Heterogeneity, Trust and Sustainable Cooperation in CPRs: An Experimental Test

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Abstract

Natural resources are under an increasing pressure of overexploitation: overfishing of the seas, deforestation of the rainforest and the unstustainable use of fresh water to cater the increasing consumption of humans have become every-day problems leading to the demise of natural resources. Sustainable cooperation within these common pool resource [CPR] settings is suggested to be hampered by an increasingly diverse population in terms of economic means and sociocultural characteristics, reducing mutual trust, which in its turn leads to lower individual cooperation and negative macro-outcomes for the resource. This study uses a CPR game in a laboratory experiment to investigate the effects of economic and sociocultural heterogeneity on trust and cooperation on both the micro and the macro level. Findings suggest a negative effect of sociocultural and the combination of sociocultural and economic heterogeneity, but a positive effect of economic heterogeneity under sociocultural homogeneity, compared to homogeneity on both fronts. Trust is found to have a positive effect on individual-level cooperation, and economic heterogeneity is found to have a positive effect on trust and perceived trustworthiness within the group.

1 Introduction

Achieving sustainable cooperation in common pool resources [CPRs] is under pressure of the increasing migration between countries, leading to an increasingly diverse population in terms of sociocultural and economic dimensions (Aksoy, 2015). However, how and to which extent economic and sociocultural heterogeneity affect collective action and sustainable cooperation is still contested (Olson, 1965; Vedeld, 2000; Bardhan & Dayton-Johnson, 2002; Poteete & Ostrom, 2004; L. R. Anderson, Mellor, & Milyo, 2006; Ruttan, 2006, 2008; Flache & Mäs, 2008; Andersson & Agrawal, 2011; Kölle, 2015). The aim of this paper is to provide insights on the relation between economic and sociocultural heterogeneity and sustainable cooperation in CPRs, both on the micro-level of individual behaviour and on the macro-level of collective outcomes, using a Trust Game and a CPR game in a computerized laboratory experiment. Since

part of the theoretical mechanism is often suggested to be the negative influence of heterogeneity on trust (Alesina & La Ferrara, 2002; C. J. Anderson & Paskeviciute, 2006; Delhey & Newton, 2005; Keller, 2001; Putnam, 2007), and the positive influence of trust on positive outcomes for society (Fukuyama, 1995; Knack & Keefer, 1997; La Porta, Lopez-de-Silanes, Shleifer, & Vishny, 1997; Putnam, 1993; Uslaner, 2002; You, 2012; Zak & Knack, 2001), this paper will consider trust as an important mediating variable.

CPRs are vulnerable to the famous 'tragedy of the commons' as famously described by Hardin (1968): a situation in which appropriation of the common resource is locked into a system that provides each member incentives to use the limited resource unlimitedly, which will lead to its inevitable decay. From a game theoretic perspective, this tragedy would always happen: a (myopic) rational individual will free-ride and overexploit the resource, even though the long-term rational individual would see the long-term benefits of cooperation. In practise, however, research shows higher levels of cooperation than expected, thus suggesting a more complex case than predicted by rational choice theory (Axelrod & Hamilton, 1981; Chaudhuri, 2011; De Oliveira, Croson, & Eckel, 2009; Levati, Sutter, & van der Heijden, 2007; Ostrom, 1990; Cherry, Kroll, & Shogren, 2005). This raises the question why and when people will or will not cooperate. One of the factors influencing cooperative behaviour could be heterogeneity of economic endowment or sociocultural identity. Experimental research looking into the effect of heterogeneity on cooperation is still relatively rare (Cherry et al., 2005).

Empirically analysing the influence of heterogeneity in real-life settings is difficult, due to the amount of confounding factors that influence success and failure; you may never find two identical CPRs in identical situations with different levels of heterogeneity to use in a natural experiment. This can be solved to a large extent by using laboratory experiments, using a controlled environment, in which subjects face decisions representing related real-world settings, allowing for a causal test by varying exogenous variation of variables of interest (Fehr, Fischbacher, von Rosenbladt, Schupp, & Wagner, 2003; Van Soest & Vyrastekova, 2005; Meinzen-Dick et al., 2016). For this paper, subjects first played a Trust Game to measure general trust and trustworthiness and a Common Pool Resource Game (Janssen, Holahan, Lee, & Ostrom, 2010). The CPR game will mimic a resource that the subjects can appropriate in return for money in groups of four, under different conditions of economic and sociocultural heterogeneity, induced as treatments using respectively unequal endowments and Minimal Group Experiment [MGE]. While CPR games in general are already well-adapted to mimic real-life CPR situations, this paper will take a step further by developing a resource-specific CPR game, a fishery, with key features of the game such as resource renewal and information resembling conditions similar to a fishing ground. This provide insights on more context specific traits of CPR situations.[1]

[1]For instance, in the first paper of this dissertation, trust has proved to be an important factor in fishing grounds, but not at all in irrigation systems. It is thus important to distinguish between resources with fundamentally different characteristics that influence behaviour on the

Given the increasing scarcity of CPRs world-wide under an ever-growing population, and given the increasing levels of heterogeneity of populations around the world, the subject of sustainable cooperation and heterogeneity in CPR settings is gaining importance. This study hopes to shed light on how economic and sociocultural heterogeneity influence cooperation on the individual and collective level, through trust, which may benefit policy development on reaching sustainable cooperation in modern day CPRs.

2 Theory

In this section, the possible effects of economic and sociocultural heterogeneity on collective action will be discussed, after which the mediating role of trust will be described. Lastly, hypotheses will be deduced.

2.1 Heterogeneity and cooperation

There is an extensive body of research looking into the effects of economic and sociocultural heterogeneity on cooperation. Regarding economic heterogeneity an often used argument is that asymmetrical endowments - i.e. an unequal division of payoffs within the group - correspond to a Pareto sub optimal outcome (Chan, Mestelman, Moir, & Muller, 1999). Next to this, it is argued that unequal distribution of economic assets leads to diversification of interests among individuals, which makes sustainable cooperation less likely to happen (Shanmugaratnam, 1996). For Public Good experiments it was found that heterogeneity in endowments indeed leads to a lower contribution to the public good (Cherry et al., 2005; Levati et al., 2007; Ledyard, 1993), which may be caused by an "anticipated reciprocity" effect, whereby subjects with a lower endowment expect the subjects with higher endowments to invest more, since they have more means available to invest, while subjects with higher endowments do in fact not do so (Cherry et al., 2005).

Theory on the relation between sociocultural heterogeneity and cooperation suggests that individuals are more likely to cooperate with others from their ingroup: individuals with whom they share strong, multi-stranded relationships and common interests (C. J. Anderson & Paskeviciute, 2006; Becker & Ostrom, 1995; Bowles & Gintis, 2002, 2002; Boyd & Richerson, 1985; Ellickson, 1991; Jones, 2004; Nettle & Dunbar, 1997; Ostrom, Walker, & Gardner, 1992; Ostrom et al., 1992; Portes & Landolt, 2000; Putnam, 2000; Singleton, 2001; Varughese & Ostrom, 2001). Translated to the CPR situation this would imply that if individuals or groups of individuals have to interact with others of a different identity, this would yield lower levels of cooperation than interaction with others of a same identity (R. N. Johnson & Libecap, 1982; Ostrom, 1990; Varughese & Ostrom, 2001; Gehrig, Schlüter, & Hammerstein, 17-jan-2019). Experimental research shows that (induced) group identity leads to positive behaviour towards

micro-level which ultimately leads to differences on the macro-level.

in-group members relative to out-group members (Chen & Li, 2009) and to the prioritising of group interest over individual interests (Eckel & Grossman, 2005).

