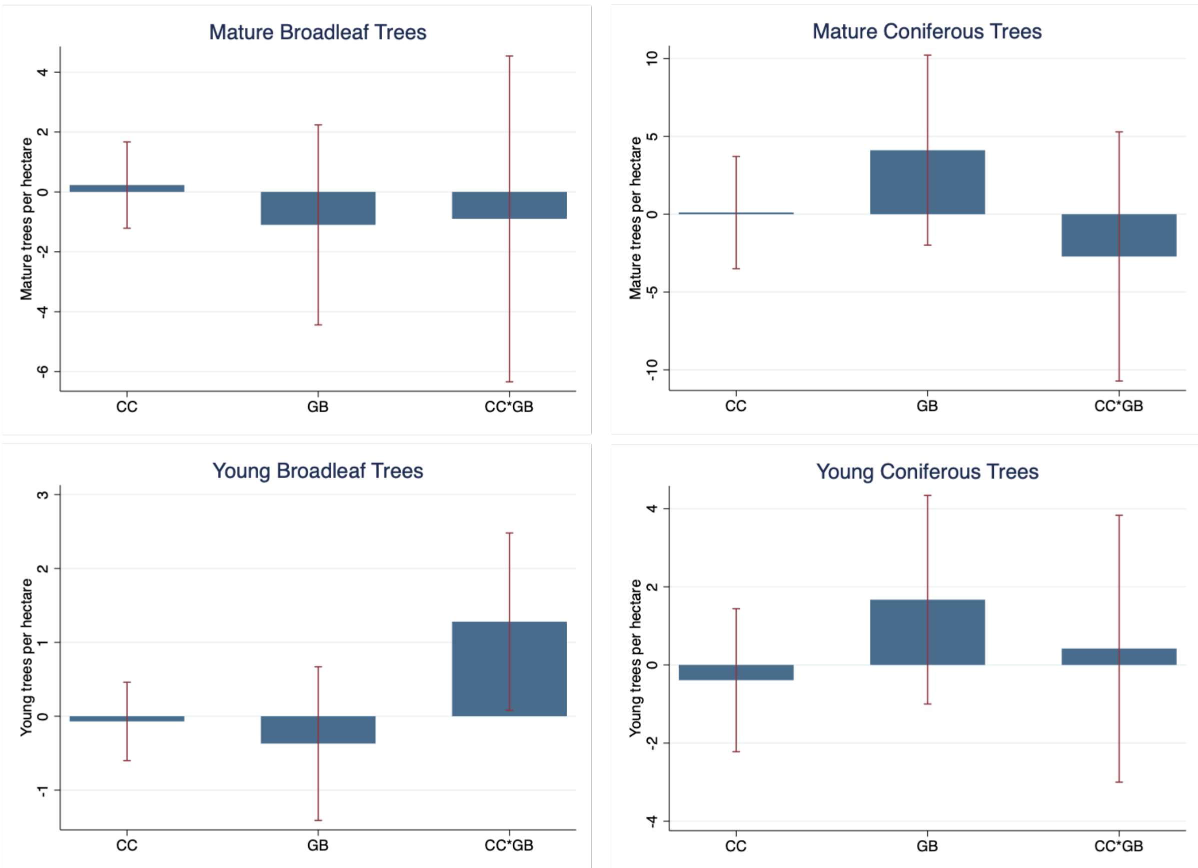

Figure 2: Distribution of Mature and Young Broadleaf and Coniferous Trees, Conditional Cooperation, Grazing Bylaws, and their Interaction Term

Notes: CC stands for conditional cooperation, GB stands for grazing bylaws, and CC*GB stands for the interaction between the these two variables. The upper panel displays results for mature trees, whereas the lower panel does this for young trees. The left panel displays results for broadleaf trees and the right panel for coniferous trees.

