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Individual Heterogeneity, Group Interaction, and Co-operative Behaviour: Evidence from a Common-Pool Resource Experiment in South Africa and Namibia

Bernd Hayo [a] and Björn Vollan [bc]

Abstract

We present econometric evidence on the influence of an individual's sociodemographic characteristics, economic background, and dynamic personal and group interactions on co-operative behaviour in a social dilemma situation. The data are from a framed common-pool resource experiment conducted in Namibian and South African farming communities. Our paper helps to better understand the discrepancy between the fact that people seem to care about advancing their relative position in real life but tend to act to reduce inequality in a laboratory setting. We analyse the first move in the game, the cumulated amount of resources gained by the players and, by taking into account the temporal dimension of the game in a panel context, each individual move.

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I. Introduction

In a rational choice framework, social dilemma situations lead each person to pursue a strategy oriented at his or her short-term individual profit. However, if all individuals pursue the selfish strategy, the long-term interest of the group or the society may be damaged. Hence, everyone would be better off by co-operating. Repeated social dilemmas, such as contributing to public goods or extracting from collectively owned resources, are important obstacles in the development of a society.

How people typically behave in trying to solve these dilemmas is investigated in a variety of field and experimental studies. Sociodemographic characteristics, institutional elements (e.g., sanctions and rewards), motivational influences (e.g., communication and group identity), and strategic elements (e.g., reciprocity conditional on what others do) seem to be essential ingredients for solving a social dilemma. Cognitive biases also influence behaviour in these situations. For instance, a person's reported level of happiness depends on how his or her income compares to others in the same reference group (Easterlin, 1995). The importance of such positional concerns is illustrated by the expression 'keeping up with the Joneses', which Duesenberry (1948) states as the relative income hypothesis. Also, research on loss aversion by Tversky and Kahneman (1991) predicts that earnings below a certain reference point have higher marginal utility than earnings above the reference point. Thus, people who earn less compared to their reference group exert more effort.

However, people often do not behave as theory would predict. First, in most economic experiments, when people can compare their experimental gains with those of others, they frequently are less concerned with boosting their own relative position, and are more concerned about increasing social welfare (Charness and Grosskopf, 2001; Charness and Rabin, 2002) or reducing relative payoffs due to inequity aversion (Bolton and Ockenfels, 2000; Fehr and Schmidt, 1999).[1] Second, when preferences are reference dependent, i.e., individual utility depends on gains and losses relative to a status quo and not on final wealth

[1] There is supporting experimental evidence of a preference for higher relative earnings in ultimatum games (Kirchsteiger, 1994) or common-pool resource experiments (Casari and Plott, 2003); however, rejection in ultimatum games or punishment in common-pool experiments could also be explained by theories of inequity aversion. In addition to theoretical models of social preferences where an individual's utility increases with group equity (Fehr and Schmidt, 1999), including reciprocal behaviour (Bolton and Ockenfels, 2000) or altruism (Andreoni and Miller, 2002), which predicts many bargaining, market, and social dilemma games, other authors distinguish individual player types as being purely selfish, conditional co-operative, altruist, or confused (Fischbacher et al., 2001; Brosig, 2002; Kurzban and Houser, 2005; Bardsley and Moffatt, 2007), or analyse intentions or learning behaviour during the experiment (Mookerherjee and Sopher, 1994; Fudenberg and Levine, 1998; Camerer and Ho, 1999). Recent research shows that players might be very competitive in one situation and co-operative in another and that so-called player types (selfish vs. co-operative) or social preferences are likely to shift over time and context (Herrmann and Orzen, 2008). This might partly explain the discrepancy between people's attempts to reduce inequality in the laboratory and their interest in advancing their relative position in competitive environments or real-life situations.

positions, it is not always entirely clear which reference point is being used. In our framed field experiment, it is important to find out whether the reference point individuals use is experimental income, cumulated experimental income, absolute or relative experimental income, real-life income or wealth, or possibly even societal norms or expectations.

In this paper, we address the question of how relative and absolute economic differences in the real world, as well as relative and absolute experimental payoff in a group of players, affect co-operation within the framework of a repeated social dilemma experiment. The data used come from a common-pool resource experiment conducted in Namibia and South Africa. Whether people try to increase their relative position in the group is an issue with far-reaching implications for the management of real-world commons. In our study region, such behaviour could result in a vicious circle: overuse of the land, leading to degradation and increasing poverty for the lowest income groups in rural areas, which will again exacerbate overgrazing. Solving the social dilemma could safeguard the livelihood of rural populations in many developing countries. Land-reform processes that offer access to private land and incentives to leave the commons will reduce resource pressure only temporarily; stable institutional arrangements that account for individual motivation and different degrees of co-operation across social groups are needed to achieve equilibrium in the longer run. If the relative income hypothesis holds and villagers are trapped in a vicious circle of competition for the commons (i.e., trying to keep more animals than the other villagers), only a rule backed by sanctions ensuring an appropriately low and equal number of animals on the village commons could solve the dilemma. Such a rule could either be provided formally by a governmental authority or informally through social agreement within the village community.

In the following, we discuss our empirical methodology and how it relates to the relevant literature. Section III presents the *a priori* economic hypotheses that will be tested within our setup. The first round of choices is studied in Section IV and, with the help of cross-sectional analyses, the cumulated amount of extracted resources in Section V. Section VI presents a dynamic panel data model that helps explain the players' choices in each round. In the last section, we summarise the findings and derive the main conclusions.

II. Related Literature, Empirical Methodology, and Experimental Design

Communal farmers and nonfarmers from rural villages in South Africa and Namibia participated in our common-pool resource experiment. These people use the commons for subsistence-level sheep and goat farming. The experimental task is framed as a decision on the number of animals individuals want to possess on a jointly-owned grazing land. In a similar experiment, Cardenas (2003) shows that actual individual wealth and the heterogeneity of the group with regard to wealth are important factors in explaining the variation between groups and individuals. In his study, poorer people appear to be more co-operative and he argues that less-wealthy farmers are more dependent on the commons and thus better able to sustain co-operative outcomes. However, Cardenas (2003) uses a subsample of the last three out of twenty rounds in the game that is, the face-to-face communication treatment only. He neither takes the different treatments nor the dynamics of the complete game into account, and his explanations might be misleading.[2]

Burns and Visser (2007) use different initial experimental endowment as a measure of wealth and Buckley and Croson (2006) employ different levels of per-round earnings to create heterogeneity among individuals. Based on the altruism and inequity aversion literature, Buckley and Croson (2006) expect that people with lower experimental earnings and cumulated earnings below the group median will contribute less to the public good. However, they discover that people with lower earnings and lower wealth contribute the same absolute amount to the public good as everyone else and that models of inequity aversion and altruism do not predict the behaviour of the better-off subjects. Indeed, given the difference in initial wealth, the less wealthy contribute relatively more.