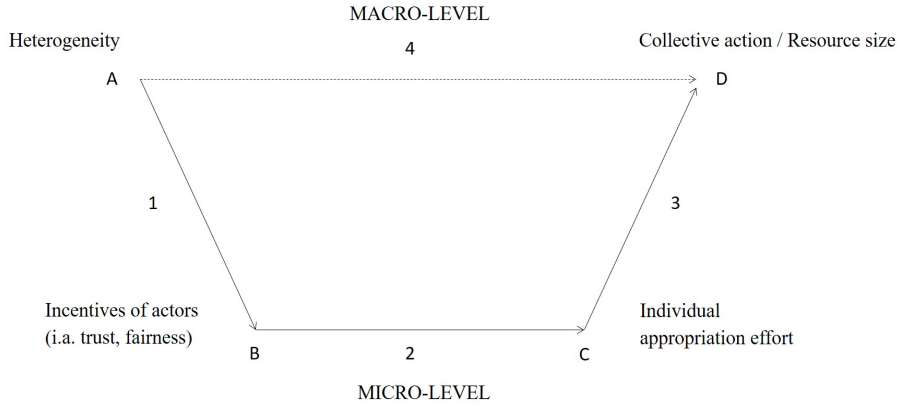
2.2 Trust

Trust is considered to be a mediating variable between the effect of heterogeneity on cooperation; heterogeneity would reduce trust, while higher trust would yield a higher level of cooperation amongst a group of individuals (Alesina & La Ferrara, 2002; Barr, 1999; Coleman, 1994). Implied here is that individuals trust others with a similar identity - for instance religion, ethnicity, culture, social identity or something else - more than others with a different identity (Alesina & La Ferrara, 2002; Bouckaert & Dhaene, 2004; Delhey & Newton, 2005; Knack & Keefer, 1997; Putnam, 2007; You, 2012; Zak & Knack, 2001). Alesina and La Ferrara (2002) find in their study using individual level data from the US that amongst others belonging to a minority, being economically unsuccessful and living in a heterogeneous community in terms of income disparity are the strongest factors associated with low levels of trust, supporting the argument that both sociocultural and economic heterogeneity will affect trust negatively. An artefactual field experiment by Barr (1999) with villagers of resettled and non-resettled households, placed in situations with respectively strangers and non-strangers, shows a decrease in trust in strategic situation if there is less within-village familiarity. Next to that, experiments of Glaeser, Laibson, Scheinkman and Soutter (1999, 2000) found higher levels of social connection amongst individuals resulted in higher levels of trust and trustworthiness. Higher levels of trust amongst individuals has shown to have positive effects on society as a whole, promoting cooperation and participation in social activities, strengthening social cohesion (Alesina & La Ferrara, 2000, 2002; La Porta et al., 1997). Higher trust means a lesser need for formal protection against betrayal in interactions (Knack & Keefer, 1997). Instead, more informal rules can be established, lowering transaction costs, leading to more economic efficiency and promoting cooperation and participation in social activities (Alesina & La Ferrara, 2002; Knack & Keefer, 1997). Rational choice theory would suggest that fully rational players should invest as much as possible in appropriation of the resource, to optimise their individual outcome (Kreps, Milgrom, Roberts, & Wilson, 1982; La Porta et al., 1997). However, as the long term expected utility in a CPR game is higher for cooperative behaviour than for rational, selfish behaviour, it is in players' best interest to behave cooperatively. High levels of mutual trust will facilitate this cooperative behaviour and the long term benefits thereof. It has been shown that even in one-shot cooperation dilemmas players will behave cooperatively rather than fully rational based on the trust that the others will behave cooperatively as well (Camerer & Thaler, 1995; La Porta et al., 1997).

2.3 Macro-outcomes and micro-foundations

In order to say anything about mechanisms on the macro level, one should also investigate what happens on the micro level (Aksoy, 2015; Coleman, 1987; Hedström, 2005; Raub, Buskens, & Van Assen, 2011). To analyse how economic and sociocultural heterogeneity influence the macro-outcomes of CPRs - the level of collective action, reflected by the size of the resource - insights on what happens on the micro-level - individual appropriation effort - are necessary. Figure 1 presents a macro-micro-macro model: a stylised scheme designed by Coleman (1987) as a way for representing micro-macro links in the reconstruction and analysis of social phenomena. The initial macro-condition in this figure is economic or sociocultural heterogeneity among appropriators in a population (A). The micro-conditions are the incentives for the actors to behave in a certain way; to cooperate and appropriate the resource in a sustainable manner, or to deviate and overexploit the resource. This is the part where mutual trust among appropriators plays a role; more trust among appropriators is expected to keep them from deviating. Arrow 1 represents assumptions on how economic and sociocultural heterogeneity as macro-conditions influence these incentives of appropriators. The behavioural outcome of these incentives, in this case the individual appropriation effort (C), leads to the expression of certain behaviour of the individual, represented by arrow 2. Subsequently, arrow 3 represents assumptions on how the combination of individual actions - the aggregation of cooperative or defective behaviour - is translated into macro-outcomes; in this case the consequences for the CPR in terms of resource size and collective action (D). Together, these arguments explain how economic and sociocultural heterogeneity may affect resource size and collective action, as represented by arrow 4.

Figure 1: Macro-micro-macro model



2.4 Hypotheses

To summarize, there is evidence from experimental research and case studies that suggest that both economic and sociocultural heterogeneity affect cooperation negatively, due to the differences in interests between individuals. Trust is suggested to have a positive relation with cooperation, participation in social activities and collective action. Lastly, heterogeneity is expected to have a negative relation with cooperation through partial mediation of trust: heterogeneity lowers trust amongst individuals, which affects cooperation negatively. In agreement with the macro-micro-macro model formulated earlier, separate hypotheses are deduced for the micro and the macro level. Based on the above, the following hypotheses are deduced:

Hypothesis 1 *(a) Economic (b) sociocultural and (c) the coincidence of economic and sociocultural heterogeneity have a negative effect on macro-level outcomes of cooperation*

Hypothesis 2 *(a) Economic (b) sociocultural and (c) the coincidence of economic and sociocultural heterogeneity have a negative effect on micro-level trust.*

Hypothesis 3 *Trust on the micro level has a positive effect on cooperation on the micro level*

Hypothesis 4 *Part of the negative relation of (a) economic (b) sociocultural and (c) the coincidence of economic and sociocultural heterogeneity with macro-level cooperation is mediated by micro-level trust.*

3 Methods

Using the controlled environment of a laboratory experiment allows for precise measurements of different outcomes of decisions under different conditions. However, generalizability is limited due to the subject pool often being limited to students, and due to the artificiality of the context. This increases the likelihood of subjects making decisions they would not make in real life situations, and can pose a problem for interpretation of the results (Anderies et al., 2011; Smith, 2010). However, if the aim of the research is to investigate relationships between human behaviour and social, biological or economic contextual variables, experiments are a good way of doing do (Anderies et al., 2011).

3.1 Experimental design

3.1.1 The Investment Game

The game that is used to measure trust before the main experiment is a variation of an investment game, as designed by Berg, Dickhaut and McCabe (1995). The Investment Game, also called the Trust Game, is the most frequently used game to study trust (Evans & Revelle, 2008).

The game is played as follows. Both players are given an endowment of 10 points. Both players are given the choice of sending points to another player, ranging from 0 to 10 points, after which that amount will be tripled before it reaches the other player. Next, both players are put in the shoes of the receiving player; they are asked how many of the points received by the other player they would send back, for every possible amount of points received, ranging from 0 to 30 points.[2]This is called the strategy method, which provides the advantage of allowing me to see the percentage of points to return that is perceived as fair by subjects (Bahry & Wilson, 2006).The subjects will then randomly receive the role for which they will receive their payoff and be matched to another player with the other role for their final payoff. The utility functions for the players are as follows: For player 1, the sender/trustor, the general utility payoff function is:

$$U\ i\ = E\ i\ - S\ ij\ + R\ ji$$

Where $E\ i\ $ is the initial endowment of sender i, $S\ ij\ $ is the amount of points sent from the sender i to the receiver j, and $R\ ji\ $ is the amount of points returned from the receiver to the sender. For player 2, the receiver/trustee, the general utility function is:

$$U\ j\ = E\ j\ + 3S\ ij\ - R\ ji$$

Where again $E\ j\ $ is the initialendowment of received j, $S\ ij\ $ is the amount of points sent from the sender i to the receiver j but this time multiplied by 3 by the experimenter, and $R\ ji$ is the returned amount from the receiver to the sender. In the currect game, $E = 10$ for both players. The two dependent variables, operationalised following Johnson and Mislin (N. D. Johnson & Mislin, 2011) will be measured as follows:

$$Trust = \frac{number\ of\ points\ sent\ by\ i}{endowment\ of\ i} = \frac{S\ ij}{E\ i}$$

$$Trustworthiness = \frac{number\ of\ points\ returned\ to\ i\ by\ j}{number\ of\ points\ available\ to\ return\ to\ i\ by\ j} = \frac{R\ ji}{E\ j\ + 3S\ ij}$$

[2]30 points would be the maximum amount to be received by player 2, since the maximum amount of points that player 2 can send is 10, and $3x10 = 30$.

3.1.2 Characteristics of the Investment Game

There are many variations on the Investment Game. In this version of the game, choices were made with regard to the following characteristics.

(1) Players will play the role of sender as well as the role of receiver once. Burks, Carpenter and Verhoogen (S. Burks V., Carpenter, & Verhoogen, 2003) found that letting the players play both roles takes away a feeling of guilt that subjects in the sending role would otherwise experience towards the receivers, since the payoff would rely on only one interaction However, they also find that playing both roles reduces mutual trust and reciprocity. In this experiment, players play both roles but will be paid for only one. However, since subjects do not know for which interaction they will receive their payment, I expect the players' behaviour to be uninfluenced by feelings of guilt. An advantage of letting subjects play both roles is that more data on trusting and trustworthiness can be gathered, and different types of players - such as altruists, egoists and conditional co-operators - can be identified (see also S. Burks, Carpenter, & Goette, 2009).

(2) Real players are used instead of computerised counterparts. If subjects suspect or know that their counterpart in an interaction is computerised, they will behave differently in the sense that they will send less money to the receiver (Bottom, Holloway, Miller, Mislin, & Whitford, 2006; Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003). The meta-analysis of Johnson and Mislin (2011), comprising 162 replications of the Investment Game, shows that playing against a real counterpart has a positive effect on trusting behaviour e.g. playing with a real person will yield higher amounts of points sent by the sender. (3) A form of random payment is introduced, as stated earlier, in the sense that all subjects will be paid for one out of in total two interactions; they will be paid either for the sending or the receiving role. Random payment is in general suggested to yield more risk-averse behaviour from subjects, resulting in lower amount of points sent by the sender (Bottom, 1998). The meta-analysis of Johnson and Mislin (2011) points out that there is indeed a negative effect of random payment on trust. However, this random payment is defined as only a subset of subjects receiving payment, while in the current experiment all subjects will be paid; the randomness lies in which role interaction will be paid. Based on the latter, subjects are not expected to be influenced by random payment.