Table 4 confirms these results after controlling for relevant covariates from Table 1. As before, the coefficients are standardized. I start by showing in columns 1-2 that there is indeed no effect of the interaction term on mature broadleaf or mature coniferous trees. The coefficient on the interaction term is not only small in magnitude but it is also statistically insignificant. These results suggest that for the bias to arise, the omitted variable(s) must be correlated with the count of young and not mature trees. To alleviate this concern, I conduct a within young tree analyses. Column 3 shows that the interaction term is positively and significantly associated with the count of young broadleaf trees. Specifically, one standard deviation increase in the interaction term increases young broadleaf tree count, on average, by 1.38 tree per species per hectare. This is a large effect given that the mean count is 2.99 young broadleaf trees per hectare. Since there are 19 types of young broadleaf trees (7 young ones of Division 1, 7 intermediate ones of Division I, and 5 young ones of Division II), the mean over all tree species is 26 trees per hectare (1.38 * 19). In contrast, the interaction term has no effect on the count of young coniferous trees. The coefficient is not only small in magnitude relative to its mean of 8.28 but it is also statistically insignificant. Also, since there are only four types of coniferous trees (2 young ones of Division I and 2 intermediate ones of Division I), this estimate is not economically significant. These findings therefore suggest that for the results to be spurious, the omitted variable must be correlated with broadleaf tree species, which seems implausible.

To mitigate the scope of omitted variables even further, I consider within broadleaf tree analysis. Ecological studies show that one broadleaf tree species – *Hagenia abyssinica* – is particularly vulnerable to livestock browsing because of the nutritive value of its leaves (Amente 2005, Regassa 2003, Tefaye et al. 2002). Consequently, in groups where grazing bylwas are enforced the count of young Hagenia is expected to be higher but that of mature Hagenia should remain unaffected. I perform this test in Table 5. Column 1 shows that the interaction term has a large positive effect on the count of young Hagenia trees and is also statistically significant at the 5 percent level. One standard deviation increase in the value of the interaction term increases the marginal count of young Hagenia trees by 0.5 per hectare, which is very large given the mean count is 0.75 per hectare. As before, since there is young and intermediate Hagenia, the estimates imply that there is one young Hagenia tree per hectare. In contrast, no effect is observed for mature Hagenia.

Overall, these effects confirm that the interaction effects are unlikely to be spurious, for now the omitted variable has to affect not only young and mature trees differently, but also broadleaf and coniferous trees. In addition, it must affect young and mature of the same species (Hagenia) differently, which seems highly unlikely.

VI. Plausible Channels

The above findings raise an important question: why do conditional cooperation and grazing bylaws matter for commons management success only when they are present together in groups? Theory suggests that this is because:

(a) It is easier for group members to define acts of grazing violation and also target punishment towards those who violate bylaws. Since the enforcement of grazing bylaws is through decentralized monitoring and punishment of free riders, it is expected to be stronger in groups with higher level of conditional cooperation;

(b) Enforcement generates strong incentives for free riders to cooperate, resulting in upholding the beliefs of conditional cooperators that others will not defect on their cooperation;

(c) Conditional cooperators cooperate only if the expect others to do the same. Thus, having optimistic beliefs results in higher contribution levels.

I provide evidence in support of these channels using individual level survey and behavioral data on (i) enforcement of bylaws through time spent monitoring the forest, (ii) likelihood that free riders will be punished, (iii) belief that the violation of grazing bylaws is infrequent, (iv) beliefs about contribution by the other player in the public goods game, and (v) association between beliefs and contribution. The difference in these outcomes across individuals who behave as conditional cooperators but come from groups with or without grazing bylaws is expected to be positive. Specifically, I test for

$$[y|GR = 1, CC = 1, X] > E[y|GR = 0, CC = 1, X], \tag{4}$$

where y is one of the outcomes described above. This constitutes a powerful test, as it allows me to compare outcomes across conditional cooperators with and without grazing bylaws while holding the behavioral type of an individual fixed. An individual is categorized as a conditional cooperator if the Spearman correlation is significant at p-value ≤ 0.05 (see Fischbacher et al. 2001, Fischbacher and Gaechter 2010).

