The Interdependence of Formal Rules and Civic Capital in Commons Management

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Abstract

Formal rules and civic capital interact with each other, but we know little about the effect of this interaction on economic outcomes. I fill this gap using the context of a forest commons management program in Ethiopia. The program was launched to mitigate high deforestation from browsing of young trees by livestock. I measure civic capital as the propensity to cooperate if others do the same even though defection would yield a higher payoff. Formal rules are measured as written down regulations on grazing inside the forest. I find that groups achieve best forest outcomes when they have both rules and civic capital, but not when the have only one of these. Insights from fixed effects, neighboring pairs, and forest ecology show that these effects are not due to omitted variables. Specifically, the effects are observed only for young broadleaf trees prone to browsing, but not for coniferous trees that the cattle avoid. Among the young broadleaf trees, the largest effect is observed for species highly susceptible to browsing. Survey and experimental data reveal that these results are due to the enforcement of rules by the civic minded, which deters free riding, fosters optimistic beliefs about others' contributions, eventually resulting in higher cooperation. These findings imply that both rules and civic capital are required for successful cooperation outcomes.

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I. Introduction

Many economic activities require cooperation, which is difficult to achieve due to the free rider problem. Prominent examples include team work in organizations, tax compliance, donations to charities, and provision of a wide variety of environmental goods and services.

Formal rules and civic capital are expected to play an important role in mitigating the free rider problem,[1] and in achieving superior economic outcomes.[2] This evidence is largely based on studying the effect of formal rules and civic capital in isolation by holding the other side fixed. Recent evidence, however, suggests that formal rules and civic capital do not operate in isolation. Rather, they interact with each other resulting in stable patterns of conduct, where the two are complements or substitutes.[3] This interaction is believed to matter for economic outcomes, but there is hardly any empirical evidence (see Acemoglu and Robinson 2019).

In this paper, I examine how the interaction between local formal rules and civic capital affects the provision of commons.[4] My focus is on a forest commons management program in Ethiopia, which was launched to mitigate deforestation from unregulated livestock grazing.[5] This resulted in the disappearance of young trees considered vital for healthy forest growth (Kubsa and Tadesse 2002). Under the program, several forest user groups of the Arsi Oromo people were offered secure property rights to manage their forest as a common property. The groups confront the free rider problem while managing their commons and vary widely in their success. This provides a setting conducive to studying the role of formal rules and civic capital.

Following Ostrom (1990), Bardhan (2000), and Balland and Platteau (1996), I consider formal written down restrictions on the extent of resource extraction from commons as a proxy for local rules.[6] Putnam et al. (1993) note that in a civic community, citizens need not behave as altruists, but pursue what Tocqueville ([1835] 1969) calls "enlightened self-interest" that is "alive to the interests of others". Accordingly, I proxy for civic capital as the individual propensity to cooperate provided others do the same, even though defection would have yielded a higher payoff (Elster 1989, Bicchieri 1990).

[1]Formal rules are written down regulations that foster cooperation by placing constraints on opportunistic behaviors (see North 2000, Ostrom 1990). In contrast, civic capital comprises values that help groups overcome the free rider problem in the pursuit of socially beneficial activities (Guiso et al. 2011).

[2]See for example, Ostrom 1990, Balland and Platteau 1996, Acemoglu et al. 2001, La Porta 2008, Algan and Cahuc 2010, Tabellini 2010, Guiso et al 2009, and Aesina and Giuliano (2015) for a review.

[3]See for instance, Tabellini 2008, Aghion et al. 2010, Alesina and Giuliano 2015, Guiso et al. 2016, Bisin and Verdier 2017, Lowes et al. 2017, Rustagi 2019).

[4]A growing number of studies examine the effect of local level fomal rules and civic capital on economic outcomes (see for instance, Banerjee and Iyer (2005), Michalopoulos and Papaioannou (2013), and Tabellini (2010).

[5]Forest grazing by cattle is a problem in both developing and developed parts of the world. It degrades forests by affecting tree survival, species richness, and soil erosion (see Buffum et al. 2009).

[6]see also Tang 1991, Dayton-Johnson 2000, Agrawal 2001, Persha et al. 2011. Examples of such rules includes number of trees one can harvest from a forest, or the number of cows one can graze on a grassland, or the number of days one can use water from an irrigation system.

There are theoretical reasons on why the interaction between rules and civic capital should matter for cooperation outcomes. From a generalized model of cooperation by Fehr and Schmidt (1999) and a rich case-study evidence complied by Acemoglu and Robinson (2019) three insights emerge. First, civic capital is unlikely to sustain cooperation on its own. This is because most groups are heterogeneous in their composition, comprising of both free riders and civic minded individuals. This changes a cooperation dilemma into a coordination problem, whereby equilibrium selection depends on beliefs that the civic minded hold about contribution by others. The civic minded contribute initially because of optimistic beliefs, but these turn pessimistic after they experience free riders, resulting in full free riding by everyone and breakdown of cooperation (Ostrom 1992, Fehr and Gächter 2000). Further evidence shows that this breakdown occurs even in the absence of free riders because some civic minded individuals are 'self-serving' and contribute less than the other group members (Fischbacher and Gächter 2010).

Second, formal rules alone may not be enough to sustain cooperation. This is because rules require enforcement to be effective. Generally, this enforcement is carried out by a third party like the police or conductors on public transport. However, in the context of commons management, rules are often enforced by individual users themselves. This engenders a second order free rider problem: it is individually costly to enforce rules but enforcement generates group level benefits. Since individuals are better off if others bear the cost of enforcement, selfish individuals are unlikely to enforce rules. In the absence of enforcement, rules become 'paper tigers'.

Third, both civic capital and rules are required to sustain cooperation. When there are formal rules regulating resource use, civic minded individuals would be willing to incur the cost of enforcement to ensure that free riders get punished. This is because civic minded individuals experience disutility from unfavorable payoff inequality they experience when others defect on their contribution. Rules make it possible for civic minded individuals to coordinate and discipline free riders, resulting in what Elinor Ostrom (1992) describes as "covenants with a sword". When enforced, rules bolster the belief that others will not defect, resulting in higher levels of cooperation.

In summary, theory suggests that groups *without* civic capital and rules are expected to perform poorly in managing their commons. Groups with civic capital or rules *alone* are unlikely to perform better. Rather, it is the groups with both civic capital and rules that are expected to have superior performance. I test these insights using data on the performance of each group in managing its commons. The performance was assessed twice by the program agency using the count of young trees per hectare and reveals large variation in the outcome: while some groups have only 13 young trees per hectare, others have over 165 young trees.

One challenge in tying this variation to an interaction between rules and civic capital is that there might be different kinds of rules which could affect performance. Since the disappearance of young trees in the study area is mainly due to unregulated livestock grazing, I focus on written down rules that restrict grazing inside the forest and on the same spot, which are considered vital for the survival of young trees (Amente 2005). 46 percent of the groups ban grazing for 2-5 months in a year and enforce it through decentralized monitoring by members. In the remaining groups, grazing is allowed throughout the year.[7] I measure rules as the number of months grazing is forbidden inside the group managed forest.

Measuring civic capital is difficult because observed cooperation behavior is typically confounded with benefits from reputation formation, repeated interaction, and beliefs about the behavior of others. Although civic capital includes both values and beliefs, it is important to separate these two because groups could have the same value but differ in their beliefs, resulting in multiple equilibria. I use a one-shot anonymous public goods game in which two players are randomly assigned to an experimental group (see Fischbacher et al. 2001). This rules out repeated interaction and reputation formation from playing a role. I implement the game in the strategy method in which 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 decisions regardless of what the other player contributes, whereas the civic minded increase their contribution in the contribution of the other player. I use Spearman rank correlation between self and other players' contribution to construct a continuous measure of civic capital, which ranges from zero to 0.92.

I regress young tree count on measures of civic capital, grazing rules, and their interaction term. Identifying the effect of this interaction is very difficult because rules and civic capital are not randomly assigned, which could result in omitted variables bias.[8] Ideally, one would like to form groups exogenously with high, medium, and lower levels of civic capital and then randomly assign grazing rules to one-half of the groups within each stratum. A clean experiment like this is impossible in the context of commons management, but it lays down requirements for the identification of the interaction effect.

I use three different strategies. First, historical records concur that the Oromo formed clan-based settlements. I construct clan fixed effects from detailed data on the clan of each household to absorb clan specific differences. Groups are located within villages, so I include village fixed effects to account for village specific differences. The combination of clan and village fixed effects allows me to mitigate the concern over non-random formation of groups. Second, I account for pre-existing differences in forest quality and Gini of livestock wealth, as these could have influenced grazing rule formation. Third, civic

[7]Of course, there are also other formal rules that might play a rule, such as those specifying the boundary or the set of users who have rights to access the resource. I take cognizance of such rules while conducting the empirical analysis.