(3) The strategy method is used, meaning that all subjects in the receiving role interaction have to indicate how much they would return to the sender for every possible amount of points received (Bahry & Wilson, 2006). Some research suggests that providing this choice to subjects may alter their perception of the game (Güth, Huck, & Müller, 2001; Roth, 1995). The research, on the other hand, suggests that the strategy method has no influence of subjects' behaviour (Brandts & Charness, 2000). The meta-data analysis of Johnson and Mislin (N. D. Johnson & Mislin, 2011) found no significant effects of this method on trust or trustworthiness.

(4) Subjects in the receiving roles will receive an endowment. This will cancel out the possible effect that inequity may have on subjects. If only the

sender starts with an endowment, this may cause the sender to send money to the receiver out of a feeling of injustice or guilt instead of trust (Adams, 1965; Adams & Freedman, 1976). If both players start with the same endowment, the act of sending money to the receiver can still increase the payoff for both players, and sending money while the other player has money already will be a more defined act of trust in the other player. The meta-analysis of Johnson Mislin (2011) shows no persistent negative effect of receiver endowment (only one out of three models on trust shows a significant negative effects of receiver endowment).

(5) We will use anonymity amongst subjects. Subjects will not see each other's decisions, not do they know with whom they are matched for the payoff interaction. This will prevent reputation (Kreps, 1990) and/or reciprocity of kind acts (Gouldner, 1960) from having an effect on trust and trustworthiness, enabling us to measure trust and trustworthiness without the shadow of the future nor from the past. The meta-analysis of Johnson and Mislin (2011) shows weak support of the suggestion that anonymity has a negative effect on trust.

3.1.3 Subjects

Despite the game theoretic prediction that the investor will not behave trusting and will thus not send money to the trustee, empirical results show that subjects playing the Investment Game do show trusting behaviour (Berg et al., 1995). Sending money to the trustee is found to be positively correlated with amongst others a reduced social distance between trustor and trustee (Glaeser et al., 2000). For the proposed experiment, the main group of subjects will be students. It is shown that students are less trusting and less giving than adults (N. D. Johnson & Mislin, 2011) even though the general suggestion is that adults show less trusting behaviour (Bellemare & Kroger, 2003; Fehr et al., 2003). Either way, it is important to control for being a student or not and/or for age.

3.2 The CPR Game

3.2.1 A Common Pool Resource

The game to be played by participants of the experiment is a CPR game. While it is common to measure cooperation and trust in games such as Public Good [PG] games, there are fundamental differences between CPRs and PGs that should be taken into account when looking specifically at CPR situations. Two characteristic features of a CPR situation are that exclusion of the collective good is infeasible - it is very costly to fence off part of an ocean - and that subtractability is high - the resource is finite and can run out (Ostrom, 1990; Ostrom et al., 1992). Figure 4 shows the classification of different types of goods as shown by Ostrom, Walker and Gardner (1992).

Figure 4. A classification of goods (Ostrom et al., 1992, p. 7).

		Subtractability	
		Low	High
Exclusion	Difficult	Public Goods	Common Pool Resources
	Easy	Toll Goods	Private goods

A Public Good, such as a collectively used bridge, is low in subtractability – it does not become less available once more people walk over it - and exclusion is difficult – it's hard to exclude people from walking over the bridge, even if they didn't help build it. Next to this there are Private Goods, which are the opposite of Public Goods, characterized with high subtractability and easy exclusion, and Toll Goods, characterized with low subtractability and easy exclusion. Lastly, the type of good that will be central in this dissertation is the Common Pool Resource. Like Public Goods, exclusion of potential users from a Common Pool Resource is difficult. A Common Pool Resource differs from a Public Good in the sense that subtractability is high: if one farmer takes a lot of water from the irrigation system, other farmers will have less to take. Understanding human behaviour in CPR situations is challenging but of considerable importance for policy development (Ostrom et al., 1992).

The CPR game played in the experiment is an N-person finitely repeated game. The game is repeated as to mimic real life CPR settings, that usually involve individuals making repeated decisions within the same setting; using the same resource with the same co-appropriators (Ostrom et al., 1992).

3.2.2 The Fishing Game

The CPR in the current game is a fishing ground. The previous paper of this dissertation pointed out that trust plays a much bigger role in fisheries than in irrigation systems, which is why this type of resource was chosen as the central resource in the current paper. In the game, there are four appropriators that use the CPR. There are four treatment groups: (1) economic heterogeneity, (2) sociocultural heterogeneity, (3) both economic and sociocultural heterogeneity

and (4) economic and sociocultural homogeneity (the control group). All subjects will first play the basic CPR game without treatments for three rounds, without any consequences for their payoff, to get to know the game. The game with treatments will be played for 40 periods.[3]

3.2.3 Appropriation of the resource

The appropriators all receive an endowment E of units to invest in appropriation of the resource, R, in each discrete time period t. Since appropriation of the CPR is a costly activity - e.g. it takes time and requires maintenance of the boat and fishing nets - the appropriation effort $x(0 \leq x \leq E)$ represents the amount of effort an appropriator can invest in appropriation of the CPR. The appropriators all receive the same return $(\frac{4}{R_0}R_t - 1\ )$ per appropriation effort unit of x. The utility function for the appropriators per period is as follows:

$$U_{it} = (\frac{4}{R_0}R_{t-1}\ )x_{it} + (E_i - x_{it}\ )$$

In which U_{it} is the total utility of an appropriator i at timepoint t. In the utility function, x_{it} is the invested appropriation effort of appropriator i at timepoint t, and E_i is the endowment of appropriator i. R_0 is the original resource size of the CPR (i.e. the maxmimum number of fish in the lake) for which we take $R_0 = 600$. R_{t-1} is the resource size at time $t-1$. The profit per invested appropriation effort unit of x is thus dependent on the current size of the resource, relative to its original size. If $R_{t-1} = R_0$, which is the case at the first stage of the game, the return is $4 - 1 = 3$ units per invested unit of x. When $R_{t-1} < R_0$, the return will be lower than 3 units. The amount of appropriators' endowment not used for fishing is reflected by $(E_i - x_{it}\ )$.

The actors can choose how much they want to invest in appropriation of the resource each period. All appropriators will make their appropriation choice at the same time, without knowing what the other appropriators will do that period. At the start of every new period, the appropriators will see how much is left of the resource, and how much was invested in appropriation of the resource in total as a group.

3.2.4 Resource renewal

The CPR has a certain renewal rate per period, modelled as follows:

$$R_t = min(600, 1.25\left(R_{t-1} - (\frac{R_{t-1}}{R_0})\sum_{t=1}^{4} x_i t\ \right))$$

In which 1.25 is the renewal rate of the resource and $R\,t$ is the resource at timepoint t. The maximum resource size for both sector types is $R_t = 600$; the

[3] 40 periods is a long enough time-span for subjects to see the resource fall into decay if they overexploit the resource systematically, and to adjust their investments to regrow the resource again.

resource cannot grow beyond this size. The sum of appropriation efforts of all four appropriators is indicated by $\sum_{t=1}^{4} x_{it}$).

3.2.5 Overexploitation

The CPR is overexploited when $R_t < R_{t-1}$, so when the resource size in timepoint t is smaller than in the previous timepoint. This happens if $\sum_{t=1}^{4} x_{it}$) > 120, because this is the limit of sustainable appropriation, based on $R_0 - \frac{R_0}{1.25}$. The CPR is thus overexploited when the four appropriators have invested on average 30 units in appropriation effort per person.[4] Investing stops being profitable if ($R_t = \frac{R_0}{4}$), so if the resource size decreased to 25 percent of the original resource size ($R_t = 150$), because:

$$U_{it} = (\frac{4}{600}150)x_{it} + (E_i - x_{it}) = E_i$$

This means that whatever an appropriator invests in appropriation of the resource, it will not exceed his original endowment. It also works the other way round: when the size of the resource increases again, the multiplication of the invested unit of x will increase and fishing becomes relatively more profitable.

3.2.6 Economic heterogeneity

In this treatment, economic heterogeneity is induced by varying the endowment E_i between the four subjects in appropriation groups: instead of all appropriators having $E_i = 50$ to invest in appropriation, two appropriators receive $E_i = 40$ and two appropriators receive $E_i = 60$ (see i.a. Cherry et al., 2005) for a similar operationalisation of economic heterogeneity based on variations in edowment). This way, the total endowment of the group is the same for groups with and without the economic heterogeneity treatment. Subjects know their own endowment and the endowment of others in their group. The groups in this treatment are homogeneous in the sociocultural sense, and the subjects see this at the beginning of the game, and in a history box every new period.

3.2.7 Sociocultural heterogeneity

To test the effect of sociocultural heterogeneity on cooperation, induced identification is used. So instead of natural identification, on the basis of for instance gender or ethnicity, heterogeneity of identity is artificial, and based on a trivial criterion, also called a Minimal Group Experiment [MGE] as first conducted by Tajfel and colleagues (April/June 1971) (see also Aksoy, 2015; Yamagishi & Kiyonari, 2000).

Even though natural identities may seem better suited to operationalise sociocultural heterogeneity and are often used (Bouckaert & Dhaene, 2002; Fershtman & Gneezy, 2001), some sidenotes can be made on the use of natural identities. For instance, it is not necessarily known to what extent, if at all,

[4] $600 - \frac{600}{1.25} = 120$

a subject identifies with his or her natural identity, it is unpredictable how natural identities will respond to experimental manipulations, and there are many other factors next to social identity that may vary with natural identity (Aksoy, 2015). Induced identities are, on the other hand, fully controllable and unambiguous, allowing for a bigger confidence that any behavioural differences between subjects are indeed caused by the treatment itself (Aksoy, 2015). Even though the groups are based on an artificial criterion, research shows that it is the feeling of belonging to a group, no matter on what basis categorisation takes place, is enough to operationalise social identity (Aksoy, 2015; Billig & Tajfel, January/March 1973; Singleton, 2001; Tajfel et al., April/June 1971; Yamagishi & Kiyonari, 2000).