Table 5 reports the results using the extensive margin of grazing bylaws in panel A and the intensive margin in Panel B. In column 1, the dependent variable is time spent monitoring the forest in a month (hours). The coefficient on grazing bylaws is positive and highly significant at the 1-percent level. The magnitude of the coefficient implies that conditional cooperators from groups with grazing bylaws spent twice as many hours monitoring their forest that conditional cooperators from groups without bylaws. Column 2 shows that the effect of this increased monitoring is the higher likelihood that free riders will be punished. In groups with grazing bylaws, this likelihood is 100 percentage points higher than in groups without grazing bylaws.

Columns 3 shows that in response to higher monitoring and punishment likelihood of free riders, conditional cooperators from groups with grazing bylaws hold optimistic beliefs and think that activities that contribute towards deforestation are uncommon. The coefficient on grazing bylaws is positive and statistically significant at the 1-percent level. The magnitude of the coefficient in panel A is 0.36, which is 60 percentage points higher than the baseline and implies that 97 percent of conditional cooperators from groups with grazing bylaws perceive activities resulting in deforestation to be uncommon. In column 4, I use data from behavioral experiment on beliefs about the contribution by the other player in the unconditional decision. The coefficient on grazing bylaws is positive and statistically significant at the 5 percent level in panel A and 1 percent level in panel B. The magnitude of the coefficient in panel A implies that conditional cooperators from groups with grazing bylaws have higher beliefs over others' contribution by nearly 20 percentage points than conditional cooperators from groups without grazing bylaws.

In Table 7, I further show that there is a strong positive association between beliefs and contribution in the public goods game, which is also statistically significant. This confirms that conditional cooperators with optimistic beliefs contribute significantly more than conditional co-operators with pessimistic beliefs. Together, these results explain why the interaction between conditional cooperation and grazing bylaws leads to better forest management outcomes.

VII. Conclusions

Many field studies have demonstrated the importance of policies and civic cooperation in the management of commons. However, we know little about how the interaction between these two forces affects commons management outcomes. Though theoretical and laboratory findings suggest these factors to reinforce each other in the context of cooperation dilemmas, field evidence is missing.

I attempt to fill this gap using the context of forest commons management program in Ethiopia, which was launched to arrest deforestation arising from livestock browsing. Under the program groups were offered secure property rights to manage their forest as a common property forest and an external group level punishment was put in place for poor performance, measured as the number of young surviving trees. I focus on grazing bylaws which forbid members from grazing their livestock inside the forest for certain months in a year to allow young trees to grow. To measure civic values, I focus on conditional cooperation, defined as the propensity to cooperate provided others do the same. It is measured using a behavioral experiment which precludes confounding motives and beliefs from playing a role.

In line with the theory, I show that best forest management outcomes are observed in groups with both higher levels of conditional cooperation and grazing bylaws. In contrast, groups with higher levels of conditional cooperation or grazing bylaws alone do not perform better than groups with lower levels of both of these. These results are robust to accounting for pre-existing differences in forest condition across groups, clan fixed effects, and village fixed effects. Moreover, the effects persist over time. Further sensitivity analyses together with falsification tests show that the effect is observed only for young trees that are prone to browsing damage but no effect is observed for mature trees that are not prone to browsing. Within young trees, the effects hold only for broadleaf trees that the livestock browse upon, but not for coniferous trees that are unpalatable to livestock. Within young broadleaf trees, the largest effects are observed for the species that is most palatable to livestock.

Finally, I use survey and experimental data to shed some light on the mechanisms. I find that in groups with grazing bylaws, conditional cooperators spent much more time monitoring their forest and expect free riders to be punished. As a consequence, they also hold optimistic belief about the behavior of others in both the survey and the experiment. Lastly, beliefs are positively associated with cooperation behavior in the experiment.

These findings have important policy implications. Since decentralized management of commons and public goods is likely to be successful in groups with both conditional cooperation and policies targeting resource use, the program agencies may offer together with property rights and punishment, policies targeting resource use. This might help in upholding the beliefs of conditional cooperators that others will not defect on their contribution. Future studies might consider testing this in the context of randomized field experiments.