[8]Reverse causality is unlikely to pose a concern because civic capital and rules pre-date the outcome assessment.

capital and grazing rules are positively correlated, but this correlation disappears when I account for their common determinant – distance to local markets, which was exogenously assigned (see Rustagi 2020). Fourth, I control for other important covariates like altitude, slope, sunshine, precipitation seasonality, economic heterogeneity, social heterogeneity, duration under the program, and group size. Conditional on these controls, the variation in civic capital and grazing rules across groups appears to be idiosyncratic.

Using an estimation framework that is in the spirit of differences-in-difference (DID) estimation, I find that the interaction term enters with a large positive and statistically significant coefficient. The marginal effect of one standard deviation increase in the interaction term is 24 more young trees per hectare, which is large relative to the sample mean of 67 young trees. These results persist in magnitude and significance when I use the outcome from second forest assessment, which was carried out seven years after the first assessment. The coefficient on civic capital alone turns out to be economically and statistically insignificant, but the coefficient on grazing rules alone is mostly negative and at times statistically significant. This could be because when rules are not enforced it could result in frustration or because of anti-social punishment in which free riders punish civic minded individuals (see Herrmann et al. 2008).

I proceed by combining insights from forest ecology with browsing behavior of cattle to develop novel tests which are in the spirit of DID with nth interaction term. These tests allows me to investigate whether the interaction term specifically affects the frequency of tree species susceptible to browsing, as opposed to all tree species. Cattle form preferences for trees with palatable and nutritive foliage, which depends on protein and tannin content. While moderate levels of tannin are required to absorb protein, high levels can make foliage unpalatable, indigestible, and at times even toxic. Using a unique species specific data on the distribution of young and mature trees, I show three key results.

First, ecological studies suggest that browsing affects only young broadleaf trees, but has little bearing on young coniferous trees. Accordingly, I show that the interaction term has a large positive and significant effect on the distribution of young broadleaf trees, but the effect on young coniferous trees is both economically and statistically insignificant.

Second, ecological studies further suggest that within young broadleaf trees, the effect should be larger for species most prone to browsing damage. This is exactly what I find: the interaction term has a large positive and statistically significant effect on young trees of *Hagenia abyssinica*, which is highly palatable and nutritive to livestock because of its high protein and moderate tannin content. For these findings to be spurious, omitted variables must be specifically correlated with the frequency of young Hagenia trees, which is highly unlikely. This is also evident from selection on observables which would have to be 38 times larger to explain this result.

I replicate the above results using matched pairs fixed effects approach. I focus only on neighboring groups that border each other, such that one group has both civic capital and grazing rules, but the other group has either one or none of these two. The use of fixed effects allows me to absorb common characteristics within the pair and also gain tighter control over geographical variables. The coefficient on the interaction term turns out to be positive and statistically significant, and its magnitude is also comparable to the main result. Moreover, a placebo test based on a comparison of neighboring groups where one group has either civic capital or grazing rule alone but the other group has none of these reveals a negative and marginally insignificant effect.

Theory suggests the positive effect of the interaction term arises from enforcement of grazing rules by civic minded individuals, which in return leads to group members having optimistic beliefs over others' contribution. To shed light on these mechanisms, I focus only on civic minded individuals. With respect to those from groups without grazing rules, I show that the civic minded from groups with grazing rules spend twice as much time time monitoring their forest and also expect individuals who deforest to be punished by nearly 100 percent likelihood. This generates optimistic beliefs, for the civic minded from groups with rules report fewer acts of deforestation. This is also reflected in data on beliefs over other's contribution in the public goods game. Together, these patterns clearly suggest that enforcement leads to optimistic beliefs which then translate into higher cooperation outcomes.

This paper contributes to three strands of literature. First, it connects to the growing literature on provision of public goods and common property resources. The focus of previous field studies on this topic is on the importance of rules and civic capital operating in isolation (see Tang 1991, Balland and Platteau 1996, Bardhan 2000, Dayton-Johnson 2000, Agrawal 2001, Persha et al. 2011). This paper in contrast shows that we need both rules and civic capital for collective action to be successful. In this sense, the paper complements laboratory findings on the interaction between civic capital and rules by taking into consideration a richer context and policy environment (Fehr and Gächter 2000, Gaechter and Thoeni 2005, Gunnthorsdottir et al. 2007, Ones and Putterman 2007). A closely related paper in this domain is by Rustagi et al. (2010), who show a composite effect of civic capital on forest management. This paper goes beyond in several ways. To begin with, it underpins the mechanism through which the effect unfolds by taking into consideration the rich data on grazing rules and its interaction with civic capital using two rounds of outcomes. The paper then uses a unique data made available by the program agency on species specific distribution of young trees to study carefully the effect of the interaction between civic capital and grazing rules on forest management success. In order to understand these interaction effects, the paper traces piece by piece a sequence of channels using a combination of new survey and experimental data not discussed before. Finally, the paper uses data from 30m^2 Landsat pixels to contruct baseline tree cover (see Hansen et al 2013).

Second, the paper also relates to the growing literature on the interaction of culture and institutions (see Alesina and Giuliano for a review). A closely related paper on this topic is by Bravo et al. (2017), who offer novel evidence on civic capital (proxied by village temples) as an important determinant of the effectiveness of democratic institutions in China. The findings from this paper are from a different context, which is that of commons management. It draws on insights from cultural traits that are highly relevant for collective action and elicited using a behavioral experiment to account for confounding motivations. This paper therefore combines survey and experimental data with ecological insights to shed new light on how and why the interaction between civic capital and rules matter for outcomes of collective action.

Third, the paper uses ecological insights to advance identification in situations where traditional approaches are difficult to implement. Such insights could be useful is studying forest management in many parts of world including Sub-Saharan Africa, Asia, and Latin America.

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 civic capital, grazing rules 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 the Oromia state government with support from German Organization for International Cooperation (GIZ). The purpose of this program was to conserve the Adaba-Dodola forest protection area in the Bale Mountains. Before the program launch, 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 (Trainer 1996).

During the program period, 56 groups located inside the forest were made direct beneficiaries. 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 on steep slopes 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.[9] Under the

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

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 trees per hectare (see section III). The young tree count is used to determine rent that each group must pay annually to the program agency. 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.

While managing their forest as a common property, group members face 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.

III. Data

The paper uses seven data sources: (i) The data on group performance in forest management were obtained from program offices in Adaba and Dodola. This data includes the average number of young trees per hectare in each group managed forest; (ii) The data on civic capital were obtained through a behavioral experiment conducted with group members. In addition to these two sources, I also consider five new data sources that were not used in previous studies. This includes (iii) data on grazing rules obtained using in-depth group discussions, household level surveys with group members, and books maintained by each group; (iv) data on species specific distribution of young trees per forest hectare obtained from the program office in Addis Ababa; (v) survey and experimental data on channels via which the interaction of rules and civic capital affects forest management outcomes; (vi) data on baseline tree cover in 2000 obtained from Hansen et al (2013) which uses 30m^2 Landsat pixels; and (vii) data on geographical variables expected to matter for forest growth. These data are from the program office, CEGIS (Center of Excellence for Geospatial Information), and the Map Server Ethiopia project of the University of Bern. I describe the first three data sets below, while the remaining four are discussed in section V and VI. 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 it 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 it includes all 51 groups in the sample. The second assessment was conducted in 2012-13 and it includes 27 of the 51 groups in the sample. I use data from the first assessment to report the main results and data from the second assessment to show the robustness of these results over time. Panel A, Table 1 shows that the average number of young trees per hectare 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 young tree counts from 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.

Data on species specific outcomes are discussed in section IV.B and reported in Table 3.

III.B. Grazing Rules

The main occupation of the Arsi Oromo is pastoralism and individuals with large number of cattle command a high status. The group members do not stall feed their cattle but let them browse inside the forest in herds of 7-18 animals (Johansson and Fetena 2012). Browsing serves as an important source of nutrition for cattle in the study area (Mekonen et al. 2009).

In the period preceding the program, continuous and intensive browsing by cattle led to severe forest degradation through a reduction in seedling survival and seedling growth rate. Consequently, rules regulating grazing inside the forest are considered critical for the survival of young trees and for natural forest regeneration (Amente 2005).

Since groups are responsible for the management of their forest common, the formation of grazing rules was voluntary. Each group convened a meeting of its members to decide on whether to have a rule restricting grazing and for how many months. From group discussions, household level surveys, and books maintained by each group, I find that 46 percent of the groups have grazing rules. These rules were formed within the first year the program was launched in a group. In groups with rules, grazing inside the forest and on the same spot is banned for 2-5 months in a year (the modal response is three months).

Panel B in Table 1 shows that 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 rules.

The restrictions on grazing are put in place during the rainy season when tree seeds germinate. The violation of rules 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. The rules are enforced by members themselves through decentralized monitoring. This results in a second order free rider problem: individual group members are better off if others pay the cost of monitoring to enforce the rules. When rule violators are caught, a meeting is convened in which the group leader deliberates on punishment after consulting the group members.