The framed field experiment undertaken by Burns and Visser (2007) in South African fishing communities also reveals that people with lower experimental endowment provide the same absolute, but relatively higher, amount of the public good. Thus, larger experimental income and wealth reduces an individual's willingness to co-operate or, alternatively, less income and wealth leads to an increased willingness to co-operate. However, these effects might be due to a demonstration effect or an overjustification of the less wealthy players that would not occur in real-world interactions. In contrast to these studies, we interpret cumulated experimental earnings as wealth and lagged earnings as income and derive absolute and relative measures for both variables over time.

We address the question of how sociodemographic and economic differences across individuals, and dynamic interactions within a group, affect co-operation within the framework of a repeated social dilemma with a nonstandardized and experienced subject pool in a framed field experiment. In our analysis, we follow a suggestion by Cardenas and Ostrom (2004) and take into account different layers of information the participants might use in making their decisions.

[2] Similar approaches to studying sociodemographic influences on behaviour are applied to the analyses of one-shot field experiments on trust, fairness, or risk (for a review of experiments in developing countries, see Cardenas and Carpenter, 2006). Some results of these studies are discussed in Section 3.

We start the analysis by investigating the determinants of a player's first move in the game, which we believe will be influenced solely by sociodemographic background, how the player sees the other four members in the group, and the experimental task.

Second, we analyse the average appropriation level in the game and test for the influence of sociodemographic and group variables. Differences between significant explanatory variables in the models explaining first choice and average choice of players can be attributed to game-related effects, particularly context-oriented learning. Since we control for being a farmer as well as for income and wealth, we can test whether the wealth effect is related to experience in using the commons, as argued in Cardenas (2003), or whether it is inherent to a person's wealth and/or income.[3]

Third, we study the game dynamics, which allows an analysis of how the subject's behaviour changes over (game) time due to group interaction and the impact of treatment effects, as well as the payoffs received. As individual payoffs and group extraction from the resource are the main pieces of information people receive in the course of the game, we think that participants use this information to update their beliefs about other players' earnings and to decide on their own strategies. We therefore study the influence of the choices of our probands and systematically relate them to the public signals they obtain and process.[4]

In our empirical models, we rely on cross-section, as well as panel, regressions that control for heterogeneity within and across time using fixed effects when taking into account dynamic game interactions (see Wilcox, 2006). To increase estimation efficiency, we use a consistent general-to-specific modelling approach (see Hendry, 1993) that avoids any path dependencies in the elimination process of insignificant variables.

We model grazing land as a common-pool resource (CPR) that is extensively used for grazing small ruminants. The defining features of a CPR are subtractability of the resource and nonexcludability of other users, both of which generate negative externalities that constitute a need for co-ordination and co-operation. The experiment is based on the standard problem of individual harvests from a common pool resource by N = 5 identical individuals. The model is

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[3] In our study, wealth is related to experience in using the commons (as wealth is largely measured by number of livestock). Following Cardenas (2003), we would expect that wealthier people and farmers play more co-operatively and we can control for both influences.

[4] See Houser et al. (2004) or Coats and Neilson (2005) for laboratory experiments that elicit beliefs from actual choices without inferring theoretical assumptions or direct questions. For instance, Croson (2007) discovers that voluntary individual contributions to a public good are related to reciprocity (i.e., the contributions of others or to their beliefs about those contributions) and not to commitment or altruism. In the only framed field experiment, Velez et al. (2005) measure beliefs by a direct elicitation of responses and find that model of conformism, in which it is not the actual choices but the average expected choices of others that best describe own strategies. They conclude that models of altruism, reciprocity, or inequity aversion do not describe their data. Unfortunately, Velez et al. (2005) do not report actual per capita income and wealth of the participants in their field experiments.

similar to those of Ostrom et al. (1994), Falk et al. (2002), and Casari and Plott (2003). An individual i decides how many sheep $x_i \in \{1..9\}$ he wants to own and the number of aggregate sheep is $X = x_i + x_{-i}$, with $x_{-i} = \sum_{j=1}^{N} x_j$, for $j \neq i$. He has an endowment e_i, faces constant prices p, and is confronted with a concave payoff function (Equation (1)) with decreasing returns to scale (see Velez et al., 2005).

$$\pi_i = e_i + px_i - c(x_i + x_{-i}) - dx_i(x_i + x_{-i}), \qquad (1)$$

where $dx_i(x_i + x_{-i})$ captures the social dilemma. The Nash equilibrium (NE) of the game can be derived using the first-order conditions obtained from maximising earnings by varying the number of sheep ($\partial\pi_i/\partial x_i$) in Equation (1). The best response function is

$$x_i^{NE} = \frac{p-c}{2d} - \frac{1}{2}x_{-i}. \qquad (2)$$

As all agents have identical incentives and preferences, the Nash equilibrium is unique and symmetric so that the group outcome is $X^{NE} = \left(\frac{N}{N+1}\right)\left(\frac{p-c}{d}\right)$. (3)

The Nash equilibrium results in an inefficiently high level of use. The social optimum (SO) results from maximising group revenue $\partial\Pi_i/\partial x_i$. The group profit function (Equation (4)) is nonlinear in the group total number of sheep as it first increases in X and then decreases.

$$\Pi = \sum_{i=1}^{N} \pi_i = Ne + pX - cNX - dX^2. \qquad (4)$$

The social optimum is $X^{SO} = \left(\frac{p-cN}{2d}\right)$. (5)

For N = 5, e = 900, p = 116.875, c = 17.875, and d = 2.75, the social optimum is $x_i = 2 \forall x_i$ and the Nash equilibrium is $x_i = 7 \forall x_i$. These numbers were chosen so as to arrive at a realistic number of sheep for the experiment. The admissible range for choices is {1,..,9}, representing {1-10,..,91-100} sheep on an area of 1000ha. If 5 players graze up to 20 sheep, the optimal carrying capacity of the commons is 100 sheep.

Forty-two groups consisting of randomly-selected participants from South African and Namibian villages play a first stage with 10 rounds of a typical common-pool resource game based on the model presented above. After the 10^{th} round, a “community election” is held and a new institution, based on the majority of votes, is implemented during Rounds 11–20.[5] The new institutions that can be voted on are:

- External regulation with imperfectly monitored and gradually increasing penalty.
- External regulation with randomised reward.
- Face-to-face communication.

We employ the experimental protocol suggested by Cardenas et al. (2000) and presented in more detail by Vollan (2008a, 2008b). Table A1 in the Appendix provides descriptive statistics of participant characteristics. A total of 210 probands participated in 42 sessions of 20 rounds each, resulting in 4200 observations for the panel analysis. It is a diverse sample: players' education ranges from 0 to 16 years, their age from 18 to 89, and their total annual income—including remittances and part-time work—from 0 to 504,000 South African rand.[6]

III. Theoretical Hypotheses

We conduct our empirical analysis along several dimensions. The first dimension is related to the variables of interest. Our dependent variables include: (i) the number of sheep chosen in the first period, (ii) the cumulative number of sheep in the whole game, and (iii) the number of sheep in each period. The second dimension has to do with the explanatory variables. In the analysis of (i) and (ii), we use sociodemographic variables as covariates, while (iii) allows using game-specific variables as regressors. The third dimension reflects different estimation procedures. Here, we make use of cross-sectional ordinary least squares estimates (OLS) for the first two dependent variables, and panel data methods for explaining the choice in each round of the game. We also analyse the impact of the treatments introduced after Round 10. Below, we discuss our theoretical priors with respect to the variables listed.