Following the approach of Tajfel and colleagues (April/June 1971) and Aksoy (2015), the subjects are shown five paintings by two different artists, Paul Klee and Wassily Kandinsky, after which they are asked to express their preference of either picture and they will placed in heterogeneous groups with two players of the one, and two players of the other preference. The subjects are informed about their group composition, and see the preference identity of the other players every period in the game. The division between the two groups is based on the median preference for either painter. After the grouping, group identities are enhanced by playing a short quiz in which players have to guess the painter (Klee or Kandinsky) of three paintings, in which group performance pays off [5] and playing three rounds of a binary other-other Dictator Game, as described by (Aksoy & Weesie, 2012), following Aksoy (2015). All treatment groups are shown the same set of paintings by Klee and Kandinsky, and are given the same tasks in the other-other binary Dictator Game.

3.2.8 Trust

Trust is measured in two ways: 1) by a one-shot Investment Game before the main game, as described before, 2) by asking questions on the extent of mutual trust in a post-experimental survey. The one-shot Investment Game will be used to measure general trust, to get an idea on how trusting the participants will enter the experiment. Even if this type of trust does not resemble the mutual trust necessary for repeated games (such as the current CPR Game) it is still useful as indicator of trustfulness of subjects. The post-experimental survey will contain questions on general trust, and on trust of subjects during the game. The different measures of trust can be compared, to explore potential differences.

[5] If more than half of the answers of the ingroup are right and/or if the ingroup has more right answers than the other group, players get extra points. The extra points will be shown at the end of the CPR game, in order to avoid low group performance to influence the CPR game (Aksoy, 2015).

3.2.9 Subject pool

For the proposed experiment, the main group of subjects will be students. It is shown that students are less trusting and less giving than adults (N. D. Johnson & Mislin, 2011) even though the general suggestion is that adults show less trusting behaviour (Bellemare & Kroger, 2003; Fehr et al., 2003). Either way, it is important to control for being a student or not and/or age. Having mainly Oxford students as subjects makes generalization of the results difficult, but to prove causality and to show the effect of a treatment the only assumption necessary is appropriate randomization, which the laboratory setup provides (Levitt & List, 2009).

3.3 Experimental sessions

A computerised laboratory experiment was designed and programmed in z-tree (Fischbacher, 2007). The experiment was conducted at the Centre for Experimental Social Sciences [CESS] at Nuffield College, University of Oxford from October to November 2018, and at the Experimental Laboratory for Sociology and Economics [ELSE] at Utrecht University in April 2019. The subjects for both laboratories were recruited from the Online Recruitment System for Economic Experiments [ORSEE] (Greiner, 2004). After a pre-test with 16 Oxford students, the experiment was held in 8 sessions at CESS containing 148 students, and 5 sessions at ELSE containing 96 students. Sessions contained 16, 20 or 24 subjects. A total of 244 subjects participated in the experiment, of whom 64 in the economic heterogeneity treatment and 60 in each of the sociocultural heterogeneity, economic and sociocultural heterogeneity and no homogeneity (control) treatment. 95% of the subjects were students, from varying disciplines and years/stages. 63% of the subjects were female, and the average age was 23.

Completing the experiment took 60 to 90 minutes. General written instructions in English were handed out to the subjects at the start of the experiment. In the second part of the experiment - when the subjects start the 40-period Fishing Game - subjects received specific instructions corresponding to their treatment. Subjects played for real money (GBP in the UK and EUR in the Netherlands) under an exchange rate of 500 units = 1 GBP/EUR. The average earning was 15.7 GBP/EUR.

3.4 Analytical strategy

A multilevel regression framework is deployed to test the hypotheses outlined above. For the macro-outcome resource size, a two-level multilevel model will be fitted with period-level outcomes (level 1) nested in mean individual outcomes and group outcomes (level 2). For the micro-outcome individual appropriation effort, a three-level multilevel model will be fitted with period-level outcomes (level 1) nested in individuals (level 2) nested in groups (level 3).

4 Results

4.1 Descriptive Plots

Figure 3 shows the mean resource size per treatment over time. When subjects are exposed to any degree of sociocultural heterogeneity, either by itself or in combination with economic heterogeneity, this seems to induce the quicker and harsher depletion of the resource. This is in contrast to the performance of subjects exposed uniquely to economic heterogeneity, who display a more sustainable behaviour. The primacy of economic heterogeneity holds even when compared to the homogeneity treatment. This could point to support for the Olson's theory (Olson, 1965) stating that economic heterogeneity leads to higher levels of cooperation than no heterogeneity. Strikingly, this only holds for the purely economic heterogeneity treatment, and not for the combination treatment of economic and sociocultural heterogeneity.

Figure 4 shows the mean appropriation effort per treatment over time. For the first few periods, it is shown that subjects in the sociocultural heterogeneity treatment appropriate on average much more than subjects in the other treatments. During the middle 20 periods of the game, the combination treatment of economic and sociocultural heterogeneity appropriate most on average. Coherently with the previous plot, the subjects in the economic heterogeneity treatment invest the least in appropriation throughout the entire game, resulting in a consistently higher resource size over time. In the final periods of the game, all treatment groups have converged to a sustainable appropriation rate of about 30 units, except for the homogeneity group, who is slightly above that amount. Given the results from the figure 3, the sustainable - even underexploiting - behaviour of the subjects in the sociocultural heterogeneity treatment and the combination treatment may just reflect their need to tailor their behaviour to their depleting resources. It is remarkable that subjects in the economic heterogeneity treatment behave sustainable, even when their resource is growing.

Figure 2: Mean resource size per treatment over time

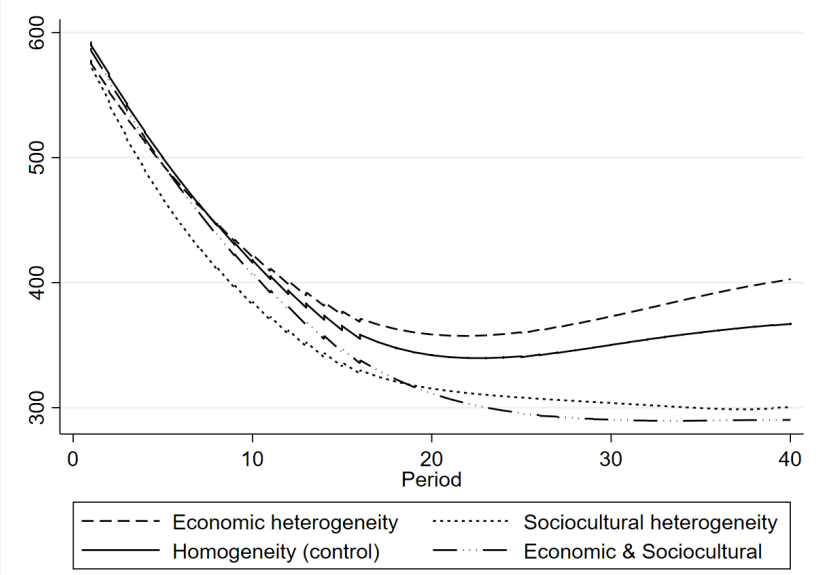
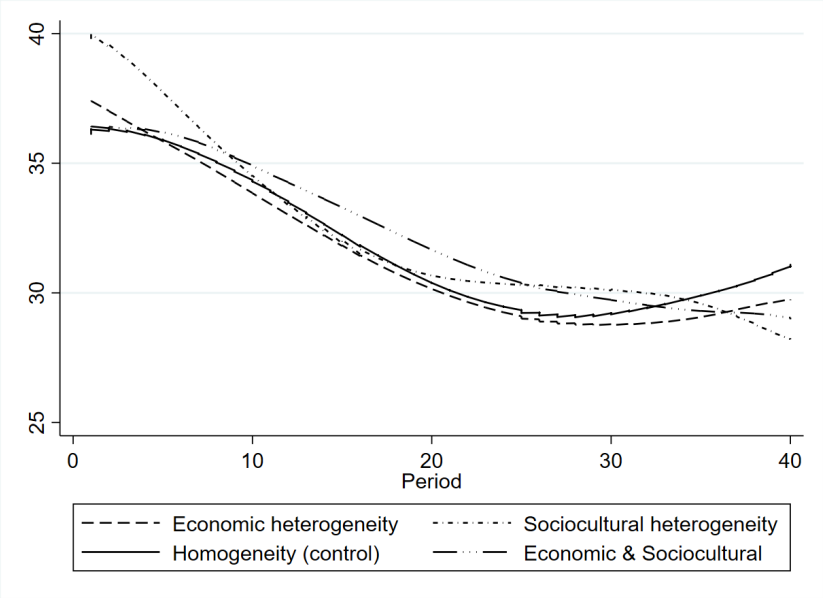


Figure 3: Mean appropriation per treatment over time



Based on these descriptive plots, some interesting areas to investigate further include (a) the difference in effects between treatments by period (b) the effect of resource size at t-1 on appropriation behaviour, and (c) the effect of general trust measured with the Investment Game and trust measured in the post-experimental survey on main-game behaviour of individuals in the different treatments. Results will be analysed separately for the macro and the micro level.