III.C. Civic Capital

Measuring civic capital 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 civic capital from groups in which little cooperation is observed because of multiple equilibria. It is possible that groups have the same level of civic capital but differ in their beliefs about others' cooperation resulting in differences in cooperation outcomes.This could result in misclassification of groups having different degrees of civic capital. To circumvent these concerns, I follow Fischbacher et al. (2001) and Fischbacher and Gächter (2010) and elicit civic capital via a one-shot anonymous public goods game. The game is implemented in the strategy method, which allows me to reliably measure civic capital 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 B). 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 civic capital. – I use the conditional decision to construct measures of civic capital. In this decision, free riders and altruists are expected to contribute respectively zero and full endowment, regardless of what the other player does. In contrast, the civic-minded are expected to contribute more the more the other player contributes. 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 civic capital. I then aggregate the Spearman ρ over individuals from a group to obtain group specific averages. If a group comprises chiefly of civic-minded members, 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 Spearman ρ in the sample is 0.495 (s.d. 0.276, Table 1, Panel B).

III.D. Determinants of Grazing Rules and Civic Capital

There is large variation in both grazing rules and civic capital across groups. Rustagi (2021) shows that this variation mainly stems from the distance of groups to local markets, whose location was the result of a historical experiment. In these markets, strangers trade mostly in livestock, resulting in problems of asymmetric information. This together with the impersonal and ephemeral nature of transaction means that buyers and sellers are locked in a Prisoner's Dilemma. The efficiency of market exchange creates a demand for civic capital and rules to resolve this dilemma, but this affects only the members of groups closer to markets, as the opportunity cost of market attendance is lower for them. In groups further away, trade is within the network and is sustained by reputation.

Figure 1 shows that the strong positive association between grazing rules and civic capital (left panel) disappears when I control for market distance (right panel).

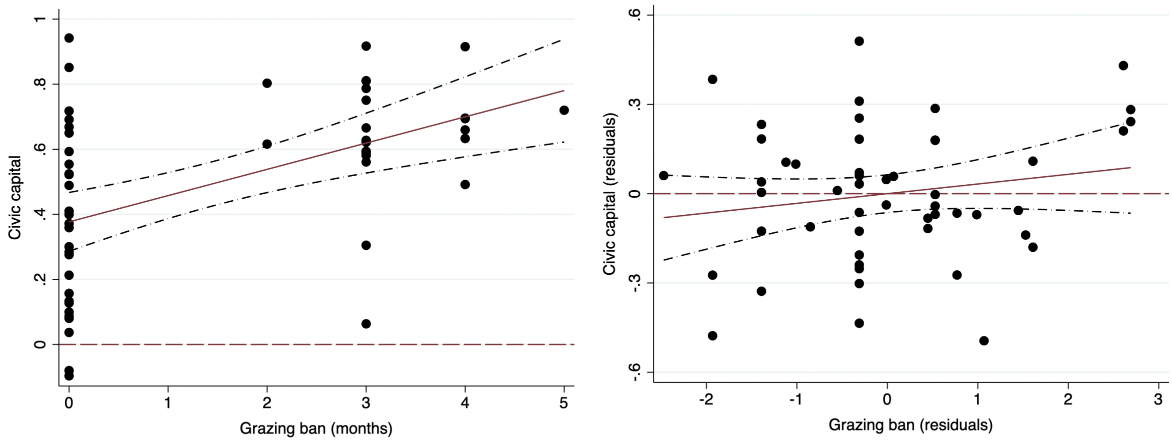

Figure 1: Association of Civic Capital, Grazing Rules, and Market Distance

Notes: Each circle represents a group. The figure on the left hand side shows a strong positive association between civic capital and grazing rules. The figure on the right hand size shows the same after factoring out market distance as the common determinant and plotting the residuals.

III.E. Descriptive Statistics

Figure 2 shows the raw association of young trees per hectare with civic capital, grazing rules, and an interaction between the two. It is based on indicator variables for civic capital ('1' means civic minded are in a majority in a group)[10] and grazing rules ('1' means a group has grazing rules).

The average number of young trees in groups without civic capital and grazing rules (None) is 48 young trees per hectare. The performance in groups with civic capital alone but without grazing rules (CC only) is indistinguishable from the performance of groups without any of these two (marginal effect = -0.09 young trees). This result suggests that having civic capital alone does not lead to better forest management outcomes. The performance in groups with grazing rules alone but without civic capital (GB only) is slightly higher (marginal effect = 14.81 young trees), but the difference is not statistically significant (p-value > 0.30); this suggests that having grazing rules alone also does not lead to better forest outcomes. Groups with both civic capital and grazing rules (Both) witness superior forest outcomes (marginal effect = 35 young trees) and the difference is also statistically significant (p-value < 0.05).

[10]The average Spearman *rho* is 0.72 in groups where the civic-minded are in a majority, but only 0.27 where they are not

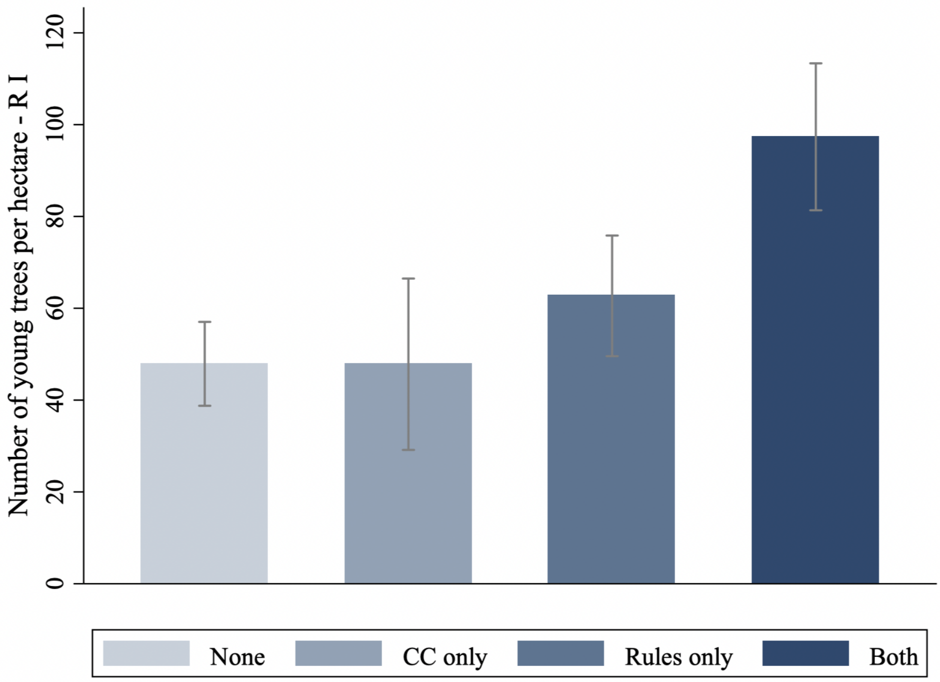

Figure 2: Association of young trees with civic capital, grazing rules and their interaction term

Notes: The categories are based on indicator variables for civic minded (1=majority, 0=otherwise) and the presence of grazing rules (1=Present, and 0=Absent). 'None' implies civic capital = 0 and grazing rules = 0; ' 'CC only' implies civic capital = 1, grazing rules = 0; 'GB only' implies civic capital = 0, grazing rules = 1; and 'Both' implies, civic capital = 1, grazing rules = 1. The final bar shows the total effect of the interaction term, which is significantly different from zero. The marginal effect of the interaction term is also statistically significant. The capped bars indicate 95 percent confidence interval.

IV. Empirical Strategy

I model the association of forest management outcomes with civic capital, grazing rules, and their interaction term using the following OLS specification which is in the spirit of differences-in-difference (DID) estimation:

$$y_{icv} = \alpha_0 + \alpha_1 y_{0icv} + \alpha_2 CC_{icv} + \alpha_3 GB_{icv} + \alpha_4 (CC * GB)_{icv} + \mathbf{X}_{icv}\alpha_5 + \theta_c + \eta_v + \epsilon_{icv} \quad (2)$$

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 baseline tree cover at the start of the program. CC is civic capital, which is measures as the Spearman rho between own and other players' contribution in the public goods game. GB is grazing rules, measured as the number of months grazing inside the forest is forbidden. $CC * GB$ is the interaction between civic capital and grazing rules. $\mathbf{X}$ 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 α_2, α_3, and α_4 capture respectively the effect of civic capital alone (when there are no grazing rules), grazing rules alone (when there is no civic capital), and the marginal effect of the interaction between civic capital and grazing rules on forest management outcome. The coefficient of interest is α_3, which is expected to be positive and > 0.

To estimate the effect of civic capital, grazing rules, and their interaction on forest management success, an ideal experiment is the one in which a researcher a) sorts individuals by types to form groups exogenously such that they have high, medium, and low prevalence of civic capital; b) stratifies groups by the prevalence of civic capital and randomly assigns grazing rules to one-half of the groups within each stratum. This approach ensures that civic capital, grazing rules, and their interaction is uncorrelated with potential outcomes.