References

Amente, G. 2005. "Rehabilitation and Sustainable Use of Degraded Community Forests in the Bale Mountains of Ethiopia," Freiburg im Breisgau: Faculty of Forest and Environmental Sciences, Albert-Ludwigs University, 161.

Baland, J.M., and J.P. Platteau. 1996. Halting Degradation of Natural Resources. Food and Agricultural Organization of the United Nations and Oxford University Press.

Bardhan, P.K. 2000. "Irrigation and Cooperation: An Empirical Analysis of 48 Irrigation Communities in South India," *Economic Development and Cultural Change*, 48, 847-865.

Brandts, J. and G. Charness. 2011. "The Strategy Versus the Direct-Response Method: A First Survey of Experimental Comparisons," *Experimental Economics*, 14, 375-398.

Coleman, J. S. 1990. Foundations of Social Theory. Cambridge: Harvard University Press.

Dayton-Johnson, J. 2000. "Determinants of Collection Action on the Local Commons: A Model with Evidence from Mexico," *Journal of Development Economics*, 62, 181-208.

Fehr, E. 2009. "On the Economics of Biology and Trust," *Journal of the European Economic Association*, 7, 235-266.

Fehr, E. and S. Gaechter. "Cooperation and Punishment in Public Goods Experiments," *American Economic Review*, 90, 980-994.

Fehr, E., and K. Schmidt.1999. "A Theory of Fairness, Competition, and Cooperation," *Quarterly Journal of Economics*, 114, 817-868.

Fischbacher, U., S. Gaechter, and E. Fehr. 2001. "Are People Conditionally Cooperative: Evidence From a Public Goods Experiment," *Economic Letters*, 71, 397-401.

Fischbacher, U., and S. Gaechter. 2010. "Social Preferences, Beliefs, and the Dynamics of Free Riding in Public Goods Experiments," *American Economic Review*, 100, 541-556.

Fischbacher, U., S. Gaechter, and S. Quercia. 2012. "The Behavioral Validity of the Strategy Method in Public Goods Experiments," *Journal of Economic Psychology*, 33, 897-913.

Fukuyama, F. 2000. "Social Capital," In Culture Matters: How Values Shape Human Progress, edited by Lawrence E. Harrison and Samuel P. Huntington. Basic Books.

Gaechter, S. and C. Thoeni. 2005. "Social Learning and Voluntary Cooperation among Like-Minded People," *Journal of the European Economic Association*, 3, 303-314.

Gunnthorsdottir, A., D. Houser, and K. McCabe. 2007. Disposition, history and contributions in public goods experiments. *Journal of Economic Behavior and Organization*, 62(2), 304–315.

Kosfeld, M., A. Okada, and A. Riedl. 2009. "Institution Formation in the Public Goods Game," *American Economic Review*, 99, 1335-1355.

Kosfeld, M. and D. Rustagi. 2015. "Leader Punishment and Cooperation in Groups - Experimental Field Evidence from Commons Management in Ethiopia," American Economic Review, 105, 747-783.

Kubsa, A. and T. Tadesse. 2002. "Granting Exclusive User Rights to the Forest Dwellers in the

State-Owned Forest: The Wajib Approach in Ethiopia." Rome: FAO, 89-98.

Ones, U. and L. Putterman. 2007. "The Ecology of Collective Action: A Public Goods and Sanctions Experiment with Controlled Group Formation," *Journal of Economic Behavior and Organization*, 62, 495-521.

Ostrom, E. 1990. Governing the Commons: The Evolution of Institutions for Collective Action. New York: Cambridge University Press.

Persha, L., A. Agrawal, and A. Chhatre. 2011. "Social and Ecological Synergy: Local Rule-making, Forest Livelihoods, and Biodiversity Conservation," *Science*, 331, 1606-1608.

Pankhurst, R. 1998. The Ethiopians. Oxford: Blackwell Publications.

Putnam, R., R. Leonardi, and R. Y. Nanetti. 1993. Making Democracy Work: Civic Traditions in Modern Italy. New York: Simon and Schuster.