4.2 Macro-level results

Table 1 shows the two-level multilevel regression on the macro-level variable resource size. Model 3 is the model including treatments, trust and all the group characteristic control variables. The model shows that over time, economic heterogeneity has a significantly higher resource size compared to the homogeneity treatment ($B = 1.052$, $p = 0.004$). This implies higher levels of cooperation for economic heterogeneity than in the homogeneity treatment, which is a surprising but interesting result, contradicting expectations as formulated in hypothesis 1a. The model also shows that the treatments with sociocultural heterogeneity ($B = -0.896$, $p = 0.015$) and the coincidence of sociocultural *and* economic heterogeneity ($B = -2.286$, $p < 0.001$) have a significantly lower resource size over time, compared to the homogeneity treatment, implying lower levels of cooperation compared to the homogeneity treatment on the macro level. The latter results support hypotheses 1b and 1c, predicting negative effects of heterogeneity on macro-level cooperation.

The average level of trust - as measured by the Investment Game at the beginning of the experiment - in the group does not have a significant effect on resource size. Although we don't find significant support for hypothesis However, the coefficient is positive, which is in the expected direction; higher average trust in a group would result in higher levels of cooperation on the macro level.

As for the control variables it is visible that average age in the group of players has a significant positive effect on resource size ($B = 16.468$, $p = 0.012$), implying that a higher age is associated with higher levels of cooperation within the group. Lastly, the model shows the significant effects of period ($B = -2.199$, $p < 0.001$), begin game ($B = 147.785$, $p < 0.001$) and endgame effects ($B = 42.297$, $p < 0.001$).

Table 1: Two-level multilevel regression on Resource size

	Dependent variable:		
	Resource Size		
	(1)	(2)	(3)
Economic heterogeneity	−6.947	−8.498	−11.267
	(41.222)	(41.476)	(40.983)
x Period	1.052**	1.052**	1.052**
	(0.363)	(0.363)	(0.363)
Sociocultural heterogeneity	−19.948	−17.229	−18.083
	(41.882)	(42.266)	(41.277)
x Period	−0.896*	−0.896*	−0.896*
	(0.369)	(0.369)	(0.369)
Economic & Sociocultural	11.433	14.379	20.419
	(41.882)	(42.299)	(41.959)
x Period	−2.286***	−2.286***	−2.286***
	(0.369)	(0.369)	(0.369)
General Trust		67.988	65.054
		(100.272)	(106.407)
Age			16.468*
			(6.293)
Friends			−25.148
			(21.954)
Game Theory Experience			−45.456
			(57.678)
Student			206.160
			(160.569)
Period	−2.199***	−2.199***	−2.199***
	(0.301)	(0.301)	(0.301)
Begin effects	147.785***	147.785***	147.785***
	(5.726)	(5.726)	(5.726)
Endgame effects	42.297***	42.297***	42.297***
	(5.726)	(5.726)	(5.726)
Constant	403.240***	363.467***	−186.094
	(29.787)	(65.851)	(269.222)
Observations	2,440	2,440	2,440
Groups	61	61	61
Log Likelihood	−14,066.500	−14,060.740	−14,039.430
Akaike Inf. Crit.	28,157.000	28,147.490	28,112.870
Bayesian Inf. Crit.	28,226.550	28,222.830	28,211.360

Note: *p<0.05; **p<0.01; ***p<0.001
Tables produced with *Stargazer*(Hlavac, 2018)

4.3 Micro-level results

Table 2 shows the three-level multilevel regression on the micro-level variable appropriation effort. Model 3 and model 4 are the complete models including control variables for respectively appropriation effort, and the log of appropriation effort.[6] The unstandardized coefficients will be discussed.

Model 3 shows no significant effects of the treatments - as main effects or by period - on individual appropriation effort, compared to the homogeneity treatment. The model does show a significant negative effect of trust - measured by the IG at the beginning of the experiment - on appropriation effort (B = -5.139, p = 0.002), indicating that higher levels of individual trust yields more cooperative behaviour on the individual level, supporting hypothesis 3. Regarding control variables, the model shows a significant negative effect of resource size in $t-1$ on appropriation effort (B = 0.015, p $<$ 0.001), and a positive effect of sum of appropriation of the other players in t-1 (B = 0.054, p $<$ 0.001). Lastly, the model shows significant positive effects of period (B = -0.154, p $<$ 0.001) and endgame effects (B = 1.493, p = 0.0013). Model 4, taking the log of individual appropriation effort, shows significant negative effects of the treatments by period: economic heterogeneity (B = -0.023, p = 0.0030), sociocultural heterogeneity (B = -0.022, p = 0.006) and the combination treatment of sociocultural and economic heterogeneity (B = -0.025, p = 0.002). This implies that compared to individual appropriation effort over time in the homogeneity group, there is a 2.32%, 2.20% and 2.49% steeper decrease in appropriation effort per period for respectively the economic, sociocultural and economic and sociocultural heterogeneity treatments.[7] Similar to model 3, trust in model 4 has a significant negative effect on appropriation effort (B = -1.120, p = 0.001), indicating that higher levels of trust lead to an average 67.37% decrease in appropriation effort over the entire game, supporting hypothesis 3 stating the positive effect of trust on cooperation.

[6] Taking the log will normalise the relation with the covariate, and add the advantage of looking at percentage change in the variable, which is interesting when analysing individual behaviour over time

[7] Retrieving the percentage change of coefficients B by taking $100(exp(B)-1)$ (Treiman, 2009)

Table 2: Three-level multilevel regression on Appropriation effort

	Dependent variable:			
	Appropriation			Appropriation (log)
	(1)	(2)	(3)	(4)
Economic heterogeneity	0.009	0.184	0.435	−0.057
	(1.367)	(1.400)	(1.488)	(0.372)
x Period	−0.020	−0.032	−0.025	−0.023**
	(0.029)	(0.029)	(0.030)	(0.008)
Sociocultural heterogeneity	1.214	1.290	1.291	0.180
	(1.388)	(1.424)	(1.509)	(0.377)
x Period	−0.036	−0.026	−0.013	−0.022**
	(0.030)	(0.029)	(0.031)	(0.008)
Economic & Sociocultural	1.148	0.837	0.684	−0.121
	(1.388)	(1.424)	(1.509)	(0.377)
x Period	−0.030	−0.002	0.004	−0.025**
	(0.030)	(0.030)	(0.031)	(0.008)
General trust		−4.026**	−5.139**	−1.120***
		(1.553)	(1.655)	(0.335)
Resource size t-1		0.012***	0.015***	0.007***
		(0.002)	(0.002)	(0.0004)
Sum appropriation others t-1			0.054***	
			(0.005)	
Sum appropriation others t-1 (log)				−0.089***
				(0.027)
Age			−0.036	−0.011
			(0.081)	(0.016)
Sex			−2.119*	−0.143
			(1.021)	(0.209)
Friends			0.504	0.003
			(0.353)	(0.072)
Game Theory Experience			1.048	−0.093
			(0.976)	(0.199)
Period	−0.220***	−0.194***	−0.154***	−0.014**
	(0.024)	(0.024)	(0.025)	(0.007)
Begin effects	1.528***	−0.228	−0.120	−0.758***
	(0.459)	(0.509)	(0.529)	(0.138)
Endgame effects	2.434***	1.931***	1.493***	0.229*
	(0.459)	(0.461)	(0.464)	(0.121)
Constant	35.609***	33.173***	28.355***	2.213***
	(1.015)	(1.503)	(2.715)	(0.584)
Observations	9,760	9,760	9,477	9,477
Subjects	244	244	243	243
Groups	61	61	61	61
Log Likelihood	−38,262.620	−38,233.740	−37,137.280	−24,371.890
Akaike Inf. Crit.	76,551.240	76,497.490	74,314.550	48,783.790
Bayesian Inf. Crit.	76,644.650	76,605.260	74,457.650	48,926.880

Note: *p<0.05; **p<0.01; ***p<0.001
Model 3 & 4: N = 243 due to 1 missing response on sex
Tables produced with *Stargazer*(Hlavac, 2018)

4.4 Trust results

Table 3 shows results of an ordinal logistic regression on two trust questions from the post-experimental survey. Both questions are measured on a 7-point Likert scale ranging from 'completely disagree'(0) to 'completely agree'(6). Model 1 shows that subjects in the economic heterogeneity treatment are 2.08 times as likely to report higher levels of trust in other players of their group (group here being the four person group in the Fishing Game) than the homogeneity treatment (OR = 2.083, p = 0.028), indicating higher levels of mutual trust in the economic heterogeneity treatment. Model 2 shows a similar effect: subjects in the economic heterogeneity treatment are 2.202 times as likely to report higher levels of trustworthiness of their fellow players than subjects in the homogeneity group (OR = 2.02, p = 0.018), indicating higher levels of trustworthy behaviour. Both models control for amongst others average appropriation of the other three players in the group, average resource size, perceived fairness ("I felt treated fairly while playing the Fishing Game, 0-6") and individual characteristics, showing that it is not just the success of the resource and with it the higher benefit per invested unit x, nor individual characteristics, but something else originating from the economic heterogeneity treatment that increases mutual trust among subjects. These findings are surprising given the expected negative relation between economic heterogeneity and trust, as hypothesized in hypothesis 2a. The models do not show any significant differences in trust and perceived trustworthiness for sociocultural heterogeneity or the combination treatment, hereby not supporting hypothesis 2b and 2c.