Age: Sutter and Kocher (2007) provide evidence that trust in anonymous partners increases almost linearly from early childhood to early adulthood but stays constant afterward. List (2004) finds, in three different field experiments related to public goods, that the younger and middle-aged cohort behave the same as they have been shown to do in laboratory experiments but that the older cohort (age > 49) co-operates at a higher rate than would be expected from laboratory experiments. Thus, we expect a (nonlinear) effect of age, with older participants showing a higher degree of co-operation.

[5] In the situation where two players voted for institution x, two players for institution y, and one player for institution z, the choice between institution x and y was based on chance.

[6] The exchange rate of the rand with the US dollar was 6.38 rand/dollar at the time of the experiment (1 March 2006). One South African rand is equal to one Namibian dollar. The South African rand is an authorised means of payment in Namibia.

Gender: Croson and Buchan (1999) and Croson and Gneezy (2009) find no substantial differences between men and women playing the trust game. Schwieren and Sutter (2008) discover a weak gender effect for trust in ability but no gender effect for trust in co-operation. Other experimental studies show women to behave less selfishly than men (Eckel and Grossman, 1996) and they appear to be less competitive than men (Gneezy et al., 2003). Female probands exhibit less trust (but more reciprocity) (e.g., Greig and Bohnet, 2008; Barr, 2003).

Thus, although the precise relation between gender and pro-social preferences remains unclear, we in general expect more co-operation from female participants.

Marital status: Our *a priori* hypothesis is that due to their greater economic capacity, married people will choose fewer sheep as they are not as dependent on additional life-preserving earnings as are widowed or divorced people, who form the reference category. Similarly, single persons will choose fewer sheep, but we would expect the difference to be smaller.

Household: Our prior is that since the head of the household is responsible for the well-being of all household members, often under adverse conditions, he is more used to thinking in terms of ensuring the survival of the group. Larger households need more resources and perhaps are also more familiar with the concept of competing for resources; thus members of large households may choose a large number of sheep. A similar argument holds in the case of the number of children; a household with children will need more resources since children cannot contribute to the survival of the household as much as adults.

Education: In our sample, education is measured as the number of years of schooling. *A priori*, we expect that those who are better educated have a better understanding of overgrazing or co-operation problems. However, the better educated may also be more cognisant of the advantages to be gained from exploiting the group.

Local attachment: In our experiment, all players in group are from the same village, and we thus proxy local attachment by the number of years a person has lived in the village. Our expectation is that those with a greater degree of community spirit (i.e., longer local attachment) will play more co-operatively.

Religion: Respondents who are members of a religion that emphasises the equality of human beings and the duty to help neighbours should play more co-operatively. For instance, Christian beliefs put a strong focus on sharing resources, with Protestant faiths (Methodist, Lutheran, Dutch Reformed (NGK/VGK), and Anglicans) being particularly critical of amassing wealth.[7]

Church attendance: Owen and Videras (2007) report that religious beliefs and church membership affect the voluntary provision of environmental public goods. We use the number of church visits per month as a proxy for a person's religiosity. More religious persons may be willing to give up resources and act more co-operatively.

Occupation: We conjecture that the unemployed and pensioners have a greater need for resources as they are less able to fend for themselves. We thus expect the permanently employed to choose fewer sheep. Also, experienced farmers should understand the problem of overgrazing and thus may play relatively more co-operatively.

Economic situation: We expect that high-income participants have less need for additional resources. In a public good game, Burns and Visser (2007) find that people with higher per capita income behave more co-operatively. Johansson-Stenman et al. (2006) and Greig and Bohnet (2008) find positive correlations between income, trust, and reciprocity; Cardenas (2003) reports negative ones for absolute wealth and heterogeneity of wealth. However, a high income may also reflect a greater preference for consumption than for leisure, which would suggest choosing a larger number of sheep.[8] When looking at the relative income position in terms of income quartiles, there is an incentive to choose more sheep to defend or advance one's position. Similar arguments apply to *absolute and relative wealth*, too. Thus, we expect the absolute income effect to have a positive influence and the relative income effect to have a negative influence on co-operation.

Collective action: Membership in the Community Committee[9] may be indicative of active participation in the provision of collective goods, which should imply choosing fewer sheep. The social capital literature argues (Glaeser et al., 2000) that membership in organisations leads to more co-operative behaviour. However, given that work is sometimes distributed via Committee membership, such membership could also indicate a stronger income orientation. This is another situation where the results of experiments have been ambiguous. For example, in a public good experiment comparing kibbutz members to city residents in Israel, Ruffle and Sosis (2006) find that kibbutz members do not play more co-operatively when paired with non kibbutz members. Perhaps it is that the co-operative enhancing effect of membership and

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[7] In South Africa, Christianity is the major religion, albeit in many different forms. Roman Catholic, Methodist, Dutch Reformed, and Anglican are most prevalent in our study region. Due to its German colonial history, Namibia is the only country outside Europe with a Lutheran majority.

[8] This assumes that the income level is above the minimum needed to ensure the person's basic physical survival.

[9] Community Committees are supposed to make decisions on different areas of public life in the village.

collective action only works for in-group encounters. To what extent village residence can be understood as a proxy for group membership is not clear and to shed a little light on this uncertainty, we will employ a second collective action proxy, namely, days of unpaid collective work.

Regional differences: A dummy variable for Namibia is included as a control for regional differences.[10]

Payoff of player in t-1: In traditional microeconomic models, agents are interested only in their own situation and the relevant variables enter the utility function in absolute values. If this model of behaviour is correct, we expect that a player's individual winnings will strongly affect the player's choices.

Cumulated payoffs of player in t-1: This is a variant of the previous argument, now focussing on winnings over a period of time instead of at just one point in time. This could be interpreted as a sort of trend effect in contrast to the short-term impact captured by the previous variable. It may also reflect a slow adjustment effect.

Payoffs of group in t-1: A negative correlation of group play and individual choice in round t suggests reciprocity (i.e., when the group has performed well, an individual member of it will reduce the number of his or her sheep further; when the group has performed badly, the member will increase his or her own payoff to punish the others). Note that the value for the group is computed without the payoff to the respective individual.

Cumulated payoffs of group in t-1: This variable takes into account a delayed effect over a period of time and can indicate a trend or a slow adjustment process.

Relative payoff of player in round t-1: Based on Buckley and Croson (2006) and models of inequality aversion and altruism, we hypothesise that people with higher accumulated payoffs will play more co-operatively. Thus, a negative correlation between (relative) payoff in the previous round and appropriation choice in the current round suggests immediate effects of inequality aversion or altruism as people change their strategies. High (low) payoffs are followed by low (high) appropriations levels. A positive correlation indicates that players are reinforcing their strategies and playing competitively. High payoffs lead to high appropriation (low co-operation) and low payoffs to low appropriation (more co-operations). These effects become clearer when measured in relative terms.