Regassa, A. 2003. Impact of WAJIB forest management on structure and regeneration of indigenous tree species-the case of Adaba-Dodola regional forest priority area. MSc Thesis, Swedish University of Agricultural Sciences and Wondo Genet College of Forestry, Wondo Genet, Ethiopia.

Rustagi, D., S. Engel, and M. Kosfeld. 2010. "Conditional Cooperation and Costly Monitoring Explain Success in Forest Commons Management," *Science*, 330, 961-965.

Tabellini, G. 2008. "The Scope of Cooperation: Values and Incentives," *Quarterly Journal of Economics*, 123, 905-950.

Tang, Shui-Yan. 1992. Institutions and Collective Action: Self-Governance in Irrigation Systems. San Francisco: ICS Press.

Tesfaye, G., D. Teketay, M. FETENE. 2002. "Regeneration of Fourteen Tree Species in Harenna Forest in Southern Ethiopia,". *Flora* 197, 461-474.

Trainer, J. 1996. "Forest Inventory of Indigenous Forest of Pilot Area Peasant Associations: Denaba, Bura, Burachele-Adele," Dodola, Ethiopia: IFMP, 19.

Tables

Table 1: Summary Statistics

	Mean	Std. Dev.
	A: Forest Outcome	
Young trees per hectare	66.792	34.611
Mature trees per hectare	54.883	19.887
	B: Main Variables	
Conditional cooperation	0.495	0.276
Months grazing is forbidden	1.471	1.701
Interaction term	0.958	1.187
	C: Control Variables	
High altitude forest	0.112	0.229
Plantation forest	0.067	0.332
Border with outsiders	0.608	0.493
Market distance	2.631	0.949
Gini cattle ownership	0.337	0.081
Female share	0.200	0.114
Settlement fragmentation	0.550	0.182
Clan heterogeneity	0.393	0.234
Duration (months)	22.922	19.913
Group size	26.451	4.553

Notes: Young tree count is the number of young trees in a hectare of group managed forest. Mature tree count is the number of mature trees in a hectare of group managed forest. Conditional cooperation is the Spearman rho in the conditional decision of the public goods game. Months grazing is forbidden is the number of months in a year group members are forbidden to graze their livestock inside the forest. Interaction term is the interaction between conditional cooperation and months grazing is forbidden. High altitude forest is the share of total forest managed by the group that is above 3100m. Plantation forest is the share of group managed forest that is planted and not natural. Border with outsiders is an indicator variable that equals 1 if groups share a border with outsiders (groups that are not under the program). Market distance is the number of hours on foot weighted by equine ownership to the nearest market (one-way only). Female share is the share of females who are officially registered as group members. Settlement fragmentation and clan heterogeneity are measured using Herfindahl index. The index varies from 0 to 1 and measures the probability that two persons selected randomly from a group will not be from the same settlement / clan. Gini of cattle ownership is the Gini coefficient of cattle wealth. Duration is the number of months a group has been under the forest management program. Group size is the number of households registered officially as members. The number of observations is 51.

Table 2: Pre-existing Differences
and the Interaction of Conditional Cooperation and Grazing Bylaws

	Pre-Program outcome (1)	Forest area per person (2)	Forest area per cattle (3)	Forest importance (4)
CC	-0.681	0.075	-2.566	-0.051
	(3.572)	(0.419)	(5.697)	(0.044)
GB	-3.000	-0.281	0.821	-0.070
	(6.503)	(0.423)	(7.216)	(0.158)
CC*GB	2.141	0.015	-1.626	0.047
	(8.120)	(0.619)	(9.334)	(0.170)
Constant	54.883	2.748	41.484	1.596
	(2.864)	(0.260)	(3.171)	(0.040)
R^2	0.01	0.02	0.02	0.05
p-value	0.35	0.77	0.68	0.49
Obs	51	51	51	51