However, such a clean experimental approach may be difficult to achieve in the field because it is impossible to form groups exogenously and then randomly assign rules to some but not the others. Therefore, I have to deal with observational data which is prone to omitted variables bias – groups with stronger civic capital and grazing rules might 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 civic capital and not grazing rules (and vice versa) is very difficult.

In the face of these limitations, I combine three identification strategies to mitigate the concern over omitted variables.

IV.A. Fixed effects and control variables

As the thought experiment lays out, it is important to account for non-random formation of groups and grazing rules. I attempt to achieve this by controlling for fixed effects and control variables.

Fixed effects.– Historical records concur that the Arsi Oromo formed clan-based settlements in the past (Pankhurst 1998). This has two important implications. First, it could be that some clans are more cooperative and have rule based order than the others. Second, clan homelands could differ systematically in geography. Together, these features could have affected both civic capital and rule formation, as well as forest management outcomes.

It is possible to mitigate the effect of such time invariant pre-existing features via controlling for clan-fixed effects. But, we do not know which clan used to reside in which group in the historical period. In the absence of inter-clan warfare, large-scale migration, and clan endogamy, it is reasonable to infer a group's clan composition in the past from the clan composition that we observe today, as long as each group is still dominated by a particular clan.[11] From the detailed data that I assembled on the clan of each household in the study area, I find that 85 percent of the households in a group are from the same clan. Accordingly, I use an indicator for the dominant clan in a group to construct clan fixed effects.

Since clan boundaries may overlap with those of several groups, I also use village fixed effects. The groups today are part of a larger administrative units called *kebele*, which is synonymous with a village. To ensure that the interaction term is not picking up village specific differences such as administration quality, I include village fixed effects. This additionally allows me to control for several geographical features that are common across groups from the same village. The combination of clan and village fixed effects allows me to mitigate the concern over omitted variables bias from non-random formation of groups, as I now compare groups from the same clan and from the same village but with different levels of civic capital and grazing rules.

Control variables.– Variation in formation of grazing rules across groups could be due to baseline differences in forest condition, cattle density, and the ease with which groups can coordinate. Following seminal studies on commons management (Ostrom 1990, Balland and Platteau 1996, Bardhan 2000, and Agrawal 2001), I consider a variety of proxies of these variables. I conduct a balance check by regressing one covariate at a time on civic capital, grazing rule, and their interaction term and report the coefficient obtained in Table 2.

The need for grazing rule formation is expected to be stronger in groups with poor baseline forest condition and high number of cattle. Panel A-B of Table 2 show that different proxies of these variables are uncorrelated with civic capital, grazing rules, and their interaction term. The coefficients are not only small in magnitude but are also statistically insignificant.

The combination of clan and village fixed effects absorbs common geographical features, but there could be within variation which could be a source of omitted variables bias. Accordingly, I control for altitude, slope, and share of plantation forest. The program guarantees groups the security of property rights, but these could be weaker in groups that share a border with settlements that lack forest and are thus excluded from the program. Individuals from such settlements may foray with their cattle into the forest of the nearest group in search for fodder. This could cause group members to take

[11] The advantage of *within* clan comparison is lost if some groups within the same clan were subjugated by other clans in the deeper past but became independent in the recent past. In this case, while the geographical characteristics are unaffected, clan characteristics may no longer be the same if the members of subjugated groups acquired characteristics of subjugating clans. However, this process seems unlikely because the Oromo practice clan endogamy, which means an individual must marry outside the clan. This created inter-clan networks dissuading the likelihood of conflict. Even if the conflict did arise, the Oromo people had dispute resolution mechanisms in the form of inter-clan councils.

stronger (weaker) interest in grazing rule formation. I control for an indicator of whether a group borders outsider settlements or not. Panel C of Table 2 clearly shows that none of these variables are correlated with civic capital, grazing rule, and their interaction term.

Civic capital and grazing rule formation are likely to be stronger in groups that are more homogeneous as this facilitates coordination. I control for several proxies of heterogeneity such as share of female group members, settlement fragmentation, and clan heterogeneity. Similarly, through the groups are small and vary in size from 18-30 households, this variation may affect coordination. Groups that have been under the program for a longer duration may have learnt the benefits of cooperation. Accordingly, I also control for group size and program duration. Panel D of Table 2 shows that with the exception of settlement heterogeneity, the other variables are uncorrelated with civic capital, grazing rule, and their interaction term. Although settlement heterogeneity is lower in groups with both civic values and grazing rules, the difference is only weakly statistically significant (p-value = 0.09).

So far, we see that none of the control variables are associated with civic capital, grazing rule, and their interaction. This raises the question: what explains then the variation in both civic capital and grazing rules? As mentioned before, Rustagi (2020) shows that it is the proximity of groups to local markets, whose location was the result of a historical experiment. Groups that are further away from markets are less likely to have both civic capital and grazing rules. However, as Panel C of Table 2 shows this has no implication for the interaction term, which carries a small and statistically insignificant coefficient. In addition, once I control for market distance, the association between civic capital and grazing rule also weakens in magnitude and disappears.

Conditional on the inclusion of fixed effects, baseline forest condition, market distance, and other relevant controls, it is likely that the variation in civic capital and grazing rules across groups is idiosyncratic.

IV.B. Ecological mechanisms

I complement the above strategy by combining insights from forest ecology and browsing behavior of cattle to develop novel tests, which are in the spirit of DID with nth interaction term. These tests allows me to investigate whether the interaction term specifically affects the frequency of only those tree species that are susceptible to browsing, as opposed to all tree species including those that are unaffected by browsing. This exercise has the potential to lend strong credibility to the main findings, for now omitted variables must be specifically correlated with trees prone to browsing to explain away the main results. Given the nature of the tests described below, this seems rather unlikely.

Data. – To conduct these tests, I use a new dataset made available by the program agency. The dataset is from the first assessment conducted in 2005 and includes species specific count of all major young and mature trees found in the study area. Altogether, there are 12 different species, whose names together with descriptive statistics are listed in Table 3. The young trees of these species are organized by the program agency into two divisions on the basis of diameter at breast height (DBH):

Division I. – includes seven species that attain a DBH of $\geq$ 40 cm at maturity. These species are organized further into two sub-divisions, "very young" (DBH of $<$ 20 cm) and "young" ($20 < \text{DBH} < 40$).

Division II. – includes five tree species that attain a DBH of $\geq$ 25 cm at maturity. These species are not organized into further sub-divisions.

Given this organization, there are 19 observations per group: 14 from Division I (seven each from the two sub-divisions) and 5 from Division II. This dataset is available for 38 of the 51 groups in the sample, so I first verify that the positive effect of the interaction between civic capital and grazing rules holds in this sub-sample (coef. 23.26, s.e. 10.79).

Background information. – for understanding the ecological insights, the following background information on natural regeneration of trees in the study area is crucial:

i) Of the 12 tree species found in the group managed forests, two are coniferous and ten are broadleaf (see Table 3). Though the group managed forests range in altitude from 2600 meters to 3700 meters, their location just 6 degrees north of the Equator means that the effect of altitude is mitigated. As a result, coniferous and broadleaf trees are found in all 38 groups.

ii) Since there was no silviculture program (tree plantation drive) in the study area, depending on the susceptibility of the tree species and conditional on controlling for climate variables, the variation in tree count is most likely due to browsing intensity.

iii) The main herbivore that browses in the group managed forests is local cattle. This means any browsing damage to trees can be attributed to cattle alone and is not confounded with browsing by wild herbivores.[12]

iv) None of the tree species found in the study area require cattle for their seed dispersal (Teketay 2005). This means any positive effect of the interaction term can be attributed to ban on grazing and is not confounded with other ecological functions that the cattle may perform.

v) Trees which are of little value to cattle have other values, such as for timber (Juniper and Podocarpus) and medicine (Ekebergia). This means, groups members do not offer

[12]Although goats also browse on trees they are herded close to the settlements to protect them from predators like hyenas found in the forest (Johannson and Fetena 2012). The only wild herbivore that also browses - Mountain Nyala - is uncommon in the study area (see Evangelista et al. 2007).

special protection to fodder trees alone, while leaving the rest to nature.

Ecological insights. – Based on the literature on forest ecology and browsing behavior of cattle, I develop the following tests:

I. *Young coniferous and broadleaf trees*

• Cattle readily browse the foliage of broadleaf trees, but usually avoid that of coniferous trees (Tesfaye et al. 2002, Regassa 2003). Therefore, the interaction term should have no effect on the frequency of young coniferous trees, but a positive effect on the frequency of young broadleaf trees.