Cumulated relative payoffs of player in t-1: Here, the same correlation is true as above, but the effect of inequality aversion and reciprocity only becomes apparent after the passage of

[10] A significant country effect for certain treatments in the data set was reported by Vollan (2008b).

time. Moreover, a negative correlation with cumulated relative payoffs suggests a certain threshold level of guilt that occurs when a person exploits the group for too long.

IV. Explaining the First Move in the Game by Sociodemographic Variables

In a one-shot game, by definition, game-related aspects cannot explain a player's first move. However, the move may be influenced by the player's sociodemographic characteristics. Given that group memberships are allocated randomly, one might expect group effects to be irrelevant. However, in this particular experiment, most people know each other as they are from the same village. Thus, they hold views about the other group members that may very well affect their first move. Second, there is some, if rather limited, group interaction before the game begins, which may give rise to first impressions about the other group members. Thus, we include group dummies and then statistically test to see whether or not they matter. The estimation method is ordinary least squares and the diagnostic tests of the residuals of Model 1, the general model, show no violation of standard assumptions (see Table 1).

It is apparent from Model 1 that most variables are insignificant when judged by their t-tests. To reduce the number of variables in the model, we apply general-to-specific modelling (see Hendry, 1993).[11] Before applying a consistent testing-down procedure at a 5% nominal significance level, we ensure that our general model is a congruent representation of the data, i.e., that none of the diagnostic tests indicates a problem. Given the relatively small number of observations, we allow the inclusion of the group dummies in the model-reduction process.

Table 1: Explaining the number of sheep played in the first round

Model	1 General model		2 Reduced model	
Variables	Coefficients	SE	Coefficients	SE
Age				
Age	0.13	0.080		
Age squared	-0.001	0.0009		
Gender				
Male	-0.59	0.498		

[11] We use the Gets algorithm (Hendry and Krolzig, 1999), which improves on the automatic general-to-specific modelling procedure of Hoover and Perez (1999). These procedures avoid problems associated with possible path dependencies in the reduction process by checking each possible reduction path and ensuring that none of the diagnostic statistics are violated.

Marital status				
Married	0.24	1.026		
Single	0.70	1.087		
Household				
Head of household	0.29	0.607		
Household size	0.10	0.094		
Number of children	0.01	0.149		
Education				
No. of years	-0.03	0.095		
Local attachment				
Years living in village	-0.02	0.017		
Religion				
Lutheran	-1.38	0.997		
NGK/VGK	-0.76	1.291		
Catholic	-0.98	0.723		
Others	1.13	0.915	1.25(*)	0.657
Church attendance				
Number of church visits per months	0.14	0.198		
Occupation				
Unemployed	4.02	2.769	5.39**	0.317
Pensioner	0.78	1.374		
Permanently employed	0.90	0.985		
Farmer	0.87	0.686		
Economic situation				
Absolute individual income	-0.000001	0.000007		
Lower-middle quartile	3.91	2.822	5.18**	0.309
Upper-middle quartile	4.75(*)	2.783	6.45**	0.321
Highest quartile	3.57	2.912	5.77**	0.305
Absolute HH wealth	-0.000004	0.000007		
Lower-middle quartile	0.52	0.693		
Upper-middle quartile	-0.25	0.633		
Highest quartile	0.45	0.906		

Collective action			
Committee member	-0.14	0.507	
Days of unpaid collective work	0.01	0.007	
Controls			
Namibia	-1.51	2.73	
Constant	-0.23	4.11	
Group dummies	40 groups		5 groups
No. of observations	192		192
SE of regression	2.24		2.09
R^2	0.37		0.18
Adj. R^2	0.01		0.14
Joint test of all variables	F(70,121) = 1.02		F(10,182) = 138.6**
Heteroscedasticity test	F(79,41) = 0.30		F(10,171) = 1.03
Normality test	$Chi^2(2)$ = 0.09		$Chi^2(2)$ = 1.52
RESET test	F(1,120) = 0.41		F(1,181) = 0.001
Testing exclusion restriction			F(61,121) = 0.60

Notes:

i) The estimator is OLS.

ii) The symbols **,*, and (*) indicate significance at the 1, 5, and 10 % level, respectively.

iii) Reference categories of dummies that are not self-explanatory: Marital status: Widowed and divorced; Occupation: Occasional work; Farmer: All other types of work; Religion: Methodist; Income quartiles: lowest quartile; Wealth quartiles: lowest quartile.

iv) Diagnostic statistics: Heteroscedasticity test: White (1980) test using squares of the regressors; Normality test: Jarque and Bera (1987) test with a small-sample correction; RESET test: Misspecification test developed by Ramsey (1969).

v) The R^2 in the reduced model is based on the squared correlation coefficient between original and fitted series.

Since none of the diagnostic tests (see bottom part of Table 2) is violated, Model 1 is a congruent representation of the data-generating process. Applying the reduction algorithm leads to the much smaller Model 2, which also passes all the statistical tests.

First, there are five group dummies left in the equation, which are jointly significant at the 1% level (F(5,182) = 5.49**). This suggests that the participants either had preconceived ideas about the other group players based on previous acquaintances or that the short group interaction before the game was sufficient to influence the first move. These group effects are also economically relevant as the largest effect in absolute terms is due to one group that chose, in its first move, on average almost four sheep less than the others.

Being unemployed significantly influences the number of sheep chosen, which is in line with our theoretical prior. The economic relevance of this statistical effect is large, as we cannot reject the hypothesis that the unemployed chose five sheep more on average in their first move than the other participants ($Chi^2(1) = 1.50$).

Those who do not adhere to any of the listed religions choose significantly more sheep than those having religious beliefs. The effects are economically relevant; we cannot statistically reject that these persons choose 1.5 sheep more than those with a stated religious belief ($Chi^2(1) = 0.14$).

Finally, we observe statistically highly significant positive effects for the income quartiles. Those who are relatively better off choose a noticeably larger number of sheep in the first period compared to the lowest income group. However, there appears to be a nonlinear effect with regard to the relative income position in society. Those who are in the two highest income categories choose one sheep more than those who are in the lower-middle income quartile. The coefficients on the upper-middle and highest income category are statistically indistinguishable from 6, and the coefficient on the lower-middle income category is 5 ($Chi^2(4) = 2.99$), which is in general accord with our theoretical prior of a defence of the relative income position in society. The larger point estimate of the coefficient on the upper-middle income quartile could be interpreted as an expression of this group's interest in moving into the highest income quartile; however, the main dividing line is between the poorest quartile and the three richer quartiles, the latter choosing noticeably more sheep than the former.

V. Explaining the Cumulated Number of Sheep Chosen in the Game

We now discuss and explain the cumulative number of sheep played in all 20 rounds of the game. Due to the aggregation across time, we can use only the sociodemographic variables. We again include group dummies to control for group-specific fixed effects. The outcome of the analysis is shown in Model 3 of Table 2. The diagnostic statistics of Model 3 in Table 3, the general model, are acceptable, i.e., the model is a congruent representation of the data-generating process. A consistent testing-down process at a nominal significance level of 5% leads to the much simplified Model 4.