Table 3: Ordinal Logistic Regression on post-experimental measures of trust

	Dependent variable:	
	" I trusted the other players in my group "	"The other players in my group were trustworthy "
	(1)	(2)
	Odds Ratios	Odd Ratios
Economic heterogeneity	2.083*	2.202*
	(0.695)	(0.733)
Sociocultural heterogeneity	1.242	1.196
	(0.404)	(0.395)
Both	1.751	1.823
	(0.596)	(0.622)
Age	1.049*	1.013
	(0.025)	(0.025)
Friends	0.999	0.817*
	(0.073)	(0.091)
Game theory experience	1.347	1.031
	(0.317)	(0.246)
Sex	1.344	1.042
	(0.340)	(0.269)
Student	1.236	1.117
	(0.769)	(0.716)
Mean appropriation others	1.019	0.950**
	(0.017)	(0.018)
Mean resource size	1.005***	1.004***
	(0.001)	(0.001)
General trust (IG)	1.852	0.888
	(0.771)	(0.369)
Perceived fairness	1.476***	1.969***
	(0.115)	(0.169)
Observations	243	243

Note: *p<0.05; **p<0.01; ***p<0.001
N = 243 due to 1 missing response on sex
Tables produced with *Stargazer*(Hlavac, 2018)

4.5 Revisiting expectations

Despite the unexpected direction of the effect, the combination of results in table 1, 2 and 3 does support the theoretical macro-micro-macro framework as depicted in figure 1. Table 1 shows that economic and sociocultural heterogeneity affect collective action and resource size on the macro level respectively in a positive and negative way compared to homogeneity (arrow 4). Table 3 shows a positive effect of economic heterogeneity on individual level trust as measured in the post-experimental survey (arrow 1). Table 2 shows a positive effect of trust - as measured in the Investment Game - on individual appropriation effort (arrow 2). Lastly, it is a characteristic of the game that the aggregate of higher individual appropriation efforts will lead to a decrease in the resource size, as depicted in arrow 3.

Despite the majority of research suggesting a negative effect of heterogeneity on cooperation, the positive effect of heterogeneity is theorized by the economist Mancur Olson in his book *The logic of collective action: pubic goods and the theory of groups.* (Olson, 1965) describing what is known as the "Olson-effect":

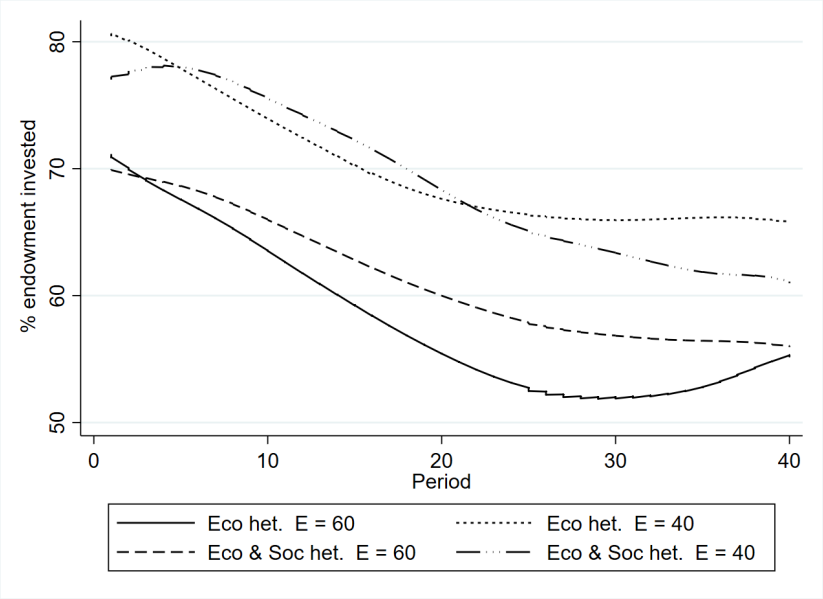
> *"In smaller groups marked by considerable degrees of inequality – that is, in groups of members of unequal "size" or extent of interest in the collective good – there is the greatest likelihood that a collective good will be provided; for the greater the interest in the collective good of any single member, the greater the likelihood that that member will get such a significant proportion of the total benefit from the collective good that he will gain from seeing that the good is provided, even if he has to pay all of the cost himself"(Olson, 1965, p. 34).*

Although not directly mentioning the positive effect of economic heterogeneity on cooperation, this quote does hint to the theoretical mechanism of the richer bearing the cost of cooperation for the poorer by overinvesting in cooperation. In the context of the current CPR experiment, the higher endowed subjects may have invested less than they could have, to provide space for the lesser endowed to invest in the resource for profit. The cost for not investing in the resource is lower for the higher endowed subjects, as they have more points to begin with, that they can keep if they don't invest them. A striking fact is that no positive effects were found on either resource size or trust in the combination treatment where economic and and sociocultural heterogeneity coincide.

To explore the possibilities of the Olson-effect in the current experiment, figure 4 shows a plot of the investing behaviour of the high and low endowed subjects in the economic heterogeneity and combination treatments. The figure shows that in the economic heterogeneity group, the investments in appropriation relative to the endowments for the higher endowed people are lower than the relative investments from the same group in the combination treatment. For both treatments, the lower endowed subjects have about the same relative appropriation over time. It may thus be the case that subjects in the economic

heterogeneity treatment are more successful in finding a cooperative understanding between players. However, it is still the case that the higher endowed in both treatments overappropriate on average, but an unpaired t-test points out that the higher endowed appropriate more in the economic heterogeneity (M = 34.519, SD = 0.446) than in the combination (M = 36.666, SD = 0.498) treatment (t(2478) = -3.219, p = 0.001).

Figure 4: Relative endowment high and low endowed in economic heterogeneity and combination treatment



As there seems to be a clear difference between treatments with sociocultural homogeneity and heterogeneity, a closer look can be taken at the effect of the MGE on in-game behaviour. Comparing the average trust in the neutral IG (i.e. playing with a random other player before the MGE) with average trust in the outgroup IG (i.e. playing with an outgroup member after the MGE) a paired-samples t-test shows that there is a significant difference in average trust between a general (M = 0.570, SD = 0.019) and an outgroup (M = 0.470, SD = 0.021) interaction (t(243) = -7.058, $p < 0.001$). The average trust in the ingroup (M = 0.577. SD = 0.020) and outgroup (M = 0.470, SD = 0.021) IG interaction is also significant (t(243) = 8.082, $p < 0.001$). These results show that even with a division that is as artefactual as painting preferences of painters in the same discipline, group identities are strong enough to behave differently towards ingroup and outgroup members.

5 Discussion

The aim of this paper is to study the impact of economic and sociocultural heterogeneity and the coincidence of both through trust on micro- and macro-outcomes of cooperative behaviour in CPR settings. Using a laboratory experiment, allowed for the effects of economic and sociocultural heterogeneity and trust to be disentangled and to establish the causal direction of effects. Existing literature largely suggests negative effects of heterogeneity on trust and on collective action, and positive effects of trust on societal outcomes.

The results show a negative effect of sociocultural heterogeneity and the combination of economic and sociocultural heterogeneity on the macro-outcome resource size compared to the homogeneity treatment. Surprisingly, a positive effect of economic heterogeneity is found on resource size, indicating that the negative effect found in the combination treatment stems from the sociocultural heterogeneity influence, and not necessarily from the economic heterogeneity in itself. When looking at differences in behaviour between subjects with high and low endowments, it is visible that subjects with high endowments in the economic heterogeneity treatment invest less on average than subjects with a high endowment in the combination treatment. Regarding trust, it was found that subjects in the economic heterogeneity treatment reported higher trust in other players and higher trustworthiness of other players during the Fishing Game, compared to the homogeneity treatment. The Investment Game results also showed that subjects acted more trusting towards ingroup members than to outgroup members, and even less trusting towards outgroup members than to a random other person before the MGE. Trust itself is found to have a positive effect on individual level cooperation.

These results show firstly that heterogeneity on the macro level indeed affects individual considerations like trust on the micro level, which in turn influence micro-level actions that sum up to macro-level outcomes as described in the macro-micro-macro model. They also show that it is important to distinguish between different types of heterogeneity and the combination of these different types, as this can influence the way in which heterogeneity does or does not influence cooperation. Despite the numerous research articles advocating a negative effect of economic heterogeneity, it may be possible that instead economic heterogeneity may have positive consequences for collective action, if the rich act as catalysts for cooperation by bearing the cost of collective action just a little more than the poor, as suggested by Olson (1965).

Some critical comments can be made about this study. Firstly, a well-known criticism of laboratory experiments using mainly students as their subjects is that it does not represent any situation in the real world, while generalising the results as real-world outcomes. However, it is important to first observe human behaviour in simple cases before one is able to understand the more complex picture; a controlled laboratory setting is tailor-made to point out causal directions of hypothesized effects. The external validity of experiments can be secured as long as the environment under which the results are generated capture essential characteristics of the real-world version of the phenomenon that

is being researched (Fehr et al., 2003). In the current paper, a CPR experiment was conducted, containing key aspects of the way CPRs work in contrast to for instance Public Good Games. Regarding the subject group, the criticism is largely valid: students will probably behave differently from other groups in society, especially from local fishermen whose entire life depends on profits made by the CPR. An improvement on this study could be made by setting up an artefactual field experiment, better known as a lab-in-field experiment, which used a similar controlled environment, artefactual games, but a subject pool that is more like the population of interest; in this case, CPR users. Understanding cooperative behaviour and trust under different conditions of heterogeneity is a core question within social sciences, but is also of grave importance to understanding how and why societies work the way they do. Especially in a time of increasing depletion of natural resources, manifested in overfishing of the seas, deforestation of rainforests and the unsustainable use of fresh water for farming, it is crucial to understand the behaviour of the humans involved in overexploitation. The investigation of relations between heterogeneity, trust and cooperation are not only important to advance insights within the social sciences, but also demonstrate the importance of scientific research on real-world developments.