II. *Young Hagenia trees*

• Cattle do not browse the foliage of every broadleaf tree species. Instead, they use pre-and post-ingestive signals from feeding to form preferences for trees with palatable and nutritive foliage. This ultimately depends on protein and tannin content of foliage. Tannin content can potentially alter the nutritive value of foliage – while moderate amounts of tannin are required to absorb protein, high levels can make the foliage unpalatable, indigestible, and at times even toxic (Woodward and Reed 1989, Van Soest 1994). Among the broadleaf trees found in the study area, *Hagenia abyssinica* is particularly prone to browsing because of high protein and moderate tannin content, which makes it nutritive and palatable to cattle (Amente 2005, Mekonen et. al 2009). Therefore, the interaction term should have a large positive effect on the frequency of young Hagenia trees.

Estimation strategy.– I run equation 2 at the tree species level using an OLS estimation. The dependent variable in these regressions is the average count of trees per species. The results hold if I use negative binomial estimation and the marginal effects are very similar to OLS estimates.

Since the frequency of different tree species varies in the forest, the magnitude of the coefficients must be interpreted with respect to the average frequency of each tree species. Accordingly, I standardize the count of trees using species specific mean and standard deviation. In addition, to allow for the correlation of standard errors within a group, I cluster these at the group level. Wherever necessary, I also include a fixed effect for Division II species.

The natural regeneration of different tree species is expected to be sensitive to geographical features. While conducting robustness checks, I consider besides altitude and slope, two aspect variables – North and East – to account for differences in sunshine and related features. North captures the extent of north/south facing slope, whereas east captures the extent of east/west facing slope. In addition, I also consider precipitation seasonality, which is the coefficient of variation in precipitation over 1979-2013. I do not separately control for temperature, soil, and other precipitation variables, as these are highly correlated with altitude (p-value > 0.8).

IV.C. Matched pair fixed effects analysis

My third strategy involves comparing neighboring pairs of groups using a matched pair fixed effect (see Banerjee and Iyer 2005, Michalopoulos and Papaioannou 2013). This approach allows me to absorb common features within neighboring pairs. In addition, differences in many factors, in particular geography, are expected to be smaller within neighboring pairs.

I construct 'treated' matched pairs such that one group has both civic capital and grazing rules (treated), but the other group has civic capital alone or grazing rules alone or none of these (control). I include different configurations in the control category because there are not many matched pairs that separately capture these. This approach seems reasonable given that theory suggests the outcome to be similar across different configurations in the control group, which as Figure 2 also shows, seems to be the case. I further test for this by constructing 'placebo' matched pairs in which one group has either civic capital or grazing rules, but the other groups lack both.

I apply this strategy to the main sample where the outcome is young tree count per hectare of group managed forest. There are 23 treated matched pairs and 20 placebo matched pairs in the this sample. Figure 3 illustrates the strategy using one treatment group that borders four control groups. The treated group is *Xuqa Cara* and it has both civic capital and grazing rules. The four control groups have civic capital alone (*Sorxoxa*) or grazing rules alone (*Xuqa Shifa*) or lack both of them (*Jiddola* and *Karo*). It is evident from the figure that the young tree count is higher in *Xuqa Cara* by around 20 young trees, but it is similar across the four controls groups (around 60 trees).

I also extend this strategy to the species specific sample where the outcome is the count of young trees of different types. There are 23 treated matched pairs and 9 placebo matched pairs in the this sample. Since the number of placebo pairs is small for a meaningful analysis, I focus mainly on treated matched pairs.

All throughout, I cluster the standard errors on the matched pair. Since the number of clusters is small, I follow Cameron et al. (2008) to show the results hold when using this procedure.

IV.D. Other strategies

There is a possibility that groups with higher civic capital and grazing rules experienced favourable weather conditions in the assessment year resulting in better forest outcomes. I doubt that this was the case, as the groups cover a small geographical area (25km^2) and experience very similar weather shocks. Moreover, while conducting robustness checks I do control for weather shocks in terms of precipitation seasonality over a 30 year period. To alleviate this concern even further, I use data from the second assessment (2012-13) to test whether the results still persist over time under the assumptions that the same groups did not experience similar weather shocks in 2005 and in 2012-13.

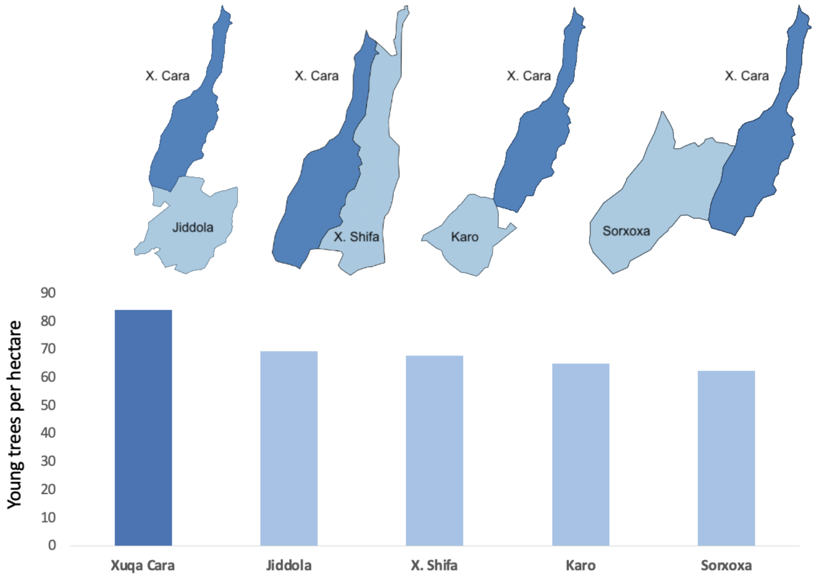

Figure 3: Matched pair identification strategy

Notes: The figure shows four matched pairs, where the group *Xuqa Cara* is treated (has both civic capital and grazing rules), but the other group serves as the control (has either civic capital alone, or grazing rules alone, or none of these). The bars show average PCT in treated and control groups.

V. Results

I first present main results based on the count of young trees aggregated over all tree species. Subsequently, I present species-specific results based on ecological insights. Finally, I present results using matched-pair fixed effects.

V.A. Main results

Table 4 presents the main results. Since civic capital, grazing rules 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 civic capital (CC) and rules alone (GB) are small in magnitude and are also individually as well as jointly statistically insignificant (p-value = 0.52). However, the interaction term (CC*GB) has a large positive coefficient which is statistically significant at the 5-percent level. According to this estimate, one standard deviation increase in the interaction term increases the young tree count by 21 trees, which is a large economic effect. Together, civic capital, grazing rules, and their interaction explains 50 percent of the variation in the young tree count.

In column 2, I control for the pre-program forest condition, measured as the tree cover in 2000. It enters with a small and statistically significant coefficient. The coefficient on the interaction term remains stable in magnitude and significance. In column 3, I introduce control variables including proxies of geography, economic heterogeneity, social heterogeneity, and duration under the program. The coefficient on the interaction term rises in magnitude to 26 trees. In column 4, when I additionally introduce a vector of clan and market-village fixed effects, the coefficient on the interaction term rises further in magnitude to 28 trees and is now significant at the 1-percent level.

These estimates could be due to some weather shocks that positively impacted groups with higher civic capital and grazing rules, but negatively the remaining groups. To counteract this concern, I show in columns 5 that the result holds even when I consider second forest management outcome which is available for slightly over one-half of the groups. As before, the coefficient on the interaction term is positive and statistically significant. It's magnitude is also comparable to the results from the first assessment.

The coefficients on civic capital alone and grazing rules alone are mostly negative and statistically insignificant. The negative coefficient on civic capital is due to two groups which comprise mainly of altruists.[13] One reason behind the negative coefficient on grazing rules could be frustration when rules are not enforced. Another reason could be spiteful punishment. Herrman et. al. (2008) show that punishment leads to increase in contribution only in groups with higher civic capital. In these groups punishment is targeted by civic minded towards free riders. However, in groups with low civic capital, free riders engage in counter punishments resulting is poorer provision of public goods.

The control variables are powerful predictors of the forest management outcome and their inclusion leads to a jump in the R-squared from 0.5 in column 1 to 0.84 in column 4. Consequently, when I conduct a test that follows Oster (2019), it turns out that the selection on unobservables would have to be 12 times larger than the selection on observables to explain away these results, which seems unlikely.

I conduct several robustness checks to ensure that the main results hold in magnitude and significance. The results are reported in Appendix A. In Table A1, I show that the results hold when I use an interaction between indicators variables of civic capital and grazing rules (column 1). The results are also robust to controlling for additional geographical variables like precipitation seasonality and aspect (the extent of north and east facing slopes, column 2). Although education is expected to play a key role in the formation of both civic capital and grazing rules, most group members are either illiterate

[13]Note that altruists are only confided to these two groups and their overall share in the sample is negligible - $<$ 3 percent.

or have just primary level of education. Therefore, the results do not change when I control for the share of group members with primary school education in column 3.