We find that players who engage in unpaid community work and those who have higher income accumulate a relatively larger number of sheep over the course of the game (only significant at a 10% level).

Table 2: Explaining the cumulated number of sheep

Model	3 General model		4 Reduced model	
Variables	Coefficients	SE	Coefficients	SE
Age				
Age	0.29	0.700		
Age squared	-0.006	0.007		
Gender				
Male	-2.95	4.314		
Marital status				
Married	-12.21	8.881		
Single	-13.26	9.410		
Household				
Head of household	-1.65	5.255		
Household size	1.12	0.813		
Number of children	0.64	1.285		
Education				
No. of years	0.32	0.822		
Local attachment				
Years living in village	-0.21	0.149		
Religion				
Lutheran	-11.90	8.635	-14.93**	5.236
NGK/VGK	9.71	11.18		
Catholic	-0.59	6.257		
Others	4.42	7.923		
Church attendance				
Number of church visits	-0.89	1.712		
Occupation				
Unemployed	-6.23	23.97		
Pensioner	22.96(*)	11.90		
Permanently employed	14.17(*)	8.527		
Farmer	3.78	5.942		

Economic situation				
Absolute individual income	0.0001*	0.00006	0.00007(*)	0.00004
Lower-middle quartile	-10.02	24.44		
Upper-middle quartile	-15.33	24.10		
Highest quartile	-24.83	25.21		
Absolute HH wealth	-0.000002	0.00006		
Lower-middle quartile	-2.52	6.001		
Upper-middle quartile	-1.08	5.479		
Highest quartile	-3.67	7.840		
Collective action				
Committee member	-1.026	4.390		
Days of unpaid collective work	0.08	0.058	0.10*	0.042
Controls				
Namibia	19.44	23.88		
Constant	87.36*	36.10	97.19**	1.637
Group dummies	40 groups		7 groups	
No. of observations	192		192	
SE of regression	19.41		18.54	
R2	0.44		0.24	
Adj. R2	0.12		0.19	
Joint-test all variables	F(70,121) =	1.36(*)	F(10,181) =	5.60**
Heteroscedasticity test	F(79,41) =	0.47	F(12,168) =	1.74(*)
Heteroscedasticity test with cross-products	n.a.		F(29,151) =	1.12
Normality test	Chi2(2) =	2.54	Chi2(2) =	3.51
RESET test	F(1,120) =	0.11	F(1,180) =	0.13
Testing exclusion restriction			F(60,121) =	0.74

Notes: See Table 1.

Those belonging to the Lutheran faith choose relatively fewer sheep than those adhering to other faiths. The sign for the Lutheran faith indicator is in line with our theoretical prior, and the positive effect of income supports the consumption-leisure trade-off argument rather than the basic needs hypothesis.

In the case of voluntary work for the community, our expectations turn out to be wrong: those who volunteer more hours choose more sheep over the course of the game. There are several possible explanations for this unexpected finding. First, the variable may not really capture a person's willingness to contribute to a collective good, that is, it could be that the person engages in volunteer work to feel good about himself or herself rather than to do good for the community. Second, it could be that volunteers look upon the unpaid work as "paying their dues" and hope to be rewarded for it by gaining a paid job from the community in the future. Thus, engaging in voluntary work could be an indicator of a person's work ethic (Stiglitz, 1988). Third, since there was no way of verifying the stated number of volunteer hours, the data could be faulty.

An assessment of the quantitative impact of the remaining explanatory variables in Model 4 reveals that the estimated economic effects are not particularly high. To raise the cumulated number of sheep by one, individual income must increase by more than 14,000 rand. Computing the corresponding elasticity reveals that a 1 percentage point rise in income leads to a 0.01 percentage increase in the number of sheep chosen over the whole game. Regarding the days of unpaid collective work, 10 more days of community-oriented work raises the number of sheep chosen by one. This implies an elasticity of 0.01, yet again a highly inelastic reaction. Finally, converting from Methodist faith to Lutheran will, *ceteris paribus*, reduce the number of accumulated sheep during the course of the game by five and a half, which is almost 6% of the average number of cumulated sheep. Thus, for the cumulative number of sheep, the only economically relevant case is the difference between Lutherans and other religious faiths, with the former choosing noticeable fewer sheep than the others.

We also find that there are seven significant group effects in Model 4, the coefficients of which range from 22 to –26. Thus, group membership can have a substantial impact on the accumulated number of sheep chosen by an individual. As the allocation of players to specific groups was random, this suggests that social processes within groups may play an important role in explaining individual choice. Consequently, we analyse group-specific behaviour further in Section VI.

It is also instructive to compare these results with those obtained from the regression on players' first moves. Income has a similar positive effect on the number of sheep played, but it is relative income that influences the first move and absolute income that affects the cumulative number. Regarding the impact of religious beliefs, it is noteworthy that respondents not affiliated with a major religion choose more sheep in the first move, while those of Lutheran faith select fewer sheep over the course of the game. The unemployed, who choose significantly more sheep in the first round, select an average number of sheep over the course of the full game, a behavioural change suggesting that social processes and learning effects lead to more pro-social behaviour and can be effective regulating devices in groups.

Finally, it is interesting to look at the impact of the different treatments on the cumulated number of sheep. We cannot include the treatment effects in the previous model due to multicollinearity arising with the group dummies. Nevertheless, it is interesting to see the estimation results in a setting with treatments and excluding group dummies. The consistent testing-down process (exclusion test: $F(30,159) = 1.02$) leads to Equation (6):

Cumulated no of sheep = 98** + 0.0001** individual income – 9.2** reward (6)

No. of obs.: 192; SE of regression: 20; $R^2 = 0.07$; Adj. $R^2 = 0.06$; $F(2,189) = 7.14$

Note: ** indicates significance at a 1% level.

The diagnostic tests do not indicate any statistical problems and the results imply that those with higher personal income choose a relatively larger cumulative number of sheep. This is in line with the outcome of the model including group dummies instead of treatments. However, the only other significant variable is the dummy indicating the group choice of 'reward'. Those groups that select 'reward' choose a much smaller number of sheep that is both statistically significant and economically relevant.

However, comparing model selection criteria for the reduced group model with those for the treatment model leads to the conclusion that including group dummies is statistically preferable to considering treatment effects.[12] Hence, individual group effects dominate the impact of treatments with regard to explaining the cumulative number of sheep chosen.