Notes: OLS estimates with robust standard errors in parentheses. CC stands for conditional cooperation, GB for grazing bylaws and CC*GB for the interaction between these two variables. The coefficients are comparable to each other as the variables are standardized. In column 1, pre-program performance is measured as the number of mature trees per hectare. In column 2, forest area per person is the forest area in hectares per person in a group. In column 3, forest area per cattle is the forest area in hectares per cattle. In column 4, forest importance is the average of individual responses on the importance of forest in livelihood on a scale of 1-3, where 1 means no importance, 2 means medium importance, and 3 means high importance. CC stands for average propensity for conditional cooperation in a group, GB stands for grazing bylaws, and CC * GB is the interaction between these two variables. The p-value is of the joint significance of CC, GB, and CC*GB.

Table 3: Forest Management Outcome
and the Interaction of Conditional Cooperation and Grazing Bylaws

	Dependent variable: Young trees per hectare						
	2005					2012-13	
	No controls	Pre-program outcome	Control variables	Fixed effects	Indicator variables	Control variables	Indicator variables
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CC	−2.803	−2.452	−2.517	−1.926	−4.717	−3.586	−2.463
	(4.200)	(2.766)	(2.717)	(3.303)	(5.737)	(6.181)	(9.494)
GB	5.044	6.587	−13.433	−21.900	−7.349	−15.368	−13.393
	(7.382)	(7.064)	(7.970)	(10.874)	(13.879)	(7.929)	(9.720)
CC*GB	21.103	20.002	22.115	29.497	25.474	24.058	26.794
	(8.277)	(7.909)	(7.656)	(9.636)	(12.526)	(8.727)	(10.103)
Constant	66.792	38.562	64.355	35.783	67.062	75.202	97.578
	(3.550)	(10.811)	(23.854)	(29.133)	(30.720)	(17.259)	(14.358)
R^2	0.50	0.58	0.86	0.87	0.85	0.91	0.92
p-value	0.52	0.35	0.24	0.14	0.68	0.03	0.36
Controls	No	No	Yes	Yes	Yes	Yes	Yes
FE	No	No	No	Yes	Yes	No	No
Obs	51	51	51	51	51	27	27

Notes: OLS estimates with robust standard errors in parentheses. The coefficients are comparable to each other as the variables are standardized. The dependent variable in columns 1-5 is the young tree count in 2005, whereas in columns 6-7 is the young tree count in 2012-13. The data from the second assessment are available for 27 groups only. Column 1 is without any controls, column 2 controls only for the pre-program performance, column 3 includes all controls in the panel C of table 1, column 4 includes fixed effects for clan and village, column 5 reproduces results using the indicator variables for conditional cooperation and grazing bylaws. Column 6 uses continuous measures of conditional cooperation and grazing bylaws, whereas column 7 uses their indicators variables. The p-value is of the joint significance of CC and Grazing Bylaws. Control variables include pre-program outcome, high altitude forest, plantation forest, border with outsiders, market distance, Gini of cattle ownership, female share, settlement fragmentation, clan heterogeneity, duration under the program, and group size. In columns 6-7, because of the small sample size I include only a selective list of control variables including pre-program performance, high altitude forest, market distance, Gini of cattle ownership, settlement fragmentation, and duration under the program.

Table 4: Falsification test: Comparing Mature and Young Trees Across Broadleaf and Coniferous Tree Types

	Mature Trees		Young Trees	
	Broadleaf	Coniferous	Broadleaf	Coniferous
	(1)	(2)	(3)	(4)
CC	1.305	1.505	−0.452	0.160
	(1.449)	(1.375)	(0.191)	(0.926)
GB	4.677	−1.225	−0.213	−1.383
	(3.912)	(3.674)	(0.551)	(2.179)
CC*GB	−3.194	1.525	1.382	0.859
	(3.660)	(3.312)	(0.370)	(1.983)
Constant	49.949	−19.151	−3.477	52.569
	(37.062)	(22.728)	(4.635)	(15.610)
R^2	0.06	0.16	0.28	0.26
Controls	No	No	Yes	Yes
Fixed effects	No	No	Yes	Yes
Obs	380	76	570	152
Mean	4.21	13.55	2.99	8.28