Leaders, members of the executive committee, and rich individuals are expected to have a stronger say in group decision-making. Therefore, I try and control for such factors in Table A2. Kosfeld and Rustagi (2015) show that leader punishment behavior is an important determinant of forest management outcome. Consequently, in column 1, I control for the group leader's punishment behavior. Rule formation or lack thereof is likely to be influenced by individuals with high livestock wealth, as they are affected the most by grazing ban. While the regressions already control for the Gini coefficient of cattle wealth, I separately control for the civic capital of individuals with highest livestock wealth in a group in column 2. In a similar vein, the civic capital of individuals who are part of the group executive committee might have played an important role in rule formation, so I also control for this separately in column 3. Finally, in column 4, I consider additional aspect of leader characteristics, such as age, education, and clan. The inclusion of these additional controls has no effect on the coefficient on the interaction term, which remains economically large in magnitude and is also always statistically significant.

V.B. Ecological insights

I now present results using specifies specific data, which relies on insights from forest ecology and browsing behavior of cattle. As mentioned in Section IV.B, I standardize the outcome variable to allow for the comparison of coefficients across different tree species. This means now both the dependent and the independent variables of interest are standardized. The summary statistics on different tree types are reported in Table 3.

Table 5 presents results on the frequency of young trees per forest hectare. Columns 1-2 show that in line with Ecological Insight I, there is no effect of the interaction term on the count of young coniferous trees. In fact, the magnitude of the coefficient is very small and it is also statistically significant. In contrast, the interaction term has a large positive effect on the count of young broadleaf trees, which is statistically significant at the 1-percent level. One standard deviation increase in the interaction term increases the count of young broadleaf trees by 0.27 standard deviations. This corresponds to nearly 1.6 more trees per hectare or over one-half of the mean frequency of young broadleaf trees in the sample. Since there are 15 types of young broadleaf trees, the effect over all types turns out to be almost 24 trees per hectare. Note that the effect of the interaction term on young broadleaf trees (column 2) is significantly larger than the effect on young coniferous trees (column 1). These findings suggest that for the main result to be driven by omitted variable they must be correlated with the count of young broadleaf trees, which seems implausible. In fact, selection on unobservables would have to be 14 times larger than selection on observables to explain away these results.

Not all broadleaf trees are equally susceptible to browsing. I exploit this variation in column 3 to provide evidence in support of Ecological Insight II. The interaction term has a large positive and significant effect on the frequency of young Hagenia trees. In fact, the magnitude of the coefficient is largest for any tree type. Given that cattle readily browse on Hagenia, young trees of this species are expected to benefit the most from a grazing ban. One standard deviation increase in the interaction term increases the count of young Hagenia trees by 0.81 standard deviations. This corresponds to nearly 0.5 more trees per hectare which is large relative to the mean frequency of young Hagenia trees in the sample. Since there are young Hagenia trees from Division I and Division II, the effect over both the divisions turns out to be one tree per hectare. As before, I confirm that the effect of the interaction term on young Hagenia trees (column 3) is significantly larger than the effect on young coniferous trees (column 1) and marginally significantly larger than the effect on young broadleaf trees (column 2). For omitted variables to explain away this result, they must be specifically correlated with the count of young Hagenia trees, which seems highly unlikely. This is further confirmed by the large statistic on selection on unobservables, which now need to be 38 times larger to explain away this finding.

In Table A2, I show that these results are robust to controlling for other geographical variables, such as aspect and precipitation seasonality. They also hold when I use randomization inference tests. Overall, results from Ecological Insights lend strong credibility to the main findings on the positive effect of the interaction between civic capital and grazing rules.

V.C. Matched pair fixed effects

Table 6 presents results from matched pairs fixed effects analysis. Column 1 controls only for matched pair fixed effect and shows that the coefficient on the treatment dummy, which captures the interaction between civic capital and grazing rules, is positive and statistically significant at the 1-percent level. The magnitude of the coefficient implies that groups with both civic capital and grazing rules have 15 more trees per hectare. The coefficient rises in magnitude to nearly 20 young trees per hectare and remains highly significant when I introduce control variables and fixed effects in column 2.

I also report results from placebo matched pairs. Column 3 controls only for matched pairs fixed effect and shows that the coefficient on an indicator, which captures civic capital alone or grazing rules alone, is very small in magnitude and statistically insignificant. However, the coefficient becomes negative and statistically significant at the 10-percent level when I introduce control variables in column 4. Its magnitude implies that in groups with civic capital or grazing alone, young tree count is lower by nearly 14 young trees. These results are similar to those obtained from using the full sample (see Table 4).

Figure 4 reports results from ecological insights combined with matched pairs analysis.

It is evident from the figure that there is no evidence on the effect of the interaction term for young coniferous trees. In contrast, the interaction term has a large positive effect on young broadleaf trees, and an even larger effect on young Hagenia trees. These results mirror closely those reported in Tables 5 and 6.

This finding further confirms that when operating in isolation, civic capital and grazing rules alone are unlikely to matter for forest management success. Instead one needs a combination of both civic capital and grazing rules.

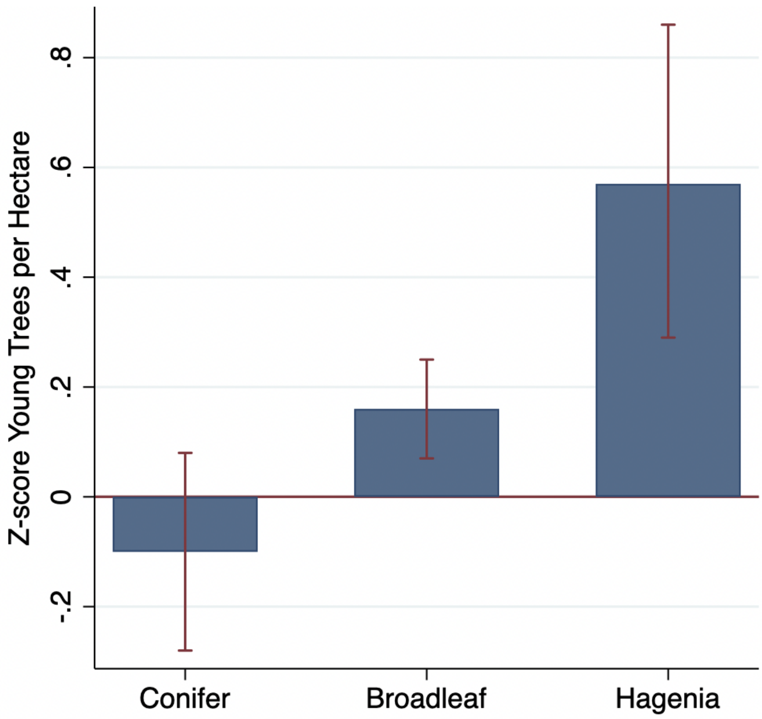

Figure 4: The Effect of the Interaction Term on Young trees of Different Types

Notes: The figure plots coefficients and 95 percent confidence intervals. Estimates are based on OLS regressions after controlling for covariates and fixed effects. These include baseline tree cover, altitude, slope, border with outsiders, market distance, Gini of cattle ownership, female share, settlement fragmentation, clan heterogeneity, duration, group size, clan and market-village fixed effects

VI. Plausible Channels

Theory suggests that the positive effect of the interaction between civic capital and grazing rules on commons management outcome arises because of the following channels:

(a) The enforcement of grazing rules through decentralized monitoring is expected to be stronger in groups with higher civic capital.

(b) Stronger monitoring is expected to generate strong incentives for free riders to cooperate, resulting in optimistic beliefs among the civic minded that others will not defect on their cooperation.

(c) Optimistic beliefs are expected to result in higher contribution as the civic minded cooperate only if they expect others to do the same.

I provide evidence in support of these channels using data at the individual level from household survey and behavioral experiment. It covers the following topics: (i) enforcement of rules through time spent monitoring the forest, (ii) belief over the punishment of individuals who deforest, (iii) belief over the frequency of deforesting acts, (iv) beliefs about contribution by the other player in the unconditional decision of the public goods game, and (v) association between beliefs and contribution in unconditional decision of the public goods game. To tease out these channels, I run the following specification:

$$Channel_{ig} = constant + \tau GB_g + \mathbf{X}_i \zeta + \mu_{ig}, \tag{3}$$

where $Channel_{ig}$ is the response of individual i from group g to the five items listed above. GB is grazing ban *rho*, which is captured using both the extensive and the intensive margin. $\mathbf{X}$ is a vector of control variables. It includes gender, education, land holding, livestock holding, and status within a group (part of the executive committee or not). The coefficient of interest is τ which captures the difference in the expected value of a channel across members from groups with and without rules. To ensure that it captures the spirit of the interaction term, I run equation 3 only for the civic minded who are found in all 51 groups. This constitutes a powerful test, as it allows me to hold the type of an individual fixed. Since I compare the responses of only the civic minded across groups with and without grazing rules, τ can be written as:

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

where CC is an indicator for civic minded individuals. I categorize an individuals as having civic capital if the Spearman correlation in the conditional decision of the public goods game is significant at p-value ≤ 0.05 (see Fischbacher et al. 2001, Fischbacher and Gaechter 2010).