VI. Explaining the Number of Sheep Chosen in Each Round

We now take a look at the number of sheep chosen in each round by each individual player, i.e., we make use of the time dimension in our data set. Since we now include group-related variables, we can model how group dynamics affect individual strategies over the course of the game. Technically, this means that we move toward a panel data analysis. If the individual-specific effects are random, it would be appropriate to apply an asymptotically

[12] Model selection criteria: Akaike: 6.009 (treatment dummies), 5.896 (group dummies); Schwarz: AIC: 6.060 (treatment dummies), 6.082 (group dummies); Hannan-Quinn: 6.030 (treatment dummies), 5.971 (group dummies); final prediction error: 407.1 (treatment dummies), 363.5 (group dummies).

efficient random effects model estimated via feasible generalised least squares. As it turns out, though, the individual dummies are highly significant, which implies that a GLS random effects model is not appropriate (Mundlak, 1978). Therefore, we employ a fixed effects estimator in the form of a least squares dummy variable model (LSDV), the results of which can be found in Table 3. As the sample is large (almost 4000 observations), making the statistical tests very sensitive to violations of the null hypotheses, we test at a 1% level following Leamer (1983), who recommends adjusting the significance level inversely with the sample size.

Table 3: Explaining the number of sheep played in each round

Model	5 General model		6 Reduced model	
Variables	Coefficients	SE	Coefficients	SE
Game-related variables: Individual				
Payoff of player in t-1	0.006	0.004		
Cumulated payoffs of player in t-1	0.00001	0.0003		
Game-related variables: Group				
Payoffs of group in t-1	-0.003**	0.001	-0.002**	0.0003
Cumulated payoffs of group in t-1	0.0003**	0.0001	0.0003**	0.0001
Relative payoff of player in t-1	-3.22	4.74	3.42**	0.98
Cumulated relative payoffs of player in t-1	-14.46**	3.65	-14.09**	3.24
Treatment variables				
Penalty	-0.06	0.37		
Reward	0.10	0.41		
Individual decision on treatments				
Agree to treatment	-0.75	0.62		
Agree to penalty rule	-0.55	0.54		
Agree to reward rule	0.34	0.38		

Controls				
Constant	11.49**	1.47	9.71**	0.88
Individual dummies	209		209	
Group dummies	41		41	
Time dummies	18		18	
No. of observations	3990		3990	
SE of regression	2.252		2.254	
R^2	0.271		0.268	
Joint test: substantial variables	$Chi^2(11)$ = 99.7**		$Chi^2(4)$ = 89.0**	
Joint test: time dummies	$Chi^2(18)$ = 59.7**		$Chi^2(18)$ = 135.4**	
Joint test: group dummies	$Chi^2(41)$ = 2107**		$Chi^2(41)$ = 1333**	
Joint test: individual dummies	$Chi^2(209)$ = 1353**		$Chi^2(209)$ = 1465**	
Autocorrelation test: AR(1)	N(0,1) = 0.12		N(0,1) = 0.41	
Autocorrelation test: AR(4)	N(0,1) = 1.95		N(0,1) = 1.86	
Testing exclusion restriction			$Chi^2(7)$ = 5.55	

Notes:

i) Least squares dummy variables estimator. Robust standard errors are based on Arellano (1987).

ii) ** indicates significance at a 1% level.

iii) Diagnostic statistics: Autocorrelation test: AR(n): n^{th}-order panel autocorrelation tests distributed normally under the null.

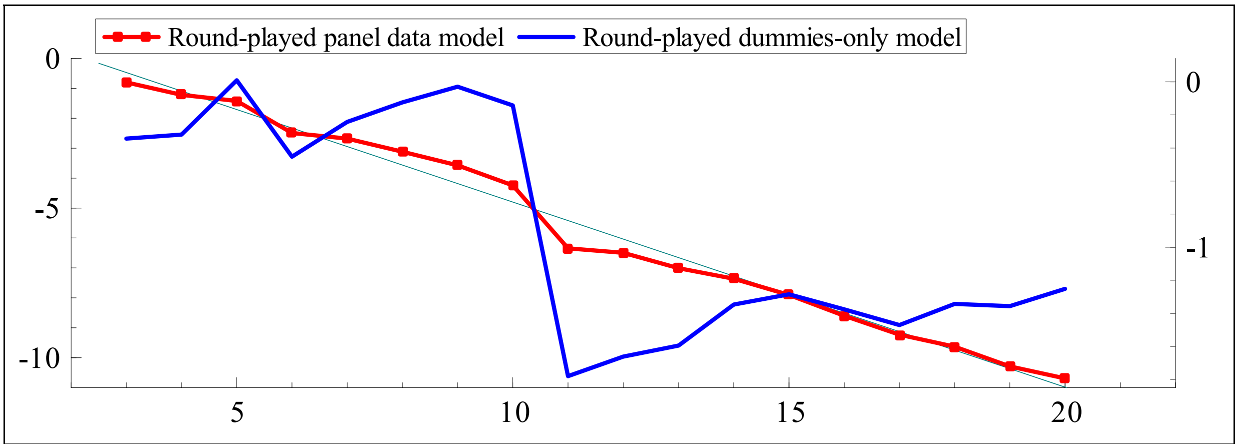
The large number of observations also allows for the application of heteroscedasticity-consistent errors, based on Arellano (1987), which rely on asymptotic properties. Panel tests for autocorrelation indicate no significant degree of correlated residuals.[13] As controls, we include individual, group, and time (round-played) dummies. Given the large number of observations, we do not include the controls in the testing-down process. All three dummies are highly significant, as can be seen from the joint Chow-type tests. This underscores the finding from our previous sections, namely, that group effects play a role in the number of sheep chosen by the players. Since the sociodemographic information we analysed previously is time invariant, it cannot be included here due to the fixed effects. However, if we substitute

[13] We also estimate a dynamic panel data model of the Arellano-Bond type that allows for an unbiased estimation of a lagged dependent variable. However, in our specification including game-related variables, as well as time, group, and individual dummies—and using instruments that satisfy the Sargan test—we do not find evidence of a significant lagged dependent variable (results available on request).

the individual dummies by these sociodemographic variables and keep the pooled data format, we find the following effects relative to the reference categories (see notes for Table 1). Married and single persons choose, on average, 0.40 to 0.35 sheep less (difference not significant), the head of household chooses about 0.25 fewer sheep, Lutherans select about 0.4 sheep less, and with every 1000 units of income, 0.002 more sheep are chosen. The latter two effects were also seen in the analysis above. The values for family-related variables here suggest that widowed and divorced persons act more selfishly than others, as theorised. The problem of collective goods appears to be relatively more relevant for those who are household heads. Suggestive as these results are, note that the exclusion of individual-specific dummies will be rejected by the data.

The estimates of the round-played dummies from Model 6 of Table 4 show a very interesting pattern when plotted against time as illustrated in Figure 1.

Figure 1: Round-played effects in LSDV and dummies-only model



Notes: Left-axis: time dummies from fixed-effects model (Equation (6)); right-axis: time dummies from pure dummy variable model.

Over the course of the game, there is an almost linear decline in the number of sheep chosen, as indicated by the trend line in Figure 1. This implies that with each round, the average number of sheep chosen declines by almost 0.5.[14] This result is noteworthy, as the literature (e.g., Fehr and Gächter, 2000) typically reports that co-operation rates decline as the experiment proceeds. Thus, our results suggest that the time pattern of co-operation identified in other experiments should not be treated as a fact; further research is needed.