Notes: OLS estimates with robust standard errors clustered on the group in parentheses. CC stands for conditional cooperation, GB for grazing bylaws and CC*GB for the interaction between these two variables. The coefficients are comparable to each other as the variables are standardized. In columns 1-2, the dependent variables are number of mature broadleaf and mature coniferous trees per species per hectare, respectively. In columns 3-4, the dependent variables are number of young broadleaf and young coniferous trees per species per hectare, respectively. Control variables include altitude, border with outsiders, market distance, Gini of cattle ownership, female share, settlement fragmentation, clan heterogeneity, duration, group site. Fixed effects include indicator for Division II species and for villages.

Table 5: Falsification test: Hagenia abyssinica
Young vs. Mature Trees

	Young Hagenia	Mature Hagenia
	(1)	(2)
CC	-0.078	-0.336
	(0.095)	(0.637)
GB	-0.102	0.439
	(0.252)	(1.919)
CC*GB	0.507	1.688
	(0.228)	(1.558)
Constant	-2.665	-14.869
	(1.873)	(14.248)
Controls	Yes	Yes
Fixed effects	Yes	Yes
Obs	76	38
Mean	0.75	4.37

Notes: OLS with robust standard errors in parentheses. In column 1 the standard errors are clustered on the group. CC stands for conditional cooperation, GB stands for Grazing Bylaws, and CC*GB is the interaction between these variables. The dependent variable in column 1 is the average number of young Hagenia trees per hectare of commons managed forest, whereas in column 2 it is the average number of mature Hagenia trees per hectare. Control variables include altitude, border with outsiders, market distance, Gini of cattle ownership, female share, settlement fragmentation, clan heterogeneity, duration, group site. Fixed effects include indicator for Division II species and for villages.

Table 6: Mechanisms: Monitoring, Punishment,
and Beliefs about the Behavior of Others

	Time spent (monitoring)	Punishment likelihood	Belief survey	Belief experiment
	(1)	(2)	(3)	(4)
	Panel A. Extensive margin (Indicator variable)			
Grazing Bylaw	19.075	0.463	-0.359	0.530
	(2.663)	(0.108)	(0.123)	(0.280)
R^2	0.40	0.38	0.14	0.05
	Panel B. Intensive margin (number of months)			
Grazing Bylaw	4.977	0.123	-0.126	0.164
	(0.947)	(0.032)	(0.033)	(0.078)
R^2	0.33	0.35	0.19	0.06
Controls	Yes	Yes	Yes	Yes
Obs	221	221	220	288
Control mean	21.66	0.47	0.76	2.62

Notes: OLS estimates with robust standard errors clustered on the group in parentheses. Panel A reports estimates using an indicator variable for grazing bylaws, where '1' means present and '0' means absent. Panel B reports estimates using the number of months grazing is forbidden. The dependent variables are as follows: In column 1, it is number of hours spent monitoring the forest in a month; In column 2, it the perceived likelihood that free riders will be punished (1= yes, otherwise, 0); In column 3, it is the belief that there are fewer activities resulting in deforestation (1= yes, 0 = no); In column 4, it is the belief about the contribution by the other player in the public goods game. Control variables include age, education, gender, land wealth, livestock wealth, position in the group. The sample includes only those individuals who are classified as conditional cooperator. The sample size is smaller in column 1-3 because not every player was interviewed using a detailed household survey.

Table 7: Contribution and Beliefs
in the Public Goods Game

	Dependent variable: Contribution	
	No controls	Controls
	(1)	(2)
Belief	0.336	0.356
	(0.080)	(0.085)
R^2	0.14	0.22
Controls	Yes	Yes
Obs	335	288
Control group mean	2.179	2.179

Notes: OLS with robust standard errors clustered on the group in parentheses. Data on contribution and belief are in Ethiopain Birr from the unconditional decision of the public goods game. Control variables include age, education, gender, land wealth, livestock wealth, position in the group. The sample includes only those individuals who are classified as conditional cooperator.