Table 7 reports the results using the extensive margin of grazing rules in panel A and the intensive margin in Panel B. In column 1, the dependent variable is time spent monitoring the group managed forest in a month (hours). Rustagi et. al (2010) show that civic minded individuals spend much more time monitoring their forest. Here I show that among the civic minded those from groups with rules spend even more time. The coefficient on grazing rules is positive and highly significant at the 1-percent level. The magnitude of the coefficient implies that the civic minded from groups with grazing rules spend twice as many hours monitoring their forest as the civic minded from groups without rules (21.66 hours). This clearly shows that the civic minded are willing to engage in costly enforcement when there are rules than otherwise.

This increase in monitoring is expected to result in optimistic beliefs over the punishment of those who deforest. When I regress punishment likelihood on grazing rule in column 2, the coefficient turns out to be positive and highly significant. This means in groups with rules the belief that individuals who deforest will get punished is twice as high than in groups without rules (47 percent). Since this is close to 100 percent, the belief is that individuals who deforest are almost guaranteed to receive punishment.

Given the above results, the perception over activities resulting in deforestation is expected to be lower in groups with grazing rules. Indeed, as column 3 shows, the coefficient on grazing rule is negative and statistically significant. In groups without grazing rules, the civic minded believe the likelihood of activities resulting in deforestation is as high as 76 percent. This drops by one-half to 36 percent in groups with grazing rules.

The survey responses on belief coincide with beliefs over the contribution by the other player in the unconditional decision of the public goods game. Column 4 shows that the coefficient on grazing rules 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 the civic minded from groups with grazing rules have higher beliefs over others' contribution by nearly 20 percentage points than civic minded from groups without grazing rules. This result is striking because unlike in the field in the game there is no punishment for non contribution.

Higher beliefs are expected to result in higher actual contribution to the public good. Table 8 shows that there is a strong positive association between beliefs and contribution in the public goods game, which is also statistically significant. This shows that the civic minded with optimistic beliefs contribute significantly more than civic minded with pessimistic beliefs.

I offer suggestive evidence on election of leader type as another channel. Kosfeld and Rustagi (2010) show that leaders vary in their punishment behavior. While some punish when rules are violated, others punish indiscriminately. I find that groups with civic capital and grazing rules are 36 percentage points more likely to elect leaders who punish rule violators than otherwise. This result should not be confused with leaders driving both civic capital and rule formation. As the results in section V point out, the effect of the interaction term is robust to controlling for both leader type and other leader characteristics.

Figure 5, I offer descriptive evidence that these beliefs and contribution are positively associated with the count of young trees per hectare. As expected the association of young trees is positive with beliefs over punishment of those who deforest, beliefs over contribution in the experiment, and actual contribution, but negative with belief over deforestation being common.

Together, these results explain why the interaction between civic capital and grazing rules leads to better forest management outcomes.

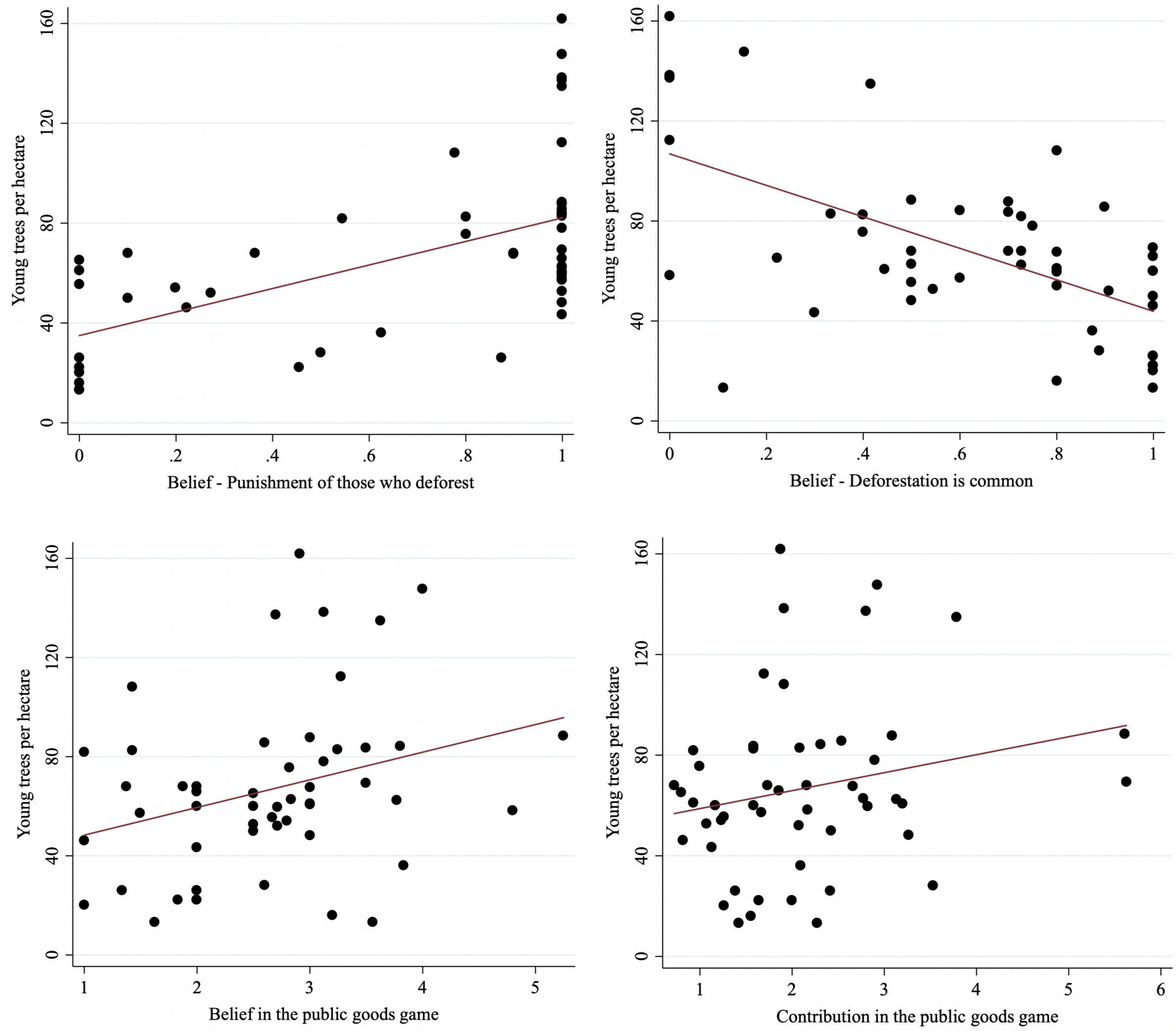

Figure 5: Young trees per hectare, beliefs, and contribution

Notes: The figure shows raw association of young trees per hectare with beliefs in the survey, as well as beliefs and contribution in the experiment. The survey and experimental data are aggregated from individual responses to compute group specific averages. Each circle represents a group.

VII. Conclusions

Many studies have demonstrated that rules and civic capital interact with each other. However, we know little about how this interaction affects economic outcomes. Though theoretical and anecdotal evidence suggests these factors to reinforce each other, field evidence is largely missing. I attempt to fill this gap using the context of forest commons management program in Ethiopia, which was launched to mitigate deforestation arising from livestock browsing. I focus on grazing rules which forbid members from grazing their cattle inside the forest for certain months in a year to allow for young trees to grow. I measure civic capital using a behavioral experiment which precludes confounding motives and beliefs from playing a role.

I find that the best forest management outcomes are observed in groups with both civic capital and grazing rules. In contrast, groups with civic capital or grazing rules alone do not perform better than groups with none of these. These effects persist over time. I use insights from forest ecology and browsing behavior of cattle to show that the effect is observed only for young broadleaf trees that the cattle browse upon, but not for coniferous trees that the cattle usually avoid. Among the young broadleaf trees, the largest effect is observed for the species that are most palatable to cattle.

I use survey and experimental data to shed light on channels via which the interaction effect operates. I find that in groups with grazing rules, civic minded individuals spend much more time monitoring their forest and expect individuals who deforest to get punished. As a consequence, their beliefs about the behavior of others in both the survey and the experiment are optimistic, which results in higher cooperation in the experiment.

These findings have important policy implications. Since decentralized management of commons is likely to be successful in groups with both civic capital and rules targeting resource use, offering secure property rights alone is unlikely to resolve the free rider problem. Program agencies may consider integrating as part of the program package different ways to uphold the beliefs of civic minded individuals that others will not defect on their contribution. Future studies could consider designing and testing such mechanisms using randomized field experiments.