[14] The R^2 of a regression of round-played dummies from Model 6 on a deterministic linear trend is almost 0.98. The coefficient on the trend term is 0.48**.

Note that this particular time pattern is conditional on controlling for game-related variables. To illustrate this, Figure 1 also contains a line showing the estimated time dummies in a model that includes dummy variables only. The line fluctuates around a stationary value before the treatment in Round 10. The introduction of the treatments has a negative effect of about one and a half units on the chosen number of sheep. However, over time the importance of the treatment appears to decline and the number of sheep chosen rebounds. Given the information from Model 6, we can infer that this rebounding effect is due to the influence of game-related variables such as relative payoffs, which are discussed in more detail below.

Of particular importance is the question of whether the treatment has an impact on the game. We established in the previous paragraph that the number of sheep declines approximately linearly across time; however, there is a noticeable difference occurring after the treatment, as the coefficient falls faster than would be linear from about –3.2 in Round 10 to –5.1 in Round 11. To test whether this difference is statistically significant, we include an impulse dummy for this period into the regression of round-played dummies on a linear time trend. The coefficient of this treatment impulse dummy is significant at a 1% level and takes on quite precisely a value of unity. This implies that the treatment caused a reduction by one in the number of sheep chosen. Given that the average number of sheep chosen per round over the full game is below five, this treatment effect is not only statistically significant but also economically relevant.

Note that the dummies capturing different types of treatments are neither significant in the general Model 5 (Table 3), nor do they survive the testing-down process leading to the more parsimonious Model 6. This shows that there is no statistical difference between the three possible treatments—penalty, reward, or communication. All treatments have the quantitative effect of lowering by one the number of sheep chosen. We suggested above that it may make a difference whether or not participants agree to the rule change. The hypothesis was that they may be more willing to co-operate if they support the new rules. However, it turns out in Models 5 and 6 that it does not matter statistically whether participants have agreed to the implemented change in the game rules or not. Thus, players adjust to whatever rule is implemented, independent of their own preferences.

However, the preference for a particular rule may not be due to randomly distributed individual-specific factors, but could be related to sociodemographics or game-related experiences. To investigate this idea, we explain the choice of treatments in the framework of a multinomial logit model. As explanatory variables, we use the regressors from Table 3 in addition to the game-related variables (computed over the first 10 rounds): cumulated number of sheep chosen, cumulated payoff, cumulated payoff of the group (excluding the individual), and relative payoff. To account for a possible current-period bias, we also include values of these variables for Round 10 only. The final model is based on a statistical reduction process using likelihood-ratio tests at a 5% level of significance.

Table 4 summarises the results by reporting marginal effects at the respective means of the variables as the actual estimated coefficients in a multinomial model cannot be interpreted straightforwardly.[15] The estimated model is statistically significant and the predicted and actual frequencies of treatments are similar.

Table 4: Marginal effects for the choice of treatments based on a multinomial logit model

	Communication	Reward	Penalty
Occupation			
Farmer	-0.17**	0.24**	-0.07**
Religion			
NGK/VGK	-0.10*	-0.09*	0.18*
No. of observations		192	
Log likelihood		-190.73	
Pseudo R^2		0.05	
Frequency in % (actual/predicted)	43.2 / 44.2	38.5 / 38.4	18.2 / 17.3
LR test joint significance		$Chi^2(2)$ =18.02**	
LR test exclusion restriction		$Chi^2(71)$ = 75.6	

Notes: (*), * and ** indicate significance at a 10%, 5%, and 1% level, respectively. For coding information on variables, see Table A1 in the Appendix.

None of the game-oriented variables are significant; however, some sociodemographic variables help explain the choice of rules. Being a farmer increases the probability of choosing reward by 24 percentage points, whereas it decreases the probability of voting in favour of communication or penalty by 17 and 7 percentage points, respectively. Becoming a member of the Dutch Reformed Church raises the likelihood of preferring a penalty-based system by 18 percentage points and decreases preference for communication by 10 percentage points and for reward by 9 percentage points. Thus, the choice of treatments is not completely dependent upon unobserved individual characteristics. However, it does not relate to

[15] For the remaining significant dummy variables, farmer and NGK/VGK, the change from 0 to 1 is given as the marginal effect.

measurable outcomes of the game up to the period when the choice is made and only very few sociodemographic variables are robustly significant.

Table 4 shows that members of the Dutch Reformed Church appear to view penalties as an appropriate method for preventing non-co-operative behaviour. Concentrating the analysis on the penalty treatment subsample reveals that Dutch Reformed Church members play more co-operatively under this rule compared to members of other religious groups. We conjecture that this behaviour is related to the Calvinist emphasis on the importance of obeying external rules (Frame, 1996). Note that this finding also gives empirical support to Max Weber's argument about the economic success achieved by those societies dominated by Protestant ethics (Weber, 1987).

In contrast, farmers rely on positive incentives to foster co-operation, which also seems instructive since the rule was framed as a well-known 'drought relief programme'. In the Namaqualand, subsidies are granted in form of additional fodder, whereas the Namibian government offers market incentives of N$15 for each head of small stock that is sold, as well as a leased grazing subsidy (Sweet, 1998). Thus, we believe that our chosen framing facilitates a transfer of individual real-life experiences to the experimental setting and offers important additional insight to laboratory experiments.

The final group of variables in our panel data model explaining the number of sheep chosen in each round relates to game-specific aspects, i.e., we analyse how performance during the game influences the players' choices. While the payoff received by participants in the previous round of the game has a positive effect on the number of sheep selected, this effect is not statistically significant even at a level of 15%. In the case of an individual's cumulative payoffs, this conclusion holds even more strongly. Thus, the first important conclusion that can be drawn from these findings is that there is no statistical evidence that a player's direct winnings influence his or her choices.

Investigating the estimated coefficients for the group-oriented payoff variables reveals that they play a prominent role statistically, as testing all group-oriented payoff variables jointly indicates that they are significant at the 1% level. Of the four group-oriented variables that remain after the testing-down process, two have negative coefficients and two have a positive sign. Looking first at the winnings of the group as a whole (excluding those of person i), we find that large gains by the other group members leads players to play more co-operatively. The absolute effect is substantial, as the average payment over all groups and rounds is 1230, implying a reduction in the number of sheep chosen of almost 2.5. To assess the relative importance of the last period's group winnings, we compute its elasticity evaluated at the means of the respective variables. The reaction is inelastic with a value of –0.49. These results suggest that reciprocal behaviour restricts individual incentive to overuse.

In the case of the group's cumulative winnings (again without player i), we find a significantly positive impact on the number of sheep chosen. The size of this impact is noticeable: in the case of the average value of cumulated group payments, the number of sheep increases by 3.8. The corresponding elasticity takes on a value of 0.85.

The second type of group variables concentrates on the relative winnings of person i compared to those of the rest of the group, both in the last period and cumulated over the game. In the case of the relative payoff in the previous period, the effect is positive and economically relevant but not as large in absolute terms as the other group-oriented variables. On average, players choose 0.85 sheep more and the corresponding elasticity is 0.18. Regarding the cumulated relative payoffs, there is a substantial negative effect that implies a reduction by about 3.5 in the number of sheep chosen. The elasticity evaluated at the respective means of the variables is –0.73.