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References

Adams, J. S. (1965, January). Inequity In Social Exchange. *Advances in Experimental Social Psychology*, *2*, 267-299. doi: 10.1016/S0065-2601(08)60108-2

Adams, J. S., & Freedman, S. (1976, January). Equity Theory Revisited: Comments and Annotated Bibliography. *Advances in Experimental Social Psychology*, *9*, 43-90. doi: 10.1016/S0065-2601(08)60058-1

Aksoy, O. (2015, December). Effects of Heterogeneity and Homophily on Cooperation. *Social Psychology Quarterly*, *78*(4), 324-344. doi: 10.1177/0190272515612403

Aksoy, O., & Weesie, J. (2012, January). Beliefs about the social orientations of others: A parametric test of the triangle, false consensus, and cone hypotheses. *Journal of Experimental Social Psychology*, *48*(1), 45-54. doi: 10.1016/j.jesp.2011.07.009

Alesina, A., & La Ferrara, E. (2000). Participation in Heterogeneous Communities.

Alesina, A., & La Ferrara, E. (2002, August). Who trusts others? *Journal of Public Economics*, *85*(2), 207-234. doi: 10.1016/S0047-2727(01)00084-6

Anderies, J. M., Janssen, M. A., Bousquet, F., Cardenas, J.-C., Castillo, D., Lopez, M.-C., ... Wutich, A. (2011, July). The challenge of understanding decisions in experimental studies of common pool resource governance. *Ecological Economics*, *70*(9), 1571-1579. doi: 10.1016/j.ecolecon.2011.01.011

Anderson, C. J., & Paskeviciute, A. (2006). How Ethnic and Linguistic Heterogeneity Influence the Prospects for Civil Society: A Comparative Study of Citizenship Behavior. *The Journal of Politics*, *68*(4), 783-802. doi: 10.1111/j.1468-2508.2006.00470.x

Anderson, L. R., Mellor, J. M., & Milyo, J. (2006, September). Induced heterogeneity in trust experiments. *Experimental Economics*, *9*(3), 223-235. doi: 10.1007/s10683-006-9124-2

Andersson, K., & Agrawal, A. (2011, August). Inequalities, institutions, and forest commons. *Global Environmental Change*, *21*(3), 866-875. doi: 10.1016/j.gloenvcha.2011.03.004

Axelrod, R., & Hamilton, W. D. (1981). The Evolution of Cooperation. *Science*, *211*(4489), 1390-1396.

Bahry, D., L., & Wilson, R., K. (2006, May). Confusion or fairness in the field? Rejections in the ultimatum game under the strategy method. *Journal of Economic Behavior & Organization*, *60*(1), 37-54. doi: 10.1016/j.jebo.2004.07.005

Bardhan, P., & Dayton-Johnson, J. (2002). Unequal irrigators: Heterogeneity and commons management in large-scale multi-variate research. In E. Ostrom, T. Dietz, N. Dolsak, P. C. Stern, S. Stonich, & E. U. Weber (Eds.), *The Drama of the Commons* (p. 87-112). Washington, D. C.: National Academy Press.

Barr, A. (1999). *Familiarity and trust: An experimental investigation* (CSAE Working Paper Series No. 1999-23). Centre for the Study of African Economies, University of Oxford.

Becker, C. D., & Ostrom, E. (1995). Human Ecology and Resource Sustainability: The Importance of Institutional Diversity. *Annual Review of Ecology and Systematics*, *26*, 113-133.

Bellemare, C., & Kroger, S. (2003). On Representative Trust. *SSRN Electronic Journal*. doi: 10.2139/ssrn.425340

Berg, J., Dickhaut, J., & McCabe, K. (1995, July). Trust, Reciprocity, and Social History. *Games and Economic Behavior*, *10*(1), 122-142. doi: 10.1006/game.1995.1027

Billig, M. G., & Tajfel, H. (January/March 1973). Social categorization and similarity in intergroup behaviour. *European Journal of Social Psychology*, *3*(1), 27-52. doi: 10.1002/ejsp.2420030103

Bottom, W. P. (1998, November). Negotiator Risk: Sources of Uncertainty and the Impact of Reference Points on Negotiated Agreements. *Organizational Behavior and Human Decision Processes*, *76*(2), 89-112. doi: 10.1006/obhd.1998.2800

Bottom, W. P., Holloway, J., Miller, G. J., Mislin, A., & Whitford, A. (2006). Building a Pathway to Cooperation: Negotiation and Social Exchange between Principal and Agent. *Administrative Science Quarterly*, *51*(1), 29-58.

Bouckaert, J., & Dhaene, G. (2002, August). *Inter-ethnic trust and reciprocity: Results of an experiment with small business entrepreneurs* (Tech. Rep. No. 2002022). University of Antwerp, Faculty of Applied Economics.

Bouckaert, J., & Dhaene, G. (2004, November). Inter-ethnic trust and reciprocity: Results of an experiment with small businessmen. *European Journal of Political Economy*, *20*(4), 869-886. doi: 10.1016/j.ejpoleco.2003.08.006

Bowles, S., & Gintis, H. (2002). Social Capital and Community Governance. *The Economic Journal*, *112*(483), F419-F436.

Boyd, R., & Richerson, P. J. (1985). *Culture and the evolutionary process.* Chicago: University of Chicaco Press.

Brandts, J., & Charness, G. (2000, March). Hot vs. cold: Sequential responses and preference stability in experimental games. *Experimental Economics*, *2*(3), 227-238. doi: 10.1007/BF01669197

Burks, S., Carpenter, J., & Goette, L. (2009, June). Performance pay and worker cooperation: Evidence from an artefactual field experiment. *Journal of Economic Behavior & Organization*, *70*(3), 458-469. doi: 10.1016/j.jebo.2008.02.012

Burks, S., V., Carpenter, J., P., & Verhoogen, E. (2003, June). Playing both roles in the trust game. *Journal of Economic Behavior & Organization*, *51*(2), 195-216. doi: 10.1016/S0167-2681(02)00093-8

Camerer, C., & Thaler, R. H. (1995). Anomalies: Ultimatums, Dictators and Manners. *The Journal of Economic Perspectives*, *9*(2), 209-219.

Chan, K. S., Mestelman, S., Moir, R., & Muller, R. A. (1999, August). Heterogeneity and the voluntary provision of public goods. *Experimental Economics*, *2*(1), 5-30. doi: 10.1007/BF01669132

Chaudhuri, A. (2011, March). Sustaining cooperation in laboratory public goods experiments: A selective survey of the literature. *Experimental Economics*, *14*(1), 47-83. doi: 10.1007/s10683-010-9257-1

Chen, Y., & Li, S. X. (2009). Group Identity and Social Preferences. *The American Economic Review*, *99*(1), 431-457.

Cherry, T. L., Kroll, S., & Shogren, J. F. (2005, July). The impact of endowment heterogeneity and origin on public good contributions: Evidence from the lab. *Journal of Economic Behavior & Organization*, *57*(3), 357-365. doi: 10.1016/j.jebo.2003.11.010

Coleman, J. S. (1987). Microfoundations and macrosocial behaviour. In J. Alexander C., B. Giesen, R. Münch, & N. J. Smelser (Eds.), *The Micro-Macro link* (p. 153-173). Berkely: University of California.

Coleman, J. S. (1994). *Foundations of social theory.* Cambridge, MA: Harvard University Press.

Delhey, J., & Newton, K. (2005). Predicting Cross-National Levels of Social Trust: Global Pattern or Nordic Exceptionalism? *European Sociological Review*, *21*(4), 311-327.

De Oliveira, A., Croson, R. T. A., & Eckel, C. C. (2009). One Bad Apple: Uncertainty and Heterogeneity in Public Good Provision. *SSRN Electronic Journal*. doi: 10.2139/ssrn.1883766

Eckel, C. C., & Grossman, P. J. (2005, November). Managing diversity by creating team identity. *Journal of Economic Behavior & Organization*, *58*(3), 371-392. doi: 10.1016/j.jebo.2004.01.003

Ellickson, R. C. (1991). *Order without Law: How Neighbors Settle Disputes.* Harvard University Press.

Evans, A. M., & Revelle, W. (2008, December). Survey and behavioral measurements of interpersonal trust. *Journal of Research in Personality*, *42*(6), 1585-1593. doi: 10.1016/j.jrp.2008.07.011

Fehr, E., Fischbacher, U., von Rosenbladt, B., Schupp, J., & Wagner, G. G. (2003, February). *A Nation-Wide Laboratory: Examining Trust and Trustworthiness by Integrating Behavioral Experiments into Representative Survey* (SSRN Scholarly Paper No. ID 385120). Rochester, NY: Social Science Research Network.

Fershtman, C., & Gneezy, U. (2001). Discrimination in a Segmented Society: An Experimental Approach. *The Quarterly Journal of Economics*, *116*(1), 351-377.

Fischbacher, U. (2007, June). Z-Tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics*, *10*(2), 171-178. doi: 10.1007/s10683-006-9159-4

Flache, A., & Mäs, M. (2008, February). Why do faultlines matter? A computational model of how strong demographic faultlines undermine team cohesion. *Simulation Modelling Practice and Theory*, *16*(2), 175-191. doi: 10.1016/j.simpat.2007.11.020

Fukuyama, F. (1995). *Trust: The social virtues and the creation of prosperity.* New York: Free Press.