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Table 1: Summary Statistics

	Mean	Standard Deviation
	A: Forest Outcome	
Young trees per hectare (2005)	66.792	34.611
Young trees per hectare (2012-13)	62.78	38.79
	B: Main Variables	
Civic capital	0.495	0.276
Grazing ban (months)	1.471	1.701
Interaction term	0.958	1.187
	C: Control Variables	
Mean tree cover	40.281	8.147
Altitude	2992.237	230.268
Slope	13.927	3.634
Plantation forest share	0.067	0.332
Border with outsiders	0.824	0.385
Market distance	2.926	1.080
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. Civic capital is the Spearman *rho* in the conditional decision of the public goods game. Grazing ban 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 civic values and grazing rules. Mean tree cover is the mean tree cover in group managed forest in 2000 from Hansen et al. (2013). Altitude is the average altitude in a group in meters. Slope is the average slope in a group in degrees. 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 to the nearest market (one-way trip). 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: Balance Check

	Civic Capital (CC) (1)	Grazing Rules (GB) (2)	Interaction Term (CC*GB) (3)
	A: Forest variables		
Mean tree cover	1.670	0.633	-2.656
	(1.493)	(3.623)	(3.964)
Forest area per person	0.075	-0.281	0.015
	(0.347)	(0.843)	(0.922)
Forest importance	-0.051	-0.070	0.047
	(0.054)	(0.131)	(0.143)
	B: Livestock variables		
Cattle per HH	0.350	-1.034	0.355
	(0.721)	(1.749)	(1.914)
Forest area per cattle	-2.566	0.821	-1.626
	(4.238)	(10.282)	(11.249)
Gini cattle per HH	0.020	-0.045	0.023
	(0.015)	(0.036)	(0.040)
	C: Geographical variables		
Elevation	-32.022	-84.747	-42.608
	(34.428)	(83.523)	(91.385)
Slope	0.441	2.066	-0.236
	(0.573)	(1.390)	(1.521)
Plantation forest	-0.014	0.025	0.083
	(0.061)	(0.148)	(0.162)
Border with outsiders	-0.119	0.038	0.113
	(0.070)	(0.171)	(0.187)
Market distance	-0.348	-0.665	0.103
	(0.141)	(0.343)	(0.375)
	D: Other variables		
Female share	-0.015	-0.025	0.020
	(0.022)	(0.053)	(0.058)
Settlement fragmentation	0.042	0.083	-0.154
	(0.033)	(0.080)	(0.088)
Clan heterogeneity	-0.017	-0.023	-0.002
	(0.045)	(0.108)	(0.118)
Duration	0.516	20.349	-7.474
	(2.784)	(6.754)	(7.390)
Group size	-0.754	1.938	-1.540
	(0.857)	(2.079)	(2.275)

Notes: Columns 1-3 show coefficients from a regression of each row variable on civic capital, grazing rules, and their interaction term. Robust standard errors in parentheses. The coefficients are comparable to each other as the variables are standardized. See Table 1 footnotes for the definition of variables.

Table 3: Summary Statistics on Tree Species found in Group Managed Forests

	Young trees	Mature trees
	A: Coniferous Trees	
Overall	8.288	13.546
	(10.346)	(14.287)
Juniperus excelsa	3.931	2.662
	(5.935)	(3.813)
Podocarpus falcatus	12.646	24.431
	(11.909)	(12.485)
	B: Broadleaf Trees	
Overall	2.994	3.022
	(6.019)	(5.991)
Hagenia abyssinica	0.754	4.365
	(0.642)	(3.757)
Ekebergia capensis	0.217	0.812
	(1.149)	(0.893)
Schefflera abyssinica	0.425	0.044
	(0.398)	(0.060)
Olea europea africana	2.070	1.455
	(4.057)	(1.463)
Mytenus species	1.122	0.923
	(1.167)	(0.871)
Hypericum lanceolatum	7.940	0.279
	(9.236)	(0.540)
Rapanea melanphloeos	12.484	9.638
	(9.424)	(12.226)
Pittosporum viridiflorum	0.397	3.961
	(0.551)	(3.643)
Erica arborea	6.512	6.364
	(8.191)	(9.749)
Others	8.397	2.377
	(7.732)	(1.804)

Notes:: Data are from the Program Office for the assessment year 2005. Standard Deviation in parentheses. Overall reports the average over all species within coniferous and broadleaf trees. Others include broadleaf trees from the genus Buddleja and Nuxia. The Program Office does not report the count of these trees separately.

Table 4: Civic Capital, Grazing Rules,
and Forest Management Outcome

	Dependent variable: Young trees per hectare				
	No controls	Pre-program outcome	Control variables	Fixed effects	Second assessment
	(1)	(2)	(3)	(4)	(5)
CC	-2.803	-2.885	-4.156	-4.729	-3.108
	(4.200)	(4.281)	(4.508)	(3.834)	(4.281)
GB	5.044	5.013	-20.330	-26.652	-19.218
	(7.382)	(7.486)	(10.739)	(12.422)	(5.477)
CC * GB	21.103	21.234	26.456	28.496	21.087
	(8.277)	(8.267)	(9.877)	(10.523)	(4.605)
Constant	66.792	64.821	-12.568	-48.228	215.628
	(3.550)	(20.584)	(46.925)	(54.173)	(52.999)
R^2	0.50	0.50	0.80	0.84	0.92
p-value	0.52	0.52	0.18	0.11	0.003
Baseline	No	Yes	Yes	Yes	Yes
Controls	No	No	Yes	Yes	Yes
FE	No	No	No	Yes	Yes
Obs	51	51	51	51	27

Notes: OLS estimates with robust standard errors in parentheses. CC stands for civic capital, GB for grazing ban, and CC*GB the interaction between these two variables. The p-value is for the joint significance of the coefficients on CC and GB. The coefficients are comparable to each other as the variables are standardized. The dependent variable is the average young tree count per hectare of group managed forest for the assessment period 2005 in columns 1-4, and 2012-13 in column 5. The data from the second assessment are available for 27 groups only. The p-value is of the joint significance of civic capital and grazing rules. Column 1 is without any controls, column 2 controls only for the baseline difference in outcomes (pre-program performance), column 3 includes all controls in panel C of Table 1, column 4 includes fixed effects for clan and market-village, and column 5 replicates the result using data from the second assessment. Control variables in columns 1-4 include pre-program outcome, altitude, slope, 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 5, I include a selective list of control variables because of the small sample size. This includes pre-program performance, altitude, market distance, Gini of cattle ownership, and duration under the program.

Table 5: Ecological Test I and II:
Young Trees of Different Types

	Young Trees per Hectare		
	Coniferous trees	Broadleaf trees	Hagenia abyssinica
	(1)	(2)	(3)
CC	0.050	-0.059	-0.184
	(0.085)	(0.018)	(0.162)
GB	-0.018	-0.170	-0.286
	(0.160)	(0.066)	(0.358)
CC*GB	-0.085	0.274	0.806
	(0.168)	(0.059)	(0.339)
Constant	6.135	-3.138	-8.071
	(1.003)	(0.455)	(1.961)
R^2	0.30	0.29	0.55
Controls	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes
Obs	152	570	76
Mean frequency	8.288	2.994	0.754
Standard deviation	10.346	6.019	0.642

Notes: OLS estimates with robust standard errors clustered on the group in parentheses. The coefficients are comparable to each other as the variables are standardized. The dependent variables are standardized. It is number of young trees per hectare of coniferous type in column 1, broadleaf type in column 2, and of Hagenia abyssinica in column 3. Control variables include altitude, slope, border with outsiders, market distance, Gini of cattle ownership, female share, settlement fragmentation, clan heterogeneity, duration, and group size. Fixed effects include indicator for Division II species, clan, market-village. CC stands for civic capital, GB for grazing ban, and CC*GB for the interaction between these two variables.

Table 6: Matched Pairs Fixed Effects Analysis

	Young Trees per Hectare			
	Treated Pairs		Placebo Pairs	
	(1)	(2)	(3)	(4)
CC * GB	15.332	19.937		
	(5.267)	(4.725)		
CC alone or GB alone			1.559	-13.900
			(5.179)	(6.798)
Fixed effects	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes
Obs	46	46	40	40
Pairs	23	23	20	20

Notes: OLS estimates with robust standard errors clustered on the matched pair in parentheses. In columns 1-2 the sample is from treated matched pairs, where groups with civic capital and grazing rules are treated, but the other groups serve as the control. In columns 3-4 the sample is from placebo pairs where one groups has either civic capital alone or grazing rules alone, but the other group has none of these. Control variables include baseline tree cover, altitude, slope, border with outsiders, market distance, Gini of cattle ownership, female share, settlement fragmentation, clan heterogeneity, duration, group size, and market-village fixed effects.

Table 7: Mechanisms: Monitoring, Punishment, and Beliefs about the Behavior of Others

	Time spent monitoring the forest (hours)	Punishment likelihood of those who deforest	Belief over activities resulting in deforestation	Belief over contribution in the experiment
	(1)	(2)	(3)	(4)
	Panel A. Extensive margin (Indicator variable)			
Grazing Rules	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 Rules	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 rules, 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 those who deforest will be punished (1= yes, otherwise, 0); In column 3, it is the belief over 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 having civic capital. The sample size is smaller in column 1-3 because not every player was interviewed using a detailed household survey.

Table 8: 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.