These findings have several implications. First, if the group did well last period, members will, on average, reduce the number of sheep chosen in the current period, leading to a virtuous circle where people co-operate conditional on others' co-operation as this will imply a high payoff for all group players next period. Second, people are concerned about their relative position in the group and play competitively. Third, if the group did well over many periods in the past, its members will choose a greater number of sheep. This effect is the smallest of the reported group effects and runs counter to the first effect of reciprocity. It implies that the virtuous circle of conditional co-operation will begin to weaken after some time. Our interpretation is that players will feel less constrained by their social environment: since the group is doing fine, the temptation to free-ride becomes greater. Players may fall prey to this temptation for two reasons: (1) if everyone else has chosen a small number of sheep for quite some time, it is likely they will continue to do so next period and thus choosing a large number of sheep next period will generate a high payoff and/or (2) if everyone is doing well in the game, one can take steps to improve one's personal situation without feeling particularly bad about doing so.

A fourth implication of our findings is that the co-operative effect of reciprocity is strengthened by inequality aversion. If a player has accumulated relatively more gains than the group during the game, he or she will reduce the number of sheep chosen despite the temptation to play Nash. If, for some reason, a player did relatively better than the group over some time, he or she will either experience social pressure or feel personal restriction and, as a consequence, cut back on the number of sheep chosen. This behaviour fits Bowles's (2004) concept of 'guilt': an individual experiences guilt when she deviates from the choices of others or from the preference to conform to other players, as argued by Velez et al. (2005).

We believe that these estimated behavioural effects make sense from a psychological point of view and emphasise that it is a combination of factors that shapes behaviour in groups, an interaction that has not received sufficient attention in the literature to date.

VII. Conclusion

The results of this paper contribute to understanding social dilemma situations. First, we find that individual income is an important determinant of co-operation in a repeated social dilemma game. More precisely, we find that people with more annual income play less co-operatively. This finding is in agreement with Cardenas (2003), who reports that actual wealth negatively affects co-operation. Cardenas claims that wealthy people are less experienced in extracting commonly owned resources, as they do not depend on them. We do not discover any positive effect of being wealthy or being a farmer and conclude that this type of experience does not influence co-operation. Instead, we argue that high income might reveal a person's stronger preference for consumption, risk, or other social traits.

For example, people with a permanent job—interpreted as an indicator of a high income—could be more risk loving and thus less averse to the threat of a penalty during Rounds 11–20. They might also be more competitive, overconfident, or more averse to feedback from the group, especially during the communication treatment. These relations have been explored in studies comparing men and women (Niederle and Vesterlund, 2007) in different cultural contexts (Gneezy et al., 2008). Lastly, it is possible that people with higher income have become more selfish by leaving the collective pressure of the community structure in an attempt to escape the increasing poverty prevailing in the rural areas of Southern Africa. However, since we cannot control for these or other unobserved characteristics, we must leave this question to be answered by future research.

Our second main result has to do with inherent group dynamic processes that influence individual strategies. We show that a combination of reciprocity, inequality aversion, temptation to free-ride, and competition affect our participants. Our analysis avoids Wilcox's (2006) critique that dynamic models with experimental data containing lagged dependent variables and subjects with heterogeneous idiosyncratic abilities, motivations, or problem-solving capacities tend to be strongly biased if using random-effects or pooled data. Since we expect heterogeneity not to be randomly distributed in the data, we instead specify an unbiased fixed-effects estimator to explain the choices in the game. These effects have been previously reported in the literature, but we present them as a set of complementary motives that might even work in opposite directions. What specific motive dominates group dynamics appears to be influenced more by the composition of the group than by the actual rule chosen to solve the dilemma.

A third result of this study shows that the actual choice of treatment does not matter after taking into account group dynamics. In this sense, group interactions are more important than exogenously (even if these were endogenously chosen) imposed rules. This finding should make us highly cautious about the possibility of deriving general principles of economic co-operation. On a more practical level, our study shows that the endogenous choice of rules is dependent on the socioeconomic background of individuals. Farmers are more likely to endorse rules based on rewards for good behaviour, whereas adherents of the Dutch Reformed Church prefer a penalty-oriented system.

Our paper sheds some light on the discrepancy noted in the literature that people seem to care about advancing their relative position in real life but tend to reduce inequality in a laboratory setting. According to our results, it is true that people with high real-world income tend to increase their earnings by co-operating less on average than others. However, in our experiment, it is also true that high cumulated earnings activate a person's inequality aversion, leading to more co-operative behaviour, which then reduces the amount of resources extracted. In our view, it is likely that the differences in behaviour between people with higher income and those with lower income poses a threat to the traditional collective management of natural resources. The greater ambition of high-income people to extend their farming activities within the collectively managed commons needs to be restrained by formal or informal institutional arrangements that support subsistence farming and limit the number of animals each individual may own.

In our analysis, the actual form of this restraint does not matter, i.e., formal institutions, such as rewards or punishments, work as well as informal institutions, such as group communication. Increasing the land base for emergent farmers will additionally reduce the pressure on precious resources as it is more likely that the less co-operative members will be the ones who decide to leave the commons. As a result, subsistence farmers will be better able to manage the commons.

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Appendix

Table A1: Characteristics of participants

	Mean	Std. Deviation	Min	Max
Dependent variables				
Sheep in Round 1	5.65	2.24	1	9
Average sheep	4.84	1.04	1.45	7.40
Sociodemographics				
Age	38.1	15.5	18	89
Male	0.55	0.50	0	1
Married	0.38	0.49	0	1
Single	0.57	0.49	0	1
Head of household	0.32	0.47	0	1
Number of offspring	2	1.97	0	10
Education	8.72	2.90	0	16
Years living in village	25.9	16.2	1	67
No. of church visits per month	1.77	1.26	0	4
Religion				
Methodist	0.43	0.49	0	1
Lutheran	0.09	0.28	0	1
VGK/NGK	0.24	0.42	0	1
Roman Catholic	0.17	0.37	0	1
Other/none	0.05	0.23	0	1
Occupation				
Unemployed	0.25	0.43	0	1
Occasional worker	0.40	0.49	0	1
Pensioner	0.08	0.28	0	1
Employed	0.25	0.42	0	1
Income	11,931	36,744	0	504,000
Wealth	19,030	43,115	0	315,500
Committee member	0.30	0.46	0	1
Collective action	42.5	79.5	.00	365
Farmer	0.37	0.48	0	1

Notes:

i) Age and education are measured in years.
ii) Male, married, single, farmer, household head, occupation, religion, and committee membership are categorical variables.
iii) No. of church visits per month.
iv) Annual income includes remittances, part-time jobs, and permanent income as stated by the interviewee. Wealth includes ownership in land and livestock as well as agricultural machinery, real estate, and vehicles.
v) Collective action is measured in days of the past 12 months as stated by the interviewee.