Gehrig, S., Schlüter, A., & Hammerstein, P. (17-jan-2019). Sociocultural heterogeneity in a common pool resource dilemma. *PLOS ONE*, *14*(1), e0210561. doi: 10.1371/journal.pone.0210561

Glaeser, E. L., Laibson, D., Scheinkman, J. A., & Soutter, C. L. (1999). *What is Social Capital? The Determinants of Trust and Trustworthiness* (Working Paper No. 7216). National Bureau of Economic Research. doi: 10.3386/w7216

Glaeser, E. L., Laibson, D. I., Scheinkman, J. A., & Soutter, C. L. (2000, August). Measuring Trust. *The Quarterly Journal of Economics*, *115*(3), 811-846. doi: 10.1162/003355300554926

Gouldner, A. W. (1960). The Norm of Reciprocity: A Preliminary Statement. *American Sociological Review*, *25*(2), 161-178. doi: 10.2307/2092623

Greiner, B. (2004). The Online Recruitment System ORSEE 2.0 - A Guide for the Organization of Experiments in Economics. , 67.

Güth, W., Huck, S., & Müller, W. (2001, October). The Relevance of Equal Splits in Ultimatum Games. *Games and Economic Behavior*, *37*(1), 161-169. doi: 10.1006/game.2000.0829

Hardin, G. (1968). The Tragedy of the Commons. *Science*, *162*(3859), 1243-1248.

Hedström, P. (2005). *Dissecting the Social : On the Principles of Analytical Sociology.* Cambridge: Cambridge University Press.

Hlavac, M. (2018). *Stargazer: Well-Formatted Regression and Summary Statistics Tables. R package version 5.2.2.*

Janssen, M. A., Holahan, R., Lee, A., & Ostrom, E. (2010, April). Lab Experiments for the Study of Social-Ecological Systems. *Science*, *328*(5978), 613-617. doi: 10.1126/science.1183532

Johnson, N. D., & Mislin, A. A. (2011, October). Trust games: A meta-analysis. *Journal of Economic Psychology*, *32*(5), 865-889. doi: 10.1016/j.joep.2011.05.007

Johnson, R. N., & Libecap, G. D. (1982). Contracting Problems and Regulation: The Case of the Fishery. *The American Economic Review*, *72*(5), 1005-1022.

Jones, E. C. (2004, April). Wealth-Based Trust and the Development of Collective Action. *World Development*, *32*(4), 691-711. doi: 10.1016/j.worlddev.2003.10.009

Keller, R. T. (2001). Cross-Functional Project Groups in Research and New Product Development: Diversity, Communications, Job Stress, and Outcomes. *The Academy of Management Journal*, *44*(3), 547-555. doi: 10.2307/3069369

Knack, S., & Keefer, P. (1997). Does Social Capital Have an Economic Payoff? A Cross-Country Investigation. *The Quarterly Journal of Economics*, *112*(4), 1251-1288.

Kölle, F. (2015, January). Heterogeneity and cooperation: The role of capability and valuation on public goods provision. *Journal of Economic Behavior*

& Organization, *109*, 120-134. doi: 10.1016/j.jebo.2014.11.009

Kreps, D. M., Milgrom, P., Roberts, J., & Wilson, R. (1982, August). Rational cooperation in the finitely repeated prisoners' dilemma. *Journal of Economic Theory*, *27*(2), 245-252. doi: 10.1016/0022-0531(82)90029-1

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. W. (1997). Trust in Large Organizations. *The American Economic Review*, *87*(2), 333-338.

Ledyard, J. O. (1993). *Public Goods: A Survey of Experimental Research.* Division of the Humanities and Social Sciences, California Institute of Technology.

Levati, M. V., Sutter, M., & van der Heijden, E. (2007, October). Leading by Example in a Public Goods Experiment with Heterogeneity and Incomplete Information. *Journal of Conflict Resolution*, *51*(5), 793-818. doi: 10.1177/0022002707302796

Levitt, S. D., & List, J. A. (2009, January). Field experiments in economics: The past, the present, and the future. *European Economic Review*, *53*(1), 1-18. doi: 10.1016/j.euroecorev.2008.12.001

Meinzen-Dick, R., Chaturvedi, R., Domènech, L., Ghate, R., Janssen, M., Rollins, N., & Sandeep, K. (2016). Games for groundwater governance: Field experiments in Andhra Pradesh, India. *Ecology and Society*, *21*(3).

Nettle, D., & Dunbar, R. I. M. (1997). Social Markers and the Evolution of Reciprocal Exchange. *Current Anthropology*, *38*(1), 93-99.

Olson, M. (1965). *The logic of collective action: Pubic goods and the theory of groups.* Cambridge, MA: Harvard University Press.

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action.* Cambridge ; New York: Cambridge University Press.

Ostrom, E., Walker, J., & Gardner, R. (1992). Rules, Games and Common-Pool Resources. *The American Political Science Review*, *86*(2), 404-417. doi: 10.2307/1964229

Portes, A., & Landolt, P. (2000, May). Social Capital: Promise and Pitfalls of its Role in Development. *Journal of Latin American Studies*, *32*(2), 529-547.

Poteete, A. R., & Ostrom, E. (2004). Heterogeneity, group size and collective action: The role of institutions in forest management. *Development and change*, *35*(3), 435–461.

Putnam, R. D. (1993). *Making democracy work: Civic traditions in modern Italy.* Princeton, NJ: Princeton University Press.

Putnam, R. D. (2000). *Bowling alone: The collapse and revival of American community.* New York: Simon & Schuster.

Putnam, R. D. (2007, June). E Pluribus Unum: Diversity and Community in the Twenty-first Century The 2006 Johan Skytte Prize Lecture. *Scandinavian Political Studies*, *30*(2), 137-174. doi: 10.1111/j.1467-9477.2007.00176.x

Raub, W., Buskens, V., & Van Assen, M. a. L. M. (2011, January). Micro-Macro Links and Microfoundations in Sociology. *The Journal of Mathematical Sociology*, *35*(1-3), 1-25. doi: 10.1080/0022250X.2010.532263

Roth, A. E. (1995). Bargaining experiments. In J. H. Kagel & A. E. Roth (Eds.), *Handbook of Experimental Economics* (p. 253-348). Princeton,

NJ: Princeton University Press.

Ruttan, L. M. (2006, October). Sociocultural Heterogeneity and the Commons. *Current Anthropology*, *47*(5), 843-853. doi: 10.1086/507185

Ruttan, L. M. (2008, May). Economic Heterogeneity and the Commons: Effects on Collective Action and Collective Goods Provisioning. *World Development*, *36*(5), 969-985. doi: 10.1016/j.worlddev.2007.05.005

Sanfey, A. G., Rilling, J. K., Aronson, J. A., Nystrom, L. E., & Cohen, J. D. (2003). The Neural Basis of Economic Decision-Making in the Ultimatum Game. *Science*, *300*(5626), 1755-1758.

Shanmugaratnam, N. (1996, December). Nationalisation, Privatisation and the dilemmas of common property management in Western Rajasthan. *The Journal of Development Studies*, *33*(2), 163-187. doi: 10.1080/00220389608422461

Singleton, S. (2001). How distributional conflicts shape co-management institutions and collaborative environmental policy in the United States. In *"Economic Inequality, Collective Action and Environmental Sustainability" workshop*. Santa Fe Institute.

Smith, V. L. (2010, January). Theory and experiment: What are the questions? *Journal of Economic Behavior & Organization*, *73*(1), 3-15. doi: 10.1016/j.jebo.2009.02.008

Tajfel, H., Billig, M. G., Bundy, R. P., & Flament, C. (April/June 1971). Social categorization and intergroup behaviour. *European Journal of Social Psychology*, *1*(2), 149-178. doi: 10.1002/ejsp.2420010202

Treiman, D. J. (2009). *Quantitative Data Analysis: Doing Social Research to Test Ideas*. New York, NY, UNITED STATES: John Wiley & Sons, Incorporated.

Uslaner, E. M. (2002). *The moral foundations of trust*. Cambridge: Cambridge University Press.

Van Soest, D., & Vyrastekova, J. (2005). Peer enforcement in CPR experiments: The relative effectiveness of sanctions and transfer rewards, d the role of behavioural types. In J. A. List (Ed.), *Using Experimental Methods in Environmental and Resource Economics*. Edward Elgar Publishing.

Varughese, G., & Ostrom, E. (2001). The Contested Role of Heterogeneity in Collective Action: Some Evidence from Community Forestry in Nepal. *World Development*, *29*(5), 747-765.

Vedeld, T. (2000, June). Village politics: Heterogeneity, leadership and collective action. *The Journal of Development Studies*, *36*(5), 105-134. doi: 10.1080/00220380008422648

Yamagishi, T., & Kiyonari, T. (2000). The Group as the Container of Generalized Reciprocity. *Social Psychology Quarterly*, *63*(2), 116-132. doi: 10.2307/2695887

You, J.-s. (2012, October). Social Trust: Fairness Matters More Than Homogeneity: Social Trust: Fairness Matters. *Political Psychology*, *33*(5), 701-721. doi: 10.1111/j.1467-9221.2012.00893.x

Zak, P. J., & Knack, S. (2001). Trust and Growth. *The Economic Journal*, *111*(470), 295-321.